HISTORY OF THE SECOND WORLD WAR

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BRITISH WAR PRODUCTION

BY

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PREFACE

THE present volume has been designed to introduce a series. In his preface to *British War Economy* Professor Hancock, the General Editor of the Civil Histories of the War, made it clear that the studies concerned with war industry and with the four supply ministries would form a self-contained group of volumes, a series within a larger series. The plan of the war-production histories, which was announced at about the same time, was perhaps more ambitious than the books which are now taking shape. But the general composition of the series has not been much altered. The volumes which are now nearing completion will deal with the supply and control of raw materials, with the supply and utilisation of labour in the munitions industry, with the provision of factories, plant and machine tools, with the administrative machinery of the supply departments, with the finance of war production and with overseas supplies. There may also be a composite volume dealing with the design and development of weapons. It was also part of the original plan to introduce the series by a 'synoptic' volume covering the entire field of war production. In fulfilment of this plan the present volume is now offered.

The introductory character of this volume will account for some of its obvious features. That in a general survey of this kind a number of topics should be treated very briefly is something to be expected; and from the point of view of a general reader, or of a reader about to proceed to a study of the specialist volumes, this brevity may turn out to be a fault on the right side. What both the general reader and a serious student may find less to their liking is the book's lack of consistency in the distribution of space and detail. Whereas some topics, such as the changing demand for weapons or the trends of output and deliveries, are treated at some length, other topics, such as raw materials, labour or industrial capacity, are sketched out in mere outline.

The repeated changes in the scale of the narrative interfered with its writing as much as they may interfere with its reading, but they were nevertheless inevitable. In accordance with its introductory and synoptic purpose, this volume embraces the various subjects which form the themes of the specialised volumes. These subjects had to be treated briefly if they were to be accommodated between two covers; and this could be done in the knowledge that they were due to receive fuller treatment in other studies. The introductory volume must, however, contain certain other subjects which could not be thus compressed. Although most of the field of war production had

been partitioned among the specialised volumes, the partition was not, and could not be, so perfect as to leave no unappropriated residue. Above all, the general trends of demand and supply, i.e. the strategic and economic factors which shaped the 'programmes' of the Services and determined the flow of 'deliveries', could not be easily relegated to later volumes. They were the common denominator of all the other studies, and, besides, could not be expounded without ranging over every aspect of war industry. They had therefore from the very outset been defined as 'introductory' and consigned solely to the synoptic volume. And, so consigned, they had to be allowed more space and a greater ration of detail than the subjects which were due to be dealt with more fully elsewhere.

This inequality of scale has, so to speak, been planned. Other inequalities have been forced by circumstances unforeseen at the time of planning. The political and psychological climate in which this book was conceived is not the climate in which it is now destined to see the light of day. With the country in the midst of another effort of rearmament the interests of security demand that some topics should be eschewed altogether and that others should be cast in a form less specific than that which had at first been intended for them. Thus, the whole of the projected chapter on the quality of weapons, dealing with the problems of design, development, research and innovation has been scrapped. Such fragments of the subject as can conveniently be discussed and are intimately related to the story of production, e.g. the quality of tanks before 1944, the early history of radar, the relation of modifications to new design in aircraft production, have been salvaged from the projected chapter and incorporated in other parts of the book.

The main victims of the new circumstances have been the two concluding chapters of the study. In the original plan a large section, nearly half of the volume, was to be devoted to industrial topics. It was to deal with the size and structure of undertakings, with the managerial and technical processes in factories, with utilisation of space and machinery, with the behaviour and position of labour: in short, with the whole complex of subjects which in academic classification belong to the 'economics and sociology of industry'. This, if done, would not only have rounded off the survey but might also have improved its balance. For, in general, the civil histories of the war are, to use the phrase in Professor Hancock's preface, 'anchored to the records of Government departments'. They are written in Government offices, are planned and executed in constant consultation with civil servants and are, therefore, bound to occupy themselves with the actions of ministers and officials, and to deal obliquely and incompletely with events and processes in the nation at large. At the time when the present volume was in preparation, there was some

hope that its very subject would have made it possible to redress somewhat the 'departmental' bias of the series as a whole. The records and publications of a number of firms had to be consulted, numerous industrial undertakings to be visited, views of managers and employees to be taken; and this appeared to offer an opportunity for planning a large 'industrial' section. Unfortunately, this hope could not be entirely fulfilled. To have done this in the manner originally planned would have meant to discuss in great detail the experiences of firms and factories which are now again engaged in the making of weapons, sometimes the same weapons which they made in the last war. Considerations of security have now made this inadvisable, and, as a result, two brief and general chapters have taken the place of what was to be a large part of the volume.

The necessities of a synoptic study have determined not only the choice of topics and the internal balance of the volume, but also the very process and technique of its composition. Like all the other volumes in the civil histories this volume is based on a vast mass of original material. Most writers of individual volumes in civil histories have found their documentation voluminous to the point of being overwhelming. How much more voluminous and overwhelming must then be the documentation of a volume covering the entire field of war production and based upon the records of four Government departments and of a large number of industrial undertakings! The number of files which had to be read or looked through in the preparation of this volume may well have run into a score of thousands; recorded testimonies, opinions and reminiscences into many hundreds.

The composition of this volume had therefore to begin with a co-operative effort of pre-digestion. Much of the material had first to be turned into narratives capable of being used in the writing of this book in much the same way in which secondary authorities are used in the writing of ordinary historical treatises. Some, perhaps most, of the narratives I had to compile myself, a number of others are the work of my colleagues and assistants, and some have in fact been written as contributions to the other volumes in the series.

This volume thus owes a great deal to the researches of colleagues who will be producing books of their own. But some credit also belongs to others who will not be able to publish the results of their researches under their own names; and, of these, I should especially like to mention Mr. L. Errington and Mrs. D. Fearon, who investigated the naval programmes; Mr. C. Wrigley, who wrote the story of merchant ship building; Mrs. E. Bridge, who compiled an account of the repair of aircraft; and Mr. D. Mack Smith, who co-operated with me in the writing of the preliminary story of Royal Ordnance Factories. Throughout the years of my work on the history of war

production I have also had the good fortune of being helped by a succession of personal assistants without whom the task would have been utterly unmanageable: by my wife, by Mrs. Geoffrey Agnew, by Miss A. Nicholson and, above all, by Miss I. Bains, on whom fell most of the work of helping me with the drafting of the final version of the book, and seeing it through the various stages of correction, proof-reading and indexing. I wish space, conventions of the Civil Service and the rules established for the volumes in the 'civil series' allowed me to mention by name the very many persons in the Government departments, in industry and politics, who helped me with information, documents, criticism and encouragement. But they all know how much this volume owes to them and how conscious I am of my debt to them.

M. M. POSTAN

CHAPTER I

INTRODUCTORY: THE LEAN YEARS

(1)

'No Major War'

BRITISH rearmament between 1934 and 1939 began and grew with the rising danger of war with Germany, but what set the scale of the problem was not only the magnitude of international danger but also the low level of military equipment in the hands of the Forces in the early thirties. In dealing with the pace of rearmament it is, therefore, important to get the true measure of the deficiency which the rearmament sought to remedy.

The manner in which the deficiency arose is clear enough. In the twenties war seemed remote, and the hopes of prolonged peace ran very high. It is, therefore, no wonder that throughout most of the inter-war period the programmes of the Services were governed by the assumption that no major war was to be expected. The peace hypothesis since its first formulation in August 1919 had taken a somewhat different form from year to year and from Service to Service, but from July 1928 until March 1932 the approved formula, as agreed by the Committee of Imperial Defence, was 'that it should be assumed for the purpose of framing the estimates of the fighting services that at any given date there will be no major war for ten years'.[1] Acting on this 'ten-year assumption' the Government of the day allowed the establishment and the material equipment of the Forces to run down.

How small the national expenditure on armaments was in the inter-war years will be seen from Table 1. The figures have not been compiled on a basis sufficiently uniform to allow an exact computation of the total expenditure on the armaments of the three Services taken together. But the margin of error in a total of this kind would not be very great—rather less than five per cent.—and the annual expenditure thus computed would give an approximately accurate estimate of what the nation spent on buying and maintaining the armaments of its Forces. The annual average for the ten years was about £23 millions.

[1] This assumption was to be reviewed yearly by the Committee of Imperial Defence and any government department could raise the matter for discussion by that committee if it was thought desirable.

Expenditure on armaments and warlike stores, 1924–33[1]

TABLE I — £ millions

Year ending 31st March	Navy[2]	R.A.F.	Army
Column 1	2	3	4
1924	11·8 (5·0)	4·9	2·6
1925	13·0 (6·0)	6·9	2·6
1926	14·1 (5·4)	7·6	2·2
1927	16·0 (8·3)	7·4	1·8
1928	16·3 (9·0)	7·6	1·8
1929	15·0 (8·5)	7·1	2·0
1930	14·4 (7·7)	7·9	2·2
1931	10·7 (5·0)	8·9	1·5
1932	10·3 (4·8)	8·7	1·8
1933	10·7 (6·0)	7·8	1·6

(2)

The Naval Standards

The table makes it clear that the sums were spread not only thinly but also unevenly, and there is also other evidence to show that deficiencies were not equally grave in each of the three Services. Even though naval construction was the one branch of British armaments subject to formal international disarmament treaties, the fighting strength of the Navy had not slumped as low as that of the other two Services. By the Washington Naval Treaty of 1922 and the London Naval Treaty of 1930[3] Britain had accepted restrictions in the number and quality of capital ships,[4] aircraft carriers, cruisers, destroyers and submarines. Judged by numbers alone, the Navy was not thereby greatly enfeebled. Cruiser strength suffered most, for the number of cruisers allowed under the London Treaty of 1930 fell well short of the seventy which the Admiralty considered necessary for trade protection. The treaty allowed, however, for a continuous programme of replacements at the rate of three cruisers a year, which was higher than the rate at which Great Britain had been building previously. What is more, the number of battleships and aircraft carriers retained

[1] The principles on which these figures have been compiled are given in Appendix 6. Owing to differences in the methods of calculating expenditure on armaments in each of the three Services the figures in the columns, though roughly comparable, cannot be added together to give the total annual expenditure on armaments.

[2] The first column shows total expenditure on new shipbuilding construction, repairs, re-equipment and maintenance stores; the figures in brackets represent expenditure on new naval construction only.

[3] Cmd. 2036, Treaty Series No. 5 (1924); Cmd. 3758, Treaty Series No. 1 (1931).

[4] A capital ship was defined in the Washington Naval Treaty as a war vessel whose displacement exceeds 10,000 tons standard displacement or which carries a gun with a calibre exceeding 8 inches.

under the treaties and the strength of the small ships were sufficient to provide a fleet at least equal to the demands of the so-called 'one-power standard'; and this for the time being was thought to be sufficient. The doctrine was that naval strength should be great enough to enable the British fleet, wherever situated, to equal any other fleet, wherever situated. Since Japan was regarded as the only possible enemy, the 'one-power standard' in practice meant the maintenance of a naval force capable of meeting the Japanese Navy at its selected moment. Making allowance for the necessity of docking and refitting, the force needed to confront the Japanese in the Far East was estimated at some twelve capital ships, five aircraft carriers, forty-six cruisers, nine flotillas of destroyers, fifty submarines and a proportionate number of smaller craft. In addition, three more capital ships and four more cruisers would have had to be left behind in Home Waters and had also to be provided for in the programme.

These requirements were in fact met by the existing British fleet, and, in theory at least, very little new construction was needed to maintain British naval strength at the standard thus defined. The position, however, was not as satisfactory in practice as it appeared to be in theory. Adequate as the fleet might appear in numbers it was weakened by a great proportion of old ships. Under the 1930 Treaty the British Government accepted a rate of replacement under which it would take Britain about fifteen years to re-equip her fleet with modern ships. In actual fact the scale of new construction was even slower than that. The average annual cost of new construction from 1930 up to and including 1934 was some £6 millions;[1] this sum covered three cruisers, nine destroyers and a small number of submarines and sloops. This meant that by the end of 1936, when the 1930 Treaty was due for renewal, the full scale of replacement allowed under the treaty would be reached only for cruisers—some 91,000 new tons in all. The replacements of destroyers and submarines would still be below the treaty limits to the extent of 60,000 tons and 40,000 tons respectively. Moreover, in the prevailing conditions of financial stringency little could be done to provide out of the naval estimates for the modernising of battleships: a process in which Japan and the United States were then much more active than Great Britain. Nor was it possible to lay down reserves of ammunition and stores or to equip auxiliary vessels and bases that would be required in time of war.

The financial stringency was also affecting the quality of the ships built. Both the initial costs of construction and those of maintenance had to be pared down to the minimum, and for this purpose the size of cruisers was reduced from 10,000 tons to some 7,000 or 5,000

[1] See Table 1, p. 2. Expenditure on naval new construction in 1934 was £7·7 millions.

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tons, and that of destroyers was also for a long time kept very low.

So much for current construction. Potentially even more important was the growing weakness of the industrial reserves at home which was bound to result in a slowing down in the future rate of construction. In the past the Admiralty could, both in times of war and during periods of increased naval construction in peace-time, rely on the vast shipbuilding resources of the country. These resources were declining between the two wars. As a result of a chronic depression in the shipbuilding industry specialised labour was drifting away from the main shipbuilding areas: slowly in the early twenties, much faster in the thirties. By 1935 the total insured labour force stood at about 157,000 or about one-half of what it had been in the early twenties. Even slip capacity, of which in theory there was a superabundance, was declining. In theory, the number of suitable berths, however much reduced (in 1939 it was only fifty per cent. of that of 1930), was fully sufficient for naval needs. But, in practice, much of the surviving commercial capacity had not gone through the crisis unscathed and was now showing signs of neglected re-equipment and maintenance. It was, of course, possible to argue that even at this reduced level Britain's shipbuilding resources were greater than those of any other country and represented a reserve of specialised industrial capacity far greater than that available to the Army or to the R.A.F. Nevertheless by 1935 the margin was much narrower than in the past and also narrower than the Admiralty had been in the habit of assuming in the discussions on the shipbuilding programmes.

For all these reasons the prevailing opinion in the early thirties in British naval circles was that British naval strength had been allowed to run down below the safety limit as set by the 'one-power standard' realistically interpreted; and before long the 'one-power standard' itself came to be regarded as insufficient. Yet viewed in retrospect the position of the Navy, bad as it was, was relatively speaking no worse, and from some points of view much better, than that of the other Services. Even though the strength of the fleet fell short of strategic requirements, the gap between present strength and future needs was not as wide as elsewhere.

(3)

The Rations of the R.A.F.

In most of these respects the R.A.F. was somewhat worse off. In theory, it was expanding all through the late twenties and early thirties. By a Government decision in 1923 the Royal Air Force, then greatly reduced by demobilisation and economy campaigns, was to be raised to and maintained at a level of fifty-two squadrons for home

defence with a first-line strength of 550 machines. This decision, however, was not backed by sufficient financial appropriations and remained largely a dead letter. Aeroplanes for new formations were coming forward very slowly, sometimes not at all; 495 airframes were ordered in 1928, 573 in 1929, 855 in 1930, 728 in 1931, 445 in 1932 and 633 in 1933; but only seventy airframes were available for new formations in 1928, forty-nine in 1929, sixty-three in 1930, eighty-three in 1931 and none in 1932 and 1933. No wonder that by the beginning of 1934 the Home Force was still only forty-two squadrons strong or ten squadrons short of its minimum objective.

Production was devoted more to the re-equipment of some of the existing squadrons than to the building up of an air force to the minimum laid down in 1923. Yet even the re-equipment was little more than nominal. In the early thirties the bulk of the Air Force was still made up of aircraft types dating to the war of 1914–18. The types available for replacement, though more recent, were not only few in number, but as a rule were below the technical and operational standards of the day. As late as 1935 the principal 'new' fighter coming into service was the Gloster-Gauntlet with a speed of 230 m.p.h., and the 'new' bombers were the Hind and the Hendon with a load-carrying capacity of 500 lb. and 1,500 lb. at a range of 430 miles and 920 miles respectively. The general impression is that throughout these years the quality of R.A.F. equipment was falling below the standards which in the early thirties were being established in foreign countries, such as Italy and the United States.

With financial provisions and new output at a very low level, the Air Ministry had great difficulty in maintaining its industrial reserves. The aircraft firms, including the principal engine firms, found themselves in a position of chronic penury and sometimes on the very verge of bankruptcy. Westland Aircraft Company at one time tried to keep alive by making stainless steel beer barrels. Not all the firms were in straits quite so desperate or were compelled to adopt expedients equally unusual, but very few could have survived without the tutelage of the Air Ministry. In order to maintain a nucleus of an aircraft industry and to keep in existence facilities for aircraft design, the Air Ministry had to ration out all new work among some sixteen substantial aircraft firms. The system helped to consolidate the so-called 'family' of aircraft firms and to establish links between the Air Ministry and the aircraft industry which were to prove most valuable in future years. But for the time being the diet, though just sufficient to keep the bulk of the firms alive, was too meagre to enable them to keep pace with the aircraft industry abroad, especially in the United States, and to acquire the equipment and technique for quantity production. The Air Council and the Air Staff had thus every reason for thinking that their Service was being starved out.

(4)

The Disarmed Army

Lower still was the equipment of the field forces. The Army did not occupy a place in the traditional concepts of British power as important as that of the Navy and did not figure as prominently in plans of Imperial defence. Nor could it match the R.A.F. in its ability to impress the public and to overawe the statesmen by its terrible and yet undisclosed potentialities for destruction. The field forces were therefore bound to be the main victims of the financial stringency. The annual allocation for the purchase and maintenance of army weapons and war-stores in the decade between 1923 and 1933 seldom exceeded £2·5 millions and averaged about £2 millions, or slightly less than nine per cent. of the small sums spent on armaments in an average year.[1]

The effects of the stringency were all but crippling. The official doctrine of the War Office in the late twenties and the early thirties was that of a highly-equipped small and mobile professional army. Small it indeed was—its regular nucleus in the twenties was only four divisions strong. To some extent it was also becoming mobile, for under the current scheme of mechanisation its entire transport, cavalry and artillery, was due to be motorised. But highly equipped it certainly was not.

Mechanisation was the largest and the best-advertised of the Army's projects of modernisation, but in fact throughout the twenties and early thirties it was not carried beyond a merely experimental stage. The Royal Army Service Corps alone was completely mechanised by 1930. By 1929 some brigades of the Royal Artillery were equipped with tracked tractors, several Royal Engineer and Signal units were mechanised, and a few cavalry units had their first-line transport converted to lorries. Between 1930 and 1934 the artillery, the engineer, signal and R.A.S.C. units of the Territorials were also supplied with lorries. It was not, however, until 1934 that the infantry began to be mechanised, and it was not until 1938 that the Regular Army obtained its peace-time complement of wheeled vehicles and as much as one-half of its complement of tracked vehicles, quite apart from tanks. Before 1934 the process appeared more impressive in lists of units than in terms of actual equipment ordered and supplied. The total number of all wheeled motor vehicles ordered in the ten years from 1923 to 1932 was little more than 5,000, or about 500 per annum. Of this the six-wheeled lorries, the main element of mechanised equipment, formed somewhat less than half.

[1] See Table 1, p. 2.

Even that, however, was more than could be done for other types of equipment. Some weapons, e.g. rifles and field guns, survived in large numbers from the 1914–18 war and were held in store by the Army. Most of them, however, were out-of-date and in need of modernisation and modification. In 1935 the field gun in service was the last war's 18-pounder, with its barrels not yet re-lined and its carriage not yet mounted on pneumatic wheels. The anti-aircraft gun in service was the last war's 3-inch 20-cwt: an inadequate gun on an antiquated mounting. The automatic infantry weapons were the Vickers machine gun designed in the eighties of the last century and the Lewis gun designed in 1912. It was not until 1933 that the War Office, in its search for a modern light machine gun, picked on the Zbrojowka 0·303 gun, the Bren of the future years; and the first batch of Brens made in this country were not delivered to the Army until the end of 1937. Although designs for a modern tank and anti-tank gun (the 2-pounder) were available in the early thirties, none were ordered till December 1935, and none delivered till April 1937. Until then the Army possessed no specialised anti-tank gun, while the obsolete 3-pounder and the heavy Vickers machine gun formed the standard armament of the armoured vehicles.

The tank itself was a British invention, yet the supply and design of tanks were allowed in the late twenties and thirties to dwindle almost to vanishing point. Organisation for tank design in the War Office was rudimentary in the extreme, and but for the solitary and pioneering efforts of the designers at Vickers-Armstrongs the country would have possessed no facilities for the design and development of armoured vehicles. As late as 1936 the total equipment of tanks in the hands of the Army was 375, of which 209 were designated as light and 166 as medium. Of the total number, 304 were officially classed as obsolete, and these included all the medium tanks with the exception of two, both experimental. The rest, i.e. 164 out of 166, were the Marks I, Ia and II which had been produced between 1925 and 1929 and were from every point of view out-of-date. The only 'up-to-date' equipment consisted of some sixty-nine light tanks (Marks V and VI), but these were not introduced until 1935 and 1936, and even they were armed with nothing better than machine guns. New tanks of heavier weight, armed and armoured for infantry function and conforming to contemporary ideas of tank design were not available even in project form. As late as 1937 wooden dummies took the place of heavier tanks in army manœuvres.

So it was with many other weapons. New arms were neither ordered nor designed. Is it then to be wondered at that the industrial facilities at the disposal of the Army had declined to almost the lowest point since the Crimean War? The National Munition Factories of the first World War had all been closed down or otherwise disposed of

by 1923; the Hereford factory alone remained in Government hands, and even that was kept only as a reserve plant on a 'care and maintenance' basis. The state-owned capacity for the production of army weapons came to be restricted to the three Royal Ordnance Factories —the Royal Arsenal, Woolwich, the Royal Small Arms Factory, Enfield Lock, and the Royal Gunpowder Factory, Waltham. In each of these output and employment were by 1933 reduced to the minimum: less than 7,000 were employed at Woolwich, largely on Admiralty work, compared with 65,000 in 1918; some 800 at Enfield Lock compared with some 9,500 in 1918; and 354 at Waltham compared with some 5,730 in 1918. Privately-owned capacity dwindled even more. Whereas in 1913 there were in this country at least four great armament firms, by 1934 three of these had left the field or ceased to exist and only one fully-fledged armament firm—Vickers-Armstrongs—survived. Imperial Chemical Industries (I.C.I.) could of course be counted upon for a limited supply of explosives; some capacity for small arms ammunition was also available at I.C.I. and at Greenwood and Batley, and for small arms at the Birmingham Small Arms Company (B.S.A.) and at Vickers-Armstrongs, and there was a small nucleus of specialised firms making equipment for the Navy. But in all these firms the capacity actually engaged or immediately available for military production was very small indeed and could not be expanded at short notice. Elsewhere production of weapons would be impossible without a thorough industrial reconversion and re-education.

CHAPTER II

EARLY REARMAMENT, 1934–1938

(1)

Obstacles, Financial and Industrial

THE level of equipment at the starting point of rearmament was thus very low: indeed so low that measures to raise it might have had to be taken even had peace remained as unruffled as it appeared to be in the twenties. As we know now, peace did not remain unruffled. The first rumblings of the storm came from the Far East, the very region on which hitherto the entire British defence strategy had been focused. And no sooner did the shock of the Japanese action in Manchuria pass away than Hitler came to power in Germany. All through 1934 and 1935 the political configuration of the Axis was taking its final shape. In 1935 Italy embarked upon her adventure in Abyssinia, and in a short time the danger of conflict over the enforcement of sanctions appeared very serious. At about the same time Japan denounced the Treaty of Naval Limitations and embarked on unlimited naval expansion. In March 1935 Germany repudiated the Treaty of Versailles.

The comfortable assurance of security and the expectations of undisturbed peace which characterised the twenties could no longer be entertained. In March 1932 the ten-year hypothesis[1] was revoked, and the Government called upon the Committee of Imperial Defence to reconsider the fundamental conceptions of Empire defence. By the middle of 1933 Germany for the first time reappeared in official discussions as a potential enemy, and in the autumn of the following year the Cabinet decided to correct in the course of the next five years the accumulated armament deficiencies, thus by implication halving the 'safe' period within which no war was expected. By 1934 the first expansion programme deserving that name began to be discussed by the Services and by the Government. In the course of the following year committees of the Cabinet and of the Committee of Imperial Defence, and in the first place the important Defence Policy and Requirements Committee, reviewed the condition of the armed forces and recommended enlarged scales of equipment for the three Services. At the turn of 1935 and 1936 Hitler's remilitarisation of the Rhineland coincided with the adoption of the first rearmament programme.

[1] See p. 1.

From that time onwards the history of British rearmament and military production is one of continually mounting requirements, of an ever-widening scale of munitions industry and of a progressively growing output of war-stores. Where a process was so continuous and so cumulative the achievements of the initial phase were bound to be somewhat modest. But in the history of British rearmament the initial phase was not only modest but also very long. Rearmament programmes had been taking shape in 1934 and 1935, and the preliminary discussions of underlying political and strategic issues reached back as far as the turn of 1932 and 1933. Yet, until the very turn of 1938 and 1939 national efforts at rearmament remained on what may be described as a peace-time scale. By that time much had been done to re-equip the fighting Services and more still to lay the foundations of war industry; yet to an historian viewing the period from the vantage point of 1952 the progress may well appear slow and halting.

The pace and scale of the industrial rearmament are not difficult to explain. They may well appear insufficient if set against the needs of the war years and judged by the experience of the war effort. But at the time of its inception rearmament was not designed to establish in the country any semblance of a war economy. Indeed, in the circumstances of the mid-thirties war-time conceptions like these would have appeared both unnecessary and impossible.

To begin with, the diplomatic and strategic assumptions which until the end of 1938 underlay rearmament were not those of an eventual war. Disturbed as the international position had become, war was not yet thought to be probable, still less inevitable. The state of acute crisis both over Manchuria and over Abyssinia boiled up and subsided too quickly to turn to war the plans of the Government and the thoughts of the nation. Until 1935 international disarmament was still a popular hope and still the object of British foreign policy. For at least another three years the object of the successive rearmament programmes was not so much preparation for war as the reinforcement of peace. Their purpose was to back up diplomatic efforts with a show of force and thereby to impress the would-be aggressors and to reassure public opinion at home. The early stages of rearmament were therefore dominated by the need for a 'deterrent' display—a first-line strength impressive on paper but not necessarily backed by sufficient establishments or by industrial reserves. It was not until late in 1936 that the R.A.F. began to rearm with a view to a possible conflict;[1] and it was not until the end of 1938 that the danger of conflict came to be felt sufficiently urgently to accelerate the pace of rearmament and to overshadow other considerations. Indeed, the plans of the Government did not come to be shaped for a land war in Europe until the spring of 1939.

[1] See p. 15 for the aircraft programme approved in 1936.

In the second place, a number of domestic factors—mostly economic and financial—combined to prevent the deployment of national resources for an all-out effort of rearmament. In resisting the demands of the Services, the Chancellors of the Exchequer sometimes made use of a purely industrial argument. Industry, they argued, would not be in a position to turn out the ships, the aeroplanes and the weapons in the quantities and at the times envisaged by the Service programmes. This argument, however, took it for granted that the economy of the country could not and must not be stimulated and reshaped to suit the needs of rearmament. Had the danger of war appeared more imminent the limitations of industrial capacity would have been swept aside—as in fact they were to be swept aside at the turn of 1938 and 1939 and more still in 1940. They appeared so conspicuous and so insuperable in 1935 because the Government was not yet concerned with war.

What it was largely concerned with was the British economy convalescing from a recent crisis. Generally speaking it was the Government's policy to protect normal business from disturbance, and the official view was that economic recovery and in particular the revival of the export trade would suffer if too large a proportion of the country's economic resources were diverted to production for the Services. This view was not, of course, based on precise measurements of the resources which might be absorbed in rearmament on the scale demanded by the Services, nor was the large volume of resources still unemployed taken into account. But although not precisely measured and although imperfectly explained, the danger of economic disturbance greatly affected official thought on these matters. In addition some people also feared the 'setting-aside' of peace-time methods. If military production were greatly increased controls over industry might become necessary; and controls, they thought, were 'premature': the country was not ripe for them and their effects on the national economy were bound to be injurious.

It is therefore no wonder that Cabinet representatives on the various sub-committees of the Committee of Imperial Defence, not excluding the Minister for Co-ordination of Defence himself, were compelled to issue periodical reminders of the need to conserve freedom of industrial development. When in 1936 the completion date of the first scheme for real rearmament in the air (Scheme F)[1] was postponed for another six months, the delay was frankly ascribed to the policy of safeguarding industry from dislocation. As late as the autumn of 1937 the Minister for Co-ordination of Defence thought it necessary to remind the Chiefs of Staff Sub-Committee of the Cabinet's decision that the reconditioning of the Services was to be

[1] See p. 15.

carried out without interference with normal trade. On that occasion the Minister hinted that circumstances might force the Government to revise its directive, but it was not until March 1938 that the Secretary of State for Air was induced to ask the Government to reconsider its general industrial policy and that rearmament orders could claim some priority over ordinary civilian business.

More inhibiting still and much more fundamental were the difficulties of finance. Until the autumn of 1938 rearmament of the three Services continued to be limited by financial allocations, and in some fields the limits were not to be removed until the spring of 1939 or even until Dunkirk. No doubt the financial limits seem much narrower in retrospect than they must have appeared to some contemporaries, and above all to the men who set them up. Measured in absolute terms or related to the financial provisions of the early twenties, the budgetary allocations for rearmament between 1935 and 1939 appear generous in the extreme. The annual cost of equipment and stores for the fighting Services rose nearly eightfold from about £37 millions in the financial year ending March 1934 to £273 millions in the year ending March 1939 and, as Table 2 shows, was strongly rising all the time. By 1938 the expenditure was far greater than that ever incurred by this country in peace. To finance it the Government raised the standard rate of income tax from 4s. 6d. in the pound in 1934 to 5s. 6d. in 1936 and 7s. 6d. in 1939; and in 1937 it launched a five-year rearmament loan of £400 millions, which in its turn was raised in the spring of 1939 to £800 millions.

Estimated annual expenditure on rearmament, 1934–39[1]

TABLE 2 £ millions

Year ending March	Total	R.O.F.s[2]	Army	Navy	R.A.F.
1934	37·2	nil	6·9	20·9	9·4
1935	42·6	nil	8·5	24·2	9·9
1936	60·7	nil	12·5	29·6	18·6
1937	104·2	1·5	21·4	42·0	39·3
1938	182·2	8·7	44·3	63·2	66·0
1939	273·1	12·7	67·6	82·9	109·9

[1] Figures in this table are taken from the Annual Estimates and include gross estimated expenditure on warlike stores, factory construction and plant, works, buildings and land, research, inspection and general stores such as furniture, camp equipment, etc. They do not include military expenditure on food, clothing, medical and educational services, payment of personnel, etc. Owing to differences in methods of calculating the estimates the figures for the three Services are only roughly comparable. (*Note:* Table 1, p. 2, showed only direct expenditure on warlike stores.)

[2] Figures for R.O.F.s relate only to expenditure on factory construction and plant. Other capital expenditure and the cost of stores supplied from trade or from R.O.F.s are included in the other three columns.

Yet the financial allocations, great as they were compared with the normal peace-time expenditure on the armed forces, turned out to be inadequate in relation to their objects. They were cramping to the men in charge of rearmament and proved to be insufficient for the very purposes for which the country was rearming. The supplies they bought were not large enough either to deter the aggressor or fully to prepare this country for war.

The financial arguments employed were not in any way new. All governments, and especially all British Governments, are bound to resist additions to expenditure, and Treasury control had always been a powerful and, on the whole, a salutary brake on military extravagance. If in the early thirties the Government appeared to use the brake with great vigour, it could claim for this every theoretical and political justification. It was still engaged in fighting the great depression, and although its way of doing so might not be approved by present-day economists, it was not subjected to much critical doubt in the official circles of 1935. The days of Keynes' 'General Theory' were not yet, and the prevalent view was that the crisis had been aggravated, if not caused, by Government extravagance and could only be remedied by a drastic curtailment of Government expenditure and taxation. This was indeed the main argument against Mr. MacDonald's Labour Government and became the programme of Mr. MacDonald's National Government. And as long as these arguments prevailed new and great additions to expenditure appeared to be too dangerous for this country to adopt.

Indeed the financial dangers of excessive expenditure on rearmament continued to figure in official discussions almost to the eve of the war. As late as 1938 the Chancellor of the Exchequer, in resisting further claims of the Services, found it necessary to stress that expenditure could reach a limit beyond which it might defeat the very purpose of rearmament. Finance, he argued, was one of Britain's military resources: something in the nature of a fourth arm. Britain could not hope to match an aggressor in a lightning war, and her chances of victory rested on her ability to withstand the financial stresses of a long war. To overtax her financial resources and to undermine her financial stability for the sake of military preparedness might jeopardise her very ability to wage war.

Hence, the continuous rearguard action which the Chancellors of the Exchequer fought against the ever-rising demands of the Services. Within limits they had to give way, and the financial allocations constantly grew, but limits there always were, and for at least three years after the first rearmament programmes these limits continued to circumscribe the supply of arms for the Forces as well as the preparation of industry for the production of munitions in time of war.

(2)

The Re-equipment of the R.A.F.

The financial allocations being what they were, none of the three Services was able to launch programmes of re-equipment and expansion on a scale which on political and strategic grounds it thought necessary. But although for a long time no Service fared as well as it wished, some Services were impeded less than others and freed themselves earlier from impediments.

The R.A.F. was probably the first to overcome the purely financial limits to its expansion, and its rate of growth was higher than that of the other Services. At frequent intervals between 1934 and 1939 the Air Staff assessed the German position more or less accurately and uttered warnings more or less audibly. The effect of the warnings on the Government was to make it well aware of the crucial importance of the air arm. Indeed, as time went on, the dangers of air attack and the overwhelming importance of air defence appeared if anything greater than the war was to prove them to be. By 1938 the Government was sufficiently sensitive to the air dangers to give the R.A.F., and, to some extent, the anti-aircraft defences, the first claim on available resources. This meant rejecting the earlier doctrine of a 'balanced' allocation of resources between the three Services[1] and allowing a clear priority to the air arm. The priority was becoming more pronounced as the crisis over Czechoslovakia approached, and at the time of Munich all obstacles to air defence were swept away and nothing but industrial capacity limited the rate of rearmament in the air.

This position, however, was reached relatively late and by slow stages. When at the beginning of 1934 the Defence Requirements Committee considered the plans for the re-equipment of the Forces, the most far-reaching and ambitious of its proposals was to equip the Air Force on a scale which would enable it to engage in sustained warfare against Germany within five years. In the spring of 1934 Mr. Baldwin announced in Parliament that the Government had decided to establish parity with Germany in the air.[2] Yet neither the Cabinet nor presumably the country was as yet prepared to shoulder the financial weight of Mr. Baldwin's promise or of the Defence Requirements Committee's proposal. Even in May 1935, after Mr. Eden and Sir John Simon had travelled to the Continent and come back convinced that Hitler meant business, an additional vote of £1 million for the time being measured the financial response to the situation.[3]

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[1] See p. 29.
[2] H. of C. Deb., Vol. 286, Col. 2078, 8th March 1934
[3] 1935 Air Estimates for Vote III—Equipment.

It is possible to argue that, at first, finance was not the only limit to the expansion of the R.A.F. It is probable that in 1934 and 1935 purely technical considerations stood in the way of immediate 'all-out' re-equipment. Technical progress in the mid-thirties was on the verge of new and important developments: high-speed monoplanes, all-metal construction, new engines; and Service circles began to visualise the expanded air force in terms of aircraft which in those years had not fully emerged from design and development. And while the advance types—the Wellingtons, the Spitfires and others like them—were not yet available, the Air Staff were not at all anxious to encumber the squadrons with large supplies of all but obsolescent types.

So what with the financial stringency and the absence of new types, the early stages of re-equipment were slow and tentative. The Air Ministry did not ask for a fully-balanced air force and the Government was not very anxious to supply it. The objective of the immediate plans was merely a visible first-line capable of producing the maximum political effect both at home and abroad: to reassure the public about the Prime Minister's promises and as far as possible to impress the Italians and Germans with a show of strength. Expressed in the somewhat less direct language of the official memoranda the policy was to concentrate on the expansion of a first-line Home Defence Force even though this would not produce an air force capable of sustained warfare within the period of five years contemplated by the Defence Requirements Committee.

Needless to say, the programme was merely the first measure of expansion and others were to follow. No sooner was it put into operation than new information of Hitler's plans revealed the utter inadequacy of the provisions so far sanctioned, and further discussions and revisions of programmes followed. It was, however, not until 1936 that a real change of principle took place. What had changed in the meantime was not only the world situation but also the technical prospects of the R.A.F. In the words of an Air Ministry memorandum of February 1936, the Air Ministry had 'pressed on with the development and production of new types' and was now able to formulate 'a much more effective programme' which it hoped could be realised by 1939.

The new programme, henceforth to be known as Scheme F, was sanctioned by the Cabinet in February 1936 and was to remain in force for two years. It marked a complete departure from the purely demonstrative principles of old and introduced the first real measure of expansion. Under its provisions the Air Force was to acquire more than 8,000 new aircraft over three years compared with the 3,800 over two years under the current programme. Moreover, what was now expanded was not the political or the propaganda effect of the

Air Force but its combatant power. Although the total provision was now much higher, the number of units in the first line was, if anything, brought down while the size of reserves was greatly increased.[1]

Moreover, under the new programme the Air Force was not only to be expanded but was also to be effectively re-equipped with new and up-to-date types. The Hurricane, the Spitfire, the Battle, the Blenheim, the Whitley, the Hampden, the Wellington and the Wellesley were to form the bulk of the new establishment. And what from the point of view of the country's preparedness for war was even more important was the vast amount of industrial effort which the programme called forth. Its introduction roughly coincided with the appointment of Lord Swinton as Secretary of State for Air and with important administrative changes in the Air Ministry, and under the new régime the Ministry sponsored great additions to industrial capacity and gave the industry the shape which it was to keep for the next six or seven years.

Scheme F turned out to be the most long-lived of the aircraft programmes. As already mentioned it remained in force for two years, and no other scheme remained undisturbed for a period equally long. Nevertheless, even under that scheme the re-equipment of the Air Force fell somewhat behind the hopes of its authors in 1936 and far behind the needs of the time and the rising demands of the Services. At the time of its demise in the spring of 1938 it had run two-thirds of its allotted span with only 4,500 out of its 8,000 aircraft delivered. And even out of these 4,500 aircraft, some 3,000 had in fact been ordered under the earlier programmes and were not of the most advanced types. In fact, at that time the Spitfire, the Wellington, the Hampden, the Beaufort, the Defiant, the Skua and the Lysander were not yet in production; and the Blenheim, the Hurricane and the Whitley were only just coming into service.

It is moreover doubtful whether, even had the flow of new aircraft under the programme been faster and fully up to expectations, the needs of the times would thereby have been fully met and the Air Council have remained quiescent and satisfied. The Scheme was only just sufficient to enable the country to meet the German menace as it appeared at the beginning of 1936 and to match the plans of the *Luftwaffe* as they were known at that time. But in the meantime both the urgency of the German menace and German armament in the air had greatly grown. Throughout 1936, 1937 and 1938 the international situation moved towards a crisis by a series of successive stages: the occupation of the Rhineland, the rape of Austria and the beginning of the Sudetenland agitation. All through this period

[1] They were to cost £50 millions compared with £1·2 million under the earlier programme, and this was calculated to be sufficient to equip the R.A.F. with total reserves to the extent of about 225 per cent. of first-line aircraft.

Germany re-armed in the air at a constantly rising rate. It is no wonder that at each sign of international trouble Germany's strength in the air had to be reassessed; and that each time estimates of Germany's strength were revised the Air Council put forward demands for corresponding increases in the scale of British expansion.

These proposals invariably met with insuperable obstacles. Several successive programmes came up for discussion, and all of them were beyond the available financial resources. Even the great rearmament vote and loan of 7th March 1938 fell short of the needs of the R.A.F. That vote brought the total planned expenditure of the R.A.F. over the next four years to about £500 millions, but the cost of the minimum programme which the Air Ministry had formulated at the end of 1937 was estimated as at least £650 millions by 1941. There was thus no chance of reconciling the Air Ministry's requirements with the financial allocations, and when on 12th March 1938 the plan came up before the Cabinet, the Secretary of State for Air had to confine himself to a request that the new requirements should be accepted as a long-term project in order that the Air Ministry should be able to extend industrial capacity. In his opinion the advantage of the proposal was that it would always be possible to slow down or halt the programme at any time.

As it turned out, the chances of halting or even of considering long-term projects were very small. In the third week of March Austria was occupied and the dangers in the air at once became more immediate and apparent. There was little time to lose, and for the first time a real note of urgency crept into the discussions of the air plans at the highest level. The discussions did not begin at all auspiciously, and at first it looked as if the mood of urgency notwithstanding the Air Ministry's proposals would go the way of all previous attempts to exceed the current scale of orders. If anything the Chancellor's objections were even more radical than before, and went to the very root of the rearmament drive. He argued that the proposed figures of expenditure could not be reached unless Britain turned herself into a different kind of nation. Germany, for example, had got rid of her war debt and had not such good social services as this country. He was therefore convinced that Britain could not do these things, and proposed to revise the whole attitude to rearmament so as to organise a smaller degree of expansion within the limits of the resources which were in sight.

It is difficult to say how far this argument would have been effective had time been less urgent and had finance in fact remained the only limiting factor to air expansion. As it turned out, finance was no longer the worst obstacle in the path of rearmament in the air. By the beginning of 1938 it came to be realised in the Ministry that orders for aircraft had risen to the utmost capacity of aircraft firms. The

question was no longer what the country's finances could afford but what industry could turn out. So when the committee of Ministers under the Prime Minister's chairmanship[1] met in the early days of April to decide finally and urgently the scale of the aircraft programme, they were compelled to define it not in terms of finance or of Air Force establishment but in those of industrial capacity.

An entirely new principle thus entered into the plans. It was the Prime Minister's view that what was necessary then was not to relate the figures to any particular programme but to consider them as the most optimistic estimate that firms could give on the assumption that all went well. The original Air Ministry proposals required 12,000 aircraft in two years,[2] and this was also the maximum which the Air Ministry and the leaders of the aircraft industry thought could be produced by that date. On the 27th April 1938 Cabinet authority was consequently given to the new plans, and Scheme L of 12,000 aircraft in two years came into operation.[3]

The passing of Scheme L was thus a real turning point. Not only did it reflect the heightened sense of urgency in the Government and Air Ministry, but it also signified the end of the purely financial checks on rearmament. The R.A.F. was the first among the Services to enter into what to all intents and purposes were war-time conditions of supply, for from now on expansion in the air was to be subject only to industrial limitations: raw materials, labour and management. What is more, the industrial limitations came to be felt almost at once. The flow of aircraft production failed to keep up with industry's own forecast, and for a long time industry appeared to be all but incapable of further rapid expansion. This also was a foretaste of the industrial problems of war-time production.

The problems were not to any considerable extent those of material capacity, i.e. of factory space, plant and machinery. By the spring of 1938 most aircraft firms had travelled a long way from the state in which we found them in 1934. With the first orders under the rearmament scheme their position rapidly and strikingly improved. In 1935 and 1936 orders for the Fury helped the Fairey Aviation Company to turn the corner, orders for the Hart revived Hawker Aircraft, and orders for the Harrow injected new life into Handley Page, while orders for the Kestrel engine prevented Rolls-Royce from abandoning the production of aero engines and started them on that road to perfection which they so successfully trod in the subsequent ten years. The Bristol Aeroplane Company, which shared with Rolls-Royce the

[1] Appointed at the Cabinet meeting of 6th April 1938. Its members were the Prime Minister, the Chancellor of the Exchequer, the Minister for Co-ordination of Defence and the Secretary of State for Air.

[2] These proposals envisaged a metropolitan air force of 2,373 first-line aircraft with reserves by 31st March 1940.

[3] Revised in September 1938. See Appendix 3, Table F.

main burden of aero-engine production, was also strengthened at that period. So also were the other 'family' firms, and the industry as a whole appeared to be fully stretched.

Before long, at the end of 1936 and the beginning of 1937, most of the aircraft firms began to find that the tools and floor space inherited from the 'lean years' were no longer sufficient to deal with the expanding programme, but further additions could and, in fact, were made without much strain on available resources. Early in 1936 the Air Ministry and the firms launched a number of projects for factory construction with Government assistance, and under Lord Swinton, i.e. between 1936 and 1938, much new capacity was planned and laid down with a view to future expansion. Some of the new capacity was in the nature of 'shadow schemes', i.e. conceived as contributions to the war potential. But this conception had to be modified with the further expansion of the air programmes. 'Shadow' factories had now to be reckoned as additions to peace-time capacity, and still further capacity had to be laid down. In the course of this continuous piling up of factory buildings and plant, shortages of machine tools and delays in construction were bound to occur here and there, but the factory programme as a whole was as yet well within the powers of the building industry and of the machine-tool industry in this country and abroad, and it was in fact being fulfilled more or less according to expectations.

Thus, broadly speaking, machinery and floor space were adequate for the programmes of 1936 and 1937, and together with the new schemes carried out, approved or planned by the spring of 1938, machinery and floor space were quite adequate for the new scheme of 12,000 aircraft then introduced. So generous had been the Air Ministry under Lord Swinton to schemes of forward planning and so expansive were the policies of the firms themselves that the industry was now if anything over-provided with buildings and plant. Shortages appeared where they had been least expected, partly in raw materials but chiefly in labour. The former were due to earlier under-estimates of requirements and to insufficient provision of fabricating capacity for light alloys. The remedy was to expand the light alloy industry, and this was done. Future experience was to show that even then the fabricating branches of the light alloy industry were not expanded far enough. But apart from this fault of under-provisioning, the remedy was simple and, in so far as it was adopted, sure.

More stubborn and more complicated, however, was the problem of labour. At the end of 1937 the country maintained over a million and a half unemployed, and there was some unemployment even in the engineering industry. But such was the rate of expansion in the aircraft industry that special labour problems, especially those of absorption, were becoming acute. It took longer to train the new

entrants and to assimilate them into aircraft production than manufacturers' experience of the 'lean years' had led them to expect. When in the spring of 1938 the firms promised 12,000 aircraft within two years, they based themselves largely on rough estimates of how much labour they could obtain and digest. These estimates turned out to be too optimistic. The intake of labour was well below the programme, and so consequently was the output of aircraft. The programme assumed an average monthly output of 333 aircraft rising from the 210 actually produced in March 1938 to 690 by June 1939. But as in the first four or five months labour was absorbed to the extent of about seventy per cent. of requirements, output also ran some thirty per cent. behind the estimates, at about 200 aircraft per month.[1]

Remedies were sought and found, and in the process of adopting them in the summer of 1938 the Air Ministry took yet another step away from the methods of peace-time production and towards those of war-time economy. We saw how in the spring of 1938 financial limitations had ceased to determine the scale of aircraft production; but with the industrial measures of the summer months came also the final end of 'business first' and of peace-time methods in general.

The transformation was reflected in the administrative changes in the Air Ministry itself. Before 1934 production of aircraft was under the authority of the Air Member for Supply and Research. As the title of the office shows, the provision of aircraft was lumped together with all the miscellaneous problems of supply and maintenance in the R.A.F. In 1934 with the beginning of the expansion came the first tentative re-organisation, and the functions of design and development were separated off and put in the hands of the Air Member for Research and Development; and in 1938 they were combined with aircraft production under the newly-created office of the Air Member for Development and Production, with Air-Marshal Sir Wilfrid Freeman in charge.[2]

The new office became to all intents and purposes a fully self-contained production department, the embryo of the Ministry of Aircraft Production of future years. It rapidly expanded its functions and tightened its contacts with industry. Between 1936 and 1938, while the aircraft firms could still be relied upon to fulfil their contracts more or less on time, it was not perhaps necessary for the Air Ministry to keep a close check on the industry or to help the firms to find and manage their labour, materials and capacity. By 1936 orders had become sufficiently large and relations with firms sufficiently exacting to justify the appointment of a civilian Director of Production; but his relations with the firms remained essentially those of an

[1] Monthly output 1938: April 158; May 213; June 163; July 210; August 202. See Appendix 4.

[2] The appointment was announced in the House of Commons on 27th June 1938. See H. of C. Deb., Vol. 337, Col. 1532.

expert 'go-between', capable of watching over the progress of production and supervising the placing of orders and of reporting to the Air Council all industrial problems. In 1938, however, when the industry reached the limit of its resources and began to run into all kinds of shortages, something more was needed than a mere watch over progress. So when in June of that year it became obvious that the programme was in difficulties, the Air Member for Development and Production invited a prominent railway engineer—Mr. Ernest Lemon as he then was—to accept the post of Director General of Production (D.G.P.). The new Director General, assisted by a Canadian production engineer of great resource and ingenuity, soon found himself not only mediating between firms and the Ministry in technical matters but assuming the general planning of production.

In so doing he was forced to reshape and rearrange the previous plans of the firms themselves. In the course of the late summer his department carried out a survey of the aircraft industry, and by September he was able to report to the Air Council that in his view the industry was failing in its production and deliveries, partly through shortage of raw materials, but chiefly through its inability to absorb and to train skilled labour with all the necessary speed. To enable it to complete the current programme in time its labour force would have to rise from just over 60,000 in September 1938 to a peak figure of well over 180,000 in January 1939. This would represent a monthly increase of 30,000 or fifty per cent. of its labour force in September. Contrary to their own hopes the aircraft firms had proved unable, and could not be expected, to assimilate new labour at a rate higher than eight per cent. If war production were to be raised above the limit set by the direct recruitment of labour the previous economic assumptions and industrial methods would have to be revised.

The main point of the revision was sub-contracting. In the early days of the expansion sub-contracts were not planned for. At that time forcible transfer of labour and management to war production was as yet impossible and undesirable; but the alternative method, that of utilising the resources of general industry, was also thought to be of little use. The technical view, for the time being accepted by the Air Staff, was that the production of aircraft was so complicated that it could not be entrusted to firms without previous experience of aircraft production and could not therefore be distributed among the various engineering and allied trades. The future expansion of aircraft production was to come from additional plant under the direct management of the 'parent' firms.

It was this assumption that the Director General of Production now proposed to revise. He was not in a position (and it is difficult to say whether it was his wish) to recommend compulsory mobilisation of labour or any similar emergency measures, for although

'business as usual' no longer held back the planners at the Air Ministry, full-fledged war economy was not yet in sight. But he was anxious to exploit the possibilities of sub-contracting, by 'bringing the orders to the labour'. His proposal was that the 'parent' firms should entrust to sub-contractors at least thirty-five per cent. of the outstanding orders, thus increasing the additional employment of labour well above the rates of recruitment and absorption possible in the aircraft industry itself. With these and other less radical improvements in the supply of raw materials and in the position of individual aircraft factories, it was hoped that the programme could be fulfilled in the second half of 1940, i.e. some three months later than its original date.

These hopes were to be fully realised. With the sense of emergency in the background, sub-contracting and the other measures taken at the time soon began to produce results. The end of September and the beginning of October 1938 were marked by a great burst of production, and by the end of the year the industry began to outstrip its own promises and programmes. In the first six months of the next year the actual deliveries, compared with programmes, were as shown in Table 3.

Numbers of aircraft programmed and delivered respectively, January–June 1939

TABLE 3 Number

1939	Programmed[1]	Delivered[2]
January	425	445
February	452	579
March	504	712
April	543	634
May	594	702
June	637	681

This period, however, belongs to the next section. The reason why it is mentioned here at all is that it concludes the initial stage in the history of aircraft production. During that stage the R.A.F. greatly expanded and re-equipped itself, though it did so more slowly than its leaders thought necessary and at times even more slowly than the Government hoped and expected. The need of the period was the removal of official obstacles to the speediest possible rate of rearmament, and the Air Ministry was the first among the Service departments to free itself from the budgetary limitations. With the introduction of the Freeman-Lemon reforms it was also the first Ministry to attempt a centralised, even though a rudimentary, control of indus-

[1] Monthly programmed figures under Scheme L as revised in September 1938. See Appendix 3, Table F.
[2] See Appendix 4.

try. From now on the official management of aircraft production and its problems took the general shape—though not yet the overall dimensions—which they were to keep throughout the subsequent six or seven years.

(3)
The Renovation of the Navy

Additions to naval strength were essential and in the years between 1936 and 1939 the Navy was greatly renovated and somewhat augmented. But compared with the Air Force the rearmament of the Navy did not go either fast or far. We have seen that naval strength—especially in comparison with foreign navies—had never fallen as low as the equipment of the R.A.F., and the leeway to be made up was by comparison small. But the cost of making it up was very high: indeed so high as to leave no financial margin for additional new construction. Expenditure on naval supplies and equipment in the five financial years ending March 1939 was over £240 millions;[1] of this the bulk, more than eighty-five per cent., went to new construction or to the modernisation and equipment of naval vessels. This was a large sum, but it was far from meeting the full needs of the time and farther still from satisfying the Admiralty. It continued to feel the full rigour of financial limitations after they had ceased to control the expansion of the Air Force. No wonder that in naval circles the feeling that more could be done than was in fact being achieved lingered correspondingly longer.

The Admiralty's plans for expansion, unlike those of the other Services, took shape early and remained fairly constant. Its unvarying aim was a 'two-power standard'.[2] Long before 1936 when the 1930 Naval Treaty was due to expire,[3] events in Europe shattered the comfortable international situation which had made the 'one-power standard' acceptable. Throughout the early thirties it had been assumed that the sole naval danger lay in the Far East, and that in war very small forces would be needed in Home Waters and the Mediterranean. In the years following Hitler's rise to power and Mussolini's adventure in Abyssinia this assumption was no longer tenable, and much greater provision for European waters had to be planned.

The plans were at first very modest and in themselves need not have cost much. When at the turn of 1933 and 1934 and again to-

[1] See Table 2, p. 12.

[2] Unlike the 'two-power standard' of pre-1914 which implied that the British Navy was equal to the combined naval forces of any two other powers, the 'two-power standard' now did not take into consideration the largest naval power (U.S.A.), but was confined to naval requirements necessary to protect British interests simultaneously against Japan in the Far East and Germany in Europe.

[3] See p. 3.

wards the end of 1935 the Defence Requirements Sub-Committee of the Committee of Imperial Defence was considering the programmes of the Services, it still tried to fit the naval demands into the framework of the 'one-power standard'. The prospects of German rearmament on the sea did not yet appear either high or immediate,[1] and all that the Defence Requirements Sub-Committee therefore recommended in addition to the 'one-power standard' was a force sufficient to prevent the strongest European naval power from obtaining control of Britain's vital home terminal centres while the Navy was making the disposition for war in the Far East.

This added requirement meant a very small addition to the nominal strength of the fleet—a few more trade protection vessels, chiefly cruisers and destroyers.[2] The financial burdens were nevertheless quite heavy, for although the total number of ships was not to be greatly increased, the approaching end of the 1930 Treaty, due to expire in 1936, as well as the changing international position, made it essential to reduce the excessive proportion of old ships. It was stated that by 1942 seven battleships, twenty-four cruisers, eighty-three destroyers, two aircraft carriers, not to mention a host of smaller ships, would be well over age and would need replacing, and that in addition a large number of other ships would have to be modernised. All this needed large sums of money: something between 250 and 300 million pounds to be spent during the five years 1934–39, or at least four times the annual expenditure on naval construction in any of the previous five years. So high indeed was the cost that the prospects of going beyond the 'one-power standard' were most unpromising, and those of adding to the numbers recommended by the Defence Requirements Sub-Committee (the 'D.R.C. standard') more unpromising still.

Yet such additions appeared very necessary and were soon to be pressed by the Admiralty. The international situation was changing very fast, and before anything could be done to achieve the 'D.R.C. standard' events made its underlying strategic principle out of date. Within a year of the Defence Requirements Sub-Committee's recommendations of November 1935 the Admiralty had to raise the whole problem anew. It reckoned with the probability that the German Navy would in a few years be so strong that the Royal Navy would be unable to defend the Home Waters in addition to the Singapore area. In fact, the reappearance of the German Navy re-focused attention on the need to secure our own Home Waters, and restored

[1] By the time of the Defence Requirements Committee's third report in November 1935 the prospects of German rearmament were recognised and the committee recommended that a 'two-power standard' should be aimed at. It was, however, primarily concerned with the next three years, and as little progress could be made towards a new standard of naval strength during that period, the committee limited its recommendations to the existing approved standard of naval strength, i.e. the 'D.R.C. standard'.

[2] See Table 4, p. 25.

that requirement to its old predominance. A 'two-power standard' had thus become the ruling strategic concept. Naval strength was to be made sufficient:

(1) to enable us to place a fleet in the Far East fully adequate to act on the defensive and to serve as a strong deterrent against any threat to our interests in that part of the globe;
(2) to maintain in all circumstances in Home Waters a force able to meet the requirements of a war with Germany at the same time.

Included in (1) and (2) would be the forces necessary in all parts of the world, behind the cover of the main fleets, to protect our territories and merchant ships against spasmodic attacks.

Table 4 shows the number of vessels by 1942 which this standard necessitated compared with the number needed under the earlier proposals for expansion and with the existing naval strength in 1934.

The naval standards, 1934–36

TABLE 4 Units

	Naval strength 1934	Naval strength required by 1942: 'D.R.C. standard' 1934–35	Naval strength required by 1942: 'Two-power standard' 1935–36[1]
Capital ships	15	15	20
Aircraft carriers	5	8	15
Cruisers	50	70	100
Flotillas of destroyers	9	16	22
Submarines	50	55	82
Escort vessels, minesweepers, etc.	51	120	226

The figures were indeed very large. Added to the costs of the replacements proposed by the Defence Requirements Sub-Committee, the cost of new construction to achieve the 'two-power standard' proved too much for the national finances in 1936, and was to remain so to the end. Indeed, from 1936 onwards the whole story of naval requirements can be represented as a series of abortive attempts to approach the standard with insufficient financial means.

The first of these attempts came in 1935. The Government was now prepared to go as far as to sanction a general plan which was to be spread over seven annual programmes between 1936 and 1942 and which would, if fulfilled, have brought the Navy up to the extended 'one-power standard' as defined by the 'D.R.C.' formula.[2] More than

[1] As stated in 1936. In 1938 requirements for a 'two-power standard' in 1942 were revised as follows: 21 capital ships, 13 aircraft carriers, 90 cruisers, 21 destroyer flotillas, 73 submarines. For the estimated requirements in 1939 see p. 58.

[2] The so-called 'Deficiency' Programme of November 1935. See Appendix 1, Table A.

that the Government was not in a mood, and perhaps not in a position, to consider. The only way in which it was able to respond to the growing pressure of the Admiralty was to agree in the following year that the approved programme should be so accelerated as to complete within three years all that industry could build in that time.[1] This concession was not, however, to be taken as the first step towards a 'two-power standard', and in approving it the Government made it clear that the financial and industrial principles underlying the rearmament policy in general were not thereby set aside. The purpose of the 'acceleration' was to establish a strong Navy as quickly as appeared practicable, without resorting to emergency measures in relation to labour or to an undue diversion of shipbuilding and other connected industrial activities from their normal channels.

This limitation the Admiralty had to accept, though only for the time being.[2] In the autumn of 1937 and again at the turn of the year the Admiralty 'tried again'. In its final form the request was that the same number of ships should be built in 1938 as in 1937. The Admiralty also insisted on additional expenditure mainly to meet higher prices and wages. These proposals, however, proved no more feasible than the previous attempts to approach the 'two-power standard', and the Chancellor of the Exchequer challenged them on the same grounds as before. But in addition he was able to point out that the naval proposals would be beyond the capacity of industry; that they would have an adverse effect on merchant shipbuilding and would create unemployment in later years. His arguments carried the day, and when at the turn of 1937 and 1938 the Minister for Co-ordination of Defence submitted to the Cabinet his recommendations for the 'rationing' of defence expenditure over the next few years, he definitely declared himself against the Admiralty demands.

For the time being the Cabinet re-affirmed that finance must decide the issue, and at the beginning of 1938 the final compromise (the result of protracted negotiations) fixed the 'ration' of the Navy at £410 millions, to be expended over the next three years.[3] The new programme thus defined—to be known as the 'rationed' programme

[1] The 'Accelerated' Programme of 1936. See Appendix 1, Table B.

[2] The Admiralty could still claim to be accelerating the 'D.R.C.' programme, while in fact working up to the 'two-power standard'. After the 1937 programme, however, it would no longer be able to represent its intentions as mere modifications of the 'D.R.C.' proposals, for to do so would mean to agree to stop all new construction in a year or two hence, i.e. immediately after, as a result of the acceleration, the ships built to the 'D.R.C.' programme were laid down.

[3] Nominally this meant an increase of at least £200 millions over the limits as settled and defended by the Chancellor of the Exchequer throughout the earlier discussions. But a great deal of the increase was accounted for by the higher costs of labour and materials which had risen twenty per cent. above those of 1935, by the much enhanced requirements for anti-aircraft defence of ships and coastal installations, and by defence measures other than new construction. The new programme was to cost £60 millions in 1939 and in that year it was to contain two capital ships, four cruisers and at least fifty-six destroyers, minesweepers and fast escort vessels.

—marked a considerable increase in the cost of naval preparations, but it fell far short of the Admiralty's unvarying aim of a 'two-power standard'. Before the end of 1938 further additions were to be asked for and further expenditure sanctioned. By August 1938 an additional £10·5 millions was sanctioned for the new construction of small ships to be made available for service within a year. But it was not until 1939 that the whole scale of rearmament came under review and the very principles of British naval strength could be considered.[1]

This phase, however, belongs to the next chapter and carries the story into the war period. By comparison, the record of pre-war rearmament as told in this chapter might well appear as one of repeated defeats of the Admiralty's long-term plans and of continued failure to build-up the Navy to the strength required by the strategic position. Yet the period was by no means one of frustration. Though the Navy as yet failed to expand at a rate needed for a 'two-power standard', it did expand somewhat and, above all, its equipment was now in the process of being renovated and strengthened. Of the two million tons of effective strength of the Navy at the end of 1938 about a quarter had either been newly built or brought up to date since 1935. By the end of 1938 some 545,000 tons of naval vessels were under construction and some 123,000 tons were in the process of being modernised and refitted. In addition highly valuable industrial potential for use in war was being built up in several specialised fields. More will be said about this later.[2]

(4)

The 'Cinderella' Service

It was the War Office and the Army[3] that were called upon to feel the full effect of the financial stringency. Budgetary allocations continued to limit the plans of the Army much more than they were ever allowed to influence the plans of either the Navy or the R.A.F. Under the existing priorities the Army was bound to take the lowest place, and that place was getting lower with each successive phase in the expansion of the Forces. This does not, of course, mean that the Army was not being re-equipped. As the previous table[4] shows, budgetary allocations for army equipment rose from about £6·9 millions in the

[1] The naval programmes of new construction approved between 1936 and the outbreak of war are summarised in Appendix 1, Table B.

[2] See pp. 47–51.

[3] In view of the strong emphasis put on the anti-aircraft defences and the special treatment meted out to the Air Defence of Great Britain (A.D.G.B.), the term 'Army' in this and subsequent chapters is meant to exclude the Army's contribution to the anti-aircraft defences in so far as it can be differentiated from the anti-aircraft elements of the field army.

[4] Table 2, p. 12.

year ending March 1934 to over £8·5 millions in the following year and to over £67·5 millions in the year ending March 1939, and actual provision of new equipment grew in roughly the same proportion. But even though these allocations appeared to rise quite steeply, the share of the Army in the total expenditure did not exceed twenty-five per cent. until the end of 1938.[1] Moreover, the additions were largely absorbed by anti-aircraft defences, thus leaving the allocations to the Army proper at a level which relatively to that of the other armed forces was even lower than the above figures suggest.

To justify the disparity, the doctrine of 'limited liability' had to be called upon more frequently and displayed more prominently as rearmament progressed. Under this doctrine Great Britain could not participate in a European war with substantial field forces. The country would not be capable of a full effort in the air, on the sea and on land, and would have to concentrate on some aims at the expense of others: the expense was to be the Army's. Early in 1935, i.e., on the eve of rearmament, the limitations inherent in the 'limited liability' doctrine were not, as yet, very rigid. When in 1934 the Defence Requirements Sub-Committee of the Committee of Imperial Defence had to formulate proposals for the re-equipment of a field army of five divisions, it conceived the latter as 'a regular expeditionary force'. It foresaw that at some future point it would be necessary to support this force by contingents from the Territorial Army, and expressed the conviction that 'a force organised as above, and supported by appropriate air forces, would, as a deterrent to an aggressor, exercise an influence for peace out of all proportion to its size'.

This conception apparently continued to underlie the War Office views during 1936 and 1937. The earliest plans for industrial mobilisation and with them all the plans for the training of the Territorial Army were, to begin with, so drawn up as to provide a pool of equipment for reinforcing the regular expeditionary force on the Continent by at least two other divisions at the outbreak of war. In fact, throughout these early discussions it was taken for granted that the British Army on the Continent would require continuous reinforcements, and what was doubtful was not so much the principle of continental involvement as the size of additional contingents. It is, therefore, not surprising that in December 1936, when the role of the Army came up for discussion, the Secretary of State for War could in a written memorandum go so far as to claim that the Government was then committed to the principle of a field army of twelve

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[1] Allocations to the Army expressed as a percentage of the total estimated annual expenditure on rearmament (excluding R.O.F.s) were as follows:

1934	19 per cent.	1936	20 per cent.	1938	25·5 per cent.
1935	20 per cent.	1937	21 per cent.	1939	26 per cent.

Territorial divisions in addition to the five Regular ones. From this he went on to conclude that a future war would not be fought under conditions of 'limited liability'.

This view was not generally accepted in 1936, and even those who held it then had to give it up before long. As the demands of air defence were becoming insistent and the cost of naval programmes was mounting, the prospects of an army adequate for war in Europe were continually reassessed. The discussions on the role of the Army which had been going on in the Committee of Imperial Defence and the Cabinet since February 1934 came to a head at the end of 1936 when the Cabinet instructed the Chiefs of Staff Sub-Committee to report on the role of the Regular and Territorial Armies in war and the priority which should be accorded to them in the placing of orders. In considering these problems the Chiefs of Staff were enjoined to pay special regard to the 'relative merits as a deterrent of a land force and an air force to be provided at an equivalent expenditure'.

On that occasion the Chiefs of Staff reported in favour of a balanced policy of rearmament under which the interests of the Army would not be entirely sacrificed to those of air defence. But with financial limitations paramount, a policy favouring the Air Force at the expense of the Army appeared to be inescapable. Reporting on the allocation of defence expenditure submitted in December 1937, the Minister for Co-ordination of Defence brought a whole armoury of arguments in support of the policy. He had come to the conclusion that the policy of continental commitments no longer suited Britain's circumstances and that a number of recent events in the international field justified this change of policy. He gathered that France no longer looked to Britain in the event of war to supply an expeditionary force on the scale hitherto proposed in addition to her all-important co-operation on the sea and in the air. Furthermore, he argued that Germany had guaranteed the inviolability and integrity of Belgian territory and there seemed good reasons for thinking that it would be in Germany's interests to honour that agreement. But his chief arguments were based on the Chancellor's financial thesis. Resources being limited, rearmament must be concentrated on the vital objectives. Most vital of all was, of course, the survival of Great Britain herself from air attack. Next came the preservation of the trade routes and, in the third place, the defence of British territories overseas. The fourth objective which could only be provided for after the other objectives had been met was co-operation in the defence of the territories of any allies Britain might have in war. On the basis of this policy 'the continental hypothesis' ranked fourth in order of priority, and the primary role of the Regular Army became 'the defence of imperial commitments, including anti-aircraft defence at home'. The

role of the Territorial Army was to be adjusted accordingly. Instead of providing reinforcements for the expeditionary force on the Continent, it would merely be called upon to assist in anti-aircraft defence and to perform 'duties in connection with the maintenance of order and of essential services in this country in time of war'.

So, paradoxically, the policy of 'limited liability' reached its furthest development in 1938, i.e. at the time when peace-time rearmament was approaching its climax and the War Office, under the so-called 'new conspectus', was formulating the first really ambitious plans of re-equipment. On the 10th February 1938 the Committee of Imperial Defence confirmed that in matters of supply all war plans should be based on what might be termed a war of 'limited liability', and from the end of 1937 to the spring of 1939 the equipment of the five divisions was geared down to the level of 'colonial warfare in operations in an Eastern theatre'. According to a somewhat later War Office computation, an army thus equipped could not be used in Europe except in a defensive role and could not be brought up to full fighting efficiency without a large increase in ammunition, a partial re-equipment of tank forces, and other material changes. No wonder that in February 1938 the Secretary of State for War found it necessary to issue a special warning to the General Staff that potential allies should be left in no doubt as to the possibilities of direct assistance on the part of Great Britain. It was not until the turn of 1938 and 1939 that the whole problem of 'liability' was brought up again, and it was not until the spring of 1939 that it was revised in favour of fuller continental commitments.

The field forces thus remained the least favoured part of the most neglected Service. Whereas the other two Services could during the five years before 1939 engage in both re-equipment and expansion, the field army with its auxiliary services were not encouraged to do anything more than to re-equip themselves, and even that on an insufficient scale. The successive rearmament programmes were 'deficiency' programmes, i.e. were designed to fill gaps in the equipment and establishment of an army substantially no larger than that already in existence. Throughout the period the size of the Regular Army was taken to be more or less fixed at the level of five divisions, and the scale came to be, if anything, more narrowly defined in later programmes than it had been in the first 'deficiency' scheme.

This does not, of course, mean that the actual volume of expenditure and orders did not increase. In July 1934, when the 'deficiency' scheme was first considered by the Cabinet, its cost was put by the Defence Requirements Sub-Committee at £10 millions per annum, but this was reduced by fifty per cent. by the Cabinet. This figure was, however, a mere 'hors d'œuvre'. An army, however Ruritanian its size, could not be reared on £5 millions per annum. So by the time

the first full-fledged rearmament programmes of the Forces matured, i.e. in midsummer 1936, the cost of the so-called 'deficiency' programme of the Army over the next five years was put at about £177 millions. By March 1937 the estimated requirements as submitted to the Cabinet for the same period and approved by it had grown to about £214 millions; in the autumn plans were submitted to the Cabinet for a programme of £230 millions and in addition there were extra commitments which were estimated to cost about a further £100 millions. As has already been shown,[1] the plans were not allowed to rest at this high level, and having risen in the first draft of the 'new conspectus' to about £347 millions, they were then cut down by March 1938 to about £276 millions.[2] Yet even at that later level they stood about £100 millions higher than they had been in the 'deficiency' programme of 1936.[3]

Estimate of expenditure on 'deficiency' programmes of the Army for the five years beginning 31st March 1936

TABLE 5 £ millions

Date of programme[4]	March 1937	October 1937		January 1938	March 1938
		Original	Plus additional commitments		
Total estimate[5] . .	214	230	323	347	276
of which:					
A.D.G.B.[6] general charges and ammunition .	37	41	57	98	68
Territorial Army: training equipment .	9	9	9	7	8
war equipment and reserve . . .	nil	nil	43	15	nil
Regular Field Force: material and ammunition . . .	80	84	95	80	77

These increases however were largely due to requirements outside the main framework of the Army. As already indicated, the largest of the new requirements were those for anti-aircraft defence. Anti-aircraft defence was bound to come to the forefront as soon as the

[1] See p. 30. [2] See Table 5.

[3] The figures for 1936 are not fully comparable with those of 1937–38, for the latter include the cost of the proposed expenditure on improved accommodation and a few other smaller items of the same kind which were not included in the earlier estimates. These items amounted to about £5 millions in March 1938. In any case these figures being in the nature of forward estimates do not measure exactly the actual expenditure of the War Office. This is more accurately reflected in the previous table of annual expenditure. (See Table 2, p. 12.)

[4] Only the March 1937 and March 1938 programmes were approved by the Cabinet.

[5] Includes expenditure on industrial mobilisation, improved accommodation, etc.

[6] Air Defence of Great Britain.

German danger entered into the discussion of Army plans. When in the autumn of 1935 the Committee of Imperial Defence appointed a sub-committee to consider the needs of anti-aircraft artillery, its terms of reference were to plan on the assumption that the Germans would try to deliver 'a crippling air attack'. In formulating its proposals the Committee of Imperial Defence laid it down that plans for anti-aircraft defence in the event of war with Germany should be made upon the assumption that Germany might attempt a knock-out blow from the air at the moment of the declaration of war. Similar assumptions continued to govern Army plans until the outbreak of war, and even beyond; and they found their most extreme expression in February 1938 when, as already mentioned, the continental liabilities of the field forces were drastically whittled down, and the role of the Army was re-defined as that of 'the defence of imperial commitments, including anti-aircraft defence at home'.[1]

It is, therefore, no wonder that the financial allocation for anti-aircraft defence formed a large proportion of the Army's re-equipment programme and grew more steeply than most other items. The earliest requirements were defined in the so-called Brooke-Popham programme of April 1935. It envisaged in the more or less distant future a continuous defence system from Portsmouth round the eastward of London to the Tees.[2] But for the time being practical recommendations were confined to the defence of the London area to be finished by 1940, to be served by the existing 3-inch 20-cwt. guns of last-war vintage and to cost £13·5 millions. From these modest beginnings the expenditure on anti-aircraft defences gradually rose to the 'Ideal Scheme' as finally adopted in November 1938.[3] It owed its name to the terms of reference given to a sub-committee of the Committee of Imperial Defence in 1937 to make recommendations as soon as possible as to the 'ideal' defence it considered desirable, irrespective of considerations of supply, for the air defence of Great Britain. Yet even before then the financial and industrial needs of anti-aircraft defence formed a large and growing part of the total army requirements.

[1] See p. 29.

[2] An air defence zone had formed part of the defences of Great Britain since 1923, but in the absence of the necessary equipment its creation was little more than an item in the strategic plan.

[3] The intermediate stages were as follows. By June 1936 the C.I.D. approved in principle a more modern and costlier version of the Brooke-Popham plan which was estimated to cost £30 millions and met with the usual financial obstacles. In August 1936, however, the Cabinet finally approved the so-called 'accelerated' version costing £29 millions, and further small orders for guns were authorised during 1937 to facilitate provision of capacity. The 'Ideal Scheme' matured in June 1937 and entailed approximately doubling the scales approved under the Brooke-Popham programme; 1,264 guns instead of 608, 4,704 searchlights instead of 2,547, 1,200 instead of 600 light anti-aircraft guns, and its cost was estimated at about £46 millions. It was, however, not until 7th November 1938 that the full requirements of the 'Ideal Scheme' were accepted by the Cabinet, and its full effects were not to be felt until 1939.

The claims of anti-aircraft defence not only absorbed a large share of the Army's financial vote, but they also enjoyed priority in the provision of actual supplies. But for the urgent requirements for anti-aircraft equipment and the sums allotted to it, the army programmes would have looked much smaller than they were. According to an approximate estimate of the expenditure of the War Office under the Defence Requirements Programme, in the year ending March 1938 some £8 millions went to the Air Defence of Great Britain (A.D.G.B.) and some £13 millions to the material and ammunition of the Regular field force, out of a total of some £44 millions for the Army as a whole. Comparable figures for the year ending March 1939 were £13 millions for A.D.G.B. and £22 millions for the field force out of a total of £67 millions. From the purely technical and industrial points of view the principal victims of these priorities were the field artillery and the medium artillery, but indirectly, through the overriding financial claims of A.D.G.B., the entire army programme was held back.

In comparison with A.D.G.B., the priority of coastal defence was not of the highest order and its claims on general industrial resources were not heavy. Its requirements could to some extent be provided for from old war stocks, and orders for new equipment were relatively small. Nevertheless, it was also given preferential treatment on most equipment whenever and wherever its claims happened to clash with the requirements of the Army.

On the other hand, the equipment of the field forces was to benefit greatly from the assistance, both open and surreptitious, which it received from the accepted plans of the Territorial Army. Considered as a whole, the policy of the successive Secretaries of State and the endeavours of the Director General of Munitions Production (D.G.M.P.) at the War Office[1] were to use the Territorial Army as a means of creating equipment and war potential for a larger army. These ambitions were frankly avowed in the early stages of the 'deficiency' programmes of 1935–36 when the War Office proposed to equip three Territorial contingents totalling twelve divisions, in addition to the five-division contingent of the Regular Army. It will be remembered, however, that the Cabinet did not approve the programme in its original form and decided instead to suspend the whole problem of the Territorial Army for three years.[2]

As it turned out, the next three years saw the doctrine of 'limited liability' hardening to a degree which precluded all revival of the earlier plans for Territorial contingents. Yet in spite of the unfavourable atmosphere, the War Office was able to salvage at least a part of its Territorial plan, and thereby to add to the total volume of

[1] See p. 36.
[2] See pp. 29–30.

orders. The concession it obtained was for training equipment. After much preliminary discussion the Cabinet agreed on 3rd February 1937 that the Territorial Army should be trained in the use of the same weapons as the Regular Army. Under the authority of this decision the War Office was able to include in its scheme of orders training equipment for the Territorial Army calculated to provide by April 1940 full equipment for two Regular divisions, and thus virtually to raise the five-division programme to something approaching a force of seven.

The War Office even succeeded in getting through a slight enlargement of the official plans of the five-division force itself. Early in 1938 the Cabinet allowed the War Office to re-form the mobile division, one of the five, into two smaller mechanised divisions, and the change, though nominally no more than a reshuffle, necessitated some additional equipment. Later still, changes occurred in the size and composition of the infantry divisions and, more especially, in the establishment of the medium artillery regiments and engineer units.

More important still were the additions resulting from the War Office measures to increase the industrial facilities for armament production or, to use the technical phrase, to 'augment the war potential'. This subject, however, is sufficiently important to deserve separate treatment.

(5)

The War Potential

Until well into 1938 the objects of rearmament were too uncertain, and on the whole too political, to make it possible for the Services to embark on direct preparations for war. The successive re-equipment schemes, therefore, contained little express provision for creating in peace-time the basis of a war economy. It will be shown later[1] that as a result of increased expenditure on armaments the munitions industry inevitably expanded, and that in some fields of production the expansion was great enough to create a true 'war potential'. Where this happened it was as often as not an indirect and sometimes even a concealed by-product of rearmament. But in general direct industrial preparations for war, such as there were, had to be carried on more or less independently of the main re-equipment schemes.

Generally speaking, direct preparation for war production grew out of the routine processes of long-term strategic planning. As the thirties advanced and crisis followed crisis, the plans acquired substance and definition, and by the summer of 1939 they had become

[1] See pp. 46–47.

sufficiently detailed to supply a blue-print of the entire war-time organisation of production as deployed in the opening year of the war. Yet even then war potential was still confined to paper work and produced little more than hypothetical plans. For without large orders it was impossible to bring industry to a point at which it could be relied upon to turn out great quantities of weapons at the very outbreak of war.

The story is thus largely (though not exclusively) one of government machinery and of plans. The fountain-head of all the earlier plans was the organisation which in the inter-war period was primarily concerned with general consideration of the imperial strategy of defence, i.e. the Committee of Imperial Defence (C.I.D.). Under that Committee the body which took charge of the economic and industrial plans was the Principal Supply Officers' Committee (P.S.O.C.). It had been set up by a Cabinet decision in May 1924 and was reconstituted in April 1927 with authority 'to direct peace-time investigations in respect of all matters connected with supply in war'. Its principal functions, as then defined, were to prepare plans for the supply of commodities essential to a war effort; to ascertain and watch over stocks of raw materials; and to maintain a list of contractors capable of being drawn into war production. In its turn the P.S.O.C. bifurcated into the Board of Trade Supply Organisation which looked after raw materials, and the Supply Board which had the duty of planning for the production of war-stores. What this meant in practice was that the Board translated hypothetical war requirements into industrial terms, decided what materials would have to be controlled at the outset of war and, finally, allocated between the Services the productive capacity in the country. This work the Supply Board carried out through a series of Supply Committees dealing respectively with armaments in the narrow sense of the term, engineering products, shipbuilding, general stores, ship-building stores, petroleum-driven weapons (aircraft, tanks, road transport) and commodities of general use (e.g. food, medical supplies).[1]

The 'lean years' of the late twenties and early thirties were thus able to hand down to the men in charge of rearmament an embryo of an organisation for the planning of war potential. The years of rearmament saw a few small additions to the machinery of economic preparation and a few greater ones to the preparations themselves. The most conspicuous change at the centre was perhaps the appointment of a Minister for Co-ordination of Defence in February 1936. In theory the new Minister was in charge of all aspects of rearmament

[1] In addition the Supply Board set up two sub-committees, one in 1929, dealing with gauges (see p. 37 below), and another in 1932, dealing with machine tools which had caused special difficulty during the first World War. There was also a separate Contracts Co-ordinating Committee.

including those of war potential, and in practice he found himself involved in all the major problems of rearmament, both financial and administrative.

More closely related to the purely industrial problem of war potential was the appointment in December 1933 of a small advisory group of industrialists.[1] The group gave a broad assessment of the potential resources of industry for the manufacture of armaments and set out the main principles for the development of a 'shadow' armament industry. Its views were also sought by the Cabinet and the Supply Board on other aspects of industrial mobilisation. In general it made available to the Government expert opinion on industrial matters at a time when government plans could not be disclosed to the whole body of industrialists in the country. But its work was essentially advisory, and as long as the main problems were those of administrative planning the quality of the plans depended less on the expert advice of industrialists than on the activities of the official planners themselves.

From this point of view the most important changes in the machinery of preparations were the appointments which, from 1936 onwards, were made within the Service departments and especially in the Air Ministry and the War Office. In the Air Ministry the important new creation was that of the office of Director General of Production. It has already been shown[2] that the primary functions of this officer were to take charge of the Air Ministry's relations with the aircraft industry and to supervise the execution of the much expanded orders. To begin with it was also his function to take care of such 'war potential' as there was and all the early inquiries about production in war-time that came into his department. The Munich crisis, however, brought the subject of war potential, i.e. that of aircraft production after the outbreak of war, more forcibly to the notice of the Ministry. A more exact study of the various problems of war potential was now necessary and possible; the results of the study and the measures taken to define and to build up the 'war potential' will be discussed in the next chapter.

The administrative changes in the War Office came somewhat earlier. As the rearmament programmes were taking shape, two new appointments were made. The office of Director General of Munitions Production—a wholly new creation—and some of the activities of Engineer Vice-Admiral Sir Harold Brown, the first holder of that office, have already been mentioned.[3] His primary responsibility was for the output of stores and the general execution of the rearmament programmes, but his work also had a great effect on war potential.

[1] See also p. 392.
[2] See p. 21.
[3] See p. 33.

As a by-product of the re-equipment programme the armament industry grew more or less automatically, and the Director General of Munitions Production made it his business so to organise re-equipment of the Army as, in fact, to create the largest possible war potential. The direct planning of war potential had hitherto been carried out by a special section of the War Office under an official who was also chairman of Supply Committee No. 1, which was concerned with planning the supply of armament stores. The appointment was made specifically in order to create in the War Office machinery for carrying out decisions of the Supply Board. The same official became Director of Industrial Planning[1] in the organisation of the Director General of Munitions Production and was responsible for finding industrial capacity and for planning war potential.

So much for the evolution of the machinery. The principles on which it worked were also undergoing a change. To begin with, the actual preparations at the centre were in the nature of things very preliminary and very general. The milieu in which they were born—the Principal Supply Officers' Committee of the Committee of Imperial Defence—linked them closely with the plans and problems of the last war. The experience of the Ministry of Munitions found many reflections in the industrial plans of 1936, and nowhere more than in the layout of the sub-committees of the P.S.O.C. There was thus a special sub-committee to deal with gauges,[2] for gauges had been a 'headache' in the initial stages of the last war. On the other hand the tank, which was to prove the most troublesome weapon of the coming war, was lumped with aircraft and mechanical transport. The experience of the last war stood out equally clearly in the projected organisation for the control of raw materials. Yet this should not be taken to mean that all that the P.S.O.C. was doing was to prepare for the industrial battles of 1916. As long as the plans were general and preliminary they were bound to hark back to the historical experience of the last war; and that experience proved by no means valueless even in the later years of mobilisation;[3] but as the day of mobilisation was approaching, the plans were gradually suited to the changed circumstances and to the immediate demands of the situation.

In addition, a number of practical steps in fulfilment of the plans could now be taken.[4] Between 1927 and 1935 the P.S.O.C. and the Supply Board could do little more than allocate in a very general

[1] See p. 42.
[2] See p. 35.
[3] Although the *History of Munitions*, produced by the Ministry of Munitions after the 1914–18 war was not designed as a blue-print for future mobilisation and, as a whole, was unsuited for use as a manual, certain parts of it were carefully studied in the inter-war years and influenced the official plans.
[4] See p. 42 for an account of the industrial survey which was undertaken, and the earmarking of firms.

fashion the industrial resources of the country among the foreseeable war-time uses. By the turn of 1936–37 their preparations were sufficiently advanced to warrant more detailed planning of production, firm by firm; and it was at this point that the work was taken over by the planning officers in the Service departments, the Director of Industrial Planning and the Director of Aircraft Production among them.

From the point of view of the future, the final provisions made for raw materials were probably the most definite and concrete.[1] Preparations in the field of raw materials comprised the final blue-prints for future controls and measures to lay in strategic stocks. During the early years of rearmament, until 1936, plans for the acquisition of raw materials assumed that raw materials which might become critical on the outbreak of hostilities would be bought as soon as the warning of an emergency was received.[2] In 1936 a radical change took place in the Government's attitude towards the accumulation of strategic reserves. Now that the requirements of the Services had grown and firms were expected to turn over to war production more quickly than had once been thought necessary, demands for raw materials in the early months of a war were bound to be correspondingly greater. At the same time, with the danger of a European war taking shape, allowance had to be made for considerable dislocation in European supplies; allowance also had to be made for the possibility that the neutrality policy of the United States might deny raw materials to belligerents in a future war. The only way of meeting the new situation was for the Government to accumulate reserve stocks in time of peace. This policy was accepted by the Defence Policy and Requirements Sub-Committee of the Committee of Imperial Defence in June 1936, and within a year the building-up of reserves of a number of raw materials had begun.[3]

In addition to preparations at the centre the Service departments themselves did something to prepare for war production. Most of this activity grew out of the rearmament programmes of the individual Services. Rearmament in peace and industrial potential for war touched at several points. First of all there was the connection between the war potential and reserves of equipment held by the Services; secondly there was the connection between the industrial capacity created in peace-time for the purposes of rearmament and

[1] This subject will be dealt with in more detail in the forthcoming volume in this series on the Control of Raw Materials by J. Hurstfield.

[2] A special Anticipatory Purchases Sub-Committee of the P.S.O.C. was set up in 1931 to prepare a schedule of materials for anticipatory purchases and to make arrangements for purchase in time of emergency.

[3] The materials concerned were aluminium, magnesium, high carbon, ferro-chrome, molybdenum, tungsten, vanadium, amber mica, antimony, pyrites and magnesite. As it was found difficult to obtain reserves of amber mica, it was recommended that research should be conducted into the use of alternative materials. For further discussion on stockpiling, see next chapter, p. 89.

the capacity available for use in war. Of the two problems the former was to some extent peculiar to the R.A.F. The character of air war as foreseen in 1937 and 1938 was such as to make it difficult to discuss war potential without continuous reference to stored reserves. The Air Staff expected fighting in the air to begin on the very first day of hostilities and the wastage rates to be very high. The question of supplying the R.A.F. with aeroplanes was therefore largely one of how long war industry would take to get into its stride, and of how large must be the stored reserves of aircraft if the strength of the Force was to be kept up in the meantime.

It will be remembered that substantial reserves could not be planned until Scheme F was sanctioned by the Cabinet in February 1936,[1] and that even then it was by no means certain that reserves were sufficient to fill the gap. Throughout 1936 and 1937 the Director of Aircraft Production conducted investigations into the probable output of the existing aircraft industry under war conditions, the length of time it would take to reach maximum output and the consequent need for accumulated reserves. Towards the end of 1937 his tentative conclusions were that the industry might take as long as twelve months to reach maximum output, and that in the meantime a wide gap between requirements and supply would open up. He proposed that the gap should be filled by drastic increases in manufacturing capacity and by elaborate preparations for industrial mobilisation in war, such as the preliminary acquisition of additional accommodation and aerodromes, the purchase of necessary machine tools, and the provision of reserves of raw and semi-manufactured materials. Failing that much larger reserves of aircraft were to be kept.

The alternatives were very obvious, but the Director of Aircraft Production's memorandum of December 1937 was probably the first occasion on which they were defined for the benefit of the ministers. The harassed ministers understood them only too well and were only too ready to take refuge in them, for they offered them an obvious way of making present cuts in aircraft more palatable by offering prospects of future increases in industrial potential. At the end of the discussions of the winter of 1937–38 the Minister for Co-ordination of Defence recommended that the reserves held in peace should be reduced from sixteen weeks, as in the Air Ministry's proposals, to nine weeks, and that the reductions should be made up by increases in war potential. Needless to say the proposals invited a rejoinder from the Air Ministry, but in the end they prevailed, though in a somewhat modified form. The reduction of reserves to nine weeks was accepted, but an exception was made for fighters, trainers and overseas squadrons, i.e. the types which would have to be actively engaged from the very outset of war.

[1] See p. 15.

In reality this cut in reserves did not turn out to be as permanent as the Air Ministry feared. No sooner was the decision taken than the crisis of the spring of 1938 intervened and the emergency programme L of 12,000 aircraft superseded all previous aircraft programmes. The figure, it will be remembered, represented what the industry thought it could produce[1] and was settled without direct reference to first-line aircraft or reserves, but if carried out in full it would provide reserves on an ample scale. On the assumption that the first-line strength would remain at 2,373 aircraft as under the current Air Ministry programme, the provision of reserves to the extent of 225 per cent. as hitherto, would only have required 7,717 aircraft in all. The balance between that number and 12,000 added a further margin of safety to the Air Ministry plans.

Much more complicated was the problem of war potential in the narrower sense of the term. The main problem was obvious enough. It was essentially one of deploying in war-time the specialised capacity already available. The aeroplane with its accessories was the sole weapon of the R.A.F., and the problem of war potential was overwhelmingly that of preparing the largest and the quickest possible expansion of the aircraft industry in war-time. This meant maintaining in time of peace a large aircraft industry for, in the opinion of the Air Ministry, so specialised was the manufacture of aero engines and airframes that nobody except the aircraft firms themselves (perhaps the motor industry in the field of engines) could be relied upon to provide a war-time potential. This was one of the reasons why throughout the 'lean years' the Air Ministry endeavoured to keep in being a nucleus of aircraft and engine-making firms; and this was also the reason why for the Air Ministry the problem of war preparations largely narrowed down to the creation of additional floor space, plant and machining capacity in the aircraft industry and in a few selected motor car firms.

In trying to do this the Air Ministry was favoured by the existence of a small but important trickle of civilian demands for aircraft and by a somewhat more liberal allocation of funds than that available to other Service departments. Manufacturing capacity in the aircraft industry and its ancillary branches did, therefore, expand faster and further than in the armament industry in general As far as the admittedly imperfect returns at the Ministry of Aircraft Production (M.A.P.) could be trusted, the floor space at the main aircraft contractors' works occupied in actual production rose between August 1938 and September 1939 from five to eight million square feet. In addition to the 'shadow' factories originally conceived as contributions to war potential, a certain amount of hidden capacity also

[1] See p. 18.

accumulated in the aircraft factories. Extensions of factories were all based on a more generous allowance of floor space per worker than was strictly necessary either for current output or for output projected for the opening months of war. Above all floor space, and to a smaller extent machining capacity, had been added on the basis of one-shift working; whereas plans of industrial mobilisation invariably assumed at least two shifts both in the machine room and on the assembly floor.

As a result, by the beginning of 1939 the Air Ministry in making its plans could count on a very considerable reserve of capacity for airframe production. By that time however other gaps in the potential capacity of the aircraft industry had revealed themselves and the Ministry set about repairing them in the hope of having the potential capacity fully balanced by the beginning of war. More about this will be said later.[1]

The problem of war potential presented itself somewhat differently at the War Office. In the first place the problem of reserves did not occupy a very prominent part in its plans for army supplies. The 'deficiency' programmes of 1935–36 and, to a less extent, the subsequent rearmament programmes were primarily conceived in terms of 'capital stock' of equipment and not of those of current war-time expenditure. So small were the Army's programmes and so utterly disproportionate were they to the probable needs of an army at war, that as yet little could be done to accumulate in peace-time a cushion of stocks, i.e. reserves large enough to cover the initial wastage in time of war and to bridge the gap between the outbreak of hostilities and the full mobilisation of war industry.[2]

Preparations for war could, therefore, mean only one thing: as rapid and as wide an industrial mobilisation of resources as possible. But here too the problem differed from that of the Air Ministry. The Air Ministry, dependent as it was upon a single and highly-specialised form of armament, could base its plans upon the peace-time nucleus of a specialised aircraft industry. Not so the War Office. It could not achieve its objectives merely by increasing the productive capacity of existing armament firms. So small was the peace-time output of armaments and so diminutive was the scale of the armament industry compared with the probable demands in war, that the only solution lay in drawing into war production the entire industry of the country, and more especially its engineering and allied branches. A further argument in favour of this solution was that the range of army stores was less uniform than that of the R.A.F., and that the requirements did not converge upon the assembly of a single master

[1] See Chapter III, Section 3.

[2] Fuller provisions for wastage were, however, made in post-Munich programmes, see p. 132.

weapon like the aeroplane. There was, therefore, little opportunity and little need for directing war production into the single channel of the existing specialist firms.

That is how the problems took shape in the new Directorate of Industrial Planning.[1] Its duties were accordingly defined as the survey of industrial capacity of the country and its preparation for the production of army weapons in war. From this point of view its work was part of the activities of the Supply Board in surveying the industrial capacity of the country and allocating it to the individual Services. But in addition to its contribution to the general survey, the Directorate had to compile a more detailed register for Army uses indicating what army stores could be produced by individual firms and what degrees of reorganisation would in each case be required. The Directorate also did much to accelerate the compilation of 'process manuals'[2] with instructions for the making of armament stores and with advice and instructions on factory layout. This work was well advanced by the spring of 1939.

Above all, the register of firms available for munitions orders—the so-called List 392 or Capacity Register as it came to be generally known—which the Supply Committees had been gradually compiling[3] now took the shape which it was to preserve throughout the crucial years of industrial mobilisation. In its original form the List was not, and could not serve as, a perfect guide for the distribution of orders among firms. A report on War Office organisation compiled in February 1942 by a special committee under the chairmanship of the Director General of Army Requirements drew attention to the incomplete analysis of capacity at the outbreak of war. The same report, however, made it clear that an analysis of capacity and a compilation of a complete register would, during the war, have to be decentralised by areas. Only by decentralising the work would it be possible in war-time to ascertain where new contracts could be placed and to set afoot without much delay discussions with individual firms as to how and when capacity could best be switched from civilian to war production. These objectives List 392, even when duly supplemented, could not wholly fulfil, but it proved invaluable as the basis for the immediate allocation of capacity between the supply departments and continued to be used until the end of 1942 as an aid to the placing of orders with individual firms. By that time the Central Priority Department of the Ministry of Supply, and with

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[1] See p. 37.

[2] The 'process manuals' were at that time being compiled and published by the Directorate of Ordnance Factories.

[3] The original List 392, dated 26th January 1934, showed the provisional allocation of firms to Supply Committees up to 30th December 1933. This list replaced the former 'Black List', i.e. list of firms allocated to more than one Supply Committee which had been issued periodically since July 1930. See also p. 35.

it the List it administered, had been absorbed into the Ministry of Production.[1]

The discussions with individual firms and the measures taken to prepare them for war production were closely linked with orders under the current rearmament programmes. The War Office and, more especially, its new Director General of Munitions Production, did not accept the diminutive scale of provision so far sanctioned as in any way permanent, and frequently used the existing programmes as stepping-stones towards greater rearmament to come. Even without transcending the broad limits of the current programme, the War Office was now and again able to create some war potential as a by-product, so to speak, of its rearmament orders. A little war potential was also being created by a few orders placed in addition to current orders under the re-equipment scheme. Orders for tanks, fire control equipment, small arms ammunition, gun barrel forgings and a number of other stores were often placed with the view of creating a war potential.

In general, however, orders under the re-equipment scheme were too small to make an appreciable difference to the country's industrial preparedness. So small were some of them and so short was the period for which they were sanctioned that without the guarantee of further orders industrial firms refused to shoulder the necessary risk and expense. Over and over again in his communications to the Secretary of State for War the Director General of Munitions Production stressed the need for larger orders for 'long-term programmes of equipment' or for 'continuation orders'. As late as the autumn of 1937 he could, in a note to the Secretary of State, quote several examples of important orders which either could not be placed at all or were placed with difficulty owing to the absence of long-term requirements. The most notable instance was that of the all-important shell forging scheme at Stewarts & Lloyds which was to become one of the main sources of shell production in war-time. The firm could not accept the proposals except on a programme much longer than that which the existing five-division scheme allowed.

On one occasion—in the autumn of 1936—an important order in excess of authorised quantities had to be placed on the personal initiative of the Director General of Munitions Production. At that time the War Office depended for gun production on the R.O.F.s, Vickers-Armstrongs and William Beardmores & Company, whose total capacity was insufficient to meet the requirements of field guns and anti-tank guns under the existing programme. So when, therefore, in October 1936 a group of Sheffield firms agreed to undertake

[1] See p. 258. In July 1943 the Ministry of Production decided to abandon the work of keeping the List up-to-date and proposed to preserve it as it stood on 1st January of that year for purposes of reference by any department. Any further records of firms in the engineering industries were to be kept on a regional, and not a national, basis.

the forging of gun barrels, the D.G.M.P. decided to seize the opportunity and to place with the firms an order for forging equivalent to 500 guns, mostly anti-aircraft, at the estimated cost of £1·2 million. This appeared to be the smallest practicable order, but it was in excess of the number for which authority was available and could be obtained in time. The breach of financial authority could perhaps be excused by a genuine misunderstanding in the War Office about the relevant Treasury deicisions, but a breach it nevertheless was, and the Treasury was compelled to call the D.G.M.P. to account. The matter was not definitely cleared up until the turn of the year. Towards the end of December the Treasury was able to condone the D.G.M.P.'s order in a spirit of personal concession, or as the Treasury letter put it 'as a Christmas present' to the D.G.M.P. It was not until July 1937 that a formal Treasury letter approved orders for 200 new anti-aircraft guns out of the 500 required. The approval carried a proviso that no forgings for 25-pounder field guns were to be included.

The incident is cited here as evidence of the obstacles which lay in the way of increased orders and enlarged industrial capacity. In the end the necessity for excess orders and for continuation orders on 'industrial grounds' was somewhat half-heartedly accepted. In July 1937 the Defence Plans (Policy) Sub-Committee of the Committee of Imperial Defence decided to authorise the Treasury to consider and sanction particular orders submitted by the War Office which went beyond the approved programme if it were satisfied that the orders offered sufficient economic advantages. In reporting this decision to the Army Council the Secretary of State for War interpreted it to mean that orders could now be placed if it could be shown that otherwise the firms would be unable to produce economically. Needless to say, these instructions could not be interpreted as liberally by the Treasury as they were by the War Office, and by no means all the proposals for additional orders passed through its scrutiny. But although authorised extensions were few, they helped to prepare industry for future production on scales greater than those for the current rearmament programmes.

In this respect even more important were the so-called 'educational' orders, a device which could boast of a difficult and protracted history. The idea of 'educational' orders was in itself a very simple one. As long as the preparations were confined to co-ordination and schemes for the future, they were bound to remain ineffective, for it was often not possible to prepare and educate industry for war production without placing special orders. In this context special orders meant orders in addition to those which came to industry under the rearmament programmes, since current rearmament orders were often insufficient to prepare the firms for the full flow of war-time production.

This is in fact how the question presented itself to the planning authorities from the very outset. In November 1936 the Principal Supply Officers' Committee recommended that where the needs of the war potential were in excess of the needs of the re-equipment programmes the orders should be based on the former. In the words of their memorandum:

> the creation of a war potential of the size demanded by the War Office hypothesis for armament stores cannot, we think, be brought about by any other means than by the placing of orders in peace-time so that firms may equip and train themselves and their labour, and by the provision of additional plant so that selected firms can swell their output in emergency far beyond the capacity demanded by the peace-time orders they are engaged in fulfilling. Unless, therefore, further action is taken without loss of time on a wider basis than that covered by the Deficiency Programme, there appears to be serious risk that, in certain vital branches of supply, the 'war potential' created by that programme will be the 'war potential' actually available for the Government as on the 1st April 1939. It would, accordingly, seem that, in the placing of orders under that programme, the needs under the war hypotheses of the Service departments, where greater, should be taken as the basis, e.g. in regard to equipment of firms in advance with the necessary machine tools, jigs and gauges.

These recommendations do not appear to have received direct Cabinet authority but to have been adopted by the Cabinet and its committees as a general principle. This attitude was not perhaps clear enough to justify in every case changes in the scales of War Office requirements sufficiently drastic to bring them into line with the hypothesis of a war potential, but it established the principle of 'educational' orders. In the end the need for these orders came generally to be accepted, and became an organic part of War Office programmes. By the end of 1937 the War Office estimate of the cost of these orders was about £13 millions compared with the £130 millions of the total Army vote under the various rearmament projects. This amount was later cut down to £7 millions.

Yet even 'educational' orders were not enough. For some purposes special factories had to be erected in peace-time, and expenditure on these in the end accounted for the bulk of the sums allowed for industrial mobilisation. The need for creating some capacity for meeting in peace-time the enormous wastage of consumable stores in war had been foreseen from the outset. Here and there the need could be met by facilitating the extension of existing factory space, plant and machinery by means of special orders or of a little financial assistance. But in some important branches of war production, e.g. those of explosives, ammunition and guns, the industrial facilities in existence were so small in relation to the probable war-time needs that the mere extension of existing factories would have been of little

use. If the production of ammunition for the war potential was to be more than a paper scheme it was necessary to erect in peace-time a number of factories for explosives and propellants, for fuses and other ammunition components and also for filling and for gun barrels.

Some new factories were in fact necessitated by the needs of the 'deficiency' programmes and the Air Defence of Great Britain, and most of the new factories created provided some additional capacity for the war potential, though the additions were not always part of the original plans. In general the provision for war potential had to be excluded from all projects for factories submitted to the Treasury for approval. The planners often designed factory sites and services on them on a scale sufficient to allow for immediate expansion in war, but they had as a rule to agree to the postponement of all work that could be done during the first year of war. Yet by September 1939 a considerable war-time reserve for the making of explosives and the filling of ammunition had come, or was coming, into existence. The new explosives and filling factories had been planned on the assumption that they would replace the vulnerable capacity at Woolwich, Waltham Abbey and Billingham. But in the event, the 'vulnerable' factories continued to operate, thus providing substantial additions to the capacity planned for the 'deficiency' programmes and the Air Defence of Great Britain. No such reserves could be built up in the purely engineering branches of production; yet so conservative was the planning of R.O.F.s under the 'deficiency' programmes that with growing efficiency and economy in their use they were bound to provide facilities well in excess of their planned output in peace-time.

Some war potential, moreover, was overtly planned. Despite formidable obstacles, both financial and industrial, the War Office continued to press for immediate provision for war potential, and at some points it was able to secure small gains. Thus soon after the passing of the programme of 1936 the War Office adopted for its factory programme the hypothesis of one Territorial contingent, requiring the equipment of two Regular divisions, in addition to the Regular five divisions. This hypothesis continued to condition the factory programme for the war potential long after it had been abrogated for the Army plans as a whole. Hence by April 1937, i.e. the time when the Cabinet ruled against the accumulation of reserves and potential for extra divisions in time of peace, the Director General of Munitions Production could report to the Secretary of State for War that in many cases the capacity then available was already sufficient for the war wastage of the Regular contingent and of the Air Defence of Great Britain, and that additional capacity would presumably be made available by a number of new factories then 'in hand'. The Director General of Munitions Production expressed his fears that the Cabinet decision if strictly interpreted might

be read as precluding the provision of any further capacity including many of the factories in course of construction. Fortunately the decision was not so interpreted, and though new construction of war potential in excess of that strictly inherent in the five-division programme was disallowed, the financial allocation for that construction rose from about £17 millions in November 1935 to well over £42 millions in March 1937. Of the latter over £24 millions was represented by the cost of new R.O.F.s, and this rose again by some £6 millions by April 1938. In this way by the spring of 1939, under the auspices of a diminutive army programme, a specialised industry for the making of armaments came into existence. The events of the next two years were to show the new capacity still woefully unequal to the task of supplying a large army at war. But it was very much larger than the rudimentary war industry of 1935 and sufficiently large to provide a firm foundation for the great expansion to come.

At first sight the problems of war potential for the Navy need not have worried the Admiralty unduly. The problem of reserves, so complicated elsewhere, was confined to ammunition and similar stores. And although the meagre financial allocations in the 'lean years' did not allow, at that time, for the carrying of stocks for the opening period of a war, the position had been fully restored by 1938. The problem of war potential proper appeared more or less solved by the vast reserves of shipbuilding capacity. Yet looked at more closely the Admiralty's needs of increased industrial reserves were almost as great as those of any other Service, even though they were most felt in the specialised fields of equipment outside the main field of shipbuilding proper. By a policy which dated to the first years of the Washington Treaty of 1922, the Admiralty maintained in being a nucleus of specialised capacity in industrial fields which otherwise would altogether have been abandoned through lack of civilian demand. This nucleus proved an important starting point. In order to meet the needs of the 'accelerated' and 'rationed' programmes[1] the Admiralty had to find or to create further additions to its specialised capacity, and in so doing it made an important contribution to war potential.

As has just been said, the effect of the Admiralty orders was felt least in the shipyards themselves. Throughout the inter-war years the Admiralty assumed that the general shipbuilding capacity in the country would be sufficient not only to meet the needs of the naval programmes in peace-time but also to provide a reserve for war. In this respect the position in 1938 was somewhat less favourable than it had appeared in the twenties. As has already been shown the number of berths declined in the early thirties, and the equipment of

[1] See pp. 26–27.

some shipyards had become badly out of date.[1] Yet on the whole the assumption still held good throughout the years of rearmament, and the real problem was not so much that of berths, slips and plant, as that of labour. The size of the shipbuilding labour force which stood in 1935 at about 100,000 grew by 1939 to about 140,000, but the increase was insufficient to meet the expansion in general shipbuilding and still less the needs of the naval programmes. Skilled labour was especially short, for new entrants were few and other branches of the engineering and armament industry continued to steal skilled labour from the shipyards. By 1938 all the capacity in the yards that could be employed on new construction was fully engaged, and it was becoming clear that with the supplies of labour then available production in war could develop only at the expense of some of the peace-time projects or of merchant shipbuilding.

Another problem of war potential which the peace-time measures did not radically solve was that of gun mountings. It had always been understood that gun mountings presented one of the most difficult supply problems of naval construction. The Admiralty depended for the supply of guns on private firms, and in the absence of commercial demand for guns in peace-time privately-owned capacity was very exiguous. The chief suppliers were Vickers-Armstrongs, and the dwindling of naval orders at home and abroad since the end of the war made it impossible for them to maintain intact the specialised equipment and to keep together a sufficient number of skilled gunmakers. The firms were also allowed to dissipate much of their earlier strength in the design of guns; and designs which were slow to mature were bound to retard production and delivery.

The Admiralty was thus very conscious of the unsatisfactory prospects of gun production. So even in the 'lean years' it had tried to maintain and improve the existing facilities, and for that purpose had agreed in 1923 with the principal makers, Vickers, to give them a virtual monopoly of naval orders. On their part Vickers, acting in the spirit of the agreement, modernised their plant and were in 1935 engaged on several expansion projects. Yet all these measures were short of what the new naval programmes appeared to require. The Admiralty estimated in 1936 that under the re-equipment programme then sanctioned the requirements of gun mountings—in that year estimated at 5,325 tons—would fully engage the existing capacity and that by 1939 well over 11,000 tons would be needed. Steps were then taken to create further capacity, but a 'bottleneck' in gun mountings nevertheless developed, and by the beginning of 1938 deliveries were running at least three months late. For this the novelty of designs and the multiplicity of new types of gun mountings

[1] See p. 4.

were sometimes blamed; the priority accorded to guns for the air defence of Great Britain was also held responsible. But the chief impediment was the shortage of skilled labour. This shortage continued to be felt throughout the early rearmament period, and in the end the entire naval programme had to be re-timed to fit in with the flow of gun mountings.

Almost equally intractable turned out to be the supply of fire control gear. The Admiralty's demands for the equipment were large and growing; in addition the War Office also wanted it in considerable quantities. On the other hand production facilities, though just sufficient for the naval needs before 1932, were already strained between 1932 and 1935, and additional capacity to meet the requirements of the re-equipment programmes was obviously needed. As part of the subsidised nucleus four firms making fire control equipment and instruments for the Navy were retained in the years immediately following the Washington Treaty. The Admiralty's endeavours to harness additional firms met from the outset with difficulties. The declared Government policy was not to interfere with the normal commercial business of firms, especially of those working for export, and it so happened that the most suitable firms were precisely those which were at the time fully occupied, such as the principal firms making printing machinery, boot and shoe machinery, accounting and tabulating machinery. Certain other firms, such as electrical manufacturers, tool makers and instrument makers, were either unsuitably organised or unprovided with the type of labour most needed. In the end, however, the Admiralty succeeded in enlarging the nucleus of its contractors by drawing on the resources of five or six firms, and by organising some eleven or twelve other firms for sub-contracting. Yet from the middle of 1937 onwards it was becoming increasingly apparent that in spite of recent additions output was insufficient, and by early 1938 fire control gear became as serious a cause in the delay of the general programme as gun mountings.

This failure could be blamed on a number of causes, but whatever the cause it was not of the kind that could be obviated in time for the current programmes. The only possible remedy was yet additional industrial capacity. So early in 1938 the Admiralty tried again to call into existence further additions to plant. This it succeeded in doing, but the new capacity could not bear fruit at once and shortages were expected to continue. For example, by the middle of 1939 the principal items in the high-altitude control equipment for cruisers and battleships were to be forthcoming at the rate of about thirty-five per cent. of the requirements, and certain items for the high-altitude control gear for destroyers and sloops only to the extent of about ten per cent. Nevertheless, much had been achieved by 1939.

What was virtually a new precision light engineering industry had come into being, and where only four firms were engaged in 1936, twenty-eight were now employed with a total capacity nine times that of 1936.

Preparations were equally advanced, while shortages proved less intractable, in the supply of armour and guns. In naval circles armour was always regarded as a potential 'bottleneck', and the developments which followed the first World War boded ill for the future. At the end of 1918 armour was being produced at the rate of 44,000 tons per annum, and the five firms producing it were capable of turning out as much as 60,000 tons. As a result of the Washington Treaty, however, only three armour-making firms stayed in the business and the total capacity in the country fell to about 3,500 tons. This was just enough for such naval construction as went on between 1925 and 1931, but after 1931 a steep rise in requirements appeared probable (the official expectation was that under the new treaties new battleships might again come into the naval programme) and to meet it the Admiralty had to subsidise the erection of new armour-making plant in a number of steel-making plants for an additional 18,000 tons. Yet even this addition was insufficient to meet the needs and requirements of the 'D.R.C.' programme of 1935.[1] Under that programme it was estimated that requirements would rise from some 22,000 tons in 1936 to about 42,000 tons in 1939. The Admiralty therefore instigated a number of further extensions in armour-making capacity in June 1936, and when these proved insufficient, still further additions in 1938. At the same time over 12,500 tons were purchased in Czechoslovakia.

All these schemes, needless to say, took a long time to mature. By the end of 1937 even the first of the additions, that of 18,000 tons, was not yet available in full; some of the capacity sanctioned in 1938 was not fully in operation until well into the war; and of the Czechoslovak order only 10,000 tons had been delivered by the time war broke out. Yet by 1939 the supply position had greatly eased off. The shortages elsewhere, above all in gun mountings and fire control gear, were delaying construction to an extent which made it possible to scale down the demand for armour. In fact potential capacity was now much beyond the current need at its reduced level. The capacity available by mid-1938 could in war-time be worked up to about 62,000 tons per annum, and this was expected to cover the larger part of war-time demands as then envisaged.

Broadly speaking, the capacity for guns grew in a somewhat similar fashion. In theory the most difficult problem of all was the provision of heavy guns. It was, therefore, in this field that the

[1] See p. 24.

Admiralty planners were most active in the early years and that some subsidised nucleus capacity (mostly at Vickers-Armstrongs) survived from the 'lean years'. The Admiralty endeavoured to add to the manufacturing facilities by subsidising additions to plant at Vickers-Armstrongs and elsewhere. Yet, even with these additions, capacity proved no more adequate for the needs of the re-equipment scheme than was the nucleus capacity in other specialised fields. In the course of 1937 a crisis appeared to be developing which threatened to add to other delays in shipbuilding. On the average the last turret had to be installed some twelve months before the completion date of a battleship, and heavy guns and gun mountings had to be ready some months earlier still, thus the shortages appeared to threaten future construction for a long time ahead. When, however, in the spring of 1939 the position was again reviewed it turned out that the supplies of heavy guns as well as those of armour were greatly eased by failures in other directions. Owing to the postponement in the delivery dates of gun mountings, the whole timetable of completed ships had to be spaced out, and the Admiralty found itself with a flow of heavy guns roughly adequate for the programme and a considerable war potential in hand.

By comparison with supplies of guns of the largest calibres those of the standard medium size, and especially of 6-inch guns, were adequate throughout the early rearmament period. Certain other calibres, especially those of 4-inch and 5·25-inch, were in short supply throughout owing to the great demand for them for anti-aircraft roles. New capacity was laid down in 1936 and 1938, but the naval demand for anti-aircraft armament continued to rise more steeply than the output of the new plant, and in addition the Admiralty had to compete in this field with the demands of other Services.

There were also bound to be some delays and difficulties over the supply of light automatic guns and mountings. The demands of the three Services for 20-mm. and 40-mm. guns were not standardised; each Service singled out for special preference a favourite light gun of its own. This and the general shortage of manufacturing capacity for automatic guns of these calibres prevented the Admiralty from getting its Oerlikons as early as it needed them;[1] and this also meant that the capacity for production in war-time was not made ready beforehand.

In this way the story of the war potential which rearmament created was as much one of light and shade as that of rearmament itself. The capacity made available by the spring of 1939 fell short of the full demands of war production just as the actual scale of rearmament fell short of the full 'two-power standard'. Yet here as in

[1] The first Oerlikon 20-mm. guns to be made in Great Britain were not ready until March 1941.

other respects the Navy had a great advantage over the other Services. Its production in war-time had not to be raised so high compared with its peace-time scale (or to put it differently, its peace-time scale was not so markedly below war needs) as to make the shortcomings in war potential difficult to make good. In fact, it has already been indicated that the principal measure which the Admiralty eventually took to meet the needs of the Navy in war was to suspend some of its peace-time projects.[1] This course was not open to the R.A.F. and certainly not to the diminutive Army of 1938.

[1] See p. 48.

CHAPTER III

FROM PEACE TO WAR: OCTOBER 1938–JUNE 1940

(1)

The Munich Inquests

A NEW epoch in the history of rearmament began in the autumn of 1938 and ended in the summer of 1940. In the year and a half separating Munich from Dunkirk the nation was preparing for a 'show-down', but was not yet exposed to the rigours of a full-fledged war and was not yet putting out its highest effort. Though rearmament was now definitely geared to eventual military action and war industry rapidly expanded, the needs of war did not yet dominate the life of the nation, and economic resources were not yet fully mobilised.

War had not become the sole object of rearmament until the Czechoslovak crisis. In the Government circles nearest to the fighting Services—the Chiefs of Staff, the Service Ministries and the Committee of Imperial Defence—the conviction that war was inevitable had been hardening for some time before Munich, but the public and the Government were as yet loath to resign themselves to so hateful a prospect and continued until the winter of 1938–39 to nurse hopes of a happy ending. And as long as these hopes survived, preparations for war could not be the only, or even the main, purpose of rearmament. It has been shown that in 1936 and 1937 the Government had conceived its re-equipment schemes as a safeguard of peace or even as a prelude to rearmament, and it is therefore no wonder that it hesitated to sacrifice the essential interests of Britain at peace to the unsettling demands of a hypothetical war, or that the purpose of rearmament remained uncertain, its method half-hearted and its progress leisurely. But with the Czechoslovak crisis the uncertainties of the previous four years began to dissolve. By the time Prague was occupied preparations for war had become the single purpose of rearmament and had established a prior claim on national resources —a claim which may have fallen short of the 'reckless abandon' of the war effort to come, but without which that effort might well have been in vain.

From this point of view the concluding phase of peace merged

without a break into the opening phase of war. The 3rd of September 1939 is one of the greatest dates in the history of the western world: a day of irrevocable decision, symbolic of all that the subsequent six years were to bring. Yet in the history of war production it was much less of a landmark than either Munich or Dunkirk. The scale of industrial activity grew more or less as heretofore; its tempo did not accelerate sufficiently to mark off the period of disturbed peace from that of dormant war.

The continuity of war production reflected the underlying strategic principle of a 'long war'. The principle was apt to be taken for granted in all the pre-war discussions on rearmament, but it was not explicitly stated until the Anglo-French conversations of the spring of 1939. By then both the French and the British Governments had more or less resigned themselves to the imminence of war. Their community of interests in a war with Germany was never in question; formal discussions on common strategy were therefore bound to follow. Out of the discussions a new view of the British role eventually emerged, and in so far as this affected the Army more will be said about it later.[1] What is important to note at this stage is that the main strategic plan then worked out rested upon that principle of military gestation which was to dominate the behaviour of the Allies until the summer of 1940. Their immediate strategic object was to build up their strength until it matched the might of Germany. This, they agreed, would take a long time, but however long it took, the build-up of forces was not to be disturbed by premature military action. The Allies were to bide their time, for time was on their side.

For political reasons and in fulfilment of their pledges to Poland, the Allies were compelled to accept the challenge of war in the autumn of 1939 and to adopt an attitude to Germany which was openly and formally belligerent. But the nature of the strategic plan was not thereby affected. The military preparations on which the country had been engaged continued on a scale previously decided, and even the timetable remained more or less the same. Indeed one of the earliest decisions of the War Cabinet in this country was that plans should be based on the hypothesis that the war might last three years. In the language of dates this meant that the preparations for war on which this country embarked with every show of determination at the turn of 1938 and 1939 might continue until 1942.

The new attitude was thus not one of hurry. Indeed its very birth was marked by a momentary hesitation. For, at first, Mr. Chamberlain's action in Berchtesgaden and Munich stimulated the hope of peace—'peace in our time'—almost as much as it strengthened the will to rearm; and in the light of this hope the ghosts of dis-

[1] See p. 69 *et seq.*

armament again made their appearance in high quarters. But for all its hesitancy and compromises the purpose of the post-Munich policy was not to be mistaken. In spite of the Chancellor of the Exchequer's obvious interest in disarmament, its chances were now too ephemeral to influence official plans. Its last trace had disappeared from official papers by the end of the year, and by the spring of 1939 the new attitude had already borne its progeny of revised and accelerated Service programmes.

The genesis of the new programmes somewhat antedated the spirit which animated them, and goes back to the earliest days of the Czechoslovak crisis. During the crisis the gaps in British defences and equipment revealed themselves to the naked eye of the public, and on the morrow of Munich even the uninitiated understood to what extent Mr. Chamberlain's concessions to the Führer were due to Britain's military weakness. The Government was certainly under no illusions. The notions about the state of British armaments which Mr. Chamberlain took with him to Munich erred little on the side of optimism, and subsequent information did nothing to brighten them. Early in October the Cabinet called for a thorough survey of the deficiencies disclosed by the crisis. The replies from the Services disclosed wide gaps, even though the gaps were not at their widest at points on which public attention was at the time focused.

In view of the general preoccupation with the danger in the air, it is perhaps not very surprising to find that the deficiency which impressed the Prime Minister and Parliament most was that of anti-aircraft equipment.[1] Of the 352 3·7-inch guns approved under the current programme only 44 were available, and the medium anti-aircraft artillery consisted largely of refurbished 3-inch guns, of which 298 (out of a planned number of 320) could be deployed in a crisis. Supplies of other anti-aircraft equipment were even scarcer: 50 two-pounder barrels out of a programme of 992; 1,430 searchlights out of a programme of 4,128; 140 barrage balloons out of 450. The War Office moreover estimated that even by April 1939 only fifty per cent. of the anti-aircraft guns and sixty per cent. of the searchlights under the current programme would be available.

Air weapons also appeared insufficient. The Air Ministry reported that it was six squadrons short of requirements; that its satellite aerodromes were not ready (sixteen out of sixty-three were available); that the defence of aerodromes was deficient. From other sources it was known that there had been delays in the development of new types, by which so much store was set. In September 1938, out of thirty operational fighter squadrons, only one was equipped with Spitfires and five were in process of being equipped with Hurricanes,

[1] See, for example, H. of C. Deb., Vol. 341, Cols. 329, 358, 10th November 1938.

while the first Wellington squadrons were not to be available until the turn of 1938 and 1939. Above all, there was the obvious fact that the L programme of 12,000 aircraft was only five months old.[1] The bulk of the output under that programme—about ninety per cent.—was still to come.

The significance of these figures must not be exaggerated, although exaggerated it probably was. The inevitable tendency in the Government and among the public was to magnify the terror of air attack and to expect immense destruction and decisive military results from the first 'knock-out' attack in the air. German strength in the air was also somewhat exaggerated, but not quite to the same extent as the German ability to deliver the decisive blow. The exaggerations varied from an excess of fifteen per cent. (for first-line strength) to twenty-five per cent. (for current output of military types),[2] and in addition the prospects of British output were somewhat underestimated.

According to contemporary Air Staff estimates German first-line strength in August 1938 was 3,200 aircraft rising to 4,030 by August 1939 and 4,540 by April 1940. The actual figures, as they became known after the war, were 2,847 in August 1938, 3,609 at the beginning of September 1939 and 4,119 by the end of June 1940. Germany's monthly output in the autumn of 1938 was estimated at 600 military machines a month, whereas the real output turned out to be 436. The monthly output was expected to rise to 800 in August 1939 but it actually rose to 691. The differences in the estimates of German strength were due not only to insufficient information but also to the difficulty of defining first-line strength and of estimating the depth of German reserves. The disparity between actual output and current British estimates would also be reduced if transport aircraft, which this country did not produce, were included in the figures of German output.[3] However, the important fact was that the best estimates of German and British aircraft production available at the time gave a terrifying picture of British inferiority. The real figures, had they been known, would have revealed an inferiority in first-line strength up to sixty per cent. and a slight inferiority in monthly output figures until 1939; and this was bad enough. But the estimates current in 1938 with their slight exaggeration of German strength and slight under-estimate of British potentialities gave the impression that Germany was twice as strong numerically and was expected to retain that lead. The opinions prevailing among the better informed

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[1] See p. 18.

[2] The percentages of over-estimates are based on British Intelligence estimates and actual figures of German output, for the same periods.

[3] See Appendix 2.

critics in Parliament were even more unfavourable. Sir Hugh Seely, who initiated the great debate in the House of Commons on air strength on 12th May 1938, and Lord Lothian, who took part in the debate in the House of Lords,[1] appeared to assume that Germany might within a year possess a front-line strength of 8,000 aircraft. No wonder all political and military calculations were built on the assumption that Britain was utterly unprepared to face the devastating power of German attack in the air.

If air defences appeared somewhat poorer than they need have done, the other defences were quite as inadequate as the inquest revealed them to be. The Admiralty in its report emphasised mainly the deficiency in destroyers, trawlers and other small craft, but it reported that the coastal defences were far from complete and that the anti-aircraft defences of the ports were also rudimentary. Greatest of all, of course, were the deficiencies in the equipment of the Army. In view of the persistent neglect of the Territorial Army, it was not surprising to find that it was greatly underprovided—there were not enough clothes or stores, other than armaments in the narrow sense of the term, to equip the few Territorial units that could be mustered in an emergency. But in relation to its responsibilities the Regular Army was not much better off. Under the decision of 1937 it was being re-equipped on a 'colonial warfare' basis[2] and was not backed by Territorial reinforcements, but even on this scale its supplies were insufficient. The evidence made it clear that the stores then available to the Army would be barely sufficient to equip more than two divisions for service on the Continent.

The deficiencies exposed by the October crisis gave an approximate measure of British weakness; they gave no measure of the task ahead. The supplies of weapons were set against current programmes, but the current programmes themselves were insufficient to ward off another humiliation or to secure the country against a crushing defeat in the coming war. The Navy and the Air Force could perhaps equip themselves in time for the coming emergency without a drastic increase in their plans, and might not be called upon to do more than to accelerate the pace of their preparations and, above all, to concentrate their efforts on the immediate requirements. The Army, on the other hand, could not be made ready without radically recasting the entire scale of its equipment or, indeed, the very principle of its rearmament. And this indeed was the shape in which the plans of the Services emerged from discussions between the Committee of Imperial Defence and the Cabinet following the Munich crisis.

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[1] H. of C. Deb., Vol. 335, Cols. 1749–1876; H. of L. Deb., Vol. 108, Cols. 1070–1075, 12th May 1938.

[2] See p. 29.

(2)

The Two-Power Navy and Emergency Programmes

As a result of the crisis and of the new mood which it induced the Admiralty was at last able to grasp the final object of its desires and to plan for a 'two-power standard'.[1] The discussions which went on throughout the late months of 1938 and the first half of 1939 culminated in July 1939 in a decision of the Committee of Imperial Defence authorising the development of additional capacity and the provision of certain additional machine tools in preparation for a new scale of construction. After August financial objections to the attainment of a 'two-power standard' rapidly disappeared, and broadly speaking the Admiralty then set out to attain that standard as a long-term policy.[2]

The main issue of the Admiralty's battles was thus won, yet at the time of its winning it had lost much of its immediate value. The 'two-power standard' from now on remained the long-term programme of the Navy, but in the months following Munich, and still more in the opening phases of the war itself, long-term programmes were very much a matter of theory. Their emphasis was on fleet units, in which this country had a great superiority over Germany, whereas what was urgently wanted was small vessels for convoy-escort and anti-submarine duties, of which the Navy was very short. Although plans for ocean convoys were far advanced by April 1939 they were not as yet put into operation. The prevailing assumption still was that the enemy would keep to the Hague Convention, would limit mining warfare to moored mines and would not resort to unrestricted submarine warfare. On these assumptions anti-submarine convoys would be required only in coastal waters and in a few focal areas. Yet even so, the Navy, according to Admiralty estimates, would still need as a minimum some 1,110 trawlers and 300 escort vessels and minesweepers of which only about two-thirds were provided for in the current programmes. The small ships were therefore bound to become the first charge on the immediate programme, and in its emergency plans the Admiralty accordingly laid down that in the first year of war shipbuilding resources should be so employed as to leave enough for the small ship programme as well as for an annual output

[1] See pp. 25–27.

[2] This required by 1942 among other fleet vessels two additional capital ships over and above the nineteen previously sanctioned, seventeen additional cruisers over the eighty-three already provided for, two additional aircraft carriers and five additional flotillas of destroyers.

of 1·2 million gross tons of merchant shipping. And to make this possible the building of fleet units was to be considerably slowed down.[1]

With the outbreak of war the Navy's emergency plans had to be carried a stage further, and provision had to be made for a still larger number of small vessels. The need could to some extent be met by converting merchant vessels and by employing mercantile yards, but some small vessels had to be constructed in naval shipyards, and their number could not be increased without prejudicing the output of fleet units. Towards the end of the first month of war the Admiralty realised that its requirements of small vessels had been somewhat unrealistic. Not only were fewer auxiliary vessels capable of being diverted from their civilian uses, but the need for small vessels was more exacting than it had appeared a year earlier. Magnetic mines demanded ships differently equipped from any previously built; German submarines were more active around the coast, and this led to a higher demand for small anti-submarine boats and anti-submarine vessels of the trawler type. But the chief new factor was the activity of German ocean-going U-boats along the Atlantic routes, and this meant that at least another 100 additional escort vessels of longer range than the corvettes were needed to operate from both ends and the middle of the Atlantic and thus to provide a continuous convoy across the ocean. Requirements of other small craft also rose —the Admiralty now wanted more submarines (about 100), more M.T.B.s (about 84), more boom defence vessels, salvage vessels, and tugs. In contrast to these short-term requirements of trade protection vessels, requirements of fleet units were much less urgent and did not materially increase, with the important exception of destroyers. Indeed, in order to provide for additional minesweepers and anti-submarine flotillas and to release steel for the merchant shipbuilding programme, the Admiralty agreed in March 1940 to sacrifice the whole of the 1940 share of the long-term programme of naval construction. The only major fleet units still to be built were the *Vanguard* (because of the shortage of fast battleships) and two flotillas of destroyers—and the latter could of course be considered as part of the short-term programme.

The programmes of naval construction as well as its problems remained in essence the same until the end of 1941; the differences were merely those of scale. Above all, the emergency programmes of small vessels continued to be the main preoccupation of the Admiralty and of the shipping industry for a number of years. It will consequently be convenient to carry the story of naval construction to Pearl Harbour without a break.

[1] The number of fleet units under construction was to be maintained at the following level: 9 capital ships, 6 aircraft carriers, 35 cruisers and 6 flotillas of destroyers.

Although the Admiralty was compelled to devote most of its time and attention to the emergency programmes, its hopes for larger units were not lightly abandoned and attempts to resume the 'long-term' programmes of naval construction were made from time to time. The fall of France and the extension of the war to the Mediterranean threatened to wipe out what had hitherto been a comfortable superiority over the enemy in fleet units. British superiority in large ships over the combined Italian and German fleets was only assured until the summer of 1942. There was also the possibility of the French fleet joining the enemy; and in addition the situation in the Far East was very uncertain. It was obviously becoming dangerous to neglect the large ships altogether in favour of light craft, and both the Admiralty and Mr. Churchill's Government could be relied upon to see the danger.

Nevertheless hopes of resuming the construction of large vessels were to prove illusory, for even while the doctrine of a balanced fleet was reviving in high quarters, the emergencies on the high seas were compelling further diversion of resources to the small vessel programmes. In the autumn of 1940 and the spring of 1941 it was found necessary to provide escorts for troop convoys to the Middle East by the long Cape route and to counteract new enemy techniques and weapons such as the laying of improved types of mine, the use of E-boats in the Channel and of midget submarines in the Mediterranean. No wonder small vessel programmes failed to tail off as they were expected to do. Requirements between Dunkirk and Pearl Harbour varied with the development of enemy tactics, and for one class of vessels, i.e. trawlers, requirements actually fell. But the estimated requirements of most other classes of small vessels grew in the course of 1940 and 1941 and stood higher in the autumn of 1941 than in the summer of 1940.[1]

It was not, however, the emergency programmes alone that prevented the resumption of a 'balanced fleet' programme. Even before the Admiralty took over direct responsibility for the construction of merchant ships[2] the needs of merchant shipbuilding were very heavy and interfered with some parts of the naval programmes. At least as burdensome and in every way as urgent were the mounting totals of repairs and conversions.

The burden of repairs was perhaps all the heavier for being somewhat unforeseen, or to be more exact, greater than the planners could foresee. From the very outbreak of war the dockyards found themselves overwhelmed with ships sent for refit or repairs. In the

[1] For further details of the naval programmes of 1940 and 1941 see Appendix 1, Table C.

[2] On 1st February 1940 the Merchant Shipbuilding and Repairs Division of the Ministry of Shipping was transferred to the Admiralty in London.

opening months of war the accident rate, chiefly caused by weather and collisions (by the end of 1939 one hundred and eleven ships had been damaged by accidents compared with twenty by enemy action), was very high indeed and, on the average, well over 100 naval vessels were in hand for refit or repairs at any one time. In 1940 damage from weather and accidents declined, but in the end the decline was more than made up for by a very steep rise in the damage rate from enemy action—a rate which began to grow in the Norwegian campaign, was greatly swelled by Dunkirk, and was kept high by hostilities in the Mediterranean. During 1940 470 naval ships were damaged, nearly half from enemy action, and in 1941 the rate of damage from enemy action, especially in the Mediterranean, rose still higher. On the average about 146 naval vessels were in hand for refit or repair at the end of each month in the first quarter of 1941, and the figure rose to 166 in the last quarter of the year. Added to this, a large number of French and Allied ships and the fifty American destroyers[1] had to be partly or wholly refitted.

Average number of naval ships of corvette size and above, in hand for large refit and repair, at the end of each month
April 1940–December 1941

TABLE 6

Period	Number of vessels			Percentage of total labour force engaged on naval vessels
	Under refit and repair in British yards	Under refit and repair in U.S. yards	Conversions	
1940				
April to June	80	0	234[2]	37% April
July to September	73	0	212	35% Sept.
October to December	136	0		37% Dec.
1941				
January to March	146	0	156	39% March
April to June	144	7		36% June
July to September	132	17	62	33% Sept.
October to December	166	19		33% Dec.

The work of repairing and refitting was also made heavier by the passage of time. As months rolled by, the time taken to refit British ships increased. Ships in continuous war service had to be drastically re-equipped to keep them in fighting trim. They had to be provided with close-range anti-aircraft weapons, splinter protection, radar equipment, degaussing coils, acoustic minesweeping gear, and other types of installation requiring extensive rewiring and fitting of

[1] See p. 231.
[2] January to June 1940.

new electrical equipment. This was often in itself a major problem of design and production.

To all this work was added the conversion programmes which also turned out to be disconcertingly slow and heavy. Although small patrol vessels often took less than a month to convert, auxiliary anti-aircraft ships took from eight to eleven months, destroyer depot ships about seventeen months. It was not before the summer of 1941 that the number of ships for conversion and the general burden of the work began to decline. Altogether the work of refit, repair, and conversion absorbed more than one-third of the total labour force engaged on naval vessels in 1940; and its share rose to nearly forty per cent. of the total in the first quarter of 1941.

Finally there were also the requirements of merchant shipbuilding. The war-time emergency programme in its pre-war version was so conceived as to allow an annual output of 1·2 million gross tons of merchant shipping, and the orders placed by the winter of 1939 were calculated to secure an output of a million tons in the following twelve months. In the spring of 1940 the 'target' figure was increased to 1·5 million tons, but after Dunkirk the shortages of steel and of marine engineering capacity and the large additions of neutral tonnage to the merchant fleet led to the annual merchant shipbuilding programme being reduced to 1·1 million gross tons. This was raised in September 1940 to 1·25 million gross tons. Actual annual output did not reach the planned figure, but no relief resulted therefrom, for the merchant tonnage under repair rose and remained very high. It had reached a peak of 2·5 million gross tons in February 1941[1] and was still a little below two million tons at the end of 1941. To meet the needs of merchant repairs the Government in March 1941 again lowered the 'target' for merchant ship construction and ruled that no merchant vessel should be proceeded with which could not be completed by the end of 1941.[2] Nevertheless between September 1940 and October 1941 the combined building and repair mercantile programmes, i.e. new building and repairs taken together, enjoyed a priority in the labour market over naval shipbuilding. As a result the labour force employed on naval new construction rose by 8·7 per cent. while that on mercantile new construction rose by 29·7 per cent.: in 1941 when the labour force employed on merchant vessels increased by 17,000 that on naval work increased by 1,000 only. Moreover there was no hope of restoring to naval work the capacity lost to merchant shipbuilding until American mass production of merchant ships began to take full effect.

[1] Of this total about one million tons was undergoing relatively small repairs while loading or discharging cargo, but the remaining 1·5 million tons was withdrawn from useful service solely by reason of its damaged condition.

[2] See also p. 300.

As the pre-war planners had foreseen, all these 'emergency' requirements could be satisfied only at the expense of 'long-term' fleet programmes. To this sacrifice the Admiralty had to agree more or less against its own earlier views and expectations. Some three months after the decision of the spring of 1940 to suspend long-term construction in favour of the most urgent work for anti-invasion and anti-submarine defence,[1] the Chiefs of Staff recommended that the long-term programme should be resumed as soon as possible. And in the autumn of 1940 the emergency programme which originally only included one battle cruiser and sixteen destroyers received the addition of an aircraft carrier, four cruisers and sixteen more destroyers. Early in 1941 the Naval Staff wished to resume construction of the 16-inch battleships, the *Lion* and the *Temeraire*, and to add a number of other vessels, including two aircraft carriers, ten cruisers and forty to fifty destroyers. These wishes, however, were not to be realised. On 26th March 1941 came the Prime Minister's instruction that no naval vessel that could not be completed in 1942 should be undertaken. By that time circumstances would in any case have made it very difficult to add to the number of fleet vessels under construction. The claims of merchant shipping and of escort vessels had risen higher than ever; supplies of armour plate had to be diverted to the making of tanks; and labour shortages were becoming serious.[2] By the autumn of 1941 the Naval Staff had to reduce their requirements to one aircraft carrier, six cruisers and forty destroyers.

The decision represented a compromise with the emergency programmes, but one of the results of the compromise was to jettison important new extensions of long-term plans. There was in Admiralty circles a growing body of opinion which favoured the construction of more fleet aircraft carriers and was prepared to concede them a priority second only to destroyers. It had been suggested that two should be laid down in 1941 and two more in 1942 to make up the deficiency as soon as possible, since the course of the war in the Atlantic and the Mediterranean had conclusively demonstrated the effectiveness of aircraft with the fleet both for defence and offence. But during discussions of the 1941 programme and of the supplementary proposals in the autumn, it was concluded that the building of more cruisers and the completion of the *Vanguard* were of more fundamental importance than the construction of fleet aircraft carriers. Not only were no more of the latter ordered, but the laying down of the carrier in the supplementary programme was postponed. The fleet aircraft carrier was the only class of naval vessel in which no

[1] See p. 59. The vessels affected by this decision included the battleships *Lion* and *Temeraire*, the aircraft carrier *Indefatigable* and a number of cruisers and destroyers.

[2] There were also the new requirements of escort aircraft carriers, but these were already accounted for as part of the emergency requirements and could besides be met more quickly by converting merchant vessels in the United States.

new ships at all were laid down between the spring of 1939 and that of 1942.

The pruning of the 'balanced fleet' programme was not the only consequence of the mounting demands on shipbuilding resources. The execution of the approved programmes, indeed of the emergency programmes themselves, was impeded and delayed. At the outbreak of war it was expected that 213 ships of 264,000 tons would be completed within a year, but by October 1940 only 126 ships of 172,000 tons had been completed. By the end of 1941 the delay in the planned naval programme was at the rate of three or four months for each year's construction, and output was lagging far behind operational requirements. During the first half of that year only sixty-eight per cent. of the naval tonnage, down to and including trawlers, scheduled for completion by the end of the period, had in fact been completed; the comparable figure for the last six months was seventy-eight per cent.[1]

For this backlog a number of factors were responsible. Air-raid damage dislocated production here and there. The 'teething troubles' of a much-expanded industry also affected the rate of production, for some delays were inevitable while the firms and the government departments were still new to the task of forecasting and progressing the work of shipbuilding in war-time. Over-optimistic estimates of rates of production were repeatedly made by firms and by the production departments, and this meant that berths and slips were not vacated on the expected dates, and ships approved in one programme could not be ordered before the next programme became due. It was largely for this reason that in the spring of 1941 there were sixteen corvettes and twenty-one trawlers outstanding from previous programmes.

Low priority for materials and labour was responsible for the delays in at least some classes of warships. Under the Priority of Production Direction of May 1940[2] naval needs came within the third degree of priority if they were for ships due for completion by the 1st May 1941. All the larger ships were outside this limit; consequently difficulties were experienced in obtaining scarce materials, particularly special steels, and naval contractors found difficulty in obtaining and retaining labour.[3] Earlier in the year steel for merchant shipbuilding had been given the same priority as steel for warship construction, and twelve escort destroyers, twenty 'whalers'[4] and nineteen submarines

[1] From January to June 1941, 171,755 tons completed out of an expected total of 252,453 tons: from July to December 1941, 179,850 tons completed out of a total of 230,970 tons.

[2] See p. 160.

[3] The Essential Work (Shipbuilding and Ship Repairing) Order, S.R. & O. (1941) No. 300, was not introduced until 7th March 1941.

[4] Anti-U-boat type for long-distance action.

had been deleted from the 1940 naval programme to free additional steel for the merchant shipbuilding programme. In the summer of 1940 a proportion of the existing capacity for armour plate reserved for the Admiralty was diverted to supply the army tank programme. The reduced allocation to the Navy of 16,500 tons of armour plate proved in practice sufficient for the truncated naval programmes, but it remained one of the controlling factors in restricting the size of the 1941 programme of capital ships, aircraft carriers and cruisers.

The fundamental cause, however, was the one already dealt with: the total volume of urgent work was too great for all of it to be accomplished in time. Forced by the accumulation and conflict of urgencies, the Government found it necessary to establish priorities within the naval programme; and while this helped to clear some of the most troublesome or most dangerous arrears it also delayed still further the carrying out of the other shipbuilding tasks.

From the outbreak of war the conversion of auxiliary vessels for naval purposes was given a high priority, both as regards labour and materials, over long-term naval new construction, since only in that way could vessels speedily be made available in the early months of the war.[1] By the end of 1941 about 2,000 vessels had been converted for war service, the bulk of the work being completed by the end of 1940.

Number and types of vessels converted for war service, 1939–41

TABLE 7 — Number of vessels

Conversions to:	Total	1939	1940	1941
Minesweeping trawler and drifter	667	298	289	80
A/S trawler, whaler, drifter and yacht	290	200	82	8
Boom-working and boom-defence vessel	95	42	52	1
Fishery protection trawler	57	45	12	nil
Miscellaneous services	235	105	113	17

Essential and urgent as this work was, and important as it was to 'get it out of the way' for the sake of other shipbuilding tasks, it necessarily competed with new construction both for berths and labour. The effect was felt as early as the autumn of 1939 when, as a result of diversion of labour to urgent conversion work for magnetic minesweeping, it was seen that certain long-dated ships would be delayed. In the following spring the completion date of many small vessels ranging from trawlers and corvettes to destroyers was post-

[1] For example, by October 1939, 1,240 ships, including fifty armed merchant cruisers, had been requisitioned and time, space and labour were being occupied by the work of arming merchantmen.

poned for the same reason, and delays of from one to five months resulted. In April 1940 seventy such vessels were affected and the position did not improve until the end of the year. But no sooner did the work of conversion tail off than the burdens of repair work began to absorb much of the attention and of the resources of the shipbuilding industry. By the late spring of 1940 the claims of repair work were sufficiently strong and urgent to prevent naval shipbuilding from gaining any relief from the lessening of conversion work.

The diversion of resources, and above all of labour, from longer-term construction to repairs, conversions and other work of higher priority was especially serious in its effect on items such as gun mountings and electrical fittings which were in short supply. For example, the laying down of cruisers was delayed in 1941 because sufficient labour was not available to begin work on the gun mountings. Not only was at least one-third of the total naval labour force not available for new construction work throughout this period,[1] but at the time of the crisis in the repair yards of February to June 1941 a further check was put on the construction of fleet vessels, and labour had to be diverted from naval construction to merchant repair work.[2]

(3)

Aircraft Production 'To the Limit'

So much for the Navy. The reaction of the Air Ministry to the crisis was somewhat different, for its new measures followed more naturally from the earlier programmes and had more distant objectives in view. The current aircraft programmes were not directly affected. A concerted drive to speed up the rate of production which had been going on since the summer months of 1938 was now beginning to show results, and the actual output under the current programmes was now fulfilling all expectations. It in fact rose from a monthly average of slightly under 200 in the first six months of 1938 to about 630 in the first six months of 1939 and to about 780 in September 1939.[3] This output already stretched the resources of the aircraft industry to the furthest limit possible in peace-time; immediate increases in the current programme would therefore have been impracticable, and the Air Ministry did not try to force through a further change in the current scale of orders. On the other hand, provision had to be made for the more distant future; a great deal still remained to be done to prepare for the expansion of production

[1] See Table 6.

[2] See p. 62 and p. 300.

[3] See Appendix 4 for monthly figures of aircraft production.

under war-time conditions; and it is towards these objectives that the Air Ministry turned now its attention.

The problems of war potential were at first focused on the existing plans for 2,000 aircraft per month. It has already been shown that under the aircraft programme of 1938 the Air Ministry was building up a war potential for a much expanded output,[1] and in the late summer of 1938 the production departments gave much thought to the various hypothetical estimates of aircraft production in war. These discussions, as yet largely theoretical, came to a head after Munich. At the end of the year a new office, that of the Director of Planning of War Production (D.P.W.P.) was set up, and under the new Director the plans for war production finally crystallised.

The dimensions of the problem were by that time more or less clear. In July 1938 the Production Department of the Air Ministry estimated that if war were to break out in October of the following year the war potential then in existence or in the course of construction would be sufficient to produce 2,000 aircraft per month within eighteen months of the beginning of hostilities.[2] At that level the war potential was, in the opinion of the Air Staff, sufficient to meet operational wastage until the peak of production was reached—most probably within a year of the outbreak of war—and this became the actual target of the Ministry's preparations.

In January 1939, however, it also became clear that the agreed target could not be attained without certain additions to the existing war potential. The discussions revealed that labour and capacity might exist for many more airframes than could in fact be built from planned output of components and materials. Thus the war-time output of aircraft, as calculated by the new Director, would by March and April 1940 outrun the maximum supply of alloy sheet, extrusions and forgings, which the existing capacity could provide. Tighter still was the prospective supply of engines and of certain other main components. The manufacturing capacity of engine-makers had not expanded quite as quickly as that of airframe manufacturers, and in addition, the general trend of requirements of engines could be expected to rise faster than that of airframes owing to the coming introduction of four-engined bombers. The Director of Engine Production also drew the attention of the planners to the special difficulties of mobilising the war potential of the engine firms. So complicated were their requirements of certain special machine tools and equipment and so greatly did they vary with the type of engine, that only small increases could be brought about by working the existing machine tools, jigs, gauges, test houses, etc., all round the clock.

An improved balance of industrial capacity thus became the

[1] See pp. 18–22.

[2] See Table G, Appendix 3.

principal objective of the emergency planning of early 1939. Immediate instructions went out from the Air Ministry to increase fabricating capacity for light alloys from the 40,000 tons under the existing plans to 63,000 tons; something was also done to increase capacity for the production of turrets; before long further expansions also took place in the war potential of the engine-makers. Yet on the whole the measures then taken were neither wholesale nor drastic. By the beginning of 1939 the main core of the war potential had already been formed and did not appear to need much enlarging. The very technique of estimating the potential by computing the war-time activity of existing airframe capacity assumed that the necessary floor space, plant and machinery were already available or at least could be made available under current programmes. Indeed, writing at about that time the Air Member for Development and Production was able to assure the Secretary of State that the existing potential, if working at full capacity, could produce nearly 2,000 airframes a month and that there was, therefore, little need for more aircraft factories.

Thus as long as the final aim of the current programmes remained fixed at 12,000 aircraft by the spring of 1940, and the war potential at 2,000 aircraft per month, relatively little had to be added to the existing provisions. Before long, however, both the figure of 12,000 aircraft and that of the monthly output in war came to be reconsidered. The programme as planned was to be completed in March 1940, and in the months immediately preceding the outbreak of war the Air Ministry asked the Cabinet to authorise immediate 'follow-on' orders. Eventually the Ministry obtained the agreement of the Treasury to the raising of the total number of aeroplanes on order from 12,000 to 17,500, on the understanding that the additional 5,500 were to be delivered after 1st April 1940. But this was obviously not enough. The Air Staff had been nursing plans for following up Scheme L with a further programme in order to keep pace with continued German expansion, and it was also necessary to maintain the operational quality of the Royal Air Force. A number of new aircraft, principally heavy bombers, had been under development since 1936, and a new programme to embody them was now thought both necessary and possible. With the outbreak of war the Air Ministry had to consider the possibility of still further extensions in fulfilment of the War Cabinet decision to plan for a war of three years' duration.[1] The War Cabinet had also before it projects for an all-round increase of the Army to fifty-five divisions, and that alone would have necessitated additional aircraft for co-operation with the field forces. There were also other arguments to commend the proposals to the Air Council. A higher target would be necessary as an insurance:

[1] See p. 54.

bombing and other war hazards might reduce the planned output and wastage might also turn out to be higher than expected.

For all these reasons, no sooner was war formally declared than the Air Council opened up again the question of the maximum rates of monthly output under war conditions. On 9th September it decided that the objective of R.A.F. requirements should be increased so as to raise the production of aircraft in war from 2,000 to 3,000 per month with all ancillary equipment, the increased rate of production being attained as quickly as possible, based on a war of three years' duration. The ambition was indeed very high. The Secretary of State had discussed the implications of the new figure with the Minister of Labour[1] and the Minister of Supply and there had obviously been a certain amount of criticism inside the Air Ministry. A smaller programme was therefore worked out for submission to the War Cabinet. On the assumption that 250 aircraft per month would be available from the Dominions, the 'target' for the third year of the war was set at 2,550 per month. In this form, the proposals received the approval of the War Cabinet on 22nd September 1939. But the hopes of a 3,000 programme were not thereby buried, and the Air Member for Development and Production gave something in the nature of an advance notice of its eventual revival. Although he agreed to plan to produce 2,550 aircraft per month by June 1942 he felt that the year after it might be possible to reach a figure of 3,000. This opinion, however, did not find much support outside the Ministry and was not wholly supported even within the department, and the eventual decisions were merely to examine every means of accelerating production and to endeavour to increase the 2,550 figure.

With this hopeful addendum the programme of 2,550 which came to be known as the 'Harrogate' programme formed the basis of war-time planning and was indeed to prove the most stable and most permanent of all the estimates of future output ever made in the Air Ministry or in the Ministry of Aircraft Production.[2]

(4)

The Size of the Army

Much more drastic was the transformation of the Army. By the time of the Munich crisis a revision, and perhaps a radical one, of the current army programmes was long overdue. A rearmament policy

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[1] See p. 79, n.2.

[2] Table H. Appendix 3, shows details of the 'Harrogate' programme as revised in January 1940.

which called for a Regular Army, however small, but failed to provide it with reserves, could not prevail indefinitely; nor could the policy of equipping the Army on a scale insufficient for the one theatre of war in which everybody expected it to fight and for which it was in fact being trained. The issue was therefore bound to come up as soon as a suitable occasion occurred, and in the autumn of 1938 the suitable occasion would in any case have presented itself. By that time the five-division 'deficiency' programme was due to be completed, and the question of the size of the Army and the scale of its armaments would inevitably have arisen. The Munich crisis merely made it certain that the army programme would be recast more drastically than it might otherwise have been. What now came up for reconsideration was not only the size of the Army but the fundamental assumptions of the programme, and in the first place the doctrine of 'limited liability'.

When in the course of 1936 and 1937 the Government by a series of consecutive decisions decided to concentrate on the re-equipment of the Air Force and the Navy, it assumed that war, though probable, was not imminent, and that if a war were to break out Britain's continental allies would bear the whole burden of the land fighting. In 1938 these comfortable assumptions no longer held. Not only did war with Germany now appear more or less certain, but there was also the possibility that France alone might not be able to prevent her territory from being overrun and the Channel ports from being occupied. This possibility the Chiefs of Staff were now bound to take into account, and in doing so to find that a German occupation of France would so endanger the safety of Britain as to justify recasting in favour of France the entire order of strategic priorities. What they in fact did was to extend to the defence of France Britain's defence priority number one, as defined in the current Cabinet directive, i.e. that the security of the United Kingdom was the 'corner-stone of Imperial defence policy'.

The French themselves now made no secret of their need of British Army contingents for the defence of France. If in the earlier discussions between the military representatives of the two countries, in 1936 and early in 1938, no such clear demands had come from the French, this was merely because at that time the prospect of a war was as yet hypothetical and the negotiations were conducted on a rather low official level and were on the whole somewhat informal and vague. But after Munich the French offered, and the British agreed, to enter into full-fledged military conversations at staff level, and in accepting this offer the British Government was fully aware that the French would now ask for a British expeditionary force and might even press for a force large enough to compensate them for the loss of Czechoslovakia's thirty-five divisions.

Faced with the new facts the Government had to abandon the earlier conception of the Army. In preparing for the conversations with the French the Committee of Imperial Defence undertook a full-scale review of British commitments and from the very outset came up against the main problems of the size and role of the field forces. The War Office at first proposed a series of piecemeal increases which were obviously insufficient but which nevertheless impinged on the doctrine of 'limited liability'. At the beginning of 1939 the Secretary of State for War (Mr. Hore Belisha) supported by the Foreign Secretary (Lord Halifax) proposed that the doctrine of 'limited liability' should be formally revoked. On that occasion nothing definite could be decided, but the absence of a decision did not signify the intention of shelving the issue. On the contrary, there is every indication that at the time of its eruption in the Committee of Imperial Defence the question was already under discussion in the highest quarters. So when on 2nd February the Secretary of State for War submitted to the Cabinet a set of concrete proposals, containing one for equipping ten divisions on a continental scale, the Cabinet was almost ready for a final decision. On the suggestion of the Prime Minister the proposals were submitted for further consideration to an informal committee of the Cabinet.[1] By the middle of February they were in substance accepted by the Prime Minister. On 22nd February he recommended proposals to the Cabinet,[2] and in doing so made it clear that the new scale of equipment meant a radical break with past policy.

The Prime Minister recalled that hitherto the Cabinet had not been asked to agree to any commitment that the field divisions would be sent to the Continent. The situation had, however, been changed by the events of the previous autumn, and France now had to face the possibility of a far stronger German force. There was also a feeling in France that Great Britain would not be playing an adequate part until she made some contribution on land. The Prime Minister therefore considered it necessary to depart from the conception of an army available for service anywhere, and to envisage one army equipped for service on the Continent and a second army equipped for service in the colonies and elsewhere overseas.

'Limited liability' was now dead—more completely than only a few months ago its fiercest critics could have hoped, though not so

[1] This informal committee consisted of the Prime Minister, the Chancellor of the Exchequer, the Chancellor of the Duchy of Lancaster, the Secretary of State for War and the newly-appointed Minister for Co-ordination of Defence (Lord Chatfield).

[2] The principal difference between these recommendations and those of the War Office was that the third contingent of the field force which was to be equipped for 'defensive war in Europe' was to be ready to proceed overseas six months after the outbreak of war instead of within four months as originally suggested. This was estimated to reduce the cost by some £3–£4 millions.

completely as not to leave behind a few lingering ghosts. A reader of official documents with senses attuned to Whitehall spirits will find notions of 'a little army' continuing to haunt confidential files for another year or two. But except for one conspicuous apparition in the early phases of the war (about which more presently)[1] the ghosts no longer manifested themselves in official discussions or acts. Henceforth the War Office could plan on the assumption that in the defence of the country and in the general conduct of the war the Army's share would be as full as that of the other two Services.

The actual demands which the War Office made on the spur of the moment may not have been very large—a Regular Army of ten divisions and Territorial reserves to match. But the actual size of the programme was fluid, was soon to change again, and, viewed in retrospect, was unimportant. What was important was that in the coming negotiations with the French, British representatives would be able to promise participation in land operations in France. And once this was understood the size of the Army was bound to be adjusted to what the French thought was the least they needed and the British the most they could do. This is what in fact happened. The conversations took place while German troops were marching into Prague, and it was therefore very fitting that the size of the British expeditionary force should have been fixed at a level very nearly equal to that of France's lost ally. The French had to accept that in the opening phase of war British participation would be confined to the air and sea. But Britain undertook to make ready for service wherever required a field army of thirty-two divisions.

Thus the thirty-two-division programme came into being. It was not formally approved by the Cabinet until 21st April 1939, but a series of measures, all designed to give it effect, were being taken and made public through late March and early April. On the 29th March the Prime Minister announced the decision to bring the Territorial Army up to war establishment, and that done, to double its numbers.[2] The twenty-six Territorial divisions thus formed, together with the six Regular divisions, made up the complement of the thirty-two-division force agreed upon with the French. The other contribution to the new Army was the militia. The Prime Minister announced its formation on the 26th April,[3] and thereby not only was conscription for the first time in the history of this country introduced in what nominally was still peace-time, but a further step was taken to give reality to the programme of thirty-two divisions.

The outbreak of war did not introduce any radical changes in the plans for the Army. War scales of equipment replaced those of peace-

[1] See p. 81.

[2] H. of C. Deb., Vol. 345, Col. 2048, 29th March 1939.

[3] *Ibid*, Vol. 346, Cols. 1150–1153, 26th April 1939.

time—and in some fields, notably in the provision for wastage of ammunition and guns, war scales were very high indeed, as will appear from Table 8.

War Office requirements of certain items, December 1938 and April 1940 respectively

TABLE 8 Units

	War Office requirements	
	December 1938[1]	April 1940[2]
Tanks	5,025	7,096
Carriers		11,647
Motor vehicles and motor cycles	25,545	376,299
Field and anti-aircraft guns (including conversions)	2,226	12,677
2-pdr. tank and anti-tank guns	nil	13,561
Shells (excluding anti-aircraft)	14·8 million	64·4 million

Yet there was nothing in these scales that was new and unexpected, for some such scale of war demands had been in the minds of War Office planners when the figure of thirty-two divisions had been fixed as a maximum of British effort on land. And it remained thus fixed. True, the Chiefs of Staff appeared to view the thirty-two divisions as part of a wider plan of some fifty-five divisions, and in September 1939, soon after the outbreak of war, the War Cabinet assured the head of the French Army that thirty-two divisions were not the final limit to Britain's effort on land and that she would go beyond that number if and when she found herself in a position to supply the additional divisions. But nothing was as yet done in the War Cabinet or by the General Staff or the Ministry of Supply to give substance to this promise, and no definite proposal to extend the Army came from the Chiefs of Staff. Nor was the timetable of preparations in any way altered. Ten divisions were to be in France by the end of February 1940 as arranged in the pre-war discussions between the General Staffs. A total of twenty divisions was to be reached by September 1940, and a total of thirty-two divisions was to be ready for service in France by September 1941. Beyond that date there was no commitment and no definite plan.

This does not of course mean that the Army plans did not come in for criticism. From the very beginning of the war some of the members

[1] These were the total approved requirements under the 'deficiency' programme.

[2] These were the requirements for thirty-six divisions to be completed by September 1941 (see p. 75 below), and were additional to the provisions under the 'deficiency' programme. These figures are based on the War Office schedules of requirements of November 1939 to April 1940 and are not as 'firm' as those of the 'deficiency' programme. Only the roughest of comparisons between the two sets of figures is possible.

of the War Cabinet, and more especially the First Lord of the Admiralty (Mr. Churchill) and the Secretary of State for War (Mr. Hore Belisha), wished to commit the country to fifty-five divisions and to a faster rate of despatch. At the first meeting of the Land Forces Committee of the War Cabinet on 7th September 1939 Mr. Churchill proposed that the immediate objective should be the equipment of at least forty divisions within a year and of at least fifty-five divisions within two years, while the Secretary of State for War at one point in the discussion appeared to envisage an army greater still. These views, though pressed very hard, did not prevail. The Ministry of Supply protested that the existing programmes were hard enough to cope with. In September 1939 the programme of thirty-two divisions was still young.[1] And relative to the industrial capacity immediately available the requirements now turned out to be so large as to make further additions to army programmes appear unrealisable. The Ministry estimated that all it would be able to do within a year would be to equip a Regular contingent of from four to six divisions and fourteen Territorial divisions, and it refused to promise more than supplies for twenty divisions in the course of a year. The C.I.G.S. (General Ironside) also expressed preference for a smaller programme for fear lest the Ministry of Supply 'were pushed too far and too fast'. Other members of the War Cabinet and the Prime Minister among them refused to consider any army plans that might interfere with the priority of the air programme.

The balance of views was thus in favour of the smaller programme. As a nominal concession to the advocates of a larger army the War Cabinet decided on 11th September 1939 to instruct the Minister of Supply (Dr. Leslie Burgin) 'to do his utmost' to increase supplies beyond the twenty-divisions limit, but the programme of fifty-five divisions was postponed until the effects on the other Services had been investigated and until both the financial and labour aspects of the proposal had been thoroughly examined.

Some of the results of these investigations, especially on the question of labour, will be discussed elsewhere.[2] Their immediate effect was to relegate the fifty-five-division programme to a much later date. In December 1939 the War Office sent in its requirements for about sixty principal stores for the second year of the war, based on the assumption that by the end of that period there would be a field force of fifty-five divisions. But these figures were submitted only as an indication—one is almost inclined to say a threat—of what a larger army might involve and were not apparently meant to

[1] The current requirements were replaced by war-time scales of equipment in November 1939 and in April 1940 by full scales for thirty-six divisions by the autumn of 1941.

[2] See Chapter IV, Section (4).

be acted upon. No action was in fact taken. The Treasury and the Ministry of Supply interpreted the instructions to plan for fifty-five divisions, which the War Cabinet had issued to the Ministry of Supply, in the most restricted sense of which the term 'plan' is capable. At a meeting of the Military Co-ordination Committee on 10th January 1940 the Minister of Supply pointed out that the existing Cabinet decision gave him full authority to arrange supplies for thirty-two divisions but only to plan for fifty-five divisions, and that consequently any proposals which he placed before the Treasury for expenditure on capacity to meet requirements beyond those of thirty-two divisions were refused.

Discussions in the autumn of 1939 and through the succeeding winter centred upon the highest practicable rate of recruitment and training of the new Forces and the rate of wastage (i.e. expenditure of ammunition, loss of equipment of all kinds in training and in active operations). Thus calculated the programme agreed between the War Office and the Ministry of Supply came to thirty-two divisions: twenty by the end of the first year and a further twelve by the end of the second.[1] The decision was influenced by the desire of both the War Office and the Ministry of Supply to maintain a balanced flow of supplies. Shortages of materials and capacity were still widespread, and the two departments thought it unwise to consume materials in producing large quantities of easy items while the formations which would have used them could not be equipped through lack of other essential supplies. This concern for a proper balance may have kept the 'targets' somewhat lower than they would otherwise have been.

Nevertheless it was largely an academic question whether the ultimate 'target' should be thirty-two, thirty-six or fifty-five divisions. It was as yet difficult to gauge the full productive capacity of the country's economy, and it was even more difficult to assess what supplies would come from the United States. The Ministry of Supply therefore concentrated on providing as quickly as possible the equipment and maintenance requirements of thirty-two divisions—a task which it knew to be within the powers of war industry so far mobilised. At a meeting on the 13th February 1940 the War Cabinet finally decided that while the objective should continue to be a full programme of fifty-five divisions, the aim of the Ministry of Supply by September 1941 should be a slightly augmented thirty-two-division programme: in fact thirty-six divisions. The only practical measure definitely authorised for the fifty-five-division programme was authority for the erection of factories requiring eighteen months or more for their construction.

Little more was heard about the larger army until early summer.

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[1] See p. 73.

Broadly speaking, the effective scale of Army expansion and equipment in the first nine months of the war remained materially the same as that laid down in the summer of 1939, when the Ministry of Supply was first set up. The immediate objective was raised from thirty-two divisions to thirty-six but as the date of completion was postponed from the spring of 1941 to the autumn of the same year the scale of rearmament was not thereby enlarged. The preparations so far permitted for the fifty-five-division programme were too few and too slow to have made any appreciable difference to industrial plans and activities. As already said[1] the real difference which the outbreak of war made to the production programmes was to substitute war-time scales of equipment and wastage for those which were deemed sufficient in peace-time.

(5)

The Blue-print of War Production

The transitional character of the Service programmes on their way to war-time peaks was matched by the equally transitional and tentative character of the economic policies and administration. The principles and the machinery of government, as they affected war production, now definitely served the urgent needs of the war and were thus far removed from the uncertain policies and half-hearted measures of the mid-thirties. Yet full-fledged war mobilisation was not yet. The country was moving towards the economic policies of total war, yet neither after Munich, nor even after the outbreak of war, did the Government attempt anything that might smack of economic regimentation. The all-embracing war industry of later years was not to be born overnight. In the period here described it was being merely coaxed into existence.

Of the several elements of war administration, the administrative machinery of production was one of the earliest to appear. The first war department to arise—the Ministry of Supply—ante-dated the war by a month, and had in fact been launched at the same time as the thirty-two division Army plan. It was intimately involved with the new Army, and to this extent at least its conception was a novel one. A specialised department or departments for the manufacture of munitions had always been part of the plans of the Committee of Imperial Defence; the notion of a Ministry of Supply had also formed part and parcel of the popular agitation in favour of more

[1] See pp. 72–73.

energetic rearmament. But neither in the plans of the Committee of Imperial Defence nor in the parliamentary agitation did the Ministry of Supply figure as a department specially linked up with the army programme. Most of the administrative blue-prints which the Committee of Imperial Defence drew up in the mid-thirties envisaged that in war-time the production of munitions would be the concern of two departments roughly corresponding to the bifurcation of the Principal Supply Officers' Committee. One, a Ministry of Munitions, would take over the manufacture of weapons for the three Services, while the other, a Ministry of Material Resources, would take charge of raw materials and possibly of some other supplies common to the three Services. There was also an idea that a special department might be set up to deal with the mobilisation of manpower for military recruitment and for war industry.

The whole plan was thus an 'inter-Service' one. So was the idea of a Ministry of Supply which its various non-official advocates had in mind; and so was also the bogey of a Ministry of Supply which underlay the Government resistance to popular agitation. For over a year the Cabinet resisted all pressure to set up a Ministry of Supply in peace-time, partly from fear of adding thereby to interferences with industry, but chiefly because in its view the existing machinery was sufficient. It believed that the production departments of the Admiralty and the Air Ministry were adequate to deal with their respective expansion programmes, while the rearmament of the Army was sufficiently modest to be well within the capacities of the department of the Director General of Munitions Production at the War Office. In so far as these departments had to be co-ordinated, this was done by the various sub-committees of the Committee of Imperial Defence,[1] by the Treasury and, later still, by the Minister for Co-ordination of Defence. In fact one of the political functions of the office of the Minister for Co-ordination of Defence, when it was created in 1936, was to make some concession to the parliamentary demand for a co-ordinated effort in rearmament.

With the inception of the thirty-two-division plan, the Cabinet rapidly moved away from its earlier attitude towards a peace-time Ministry of Supply and also from its previous conception of the functions of such a Ministry. On the one hand, the suddenly expanded programmes raised vast administrative and industrial issues, and it was the Secretary of State for War himself who in April 1939 expressed a desire for a Ministry of Supply to whom the War Office could pass the execution of the new plan. On other grounds, both

[1] The work done by the committees and more especially by the Defence Policy and Requirements (D.P.R.) Committee and the Defence Requirements Sub-Committee will be more fully treated in the forthcoming volume in this series on the Administration of War Production by J. D. Scott and others.

political and psychological, the Cabinet was now more inclined to make concessions to the parliamentary demands and was less afraid of disturbing the normal process of industry. But as soon as it became known that the Government was prepared to set up a Ministry of Supply, it also became obvious that the new department would not be formed in the image either of the Ministry of Munitions of 1918 or of the departments forecast by the Committee of Imperial Defence.

To begin with, the Admiralty 'dug its toes in' against all attempts to take away from it the control of naval construction. The building of ships, it argued, was so intimately bound up with design, and the latter was so much part and parcel of the strategic planning and tactical experience of the Naval Staff, that the Admiralty could not possibly part with responsibility for naval construction. Moreover, the naval programmes in peace-time were sufficient to enable the Admiralty to maintain a fully-staffed production department, a corps of naval constructors and a network of naval dockyards: in fact all the organisation, all the men and all the experience necessary for naval construction in war-time.

Their Lordships' arguments were put with customary force and apparently struck the Cabinet as cogent; so that from the very beginning it became clear that a Ministry of Supply, if set up, would not be in charge of naval construction. But once that was admitted, the way was open for a similar argument by the Air Ministry. In principle the Air Ministry was not prepared to allow its authority to be narrowed down in comparison with the authority which the Board of Admiralty enjoyed in naval matters. And in fact the arguments which held good on naval construction also applied to aircraft production—the intimate connection between production, design, tactical lessons and strategic planning, the accumulating technical competence within the Ministry, the close contact with firms. The Air Ministry therefore had to be allowed to 'contract out', and in the end the authority of the new department in the production of weapons came to be largely confined to the army programme. It was at that stage that the Cabinet decided that the Ministry of Supply was so truncated that it could without overburdening itself also take over the responsibility for raw materials, and thus make it unnecessary to establish a separate Ministry of Material Resources. In this shape the blue-print of the 'mule' Ministry of Supply finally took shape in July 1939, and the Ministry itself started operations in August of the same year.

On the eve of the war the setting up of the Ministry of Supply was as yet the only important development in the administrative machinery of military production. Other administrative innovations were still in the blue-print stage and were not to be introduced until the actual beginning of hostilities. They were, however, brought in

and in some ways supplemented, within the first month of war. One of the first administrative acts of the Government was to set up a War Cabinet, consisting partly of departmental ministers and partly of ministers without departmental duties, and a number of new ministries.[1] Among them one—the Ministry of National Service, administratively joined to the Ministry of Labour[2]—was to be in charge of manpower problems and consequently also of supplies of labour for war industry, and indeed was to become a linchpin in the administration of war production. Almost simultaneously the War Cabinet called into being a network of committees for interdepartmental consultation and co-ordination, most of which were directly or indirectly concerned with war production. At the ministerial level the War Cabinet established, at the end of October, the Military Co-ordination Committee to provide for a regular exchange of views between the ministers primarily responsible for defence and the Chiefs of Staff and to consider reports of the Chiefs of Staff on their way to the War Cabinet. Generally speaking it was expected to deal with problems of strategy and military organisation, and in so far as strategy determined the armament programmes of the Services, munitions were also within the competence of the committee. The allocation of production resources was to be controlled by the Ministerial Priority Committee, which in its turn budded off into sub-committees for materials, production, manpower, works and buildings and transport. And to crown the edifice the War Cabinet established in October 1939 the Ministerial Committee on Economic Policy to unify and co-ordinate all the activities of the various departments which affected the war economy of the country as a whole. Most of the ministerial committees had their counterparts on the official level, and of these the Interdepartmental Committee on Economic Policy with Lord Stamp as its chief functionary was conceived as the 'Economic Staff' from which the War Cabinet expected to obtain expert advice on the main subjects of economic and industrial policy.

Thus an elaborate machinery for the management of national resources came into existence by the second month of the war. In theory it was sufficient to cover the entire field of economic policy and industrial administration; whether it was equally sufficient in practice was more doubtful. Executive action on the departmental level in the Air Ministry, the Admiralty and the Ministry of Supply, developed more or less smoothly. Though greatly expanded and diluted, the

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[1] The Ministries of Food, Home Security, Economic Warfare, Information, Shipping and National Service. See W. K. Hancock and M. M. Gowing: *British War Economy* (H.M.S.O., 1949), p. 89.

[2] S.R. & O. (1939), No. 1118. For brevity, the Ministry of Labour and National Service is called the Ministry of Labour throughout this volume.

production departments were merely continuing the work which had already been in full swing and for which experience had been accumulating since 1936. The newest of the departments—the Ministry of Supply—incorporated the nucleus of the Production, Contracts and Inspectorate branches of the War Office and was therefore able to get into stride with relatively little delay.

More uncertain were the first stages of the Raw Materials Department of the Ministry and most uncertain of all were the activities of the central machinery for control and co-ordination. The various committees concerned with economic and industrial matters attempted little and achieved even less. The sub-committees of the Ministerial Priority Committee were fairly active but proved useful in little more than exchange of information between departments on topics in which their interests met. The Military Co-ordination Committee found itself tackling one or two problems of fundamental importance to war production, about which something has already been said.[1] The Economic Policy Committee alone succeeded in asserting itself over and above the rest of the co-ordinating machinery, but such authority and power as it possessed was largely derived from the powers which the Treasury exercised through it.

Here indeed will be found the main feature of the industrial administration of the time. The state of continued crisis which came with Munich did little to modify the controlling part which the Chancellor of the Exchequer and his department played in general control of economic policy and of war production. From this point of view the outbreak of war and the elaborate system of committees it ushered in made little difference. It was in so far as the Economic Policy Committee was an instrument of Treasury control that it grew in importance in the autumn and winter of 1939 to 1940. The Chancellor was the only member of the War Cabinet concerned with economic matters; he was also chairman of the Ministerial Economic Policy Committee, while on the official level the Permanent Secretary of the Treasury acted as its chairman and was in fact its virtual director. The two men doubtless owed some of their influence to their personalities, and above all to the weight which throughout the concluding months of peace and in the early phase of war the Prime Minister attached to their advice. But the pre-eminence also reflected the fundamental principle of Government policy, and more especially the continued supremacy of financial controls in economic matters.

Needless to say Treasury control had changed and was still changing. The financial limits were no longer as narrow and seemingly unsurmountable as before, and Treasury procedure was becoming speedier and more pliable. This change was in fact sufficiently important to deserve fuller treatment in the next section.

[1] See p. 75.

(6)

The End of Financial Limitations

It will presently be stressed that the economic reason for financial limitations was no longer that of 1935, even though the theme of finance as the 'fourth arm' still made an occasional appearance in official discussions. One such anachronistic event took place on the very first day of the war when the War Office representative on the Treasury Inter-Services Committee volunteered his department's willingness to work to any system of financial control which might be adopted if for financial reasons it was necessary to wage war on a limited scale. By itself the statement was of little importance, but it betrayed an outlook which was still capable of influencing the attitude of the Chancellor of the Exchequer during a discussion of the new army programmes. Even at that late hour he could argue that the country was already spending £210 millions per month which was more than at peak periods of the last war and more than it could afford; and the same argument in a more particular form could also at times be brought forward in detailed discussions on individual proposals of expenditure.

Generally speaking, however, the view that the 'country could not afford it' and the corresponding budgetary limitations no longer determined the scale of war production. It has already been shown[1] that the R.A.F. shook itself free of financial limitations early in 1938 and was the first Service to rearm more or less regardless of cost. The other two Services attained their financial releases in the course of 1939. When in November 1938 the War Office tabled its first modest and tentative post-Munich programme—as yet nothing more than a request that the existing establishment of six divisions[2] be allowed full equipment—the Chancellor still appeared unbending. But as the discussions on the role of the Army progressed so his opposition waned; and when the deliberations of the Prime Minister's Committee ended in revoking the principle of 'limited liability',[3] the Chancellor finally gave way. His comments on the Prime Minister's proposals of the 22nd February 1939 were that other aspects of the matter outweighed finance and that therefore he had no alternative but to agree to those proposals.

The Army was thus released from the financial bounds set in 1937; and the greater freedom reflected itself in the detailed schedules of requirements for the thirty-two-division scheme with their generous

[1] See p. 18.
[2] See p. 34.
[3] See p. 71.

scales of equipment and rates of wastage. On the other hand, the Navy did not surmount the financial objections to its programme until somewhat later; its plans incorporating the 'two-power standard' continued to contend with objections which were largely budgetary till August 1939.[1]

So, on the whole, at the outbreak of war the financial limits to rearmament became so wide as no longer to limit. This does not however mean that war production could now expand unchecked by any financial obstacle of general application. For as the fears of general insolvency were weakening their place was being taken by the special argument of hard currencies. Concern about means of payment abroad and more especially about gold and dollars began to colour the financial policies of rearmament some time before war broke out. It appeared once or twice in the general discussions of military plans in the summer of 1939, and was on one or two occasions invoked at the meetings of the Treasury Inter-Services Committee. In May 1939, for instance, expenditure on the extension of a propeller 'shadow' factory under the new war potential scheme was approved after protracted discussion but only on the condition that dollar expenditure on machinery would be drastically cut. In July a draft contract for the supply of guns by a Swiss firm was rejected out of hand because the price was quoted in terms of gold. The theme became more and more pronounced as the plans and prospects of the war took shape and as all the implications of the American policy of 'cash and carry' revealed themselves.

On the whole, the effect of the dollar shortage on war supplies turned out to be even greater than the early estimates indicated. Envisaged over the entire period of three years the supply of hard currencies threatened to place a strict limitation on military purchases abroad and corresponding limitations on rearmament at home. A rough statistical inquiry at the Bank of England and the Treasury showed that the realisable reserves of foreign exchange would not allow expenditure of gold, dollars, or other hard currencies to exceed £150 millions per year for three years. This would in itself have set a limit on rearmament narrow to the point of constriction. What made it more constricting as time went on was that in the opening months of the war the country appeared to be spending foreign exchange at more than its annual dole, and, worse still, was disbursing dollars on non-munitions goods on a scale which left little for munitions and for essential industrial supplies. Rationing was slow in coming and civilian consumption was buoyant: and by the spring of 1940 employment and earnings in the country were improving rapidly. Food and raw materials for civilian requirements were therefore being purchased in larger quantities than the Treasury had

[1] See p. 58.

allowed for in its early calculations. In addition, an alarmingly large proportion of the purchases (much larger than expected) had to be diverted from sterling areas to the United States in order to economise shipping. Dollar reserves were thus being stretched to an extent which left very little room for large munitions orders and made it necessary for the Treasury to keep a close watch over all programmes which might lead to additional demands for American steel, non-ferrous metals and machine tools.

Judged by this standard drastic increases in the scale and speed of rearmament were indeed 'much more than the country could afford', and the build-up of the armed forces was bound to slow down to a rate of progress which would spread the dwindling dollar reserves over a three-year war. It was not until February 1940 that the Allied Governments showed signs of accelerating their military purchases abroad beyond the pace dictated by dollar prudence, and agreed to spend their foreign exchange more quickly than the dollar rations would allow. But the change of mind was not complete even then and was not immediately followed by a corresponding expansion of the industrial plans at home or of foreign purchases abroad. The balance of payments policy was in fact not wholly abandoned until the Churchill Government took office.

The economy of foreign payments thus provided a new principle and a new justification for financial checks on the expansion of war industry in certain directions. The check was not, however, as powerful and as general as the financial policy of old, and it did not affect the day-to-day control which the Treasury exercised over rearmament. The routine of Treasury control could still occasionally be held responsible for delaying the progress of preparations, but with war drawing near the Treasury tried to relax its procedure as far as this could be done without defeating the main objects of its supervision over expenditure.

One of the earliest relaxations of financial procedure primarily affected the powers of Parliament. With the outbreak of war the defence and supply departments and all special war services ceased to be financed under the peace-time procedure of departmental estimates and votes and were able to draw on a vote of General Credit. This decision was taken in the interests of security, but it also permitted greater flexibility in war expenditure and it meant that detailed estimates did not have to be prepared in advance, passed by the Estimates Committee and approved by the House of Commons. This also meant that finance could now be switched from department to department and from object to object to suit the needs of war.

As yet less sweeping were the changes in the procedure of financial scrutiny by the Treasury itself. At no time between the autumn of 1938 and the end of the war was there any question of the Treasury

renouncing its watch over public expenditure—for one thing the Public Accounts Committee would have refused to condone any conspicuous lapse in the Treasury's vigilance.[1] The Treasury therefore continued to scrutinise individual projects of expenditure as before and could refuse consent for proposals which appeared to be inadvisable, excessive or ill-timed.

The effects of the scrutiny need not however be exaggerated. The documents leave a clear impression of greater liberality, and the machinery of the Treasury Inter-Services Committee appeared to respond to the spirit of the times. It worked smoothly, it sanctioned at almost every meeting large items of expenditure and showed every anxiety not to hold up projects of special urgency. What is less clear is whether on the lower levels the changes were equally marked and the financial scrutiny equally speedy or equally liberal. Throughout the period there were still complaints of the length of time projects of expenditure took to pass through all the stages. As in the earlier years of rearmament some delays occurred while the projects were being 'groomed' in the financial branches of the Service departments for submission to the Treasury Inter-Services Committee. At one time in the spring of 1938 the procedure was altered to suit the newly-launched L scheme of 12,000 aircraft,[2] but the change proved purely local and temporary. On that occasion the Air Ministry and the Treasury agreed to speed the preliminary discussion of aircraft orders and set up for that purpose the Air Ministry Supply Committee which contained among its members a Treasury representative. The latter was given the power to signify his concurrence with any proposal which in his opinion deserved a speedy sanction, and acting in this spirit he was able during the summer of 1938 to concur without seeking individual sanction from his department in a series of rapid decisions involving very large sums. This system, however, though highly expeditious and to that extent welcome to the Air Ministry, reduced the actual financial control of the Treasury far below the level that the Treasury normally considered safe. It was not extended to the other departments, and even in the Air Ministry it petered out by the autumn of 1939.

Needless to say, the supply departments from time to time renewed their demand for a speedier process of financial control, but nothing of importance could as yet be done to meet the demand. In the agitated days of the Munich crisis the Treasury and the supply departments worked out an emergency scheme under which each department would receive block allotments for miscellaneous expenditure of small amounts and could in cases of great emergency

[1] For example, Public Accounts Committee, 1938, Second Report, July, para. 19; *idem* 1940, Second Report, July, para. 1.

[2] See p. 18.

issue authority for work to proceed without previous sanction from the Treasury. But as the immediate emergency lifted, the procedure was never put into operation, and subsequent discussions of the problem centred almost entirely upon the changes which might be necessary under war conditions.

Such war-time plans as emerged were not, however, far-reaching. The departments wanted powers to authorise expenditure on production orders or capital projects. The Treasury on its part was willing to raise the limits of the expenditure which the departments could incur without its previous approval, but was anxious to keep the limits very low. A compromise between the need for speedy action and the requirements of Treasury control was achieved by raising the limits within which the supply departments were allowed to sanction their own expenditure. In the first week of the war the Air Ministry received a block authorisation to cover the estimated expenditure on the current programme of aircraft production and was thus freed from the necessity of referring to the Treasury individual orders. Its capital expenditure on other items up to £50,000 each was similarly met from another block grant, the Ministry subsequently reporting details to the Treasury Inter-Services Committee for approval. From December 1939 all the supply departments had power to approve capital expenditure on individual production items of not more than £50,000:[1] all approved schemes estimated to cost over £2,000 were listed in periodical reports to the Treasury.

To sum up: in the concluding months of peace as in the opening phase of war, military preparations were no longer hemmed in by narrowly-set financial obstacles. Nevertheless, finance remained something of a limiting factor especially in so far as it invoked considerations of dollar economy; and something of a regulator (not to say a check) in so far as the routine of financial scrutiny still influenced the timetable of war production. But the main significance of this phase in financial history is more general and in a sense more relative. In view of the changes which were to follow, the remarkable feature of the period was not that financial control continued but that an alternative based on broader economic considerations had not yet made its appearance. The problems of war economy, the limits of the industrial effort and the timetable of industrial mobilisation were not yet evaluated, as they were to be later, in terms of economic resources—labour, materials, industrial capacity. Now and again, as in the report of the Stamp Survey of May 1940[2] or in one or two general memoranda in the Ministry of Supply, labour and

[1] They could also approve additions to a scheme authorised by the Treasury without further reference if within the £50,000 limit and if no radical change in the project was involved. Increases in cost up to ten per cent. over the original estimate could also be approved.

[2] See p. 219.

machine tools might figure as the limiting factors of war production and be used as yardsticks for what the country could and could not do. But in ministerial discussions of economic policy and in the day-to-day scrutiny of individual projects the yardstick was still that of finance.

(7)

The Beginning of Controls, Priorities and Stockpiling

It has already been suggested that the purely financial controls persisted largely because national resources were not yet completely mobilised. A far greater proportion of labour and capacity was now engaged in the manufacture of munitions; yet industrial capacity, labour and to some extent raw materials were still available in employments which by war-time standards were no longer essential. This does not of course mean that 'business as usual' remained the official doctrine of the Government, for it will be shown presently that by the time of Munich that doctrine was already a thing of the past. But whatever may have happened to the doctrine, the practice still persisted, and the Government had as yet done relatively little to impose the overriding claims of war production on all fields of economic activity.

The story of the official demise of the principle of 'business first' is briefly told. It ceased to operate as a Cabinet instruction to the defence departments somewhat earlier than the period covered in this chapter[1] and was abrogated as a result of prolonged and concerted pressure from several quarters. The main impetus, however, as well as the immediate pretext came from the Air Ministry. When in the autumn of 1937 the Cabinet considered further expansion of the Air Force in response to reported additions to the *Luftwaffe* (it will be remembered that the discussions eventually led to the L programme of 1938) the Secretary of State for Air took the opportunity to point out how difficult it was to expand the production of aircraft while 'business' remained 'as usual'. In recommending to the Cabinet the Air Ministry's proposals in their 1937 version (the so-called programme J) he warned it that so long as the Government did not allow rearmament to interfere with the normal processes of industry the programme could not be completed by the end of 1939 but would have to be spread over another eighteen months or two years. The note thus sounded was soon to be amplified by other voices. The Foreign Secretary came out in support of the Air Ministry; then at

[1] See p. 20.

the very beginning of 1938 the Secretary of the Committee of Imperial Defence wrote to the Minister for Co-ordination of Defence in the same sense, and in February the argument received the massive reinforcement of the Chiefs of Staff. In assessing the situation they argued strongly against the policy of non-interference with normal trade, which in their opinion could not fail to be a serious handicap when Britain was competing with potential enemies whose whole financial, social and industrial system had in fact been mobilised on a war footing for at least three years.

All these arguments related to the rearmament programmes as a whole; the Chiefs of Staff, if anything, meant to draw special attention to delays in executing the army programme. But in the conditions of early 1938 it was the argument of the Air Ministry that had the most effect, and it was the need of the aircraft industry that eventually decided the issue. It has been shown in an earlier chapter[1] that the discussions of the aircraft programmes made it obvious that in 1938 the limiting factor was the productive capacity of the aircraft industry, and that this in turn depended on the industry's ability to find the necessary resources. So when the Government finally decided to remove the financial limits to aircraft programmes and to order all that the industry could produce, it was also bound to reconsider the entire system of industrial priorities. On the 22nd March 1938 the Cabinet decided that the assumption on which the reconditioning of the Services had been based, namely, that the course of normal trade should not be impeded, should be cancelled. On the 24th March in announcing the decision in the House of Commons the Prime Minister made its purpose quite clear. Existing plans, he said, must be accelerated and there must also be an increase in some parts of the programme. From this it followed that 'men and material will be required, and rearmament work must have first priority in the nation's effort. The full and rapid equipment of the nation for self-defence must be its primary aim'.[2] Freed from the necessity of accommodating itself to the needs of civilian trade, the Air Ministry was now ready to expand its air programme to the furthest limits of the aircraft industry's capacity, and was able to embark on those negotiations with the aircraft firms from which the L programme of 12,000 aircraft was soon to emerge.

The precedence conferred on the munitions industry was thus at once reflected in aircraft production. And although the programmes of the Navy and the Army were not immediately affected (for a while they still were limited by financial allocations) in the spring and summer of 1939 they too could benefit from the new priority rule. An important landmark was thus passed; yet its importance must

[1] See Chapter II, Section (2).
[2] H. of C. Deb., Vol. 333, Cols. 1410–1411, 24th March 1938.

not be exaggerated. The end of non-interference with business did not signify the beginning of an economic emergency. Though 'business as usual' was now pronounced to be untimely, 'life as usual' still went on. The very problem of priorities *vis-à-vis* civilian demands —now so much in the forefront—bore witness to the strength of the older attitude. For when in March 1938 the Cabinet absolved the Services and their contractors from the obligation to respect the requirements of civilian economy, it did not thereby establish anything more than a rough and superficial system of priorities. As far as it is now possible to judge, the Cabinet decision enabled the Treasury to sanction armament orders where they threatened to draw capacity and take away labour from important civilian trades. In a more general way the new rule encouraged manufacturers to accept armament orders at the expense of their ordinary business. But other encouragements or inducements were very few and ineffective. Many manufacturers were now rapidly changing over to military manufacture from a sense of patriotic duty, but the main practical inducement—that of greater profits to be earned on armament contracts—was largely nullified by the various taxes on profits which culminated in an Excess Profits Tax of 100 per cent.[1] There was as yet no question of denying raw materials or labour to inessential business or of organising (still less of forcing) a transfer of firms to war work or of reducing whole branches of civilian industry in order to release plant and labour. Broadly speaking, civilian demands continued to compete with war needs for production resources on more or less equal terms, and until the initial months of the summer of 1940 little was done to check competition by political and administrative measures.

The persistence of civilian demands and their pull on the supply of resources reflected the reluctance of the Government to precipitate the hardships of a full-fledged war economy. Yet as the first phase of the war was drawing to an end it was becoming obvious that without some such hardships an unnecessarily large proportion of scarce materials inevitably escaped into inessential uses, and within war industry itself materials were not distributed in the quantities and in the order which the national need demanded.

The problem of raw materials in war as it affected Government preparations was of course wider than that of controls.[2] During the closing months of peace the Government considered a number of proposals dealing with raw materials, and now and again was even able to take immediate action to fulfil them. One of the schemes was

[1] The first restriction on profits of firms engaged in the rearmament programme was the Armaments Profit Duty of 1939. This was followed after the outbreak of war by an Excess Profits Tax levied at the rate of sixty per cent., which in 1940 was raised to 100 per cent.

[2] The subject of raw materials and their controls will be discussed in much greater detail in Mr. J. Hurstfield's volume on raw materials in this series. The facts in this chapter are largely derived from the corresponding parts of Mr. Hurstfield's book.

concerned with the further development of the earlier projects for the accumulation of reserves of important raw materials. The policy goes back to the early years of rearmament,[1] but in October 1938 it was still limited to purely 'strategic' materials. Purchases were to be confined to essential materials of which normal stocks in the country were not large. These were by definition relatively few in number, and the quantities concerned were small. The general problem of war reserves of raw materials was not thereby greatly affected. But, as war approached, the broader aspects of the problem began to obtrude themselves on the planning authorities. The initiative came from Sir Arthur Salter who in June 1939 presented a memorandum proposing that the Government should accumulate stocks of raw materials and food as a means of ensuring adequate supplies and of economising shipping and foreign currency in war-time. He recommended purchases equivalent to eight million tons of shipping space, i.e. half the 1917 imports, costing about £100 millions. The Board of Trade considered the proposal and, in the main, turned it down on grounds which were largely practical. They argued that some commodities, e.g. pit-props, could not be bought in large quantities at short notice and that a sudden influx of raw materials bought for reserves would dislocate the ordinary programme of essential imports and strain port facilities. These arguments, however, would not apply to purchases on a more modest scale, and a modest scheme was in the end adopted. At the end of July the Government authorised the Board of Trade to purchase for war reserves 150,000 tons of American cotton, 1,000,000 tons of iron ore, 120,000 tons of pit-props, 100,000 tons of phosphate rock, 40,000 tons of copper and 17,000 tons of hemp. These purchases could not be completed before the outbreak of war, and the country entered the war with a general level of stocks only a little higher than in a normal year. Yet if several important commodities, such as bauxite, zinc concentrates, wool, flax, rubber, were on the 3rd September available in quantities sufficient for nearly six months of the estimated annual requirements at war, the credit for this must be due to the measures taken in the previous couple of years, including the last-minute purchases of 1939.

Equally important, especially from the long-term point of view, were the pre-war schemes for the bulk purchase of raw materials in the Empire. The project of securing for this country in war-time the prior claim to supplies from other parts of the Empire goes back to the earliest discussions in the Principal Supply Officers' Committee in the later twenties. The first practical step, however, was not taken until 1937 when the Principal Supply Officers' Committee tried to pilot through the Imperial Conference of that year an agreement with Canada about war-time supplies of bauxite and aluminium. The

[1] See p. 38.

Conference pronounced against any commitments in peace-time for the supply of raw materials in war, but the plan was not abandoned. In July 1938 the Committee of Imperial Defence revived the earlier proposals, and in the autumn the Board of Trade entered into negotiations with Empire producers for the bulk purchase of a number of commodities—in the first place, lead, zinc and wool. The contract for the latter, involving the purchase of the entire wool clip of Australia and New Zealand, was finally concluded in October 1939.

Among the plans worked out in the concluding phase of peace were also various schemes for rearranging the sources of supply to suit the expected changes in international trade and communications; to develop home supplies of commodities like timber, iron ore, flax; to secure greater economy in the use of scarce materials and their substitution by other materials. Most of these proposals, in the nature of things, remained in the project stage[1] and did not bear fruit till much later, but their value in war was indisputable.

Nevertheless, these miscellaneous preparations did not affect the future of war industry as intimately as the more purely administrative projects for the future control of raw materials. The controlling organisation was to be erected at the outbreak of war almost overnight, for there was no question of establishing and operating controls over raw materials while peace, however nominal, was still on. Similarly the policy, which the pre-war planners had laid down for the future controls and which the controllers at first followed, could not be any more thorough than the rest of the economic policy of this transitional period. To put it paradoxically, the main feature of the pre-war plans was their studied avoidance of too clear-cut a principle. But this very avoidance set the tone for the future history of raw materials.

In the first place no attempt was made to establish a uniform organisation. The planners assumed that the separate problems of individual materials would in each case determine the character of the controlling organisation, and that in the course of the war the changing supply position would lead to changes in the organisation of the controls. Most, but by no means all, of the controls were to be given statutory powers to control prices and to lay down conditions of purchase, sale and use. Compulsory government controls were to be imposed on some materials, but where a material, though essential for the national effort, was not expected to be critical, e.g. rubber, asbestos, silk, the control was to be organised on a voluntary basis: as a rule by the corresponding trade association under the supervision of the Raw Materials Department of the Ministry of Supply.

The administrative plan was thus far from rigid or uniform; so was also the supervision which the controls were to exercise. It was

[1] For sodium and sulphuric acid manufacturing facilities were, however, sanctioned.

not part of the pre-war plans to entrust any government agency with the distribution among industrial users of all the raw materials needed for war industry. All that was recommended was that, for a limited number of raw materials which might from time to time be in short supply, statutory controls should be set up; and that when this happened, *ad hoc* directions about use and priority should suffice. The instrument of the policy would be a licensing system and not allocations.

Such were the principles of the projected controls as they took shape in 1938 and 1939. The Munich crisis gave the Board of Trade an opportunity for a 'trial run', and at its conclusion the Board of Trade reaffirmed the plans in their main outline. According to the instructions then worked out the 'short-term' policy in the opening phase of war would allow manufacturers to proceed in the usual way with stocks in their possession, but would prohibit except under licence new purchases or sales of raw materials. Long-term policy was not closely defined and was expected to vary from commodity to commodity. In general the plans assumed that the central priority organisation would issue to the individual controls general directions enabling them to discriminate between users, but that in most cases it would rest with the individual control to determine in accordance with the supply position of each material whether, in what quantities and in what order the material should be released for uses not directly related to the war and war production.

The main features of this system thus fitted well into the semi-mobilised economy of the opening phase of the war. If anything, its tentative and experimental character came out even more clearly in practice than it appeared in the blue-print. Such machinery as the pre-war plans had in mind came into existence quickly and smoothly. The Raw Materials Department of the Ministry of Supply was set up at the same time as the rest of the Ministry, i.e. more than a month before the actual outbreak of war; the Ministerial Priority Committee appeared on the scene, together with the rest of the central machinery of the War Cabinet, by the end of October 1939.[1] By that time the network of individual controls was also taking shape more or less according to plan. A group of 'essential' commodities—iron and steel, some non-ferrous metals, wool, leather, timber, hemp, flax, jute, paper and aluminium—which were scarce or were in danger of becoming scarce were placed under full-fledged controls; and one of the earliest enactments of the war gave controls the statutory powers of licensing, purchase and distribution. Another group of commodities, including rubber and mica, was subjected to the voluntary control of its trade associations, and still another group, including plastics and some non-ferrous metals, was left uncontrolled.

[1] See p. 79.

In the later stages of the war, with the general tightening of the system, individual materials were gradually transferred from the second group to the first, and materials not previously controlled were brought under control. But between the outbreak of war and Dunkirk the tentative system of September 1939 persisted more or less unaltered.

The other feature of the pre-war plans—the autonomy of individual controls—turned out, in operation, to be even greater than the planners had intended it to be. The controllers were expected to act in accordance with the general directives of the central priority organisation. But in the first few months of the war the central directives, such as there were, had little influence. They were so general and so unrelated to the requirements of consumers that the controllers largely disregarded them. Generally speaking, some of the powers which in theory should have been exercised by the central priority organisation devolved upon the officials (often junior officials) of the Raw Materials Department of the Ministry of Supply, and some were appropriated by the controllers themselves.

The shape which the controls now took affected the development of war production in several ways. In the first place the claims of different branches of war industry and of individual firms engaged in war production came to be adjudicated in a manner liberal to the point of being disorderly. The executive officers of the Raw Materials Department determined priorities by the issue of licences. But in the case of materials like steel the procedure was of little value as long as the government departments themselves were exempt from compulsory licences. This meant that the Service ministries and supply departments were able to issue priority directions to individual producers more or less as they pleased. No wonder that the controls and the firms soon found that contrary instructions arrived at the same time from different departments, and that a general inflation of priority claims was developing very fast.

By the spring of 1940 it was becoming clear that priorities could not be continued as before. All the drawbacks of the system of priorities, some of which had been foreseen and foretold, now became apparent. In the first place it proved too crude a method of discriminating between objects of greater and lesser importance. It implied that no requirement of lower priority could be met as long as any requirement of higher priority remained unsatisfied. From the administrative point of view the system was highly inefficient in that it led to the accumulation and conflict of requirements to which high priority had been given. As a result, the final sorting out of relevant urgencies was often left to accident or to the decision of the firms themselves.

Most of these difficulties could be overcome by allocations. Under

a system of allocations each requirement could be assessed in the order of its importance and be given a corresponding share in the supply of materials. This was now well understood and the machinery of priorities was therefore gradually wound up, and such arrangements for allocations as already existed were tightened and new arrangements for allocations were made. Those materials which were under the jurisdiction of the Materials Priority Sub-Committee were now allotted to each department in more or less firm quotas, and the germ of an orderly system of allocations was created. The period for which the allocations were made was reduced from a year to six or even three months, and the departments had to ensure that the applications they sponsored did not exceed the total amounts allocated to them by the Materials Priority Sub-Committee. Production of munitions was still subject to priorities, and departments could still direct firms to execute certain individual orders before others; but this was not, however, to affect the distribution of raw materials between main uses.

From the point of view of war production as a whole even more telling was the difficulty of differentiating essential needs of war from inessential civilian requirements. The War Cabinet and the ministerial committees agreed that priority belonged to war industry, to essential civilian requirements and to the export trade, but they were not yet able to define the principles by which the demands of war industry could be set against the demands of the export trade and essential civilian needs. Occasionally they might indicate the relative urgencies in the field of munitions production, but as a rule controllers had to rely upon their own judgment; and most of them, with the exception of the controller of timber and perhaps one or two others, did not at first judge civilian needs too severely. They were reluctant to cut off supplies to factories or industries for which no alternative employment in war industry was as yet available; they were sensitive to the charge of causing unemployment and they remembered the existence of the depressed areas. Above all, they seldom thought it necessary to enforce a drastic control over the use of raw materials which still happened to be in good supply. It is, therefore, no wonder that the steel cuts did not begin in earnest until April 1940, and even then doubts as to whether the cuts were enforceable continued to be entertained in high and well-informed circles; allocations of wool did not begin until March 1940; while for those commodities in which cuts had been introduced earlier, e.g. cotton and some non-ferrous metals, the detailed administrative controls were as yet too imperfect to prevent leakages into inessential uses.

More embryonic still was the control over production capacity, especially over the building of factories and the procurement of machine tools. Before the war the Government did not consider any

restrictions on building and capital construction; with the outbreak of war civilian building was reduced chiefly in order to economise timber, but nothing was done to regulate or synchronise the building of new factories and extensions by private firms. For this omission some justification could be found in the large unemployed reserves of labour, equipment, and managerial skill within the building industry; and there was also the argument that in the conditions of 1939 the building industry had little inducement to build except for essential war-time purposes. On the other hand there was some danger that firms, however public-spirited and however busy on munitions contracts, might overprovide themselves with new factory space. This they could do at little cost to themselves, for the State, to an ever-increasing extent, bore the cost and underwrote the risks of new factories and extensions.

Even more pronounced was the *laissez faire* which still prevailed in the procurement of plant and machine tools. In the course of discussions in the Ministry of Supply and in the War Cabinet, the assumptions commonly made were that there would be a shortage of machine tools and that this would limit the scale of military preparations. When the army programmes came up for discussion in November and December 1939 the 'tight' supply of machine tools in the United States and their high cost in dollars were tellingly used as arguments against ambitious proposals of expansion. Yet until June 1940[1] it was left to contractors to order machinery from abroad under individual import licences and to pay for it under individual exchange control licences. The orders went unlisted and unrecorded and frequently remained to all intents and purposes unknown to the production departments.[2] Machine tools thus ordered continued to arrive in this country until well into 1941, and the records of these orders and of the number of machine tools imported in 1939 and 1940 still remain a gaping void in official British statistics. Even the machine tools purchased in the United Kingdom were not subjected to complete control until the introduction of licensing in December 1940. There was a corresponding ignorance of facts in the production departments and a corresponding gap in statistics of United Kingdom production.

[1] By the decision of 17th June 1940, the Machine Tool Control and all the production departments agreed that all future orders in the United States should be placed through the British Purchasing Commission. This arrangement did not give the Machine Tool Control power to control the formulation of import orders in the United Kingdom. This was not achieved until 9th December 1940 when all procurement of machine tools, including imported machine tools, required a licence from the Machine Tool Control. (The Ministry of Aircraft Production did not accept the machine tool licensing of imports until March 1941.)

[2] The only machine tools and plant for which centralised ordering operated were those for Royal Ordnance Factories and for Ministry of Supply ammunition production. This was a continuation of the procedure adopted under the War Office rearmament programmes.

(8)

The Problem of Skilled Labour

Very gradual also was the mobilisation of labour. In the period between Munich and June 1940 the problem with which planners were mainly concerned was the supply of skilled operators. During the inter-war years careful thought had been given in war planning to the one lesson which seemed to emerge from the first World War, i.e. that the heavy demands certain to be placed upon the munitions industries could not be satisfied without shielding the more important skilled workers from haphazard recruiting. The idea of a 'central' schedule of protected occupations had been evolved late in the 1914–18 war when the authorities had been called upon to extricate from the Services men essential to industry. The same method was to be adopted to protect skilled labour and to provide a basis for man-power plans at the outset of any future war. Under early schemes the intention was to meet the Services' need for skilled men by the 'clean cut', i.e. by making all men under twenty-five years of age available for recruitment. This plan, however, was to prove unworkable. One of the results of improved trade and employment in the middle thirties, following bad trade and small intake of learners and apprentices in earlier years, had been to increase the proportion of younger men in the skilled grades, and thus to make it impossible to recommend the procedure of the 'clean cut' without endangering the labour supplies of war industry. This also made it all the more necessary to prevent an indiscriminate call-up.

Under the pre-war schemes, as they emerged by 1938, the protection of industry's skilled labour was to be achieved by the Schedule of Reserved Occupations to come into operation upon the outbreak of war. In its early stages the proposal raised several difficult problems, including the problem of key industrial workers among the Reservists or the Territorials. The Air Ministry early decided not to deplete its industry by calling up Reservists, and in November 1938 the Admiralty worked out a system for postponing the call-up of Reservists employed in its own dockyards. But from the point of view of the War Office, skilled men were essential both to the Army and to industry, and the problem was still unsolved at the outbreak of war.

In general until Munich the controlling of recruitment on the basis of the Schedule of Reserved Occupations was not considered either necessary or possible. But the Munich crisis produced a complete change of outlook. The decision made in the autumn of 1938 to expand the Auxiliary Forces started a wholesale scramble for recruits; and if the Services were to call up recruits irrespective of

their occupations, the whole principle of allocating labour between the Services and industry would be threatened with collapse. The solution was found in the introduction of a modified Schedule of Reserved Occupations for peace purposes which was published in January 1939.[1] According to the Ministry of Labour 4,970,000 men were reserved by this schedule, but modifications were later made in favour of Air Ministry and War Office Service demands.

The Schedules of Reserved Occupations for both peace and war had to be based on crafts, not on industries or actual occupations. The problem was not simply one of protecting skilled workers already in munitions industries but also of protecting all the potential supplies of skilled labour for munitions even if they happened to be engaged in non-essential industries. The schedule was not, however, more than a first step. Skilled labour was now protected from haphazard recruiting, but this left untouched the equally important problem of how to transfer all skilled workers to the munitions industries and to make the maximum possible use of workers 'reserved' under the schedule.

The need for the re-distribution of skilled labour had been felt in particular instances even before Munich. Occasional shortages of skilled labour had been felt in the manufacture of a few specialised armaments as early as the beginning of 1937. For example, the aircraft industry had experienced shortages of toolmakers, machinists, sheet-metal workers, coppersmiths and precision fitters. Until 1938, however, the difficulties were all local and, viewed quantitatively, unimportant. They were to become more general in 1938. In the summer of that year, the much-grown aircraft industry ran into a shortage of skilled workers which was preventing further absorption of 'green' labour and further expansion of output. By that time a similar difficulty had also developed in some shipbuilding trades.

For a time it was still possible to deal with the problem by palliatives. It has already been shown[2] that in 1938 the Air Ministry, faced with the labour problem, met it by a wholesale increase of sub-contracts or, as it was sometimes described, by 'taking work to the labour'. But there were limits to the proportion of aircraft manufacture that could be sub-contracted, and the need for more general and more drastic controls over the supplies of skilled labour was bound to arise sooner or later. It was bound to arise even sooner and more acutely in war industries less amenable to sub-contracting, i.e. shipbuilding. Shortage of skilled labour in the shipbuilding yards had been foreseen in the pre-war discussions of the war potential, but it had hitherto been felt only in such specialised branches as gun mountings

[1] *Schedule of Reserved Occupations (Provisional)*, Cmd. 5926, January 1939.
[2] See pp. 21–22.

and fire control gear. By the middle of 1938 it was also beginning to be felt in the main branches of the industry. There were still reserves of shipbuilding labour in the country, for large numbers of skilled workers had left the industry during the depression and were in theory reclaimable. But in practice their return to the industry required an organised effort from the Ministry of Labour—tracing them in their new occupations and new habitations through the employment exchanges and organising their physical return to the shipbuilding areas. And until this was done, the labour problem in the shipyards was bound to cause some anxiety.

This and similar problems of redistribution of skilled labour, already troublesome on the eve of the war, threatened to become more troublesome in the near future, and the threat was well understood. In one way or another local difficulties of skilled labour, real or threatened, were apt to be brought up, usually by the Treasury, whenever new projects of the supply departments were being considered, and in particular whenever the siting of new factories or extensions came up for discussion. In a more general way the problem repeatedly came up in high-level discussions—in War Cabinet committees and their sub-committees of civil servants. The complaint was thus well diagnosed, and the correct treatment could also easily be prescribed, for the remedies were all very simple and had in great part been adopted in the last war. In so far as the shortages were local, i.e. in so far as there were still reserves of skilled labour in the country, either among the unemployed or in firms not engaged in war production, the remedy was to organise a wholesale transfer of labour.

Until mid-1940, however, the Minister of Labour was very reluctant to enforce transfers of labour. While conscious of the need to make labour available for war production he was even more conscious of the need to maintain industrial peace; the memory of the determined opposition of organised labour to limitations on its freedom of movement had a great influence on the Ministry of Labour's outlook. The plans for controlling the movement of labour which had been worked out on the eve of the war did not, therefore, go very far. The pre-war planners did not recommend controlling the movements of labour by means of leaving certificates so unpopular with labour in the last war. All they proposed was to give the Ministry of Labour power to canalise engagements through employment exchanges or trade-union agencies and to prevent engagements through advertisements, and thus indirectly to limit the freedom of engagement 'at the door'. The Control of Employment Bill drafted on these lines was in fact introduced into Parliament at the beginning of the war, but it did not become law until its provisions, already modest, were further limited by a clause disallowing the proposed labour controls to be

applied to any industry without previous consultation with all the parties.[1] Even in this weakened form the Act was not generally enforced, and in the subsequent six months only one order of enforcement was issued.

The supply departments themselves did little to interfere with the distribution of labour. Now and again they asked the Ministry of Labour to shift workers to vacant war jobs, but the request was apt to be countered by an appeal from the Ministry of Labour to production departments to 'take the jobs to the labour' by sub-contracting and by better siting of new factories. Against this counter-appeal the Air Ministry, the Ministry of Supply and the Admiralty had the obvious rejoinder that there were limits to the proportion of work that could be sub-contracted and that the supply of labour was not the only consideration to be taken into account when determining the location of war plants. Most of the new ordnance factories were in fact located in places where labour prospects appeared to be most favourable, but extensions and 'shadow' plants could not always be so sited. Above all, the Ministry of Supply did not yet possess the local machinery which was necessary for the full employment of smaller firms on war contracts, and the labour problem could not wait until the Area Boards were fully organised.

Redistribution, however, even if it had been effectively pursued, would not alone have solved the skilled labour problem. The huge munitions programmes were eventually going to demand not only the best possible use of existing skill but also an increase in the total supply of skilled labour. In the first six months of the war the problem may not have appeared to be very urgent. In March 1940 there were still 34,503[2] unemployed in the engineering and allied industries and of this number a large proportion must have belonged to the skilled grades; in addition there were still considerable reserves of skilled labour in firms not fully engaged in essential production, and there was probably some relative superabundance of skilled labour in the older armament firms (a very important armament firm could be accused of hoarding skilled labour as late as mid-1941). Thus, in principle, it was still possible to deal with the situation by organising a wholesale transference of skilled labour; but in practice not all the local demand was thus met and before long the shortage of skilled labour in the country as a whole was bound to outgrow the limits of what could be done by redistribution alone.

That mere redistribution might not be enough to meet war-time

[1] 2 & 3 Geo. 6, c. 104. Also H. of C. Deb., Vol. 351, Cols. 507–530, 755–798, 907–916, 5th, 14th and 15th September 1939.

[2] *Ministry of Labour Gazette*, Vol. XLVIII, No. 4, April 1940. Figure quoted is the number of 'wholly unemployed', skilled and unskilled, male and female, in Great Britain and Northern Ireland in engineering, including electrical, marine and constructional engineering industries (22,453) and in the construction and repair of vehicles (12,050).

shortages was not a new discovery. Throughout the pre-war discussions the planners took it for granted that during the war skilled manpower might become short everywhere and that the shortage would have to be met by dilution, training and up-grading: had not all these measures been put into operation with the consent of the trade unions in the last war? Some civil servants and businessmen continued to make the same assumptions throughout the early months of this war. Indeed, the Interdepartmental Conference on Labour Requirements under the chairmanship of Mr. Humbert Wolfe in its report of December 1939 made great play of the shortages to come and recommended a number of measures including training and up-grading. Similar advice also came from other quarters, and by March 1940 the need for some such measures came to be accepted by the Ministry of Labour and indeed by the War Cabinet as a whole. In particular, the training of labour was an activity for which the Ministry of Labour lacked neither the experience nor the necessary machinery. Its training centres had been in operation since-1925 in a number of places, more especially in the depressed areas, and all that was necessary was to expand their network and to increase the number of men passing through them.

Yet, in the first eight months of war, the training of new cadres of skilled operatives developed slowly and patchily. The Ministry of Labour's training centres still continued to be treated as instruments for the re-education and re-habilitation of the unemployed and not as agencies for industrial mobilisation. Their numbers barely increased; and the Ministry could always point out that such centres as there were remained half empty. Much more was being done by individual firms and managers. Training schemes, some of them of ancient standing, were in existence in most large firms in the engineering and electrical industries and grew under pressure from war contracts. Some of the new ordnance factories were tackling problems of recruitment and training of skilled labour with rare energy and resource. These activities, however, were not typical of war industry as a whole and were not sufficient to solve the problem on a national scale.

Equally little was being done to augment the total supplies of skilled labour by other means, i.e. by dilution or upgrading. The will was not lacking, but action depended on the concurrence of the trade unions—a concurrence which they were reluctant to grant and which the Cabinet for political reasons was equally reluctant to beg. On the eve of the war, in August 1939, the Ministry of Labour helped the Engineering Employers' Federation and the Amalgamated Engineering Union to conclude a Relaxation of Customs Agreement (the first of its kind) which gave individual firms somewhat greater latitude in engaging, promoting and utilising their skilled labour. But the agree-

ment was not generally enforced and was not followed by similar agreements in other trades. For its part the Ministry of Labour was unwilling to compromise itself in its relations with employers and workers by forcing the principles of the agreement upon them. Moreover it was not sure that it was its duty to do so. In the previous war the dilution of labour was supervised by the Labour Inspectorate of the Ministry of Munitions, and the Ministry of Labour argued that in this war, as in the last, labour problems within factories, like all other problems of production, were the responsibility of the Ministry of Supply. The latter, on its part, did not yet possess the machinery for enforcement of labour policies and could also argue that the supplies or utilisation of skilled labour in factories raised issues of labour policy on a national scale which were not for it to settle.

Laissez faire—do as you please—thus remained the practice, if not the theory, in labour matters. In the absence of any effective action to redistribute or to increase the supplies of skilled labour, firms were bound to resort to the one method of procurement which they knew. Firms in areas where supplies of skilled labour were very scarce, especially the London region and the Midlands, tried to get whatever they wanted by offering high wages. 'Poaching' became the order of the day, and wages of skilled labour soared.

The problem was not, of course, thereby solved. The worst thing about the use of wage inducements in the conditions of 1939–40 was that they could do very little to bring about a real redistribution of labour. The poachers merely took in each other's game. Here and there (and more especially in the aircraft firms of London) higher rates of wages occasionally enticed batches of skilled workers from other areas, but the alleviation they thereby brought could be only temporary. With the entire industrial capacity fully employed, or at least fully employable, and with prices as yet largely settled on a cost-plus basis, there was nothing to prevent competitive wage rises all round—in firms anxious to attract labour as well as in those anxious not to lose it. The result was merely one of inflation of wage rates and of a high and very irregular turnover of skilled labour.

To repeat, the problem was at this time essentially one of shortage of skilled labour. The question of the total supply of industrial manpower was still a thing of the future, though it may have worried the more forward-looking or the more pessimistic of the planners. In connection with the proposed additions to the Service programmes the Government organised an official conference, under the chairmanship of Mr. Humbert Wolfe, to examine future manpower requirements of the munitions industries. By the middle of December 1939 the conference produced an estimate well in excess of pre-war calculations; an estimate which showed, as was intended, that manpower resources

set a limit to the future scale of armament industries.[1] Nevertheless, the stringencies of total supply of labour were as yet little felt in the actual conduct of war production. Throughout the period the main problem of war industry was not insufficient recruitment of new labour but the difficulty of absorbing the recruits who were available.

The total labour force engaged in war production grew all the while, but it did not grow as fast as it might and perhaps should have done. This was not, however, due to the exhaustion of the national reservoirs of manpower. Between June 1939 and June 1940 the employable population, i.e. men and women available for industrial employment or military service, received an accession of about 926,000 workers, of whom rather more than half were women. In addition, about 625,000 persons previously unemployed were taken into industrial employment or into the Forces. True enough, the one and a half million men and women thus absorbed was half a million fewer than the two million who had been called up to the Forces or recruited into the civil defence services,[2] but the decline in total employment fell mainly on non-munitions industries.[3] If industrial employment were considered under the three main war-time categories—Group I, the munitions industries proper (the engineering and chemical industries); Group II, the chief basic industries serving civilian demand as well as the armed forces (shipping, transport, mining, agriculture, public services, etc.); Group III, industries and services primarily engaged on the satisfaction of civilian demands (building, retail distribution, food trades, textiles, etc.)—the changes in the industrial distribution of the labour force between June 1939 and June 1940 would appear as shown in Table 9:

Distribution of the industrial labour force, 1939 and 1940, expressed in percentages

TABLE 9 Per cent.

	Men		Women	
	June 1939	June 1940	June 1939	June 1940
Group I .	20	24	11	13
Group II .	31	32	12	14
Group III .	49	44	77	73
	100	100	100	100

[1] See p. 99.

[2] One and three-quarter million and a quarter of a million respectively.

[3] i.e. on industries in Groups II and III where the total employment in this period fell by nearly a million workers (65,000 in Group II, 895,000 in Group III). At the same time employment in the metals and chemicals group of industries increased by nearly half a million.

These figures show that although labour was very slow in redistributing itself, such redistribution as there was proceeded in the right direction. Moreover, the real transference of labour to war industry was even greater than the figures indicate, for much of it resulted not from movement of labour from one industrial group to another, but from changes in output within Groups II and III. For there is no doubt that the restrictions on the supply of materials for civilian industry, though insufficient for a more rapid increase of war production, were sufficient to stimulate the transference of a number of civilian firms to war tasks.

In general, it remains true that by June 1940 mobilisation of labour for war production had not gone so far as to create a universal shortage of labour. Little more than half the unemployed reserve of workers had been drawn into employment. There were still large and untapped reserves of unoccupied labour, more especially women. Between August 1939 and June 1940 not more than 151,000 additional women were employed in munitions industries. There was also a large, though unmeasurable, margin of labour still to be drawn from civilian industries. In short, the general reserve of manpower was not yet one of war industry's 'headaches'. The real problems were those of redistribution and absorption, and if the latter was proving difficult the cause most commonly mentioned was the growing shortage of skilled labour.

(9)

The Progress of Industrial Mobilisation

Economic mobilisation was thus slow and incomplete; but it would be wrong to conclude that production was thereby greatly delayed. It was not out of step with the Government's strategic timetable nor with the corresponding Service programmes. As will presently be shown, the supply departments were on the whole coping well with their allotted tasks. The moderation of the Government's industrial policy was therefore coloured with a tinge of complacency, and reflected not only the hesitancies of the ministerial mind but also the official belief that production was developing as well as could be expected.

Measured in absolute terms, the output of war-stores was high and was constantly rising. And not only was an ever-growing flow of munitions finding its way into the hands of the fighting men, but the country was also acquiring the industrial capacity, organisation and experience which a year or two later was to give forth a supply of war-stores more abundant than that at any point in the first World War.

The flow of production is not at all easy to measure in physical

Deliveries of some war-stores during the period October 1938–June 1940

TABLE 10

Units

	1938	1939				1940	
	Fourth quarter	First quarter	Second quarter	July–Aug. (two months)	Sept.–Dec. (four months)	First quarter	Second quarter
Aircraft:							
bombers	255	403	424	283	727	479	936
fighters	142	302	378	197	447	477	1,027
Guns (new) and carriages (new):							
25-pdr. guns	nil	2	32	44	111	76	109
carriages	nil	nil	nil	nil	nil	20	196
2-pdr. T. and A.T. guns	135	114	248	226	412	297	395
A.T. carriages	50	39	80	172	138	179	299
3·7-inch anti-aircraft guns	97	117	93	100	191	152	354
mountings	100	76	109	98	224	159	252
4·5-inch anti-aircraft guns	4	36	79	63	117	59	47
mountings	nil	35	67	52	115	64	57
Tanks:							
light	169	122	364	68	180	80	60
cruiser and infantry	29	23	30	48	134	138	280
Armoured carriers	316	383	473	362	611	517	1,445
						— Thousands —	
Army clothing:							
battle-dress trousers	..	..	..	..	1,316	1,210	2,068
greatcoats	..	..	..	..	1,005	916	915

(.. not available)

terms. Throughout the war the statistical problem of finding a common physical measure for all the infinite variety of military supplies proved extremely difficult, thus greatly complicating the task of the planner as well as that of the historian. 'Global' physical measurements of current output are especially difficult to apply for the period covered by this chapter, for the simple reason that much of the industrial activity was at that time devoted not to the output of munitions but to the provision of factories for future production. In the absence of a satisfactory aggregate index the figures of output for the main items in the munitions programmes will perhaps provide the best illustration of the progress made. (Table 10.)

Thus presented, the general record of war industry leaves a clear impression of a continuous growth. More particularly the output of 'general stores', and especially of army clothing, which could draw upon existing civilian capacity and did not depend on the construction and manning of new factories, developed with great rapidity. The requirements of the Army for uniforms and other textile goods of every kind and for a wide variety of hardware forming part of the personal equipment of servicemen, had, from the very beginning of rearmament, been conceived on very generous scales. Moreover, clothing and other personal equipment unlike guns or tanks had to be available at the very outset of mobilisation, for soldiers had to be clad, fed and housed even before they could be trained in the use of weapons. Nevertheless, the task, for all its magnitude, had never appeared as difficult as the rest of the Service programmes, and, in the event, it was fulfilled with remarkable despatch. Much was done to harness the great resources of the textile, clothing and hardware industries between the spring of 1939 and August 1939. With the outbreak of war Lord Woolton was appointed Director General of Equipment and Stores at the Ministry of Supply[1] and under his direction the production of general stores more or less passed out of its preparatory stages and reached full rates by the spring of 1940[2].

The public, however, was not prepared to judge the achievements of rearmament by the supply of overcoats, boots or water bottles but by the flow of weapons. And the flow of weapons though still growing appeared to leave much to be desired. Although the figures for guns

[1] Before the formation of the Ministry of Supply in August 1939, the Director General of Munitions Production at the War Office had been responsible for the inspection and acceptance of deliveries of general equipment and stores, including clothing and footwear. The planning and ordering of such items had remained, to a large extent, the responsibility of the contracts branches. In April 1939, Sir Frederick J. Marquis (later Lord Woolton) had been appointed Adviser on Army Clothing. With the setting up of a Directorate General of Equipment and Stores in the Ministry of Supply, D.G.M.P.'s responsibility for these stores came to an end.

[2] Difficulties had, of course, been encountered. The supply of cotton fabrics was at first complicated by the shortage of cotton yarn, the supply of boots was for a time impeded by the difficulties of adapting the industry to War Office requirements.

were high they were not yet fully matched with those for carriages, and promising as some of the figures of other weapons may have appeared to men 'in-the-know', the public in general showed every sign of being disappointed with the production so far achieved. Now and again opinions expressed in public may have shown ignorance of the true facts; but more often than not criticism came from people who were not necessarily ignorant of the facts but merely inclined to test them by the strategic needs of the time. It was of course possible to argue that such tests could not be properly applied to the work of the supply departments. But public opinion could not be expected to consider rearmament as a departmental activity. It insisted on approaching it as the main manifestation of the war, indeed as the most important contribution to the winning of the war that the country was as yet able to make. It was, therefore, inevitable that comparison between the supply of armaments and the strategic needs should have obtruded itself upon contemporary judgment and that the verdict should on the whole have been unfavourable. The progress of war production may have been fully abreast of the timetable originally laid down by His Majesty's Government, but the timetable itself was based on an estimate of what the country could be called upon to do. The critics could not, therefore, be blamed for setting both the strategic plan and the industrial achievement against the background of the war as a whole and finding them wanting.

Considered as part of the war, the purpose of rearmament between Munich and Dunkirk was to equip the country for an eventual clash of arms. The industrial achievement could, therefore, be judged by the state of preparedness which the country actually achieved.[1] How much better prepared for war was the country in September 1939 than a year earlier and how much better was it able to engage in military operations in the spring of 1940 than it had been at the outbreak of war?

The answer to the first of these questions is largely a matter of emphasis. The supply of armaments at the outbreak of war, compared with the supply in October 1938, had improved beyond all possible dispute, but whether the improvement was sufficient to fulfil its strategic objective depends on the exact definition of the objective. If the sole strategic aim was to make this country better able to withstand attack from the air then production in the year following Munich went some of the way towards achieving it. It has already been shown that the output of aircraft was rising,[2] but what from the point of view of air defence was even more important, was the growing number of modern fast fighters among the aircraft now coming into production. The monthly output of Hurricanes rose from twenty-

[1] See pp. 111–113.
[2] See p. 66.

six in October 1938 to forty-four in September 1939 and of Spitfires from thirteen to thirty-two in the same period. The number of modern fighters and bombers in the hands of the R.A.F., and the number of squadrons equipped with them, had correspondingly grown. The land defences against the bomber showed even better results. The monthly output of anti-aircraft guns increased from forty-six in September 1938[1] to a monthly average of eighty-five in the last four months of 1939. At the outbreak of war some 730 3·7-inch and 4·5-inch anti-aircraft guns had been delivered[2] and 431 converted 3-inch guns were available. At the current rate of production it appeared more or less certain that, by the end of September 1939, fifty per cent. of the requirements of 3·7-inch and 4·5-inch anti-aircraft guns and the full requirements of 3-inch guns under the 'Ideal' scheme as approved in November 1938[3] would be met. The country would then dispose of some 1,650 anti-aircraft guns, a provision four times greater than that of October 1938.

A.A. Guns: requirements, forecasts and deliveries

TABLE 11 — Units

Guns	Requirements approved, November 1938 ('Ideal' scheme)	Deliveries made by 30th September 1938	Forecast of deliveries by 30th September 1939
3-inch 20-cwt. conversions	468	255	473
3·7-inch anti-aircraft	1,261	143	630
4·5-inch anti-aircraft	440	3	250
40-mm. Bofors anti-aircraft	1,897	5	300
	4,066	406	1,653

What was even more important was that by the outbreak of the war the country had completed what was to prove the most important link in anti-aircraft defence—the home chain of radar stations.

A fuller story of the development of radar will be told elsewhere.[4] Here it will be sufficient to note that the possibilities of detecting enemy aircraft by radio methods and of measuring the range of the aircraft from the observer had first been suggested by Mr. (later Sir Robert) Watson-Watt in January 1935 in reply to an inquiry from the Committee for Scientific Survey of Air Defence. In December 1935 Treasury approval had been given to the provision of five radar stations covering the Thames estuary, and in August 1937 the Treasury had sanctioned the construction of a home chain of twenty stations covering the east and south-east coasts. During the Munich crisis the

[1] Of which, twenty-nine were conversions of 3-inch anti-aircraft to 3-inch lined anti-aircraft.

[2] 480 3·7-inch anti-aircraft guns; 156 4·5-inch anti-aircraft guns.

[3] See p. 32.

[4] See Chapter VI, Section (7).

Thames estuary chain was in continuous operation, and by the outbreak of war the country was guarded by a chain of eighteen stations stretching from the Orkneys to the Isle of Wight.[1] Much more remained to be done to complete it to the final specification, and still more was to be added to the programme after the fall of France, but radar had become an established weapon of war.

Thus by September 1939 Britain's defences against air attack were substantially increased. On the other hand, if the strategic objective was to 'catch up with Hitler', then the achievement is somewhat more doubtful. The general impression is that, although the margin between German and British air forces had slightly narrowed, German superiority in land armaments had grown; and the general disparity in land armaments was even more overwhelming than before.

On the whole, it appears very probable that in September 1939 the Germans were not as superior in the air as they had been a year earlier. Their first-line strength had grown from 2,847 in August 1938 to 3,609 in September 1939[2] whereas the British first-line metropolitan strength in mobilisable squadrons was 1,854 in September 1938 and 1,978 in September 1939[3]. The German and the British figures are, of course, not entirely comparable for the definition of first-line aircraft in the two Services differed, e.g. the British figures contained 'immediate' reserves which the German apparently did not. To some extent, even the British figures at the two dates cannot easily be related, for in the meantime the composition of the total reserves had changed, and by the end of September 1939 the British first line was backed by 2,200 aircraft in reserve, a higher proportion than in 1938.

The general impression which these figures leave, however, was that judged by numbers of first-line aircraft unrelated to reserves and quality the German strength had grown somewhat faster than the British. On the other hand, if total additions of military aircraft of every kind during the period were counted, the corresponding figures for 1939 would be 8,295 for Germany and 7,940 for the United Kingdom,[4] i.e. the net additions of the two forces were roughly equal. Furthermore, if transport aircraft were not counted (Great Britain made very few, whereas Germany devoted a considerable proportion of her resources to their construction) the British output for the year would appear somewhat higher than the German. The main advantage that Britain had gained during the period was not, however, that of numbers but that of quality. It has already been

[1] In addition there were two independent stations.
[2] See Appendix 2 and p. 56.
[3] The British Air Staff computed the first-line metropolitan strength at 1,606 in September 1938 and at 1,660 by the end of September 1939.
[4] See Appendix 2, Table E and Appendix 4.

shown[1] that from September 1938 to September 1939 more recent types of aircraft, and above all, Spitfires and Hurricanes, were coming into use in greater numbers; the total number of squadrons equipped with modern fighters increased during this period from six to twenty-six. The German air force did not, of course, stand still, for they also were re-equipping with Messerschmitts of recent design, but they had started their re-equipment earlier in 1938 than the British and possessed, therefore, a relatively greater superiority in modern fighter squadrons in October 1938 than in September 1939. It is here, i.e. in the extent to which the leeway in the modernisation of the fighter force (the extent was from ten to twenty squadrons) was made up that the most important achievement of rearmament between Munich and the outbreak of war will be found.[2]

No such comparison of naval armaments was possible, for there the question was not one of any inferiority to the Germans but of the race between construction of German submarines and construction of British anti-submarine forces; and by September 1939 the latter though by no means negligible, had not yet benefited from the emergency programmes specially designed for the purpose. On the other hand, the relative improvements in land armaments could be compared, and the comparisons were highly unfavourable to the British effort. If the high estimates of the British War Office were accepted, the Germans would appear to have disposed in the autumn of 1938 of some fifty-one divisions more or less fully equipped and of a total field army of 690,000. On the other hand, the most reliable of the low estimates, that of General Halder, put German strength in October 1938 at twenty-one divisions.[3] These figures must be compared with the 106 divisions fully equipped and a total field force of 2,820,000 which Germany is known to have possessed at the time of the invasion of Poland. The improvement was thus five-fold if Halder's figures or the War Office estimates of the field force were taken as a basis, but not more than about two-fold if only the War Office estimates of fully-equipped divisions were taken into account. As the differences between Halder's and the War Office estimates probably spring from different definitions of what constituted a fully-equipped division, it might be reasonable to conclude that a real improvement in German strength was somewhere between the two figures, i.e. about threefold. This was probably also the extent of the immediate improve-

[1] See p. 106.

[2] The actual equivalent of the leeway made up cannot be estimated with any accuracy since the German re-equipment, having started early in 1938, continued to September 1939 and after. In comparing the two air forces it is also necessary to take into account that when assessing the aircraft at the disposal of the Allies in September 1939 the Secretary of State for Air could include on the credit side of the balance 1,735 first-line French aircraft, even though they were poorly backed with reserves and were inferior in quality to both the German and British types.

[3] See *U.S. Strategic Bombing Survey:* The Effects of Strategic Bombing on the German War Economy, 1945, p. 165.

ment in the British field forces. If in October 1938 this country was not able to put into the field more than two fully-armed divisions, it disposed in September 1939 of sufficient equipment for about five divisions more or less adequately equipped. The ratios of improvement were thus just about the same; but critics might be justified in thinking that where the final difference was still that of 106 versus five, equal ratios of improvement could in fact make little difference to the military inferiority of this country.

By the same test similarly applied, the figures on the eve of Dunkirk were equally disappointing. Measured by the relative supply of arms the British contribution towards the strategic objective of 'catching up with Hitler' was no greater in the first ten months of the war than it had been in the previous ten months of peace. As before, the country's position was improving most where its inferiority had been least, i.e. in the air. The output of aircraft in this country slumped under the immediate effect of the call-up and other war-time dislocations; so did to some extent German aircraft production, and the ratios between the two remained roughly as it had been before the war.

	British	*German*
First-line strength, September 1939 (defined as before[1]) . . .	1,978	3,609
Total output in the nine months, September 1939 to May 1940 .	7,665	7,275[2]

The same does not quite apply to the army weapons as is illustrated in Table 12.

Output of principal army weapons, British and German, September 1939–May 1940

TABLE 12 — Units unless otherwise stated

	Rifles (thousands)		Machine-guns (thousands)		Field and medium artillery		Medium anti-aircraft artillery[3]		Tanks[3]	
	German	British	German	British	German	British	German 88-mm.	British 3·7-inch	German	British
Last 4 months of 1939	279	18·7	12·7	6·9	773	nil	192	224	247	314
First 4 months of 1940	310·4	26·8	14·7	7·4	675	51	317	234	283	287
May 1940	101·6	11·1	5·2	2·9	217	63	86	94	116	138

[1] See p. 56. Transport aircraft are not included.
[2] Estimated figure computed from monthly averages. Transport types are included in the German figure.
[3] See *U.S. Strategic Bombing Survey, op. cit.*, Appendix-Tables 104 and 114 for figures of German tanks and 88-mm. guns. Figures of output of the latter are based on monthly averages.

The table is too selective to represent accurately the armament production of the two countries, and is on the whole flattering to the British record. It does not include the figures for mechanical transport (for these, reliable German returns are not available) in which this country had planned and achieved a greater output than the Germans. On the other hand, it leaves out the statistics of ammunition and also of such infantry weapons as mortars, in which Germany was very amply provided but which were not yet in serial production here. Moreover, the figures for individual weapons must be related to accumulated stocks and also to differences in policy before they can be used to illustrate the respective records of the two countries. Thus, the good showing of British anti-aircraft guns reflected the very high priority which anti-aircraft artillery enjoyed in British production plans, though even there the current output of anti-aircraft guns must be set against an equally high German output and, above all, against the very high stocks of guns that the Germans appeared to possess. By September 1939 German output of 88-mm. guns had proceeded for a period long enough to enable the Germans to accumulate a stock of at least 2,600 equipments[1] compared with the paltry 730 of the British stocks of heavy and medium anti-aircraft guns.[2] Equally misleading, though for different reasons, are the figures for tanks. The monthly output was roughly equal to the German, but whereas the German figures are all for Panzers Marks II, III and IV,[3] i.e. medium and heavy tanks of infantry type, the bulk of English tanks at that time was made up of light and cruiser (Light Mark VI and Cruisers Marks I to IV) types, while the output of infantry tanks (the Matilda I and II) was relatively small. Only sixty-three infantry tanks were produced in the last four months of 1939 and sixty-seven in the first four months of 1940.

The comparative ratios of other weapons reflect the same difference of policy and stocks, though in somewhat smaller measure. In interpreting the comparatively good showing in machine guns, it is necessary to bear in mind that whereas the British Army was still in the early stages of re-equipment with Bren guns whose output was only just beginning to mount towards its war-time peak, the Germans had by the outbreak of the war already accumulated a large stock of their standard light and heavy machine guns and were not engaged in re-equipment. On the other hand, the somewhat less favourable showing in British production of rifles was greatly mitigated by the fact that the rifles were of the standard ·303 1918 type, of which there were considerable reserves over and above the large quantity (more than half a million) reconditioned between September 1939 and May 1940.

[1] See *U.S. Strategic Bombing Survey, op. cit.* Table 114,
[2] See p. 106.
[3] See *U.S. Strategic Bombing Survey, op. cit.*, Table 86.

The differences of policy and of accumulated stocks do not, however, obscure the essential fact that the general trends of output in the two countries moved in the same direction and roughly at the same rate. In Germany, as in this country, production declined in the first four months of the war, but the general level of output was greatly in excess of the British: for most weapons it was roughly in the ratio of four or five to one. So even if the differences in stocks were not taken into account it would still remain true that by increasing its output of land armaments at about the same proportion as the Germans this country was at best managing to keep the gap between its armaments and Hitler's from widening. It was doing little, if anything at all, to reduce the enemy's crushing superiority and to make itself better able to face the German might in the field of battle.

Thus far the facts appear to give some cause for contemporary discontent. Viewed in historical perspective they are bound to make the criticism seem less relevant in some respects than in others. It is least relevant to the record of the production departments. It was not the business and not within the powers of the production departments to fit the output of weapons, and still less the total economic effort of the country, to the strategic requirements of the time. Generally the function of the production departments was executive; they did not make the policy of rearmament. They worked to programmes which were settled for them by the Government as a whole and were particularised for them, item by item, under the Treasury's close supervision. In a few isolated moments in the later stages of the war, departments might take it upon themselves to form independent judgments of strategic and tactical requirements and act accordingly. Yet even in the most crucial periods of the war these instances were exceptional and did not affect the general trends of munitions production.

The supply departments and the Government as a whole could also argue that the real achievement of the years of preparation must be judged not by the volume of current output but by the magnitude of the preparations. War industry in 1938–39 may as yet have contributed little to reducing Hitler's superiority in the field, but it was promising to do so at a future date. The activities in which the supply departments were engaged were still in the main preparatory. Therefore there was bound to be a long interval between the inception of a munitions programme and its fruition. Under each programme factories had to be built, tooled up and manned, and until that process was completed production of munitions themselves had to wait. It has already been shown that in those branches of production in which the country could draw without much readaptation or reconstruction on a large peace-time industry, such as clothing and 'general stores', production at full programme rates was achieved by April or May

1940. The bulk of the weapons, however, had to come from an industry which had produced hardly any weapons in time of peace and possessed neither the necessary equipment nor the experience.

The pace at which weapons could be turned out was thus largely set by the level (and a low level it was) at which the munitions industry had stood at the beginning of rearmament and the rate at which factories could be expected to come into production. So settled was the rate of rearmament that even the outbreak of war did not upset it. The events of the autumn of 1938, which altered the whole scale and composition of the British rearmament programmes, were a more significant landmark in the history of war industry, but not, of course, in the general history of the nation, than the outbreak of the war itself.

This does not, of course, mean that the declaration of war made no difference either to plans or to their achievements. It was part of the pre-war preparations, and especially of those of 1938, to assume that with the outbreak of war some of the pre-war schemes affecting the construction of factories would be expedited and others would be started. Thus, until the very end of August 1939, the Ministry of Supply's request to the Treasury Inter-Services Committee for authority to construct new filling factories was for two to be erected in the near future and for a third to be planned but not built. But soon after the outbreak of war, i.e. on the 8th September, the Ministry of Supply had to ask the Treasury Inter-Services Committee for immediate authority to proceed with the construction of the third factory. In August 1939 the Ministry of Supply received authority for one new cordite factory on the understanding that to meet requirements in the first six months of war another factory would be needed. As soon as war broke out the Ministry of Supply had to ask for the second factory to be authorised at once. Similar measures to put into operation plans for additional capacity were made in other branches of Ministry of Supply production—T.N.T., ammunition components, etc. Over the entire field of army stores the Ministry of Supply now placed initial orders which it had been agreed were to be placed as soon as war broke out. The factory programmes of the Air Ministry and the Admiralty also underwent a certain amount of similarly prearranged acceleration. Yet, on the whole, the main volume of activity in which the three supply departments were engaged after the 3rd September 1939 was carried on in continuation of what had been done before the war and in fulfilment of programmes agreed months or even years previously.

Thus, in the spring of 1940 the production departments were still largely engaged on the execution of pre-war or even pre-Munich programmes. The Air Ministry was engaged on the L programme and was creating the additional capacity needed under the pre-war plans

for war potential. The Admiralty was still largely engaged on vessels laid down before the war, and on urgent repair work on vessels damaged in the early months of the war. The emergency programme of small vessels could be put in hand at the very moment war broke out, and in fact all the earlier decisions on slowing down the rate of construction of fleet units and concentrating on smaller vessels and merchant ships were carried out at once. Yet the immediate effect on the actual supply of anti-submarine vessels was very small. In June 1940 by far the greater proportion of shipbuilding labour was still engaged on fleet vessels of the 1936–39 programmes, and it was not until the end of 1939 that the first trawlers and corvettes laid down under the emergency programme could be put into commission.

The same is even more true of the other production departments. In October 1938 the War Office was still engaged on the 'deficiency' programme of 1935–36. By the time war broke out the post-Munich programmes, and especially that of the thirty-two divisions, were in their initial stages. The ammunition factories which were coming into production in the early months of the war had all been laid down under the 'deficiency' programme for the Army or to meet the need of the 'Ideal' requirements of air defence. As has already been said, the war-time requirements under the thirty-two-division programme were not formulated until November 1939,[1] and it is therefore no wonder that in June 1940 the additional ordnance factories planned under the scheme were still in the early stages of construction and, with one or two exceptions, were not to come into operation before the winter. Indeed, if in actual fact the Ministry of Supply proved capable in the second half of 1940 of greatly exceeding the rates laid down in the thirty-two-division programme, this was to some extent an unearned bonus of the earlier policies of the Director General of Munitions Production and his associates who never took the official limits as final and planned expansion measures with a wide enough margin to allow a greater output in moments of need.

To this extent it was perhaps unreal to criticise the output of 1939 and 1940 without making full allowance for the great efforts that were being made to prepare for greater output in future years. What was more open to criticism but what was not, curiously enough, much discussed was the planned rate itself. It was to a large extent the result of deliberate choice and not a technical co-efficient wholly dependent on the capacity of the building and tool-making industries or on the speed with which resources could be made available. What in the main determined it was the Government's economic, financial and strategic pre-suppositions; and later events proved those pre-sup-

[1] See p. 74n.

positions to be wrong and the earlier reliance on them extremely dangerous.

To the Government of 1938 and 1939 the dangers were not as clearly visible as they were to be to the Government and the public in the summer of 1940. In 1939 the risks of spreading out the economic and financial effort over a long time may not have appeared unreasonable. At the rate of production agreed upon in the spring of 1939 and achieved in the early months of the war, this country in combination with France could perhaps hope to match the German supplies of munitions by the spring of 1942. It so happened, however, that the decisive strategic events of the period came before the culminating dates in the calendar of preparations. Neither the declaration of war in September 1939 nor the beginning of active operations in the spring of 1940 took account of the timetable of His Majesty's Government. And in that timetable the main objectives of the armament programme were so spaced out that no amount of efficiency and dispatch in the supply departments could possibly have enabled the country to 'catch up' by June 1940.

CHAPTER IV

FROM DUNKIRK TO PEARL HARBOUR

(1)

The Emergencies

In the history of war production the eighteen months between the summer of 1940 and the end of 1941—the time when Britain stood alone—were the period of great achievement. Readers need not be reminded how and why the events of the summer of 1940 drew a dividing line across the sequence of the war years. The rigours of a total war, psychological as well as material, came to this country all at once; and under a new and determined Government the country rapidly reformed itself to meet the demands of a life-and-death struggle. It was in the nature of the reformation that war industry should have been stimulated to a very great effort. Both its ambitions and its performances rose to a height which only a few months previously had appeared impossible; and stayed at that height, or very little below it, all through the hard years that followed.

War industry had now to satisfy requirements far greater than before, and what made them great were the immense long-term programmes of rearmament. But, in addition, industry was called upon at this period to meet a succession of immediate demands from the front-lines of battle. The losses of equipment in France, the Battle of Britain, the threat of invasion, the German night-raids, the crisis of the Libyan campaign, the Battle of the Atlantic and, as the period was drawing to an end, the German invasion of the U.S.S.R.: each of these events raised urgent problems of production which for a time absorbed the attention of the public and a great deal of war industry's time and effort.

The emergency needs of the Navy have already been described.[1] In a sense the entire war-time programme of the Navy in the first year of the war was made up of urgent short-term requirements. From this point of view the pressing demands for small vessels for the defence of the Channel against Hitler's invasion forces and for the Battle of the Atlantic presented nothing unusual. Much more sudden and in a sense more pressing were the emergency requirements of the

[1] See Chapter III, Section (2).

R.A.F. with which the Ministry of Aircraft Production had to cope at the outset of its career. The new Ministry, under Lord Beaverbrook, was set up at the same time as the new Government was formed. It was a new expedient, as dramatic as an administrative expedient can be, and was in itself an indication of the store Mr. Churchill and his Government now set by aircraft. The R.A.F. had suffered heavy losses in Flanders and in France: between 17th May and 1st June 458 operational aircraft—more than the current production—were lost; and almost as soon as the Battle of France was over, the Battle of Britain began. Aircraft, therefore, had to be provided in much larger numbers and at once; and the new Minister addressed himself to the task with the energy and the *élan* expected of him. Immediately on the formation of his Ministry he issued urgent appeals to workers and manufacturers for greater exertion, but appeals were by no means his only instrument. In order to speed output he decided to concentrate on the few operational types which were already in quantity production and of which the production could be immediately stepped up. This meant giving a special and exceptional priority to some types and suspending development and production of others. On the 15th May representatives of the Ministry of Aircraft Production and of the Air Staff agreed that until at least the end of September 1940 all efforts were to be concentrated on the production of Wellingtons, Whitley Vs, Blenheims, Hurricanes and Spitfires.

The aim was to get the maximum number of the five types into the air. Hence the truly overriding force of the priority they now acquired. It covered everything needed for their manufacture, for it not only safeguarded the supply of materials and equipment already earmarked for the five chosen types, but also made it possible to divert from other types the necessary parts, equipments, materials and manufacturing resources. Arrangements were to be made wherever necessary and profitable to transfer labour from other aircraft work to factories engaged on the specified types. Nothing was to stand in the way of such rearrangements, and it was specially pointed out that financial considerations were not to impede the programme.

Output of the favoured types soon responded to this preferential treatment and to the Minister's revivalist influence. The delivery of new fighters rose from 256 in April to 467 in September[1]—more than enough to cover the losses—and Fighter Command emerged from the Battle in the autumn with more aircraft than it had possessed at the beginning. The most spectacular, as well as the most important, single incident in the history of war production was thus crowned with success.

The urgent requirements of the Army over and above its long-term

[1] See Appendix 4.

programme of rearmament were not so conspicuous as the great aircraft crisis of mid-1940 or even as the 'small ship' crisis of the Navy; and they did not at first enjoy the same industrial priority. There was, however, no doubt either about their urgency or about their magnitude. In the first place the Ministry of Supply had to replace the arms and stores lost in France. The stores the British Army left behind were equivalent to the equipment of eight to ten divisions, and included 880 field guns, 310 guns of larger calibre, some 500 anti-aircraft guns, some 850 anti-tank guns, 6,400 anti-tank rifles, 11,000 machine guns, very nearly 700 tanks, nearly 20,000 motor cycles and 45,000 motor cars and lorries, to say nothing of large dumps of ammunition. These losses had to be made good at once. For having shipped to France every possible weapon necessary to maintain in action the expeditionary force, this country found itself in June 1940 standing not only alone but also unarmed. The whole of the army equipment available at home on the morrow of Dunkirk was barely sufficient to equip two divisions: and that at a time when a German invasion appeared imminent and Britain's survival depended on the success and speed with which an adequate home defence could be mounted.

The urgent needs of home defence, however, went further than the rearming of the existing Army formations. The whole nation had to be drawn into garrison duty, and to begin with, the Local Defence Volunteers (the Home Guard of the later phase) had to be supplied with uniforms, infantry weapons and certain other military stores. Fortunately much of this equipment could be drawn from the first-aid shipments of American arms. For, in response to the Prime Minister's appeal, the American Government sent to this country with the greatest dispatch a large consignment of weapons, including over half a million rifles, 22,000 machine guns, 55,000 'tommy' guns, 895 75-mm. guns and supplies of ammunition for these weapons. But, large and important as this shipment was, it did not provide for more than the initial instalment of the home defence requirements. Above all, the demand of the Home Guard for grenades, Sten guns, Smith guns and clothing had to be met from domestic sources.

The defence of Great Britain also meant a large increase in anti-aircraft weapons and in equipment for air defence, some of which was additional to the current army programmes, and all of which had to be made available with the greatest possible speed. And as the German air attacks by night reached their climax the needs of air defence rose.

Before long heavy requirements of an emergency character began to come in from the new field of battle in the Western Desert. It will be shown further[1] that the Desert campaign helped to swell the

[1] See p. 129.

current army programmes, but the influence of the campaign was not confined to current programmes and planned output. As it was nearing its climax the demand for some types of equipment became so great and so urgent as to create another 'emergency'. The Desert Army's needs of transport appeared insatiable—by the end of 1941 more than 94,000 wheeled vehicles were held in the Middle East: considerably more than the number allowed for under the scale laid down in the current army programme. Even more urgent and burdensome was the Desert Army's 'emergency' demand for tanks and anti-tank guns. From the very outset the war in the Desert developed as a tank campaign, and when in the spring of 1941 Rommel, aided by superior armour, was able to defeat the British vanguard in Cyrenaica and to drive Wavell's Army to Tobruk and beyond, tanks—more tanks and different tanks—became the *ordre du jour* at home. The tank programme had by then been much enlarged, but what was wanted was not only a greater supply of tanks for the armoured division then in process of formation, but immediate supplies of the largest possible number of tanks good enough to match Rommel's. There was also a crying need for large numbers of anti-tank guns of more advanced design and of larger calibre than the standard 2-pounder equipment.

It is, therefore, no wonder that by the summer of 1941 tank and anti-tank guns had become almost as much emergency requirements as fighter aircraft had been a year earlier, and it was not a mere accident that in June 1941 Lord Beaverbrook was translated to the Ministry of Supply. To Lord Beaverbrook himself the tank was now 'the thing'. He regarded his new appointment as an invitation to perform over tanks the same operation as he had performed over fighters, and he set about the task with his habitual hustle. If, in spite of his endeavours, the Army's demands for tanks still remained unsatisfied and British tank production did not come up to what was needed, this was not due to any lack of attention on the part of the Ministry or any lack of effort on the part of industry.

Towards the end of the period, i.e. in the second half of 1941, another series of urgent and unexpected demands for supplies arose as a result of the German attack on the U.S.S.R. Hitler's involvement in Russia provided an immediate relief to this country and greatly strengthened the chances of victory. There was no hesitation in welcoming Russia's accession to the Allied ranks. Nor was there much doubt in the Prime Minister's mind, or in that of his immediate advisers, of Russia's ability to resist and to inflict heavy damage on the enemy forces. It was therefore taken for granted from the very outset that this country would have to do its utmost to sustain Russia in her military struggles. Steps to prepare for military assistance had been taken even before the actual day of the German invasion of

Russia. Some supplies were rushed almost at once, and under the 'First Protocol' of October 1941 this country accepted a standing commitment towards Russia. The British share in the Allied supplies to Russia until the following June were to consist of some 1,800 aeroplanes, some 2,250 tanks, 1,800 Bren-gun carriers, a large quantity of machine tools[1] and other industrial machinery, large quantities of medical supplies, raw materials, principally aluminium, and foodstuffs. Added to the totals of current British programmes these undertakings imposed a heavy burden, made all the heavier by the political and military urgency of maintaining the regular shipments to Russia.

(2)

The Strategic Plan

The instances so far mentioned are no more than examples, but they should be sufficient to show how important were the emergency calls on industry. Yet for all their importance they will not give a true measure of the additional industrial liabilities. Emergency requirements could not be segregated from the rest of war production. As a rule they were met by advancing outstanding orders and by accelerating deliveries, but they often led to orders not covered by current Service programmes and thus swelled as well as disturbed the flow of production. Yet they did not represent its main current. War production was still in the main devoted to the building up of Britain's armed strength and was occupied by the long-term programmes of the Services. However insistent the military demands from the fields and the skies of battle, Britain in 1940–41, even more than Britain in 1939, was still primarily engaged in rearmament.

From this point of view the fundamental difference between the periods before and after Dunkirk was mainly one of spirit, methods and achievement: not one of aim. In the minds of the men responsible for the strategic plans of the spring and autumn of 1939 the first three years of war were to be a time of preparation. The need for preparations equally protracted also followed from the strategic ideas of 1940 and 1941, even if the character of the preparations was no longer the same. In the summer of 1940 as in the autumn of 1939 the country was still compelled to hold back from active operations while its striking forces were being built up. In the third week of May 1940, when the Chiefs of Staff were asked by the Prime Minister to report on the problems of the defence of Britain, they could not avoid stressing the overwhelming superiority of the enemy on land and in the air—a superiority which forced this country once more into a

[1] By the end of June 1942 the actual number of machine tools shipped was 1,210.

defensive strategy until its deficiencies in men and material could be made up.

This meant a long wait—two years or perhaps more. Thus, when in the last week of August the Chiefs of Staff were for the first time able to survey in detail the military position and prospects, it appeared to them clear that neither the air nor the army programme could come to fruition until 1942, and that in order to achieve the aims in 1942 the first-line expansion during 1941 must be limited. Their view was that to attempt without success to force a decision in 1941 would be to mortgage Britain's capacity to build up Forces of decisive strength by 1942. Nothing, not even America's entry into the war, would justify Britain endeavouring to accelerate her own efforts in 1941 at the risk of impairing her strength in 1942. In the following summer when the principle was stated again, and the dates were put still further ahead, the Chiefs of Staff thought the proper date for an offensive should be somewhere at the turn of 1942 and 1943. The Army and the Navy should attain their maximum strengths by about the same time; the equivalent of the existing Air Force 'target' programme would have been completed by the autumn of 1942, but it was intended to continue the expansion of the Air Force after that date in order to make certain of absolute air predominance.

The need for holding back for a number of years was thus as great as ever. At the same time it went further and meant more than mere necessity of waiting. Behind the strategy of preparation lay another and a far broader assumption which was so self-evident that it was seldom put into words and may not even have been consciously considered. In theory the same choice was open to Britain in 1940 (and for that matter to Britain in 1939) as, we are told, presented itself at the outbreak of the war to Hitler.[1] The preparations could be either 'broad' or 'deep'. 'Broad' rearmament would have aimed at a quick military decision and would not have demanded an industrial effort any greater or a waiting period any longer than was necessary to enable the greatest possible number of fighting men to take the field at the earliest possible time. Rearmament in 'depth', on the other hand, assumed that the armed forces and industrial employment would be so balanced as to make sure that the military forces were fully equipped and could be maintained in action for an indefinite time.

But, except in theory, this was not Britain's dilemma. To British statesmen and Service leaders the choice never presented itself. No matter how quickly British armed forces were mobilised the chances of their achieving a quick victory were very small; the chances of their being equipped except through a protracted industrial effort

[1] See, for example, *U.S. Strategic Bombing Survey*, *op. cit.*, pp. 18–19.

appeared smaller still. In theory the only alternative to rearmament in 'depth' was greater help from the United States of America, and it will be shown later[1] that the necessity of relying upon the United States of America for a further supply of weapons came to be accepted in the closing years of the war. Some such prospect must have been in the minds of some British representatives in Washington—Mr. A. B. Purvis and M. Jean Monnet—and of Sir Arthur Salter, then chairman of the North American Supplies Committee in London, all of whom on the morrow of Dunkirk proclaimed the need for an expansion of American output of weapons sufficient by itself to achieve victory.

Mr. Churchill himself doubtless based his constant hope of victory on the expectation of ever-greater American assistance; and on one memorable occasion made a public appeal to the Americans to give Britain the tools she needed to finish the job.[2] But neither he nor any of his advisers ever intended a division of labour whereby the United States of America would supply all the 'tools' while this country would do the entire 'job'. Such hope of a division of labour as the men of the Purvis-Monnet school may at one time have entertained was more or less scotched in the course of the negotiations about 'types' at the turn of 1940 and 1941. It will be shown later[3] that during these negotiations the British Army representatives failed to persuade the Americans to adopt the British type of field and heavy anti-aircraft gun, and remained themselves unconvinced by the American arguments in favour of their own designs. And without pooling of designs there could be no question of Britain being rearmed by America.

For a good time to come supplies from the United States consisted mainly of food, raw materials and machine tools; and the American Government was not to be asked for more than a relatively small proportion of the British requirements of weapons. The exact proportion may have varied from Service to Service; but in the main Britain's plan of preparation was self-sufficient. The size of the armed forces, the magnitude of war industry and the duration of the waiting period, were all fixed on the assumption that Britain would not be capable of passing to the offensive until her Forces had been fully armed with weapons made at home.

In this respect the main strategic plan was the same as in the opening months of the war. Where Mr. Churchill's policy of preparation differed from Mr. Chamberlain's was in the spirit which animated it and the manner in which the waiting period was to be employed. Neither the country nor its Prime Minister were in a mood

[1] See Chapter V, Section (4).

[2] Broadcast address, 9th February 1941.

[3] See p. 234.

for sitting down with folded arms while weapons were being forged; and the gathering menace of the German offensive would have made it impossible for this country to indulge in mere waiting even if its Government and people had been willing to do so. At the beginning of June 1940 the Prime Minister pointed out to his advisers that in the defensive state of mind created by the withdrawal from Dunkirk and by the possibility of a German attack, this country might suffer from 'the mental and moral prostration to the will and initiative of the enemy' which had ruined the French. As a remedy he recommended repeated small-scale inroads on the Continent—hence the development of the Commandos. But above all, in his own mind, as in the minds of his advisers, the time of preparations was to be given over to a long-range attack against the power of Germany. The strategy of the attack was bound to be indirect. Now that the French Army was no longer at our side and the continent of Europe was lost, all hopes of decisive operations by land (at any rate in the near future) had to be abandoned, and hopes had to be pinned on the other instruments of war available to this country. In the words of the Chiefs of Staff, Britain's immediate action should be to 'destroy all upon which the German war machine rests—the economy which feeds it, the civilian morale which sustains it, the supplies which nourish it and hopes of victory which give it courage'. All this was to be done by blockade, by air bombardment and by organised risings in the occupied territories.

Military preparations accompanied by acts of attrition were the guiding principles of British strategy throughout the eighteen months that separated the fall of France and the entry of the United States of America into the war. In time greater emphasis came to be placed on the defence of the British positions in the Middle East and on the possibility of defeating Italy. There was also a tendency, already mentioned,[1] to put off the date of the final offensive to 1943 and beyond. But the general forecast of the course of the war, of the chances of victory and of the means of attack, remained the same throughout the period and were not to be affected either by the entry of Russia into the war or by the approaching entry of the United States of America.

A plan thus conceived was bound to determine the entire shape of the rearmament programme—its size, its timing and the distribution of its emphasis. The changes were far from radical. In spite of the higher scales, greater urgencies and more clearly defined priorities, the rearmament programmes of the three Services were not reshuffled. In the strategic position and in the economic conditions of 1940 there was little room for a revolutionary transformation in the

[1] See p. 120.

balance of rearmament. It was not until well after the period covered by this chapter—not until 1942 or even later—that Service programmes were recast to suit the logic of changing strategy.

(3)

The Bomber Programmes

The delay in adjusting the R.A.F. programmes was the longest. The Air Force was now as much as ever the chosen instrument. Both in the war of attrition and in the final campaign of victory it was expected to play a part no less pre-eminent than the part it had been allotted in the pre-Dunkirk plans of defence. There was thus every reason why the country should 'go all out' for a vast bomber force. Such were, however, the conditions in the months immediately following Dunkirk that in spite of all the favours which the R.A.F. enjoyed, its supply of bombers could not be secured—indeed could not even be planned—until well into 1942. Even then the plans fell short of their strategic target: far shorter than the munitions programmes of the other Services fell of theirs.

The problem of bombers was in essence the same as that of aircraft production as a whole. For delays in their output the general unsettlement of the time, including bombing, and the more chronic difficulties of aircraft production (more about them will be said later) were to blame. To some extent, and to begin with, the disturbances brought about by the events of summer 1940 also had their effect. The success of the mid-1940 spurt had not been bought without disturbing for a while the normal flow of aircraft production. Stocks of materials and components and reserves of production capacity were drawn upon for immediate use, and the whole cycle of production was brought forward in a manner which sacrificed future prospects to current output. The sacrifice was well understood and willingly faced. For with the Battle of France lost and with the German invasion of Britain drawing near the Minister of Aircraft Production was justified in thinking—as he did—that the war was going to be decided—as it was—there and then, and that nothing but immediate reinforcement of the R.A.F. could save the country. But the salvation had to be paid for, and a disturbance of production was part of the price.

The disturbance, however, was only a passing one, and could not be blamed, as it sometimes was, for failures of production in later years. Within two months of the priority orders of May 1940 the Ministry was considering again its long-term prospects and reinstat-

ing into the programme the types suspended in May. By October a programme for two years ahead, the so-called 'Hennessy' scheme (Mr. Hennessy of the Ford Motor Company was at the time Lord Beaverbrook's principal personal adviser) could be put down on paper. But on paper it was destined to remain. According to the scheme, monthly production was to reach 2,565 aircraft by June 1941 and 2,782 by December 1941,[1] and experience was very soon to show how impossible the figures were. They were based on carefully worked out coefficients of floor space and machining capacity available to the industry, but they assumed a balanced supply of the factors of production—materials, components and labour. Above all they assumed the industry's capacity to utilise its manufacturing resources to the full, including multiple shifts in all stages of production. It is therefore more than doubtful whether the figures in the programme could ever have been reached. The disturbed and dramatic circumstances of 1940 and 1941, including German night bombing and the dispersal of aircraft factories, placed the programme beyond all bounds of possibility. So by the end of the winter the Minister, much as he disliked the necessity (scaling down programmes was anathema to Lord Beaverbrook), had to agree to the reduction of the 'Hennessy' programme, if only by successive stages.

Indeed, for at least another year, the story of M.A.P. programmes was a record of ambition gradually reduced to conform with the inexorable facts of industry and administration. Under each successive programme—and during the year beginning October 1940 there were several—the expectations of aircraft in the immediate future were brought lower.[2] True enough, the total of aircraft to be produced under each programme remained the same or was even increased. But to make this possible the planners in the Ministry added to the expected output in the distant future the numbers that had to be cut from immediate expectations. To use a contemporary expression, they 'lifted the tail of the production curve'. As time advanced the tail got higher and longer, and the prospects of peak production at 2,500 a month and above were receding ever further into the future.

From every point of view and above all from that of Britain's offensive strategy the prospect was not good enough. What made it worse still was that the ambitions of the Ministry of Aircraft Production had to be cut most in relation to heavy bombers. The new 'heavies' had figured very prominently in the programmes of 1938 and 1939 and were then expected to fly by the summer of 1940. But so

[1] See Appendix 3, Table I.

[2] Under the programme of 7th March 1941 production was to reach a monthly rate of 2,221 aircraft by December 1941, a figure comparable to the monthly rate of 2,187 which was planned to be reached by that date in the programme of the 3rd July (Appendix 3, Table J) and of 2,148 by the same date in the programme of 11th September 1941.

great were the difficulties of development and of initial production that in spite of continuous prodding by the Ministry the new bombers obstinately refused to appear. The early stages of the Stirling both at Austin's and at Short's were very 'sticky'; the development of the Manchester, though quicker off the mark, was dependent on the Vulture engine, and by the middle of 1941 the Vulture was showing that lack of promise which was eventually to bring about its demise. The Halifax proved at that time to be the only reliable heavy bomber about to be produced in respectable numbers, but even the Halifax was threatened with further and further delays.

Yet all the while the industry was continually pressed by the Ministry of Aircraft Production, and M.A.P. itself was under continuous and heavy pressure from the Air Council and the Prime Minister. The pressure was brought to a head by the Prime Minister's instructions of the 7th September 1941 requesting a drastic increase in bomber production. Britain's entire attack on Germany hinged upon bombers, yet the supply of bombers was insufficient. In order to achieve a first-line strength of 4,000 medium and heavy bombers, the R.A.F. required 22,000 to be made between July 1941 and July 1943; of these 5,500 might be expected from American production. The latest forecast showed that of the remaining 16,500 only 11,000 would be obtained from British factories. This in the Prime Minister's view was very unsatisfactory, and he was therefore forced to give instructions for a plan to be prepared for the expansion of the effort to produce a total of 14,500 in that period instead of 11,000.

The forecast of 11,000 to which the Prime Minister referred may have been that of the programme of the 3rd July or else that of the subsequent programme which was to be made public on the 11th September.[1] But whatever their origin the figures meant 3,500 additional bombers in less than two years, and the demand was obviously very difficult to meet. The Ministry of Aircraft Production did nothing to hide the difficulties. It pointed out that the current programmes had absorbed a vast amount of tools and labour, that continuous shifts had turned out to be impossible to work, that housing and transport were difficult, that certain types of fabricated alloys were short. The best it could do was to meet the Prime Minister's request half-way: to accept his figures but to dilute their composition and to prolong the period of delivery. The dilution was to be achieved by enlarging the output of the Wellington—a tried old stager which was at that time the type most amenable to quantity production. The extension of the date meant that another nine to eleven months were then added to the final date at which the Prime

[1] The new programme was planned for 12,879 heavy and medium bombers, but it was at the time officially assumed that actual achievement would not be expected to exceed eighty-five per cent. of the planned effort, in which case only 10,906 were likely to be produced.

Minister's 14,500 was to be reached. By 31st July 1943, the Prime Minister's terminal date, only 1,074 additional bombers instead of the Prime Minister's 3,500 could be promised.

Yet even these promises turned out to be excessive and in December they had to be cut again.[1] The planned additions to the output of heavy bombers in 1942 were scaled down below those of the 'September' programme. Additional output was scheduled to come in 1943, but even in that year the monthly additions over the July programme were to reach only fifty in June and about 100 in December compared with the 157 originally planned for that month. The additions to the medium bombers were to begin a few months earlier and to rise to a peak of 300 per month by September 1943 compared with the peak of 280 to be reached by the end of May 1943 under the 'September' programme.

In 1942 came further downward adjustments accompanied by the 'lifting of the tail'. These later adjustments, however, and the circumstances in which they were carried out differed in many respects from those of 1940 and 1941 and will be more conveniently told in the next chapter.

With plans of aircraft construction failing to fit the strategy of air offensive an even greater value attached to American deliveries. The Ministry of Aircraft Production from the very beginning put high hopes on American deliveries of complete aircraft and did much to stimulate their production on Britain's account. As time went on the American contribution began to play an increasing part in the aircraft programmes. The Middle Eastern theatre was to a growing extent dependent upon American fighters and bombers. By September 1941 more than 600 American aircraft of all types had been shipped to the Middle East. American Catalinas, B.24.s (Liberators) and Hudsons also formed an important part in the equipment of Coastal Command. The figures already quoted show to what extent the chances of the bomber offensive had come to depend on American supplies. Yet even then America's entry into the war in December 1941 made a great difference. More about this will be said later.[2]

(4)

The Irreducible Army

In spite of the secondary place which the prevailing strategic doctrine assigned to the Army, its establishment and demands for munitions were great enough to absorb a large part—much more

[1] See Appendix 3, Table K.
[2] See pp. 240 and 242.

than one-third—of the resources engaged in war production. It will be shown presently that strict quantitative limits and a clearly defined timetable governed the expansion of the field forces. Thanks to these limits and to this timetable the Government found it possible in the last two years of the war to wind up a great deal of the industrial effort devoted to the Army. But in the years which immediately followed Dunkirk, the War Office and the Ministry of Supply were more conscious of the Army's high and expanding needs than of its time-limits and of its restricted size.

The accepted strategic principles were bound to impose close limits on the Army's size. In the discussions which immediately followed Dunkirk, ardent spirits in and out of the War Office might occasionally speculate in terms of a great land army to match the German Army strength; a figure as high as 100 divisions was sometimes mentioned. But the dangers of the British military position and the limited potentialities of British economy put all such ideas out of court. In their first general survey of post-Dunkirk projects—that of August 1940—the Chiefs of Staff declared themselves against producing an army on the continental scale or running a major campaign on the western front against the German Army in its present state. Apart from defending the country from invasion the main contribution of the Army to victory would come at the end of the war, when some field forces might be called upon to clinch the victory. In the meantime the Army had to confine itself to tasks of secondary importance and to home defence.

This view came in the end to be embodied in Mr. Churchill's famous directive of 6th March 1941. Harking back to his own advocacy of a larger number of divisions,[1] he now admitted that when in the autumn of 1939 the War Cabinet approved the formation of a full army of fifty-five divisions, it was not realised that a division as contemplated by the War Office, with its share of corps, army, headquarters and lines of communication formations, would require 42,000 men exclusive of all training establishments and of all garrisons, depots or troops not included in the field army.[2] His main argument, however, was strategic and economic. In the conditions of 1939 it could be assumed that the bulk of the Army would stand in line with the French under conditions comparable to those of the last war. But there was no question now of advancing in force against the German armies on the mainland of Europe. The bulk of the Army had to stay at home and defend the island. Apart from resisting invasion, it would be impossible for the Army to play a primary role in the defeat of the enemy. That task could only be done

[1] See p. 74.

[2] The Prime Minister's computation was based on the size of divisions formed for operations in the Middle East.

by the staying power of the Navy, and, above all, by the effect of air predominance.

The strategic limits thus set were, however, much narrower in theory than they turned out to be in practice. The size of the Army may have been fixed at the same level of fifty-five divisions: the figure which Mr. Chamberlain's Government had in the last months of its existence chosen as the final target of Army expansion. The identity of the two programmes, however, was merely one of form. In the autumn and winter of 1939 the fifty-five divisions were no more than a general indication of the Army's final aims, and did not as yet determine the current plans of the Ministry of Supply. In the summer of 1940 the fifty-five divisions became the firm basis of all planning. By one of its earliest decisions Mr. Churchill's Government laid down as the general aim for the War Office and Ministry of Supply the formation of thirty-six divisions by Z + 21, i.e. by 31st May 1941, and of the rest of the fifty-five divisions by Z + 27, i.e. by 30th November 1941.

Moreover, it soon became clear that however modest the role of the Army in strategic theory, its full demands for stores would overflow the limits of the fifty-five-division programme. As the War Office pointed out in its comments on the Prime Minister's directive, the responsibilities of the Army, however 'secondary' in accepted strategic doctrine, required a very large establishment—in fact a larger establishment than anything contemplated before Dunkirk.

The needs of the final operation, i.e. the landing on the Continent, as assessed in 1940 were neither great nor definite. At that time it appeared that for some years at least a large-scale invasion of the Continent would not be possible. Long after the events of 1940 plans for army landings on the Continent continued to be cast on a very modest scale, and on the very eve of America's entry into the war Mr. Churchill still found it necessary to explain to the Russians that although Britain had every intention of intervening on the Continent —in the spring of 1942 if that could be done—all ideas of twenty or thirty British divisions being sent against the Germans on the Continent were without foundation in reality. In his directive he had spoken of a striking force of eight to ten divisions, mostly armoured, and this was also the estimate most commonly contained in the papers of the Chiefs of Staff.

The 'victory contingent' was thus conceived on modest lines, and had the army programmes been wholly or even mainly devoted to it the War Office demands for men and weapons would not have been very large. Future plans and ambitions in this respect were deliberately played down so as not to swell the Army's share of national resources. Swollen it nevertheless was. In the conditions of 1940 and 1941 the other commitments of the Army absorbed men and

arms in quantities far greater than those which in theory were necessary to equip the small landing army of the future. In the first place, home defence was bound to absorb a large and ever-growing volume of resources. By March 1941, the date of Mr. Churchill's directive, there were, in addition to the regular divisions of the 'field forces', nearly 490,000 men in the Air Defence of Great Britain, in anti-aircraft defence of merchant ships and in the defence of factories and vulnerable points; there were a further 158,000 men in garrisons and defended ports abroad.

Army requirements were also piling up as a result of changing tactical conceptions. There was a marked tendency for certain types of army weapons to grow out of all proportion to the army programmes as a whole. Thus throughout 1940 and 1941 additional requirements continued to come from the new and special formations, such as the Commandos and the Airborne Divisions, to say nothing of the unfolding programme of action in the territories occupied by the enemy. But the most prolific sources of new demands were the armoured formations. The emphasis on armour appears to grow from programme to programme. In the summer of 1940 Mr. Churchill laid it down that the Army should, to begin with, contain not less than seven armoured divisions, and the programme of August 1940 was based on the assumption that the equivalent of about ten armoured divisions would be formed. By the beginning of 1941 the official programme of fifty-five divisions came to be conceived as one of forty-eight infantry divisions plus the equivalent of twelve armoured divisions. In the spring of that year the proportion of the armoured units was raised again, to the equivalent of some sixteen armoured divisions. By the end of July the long-term plans grew to comprise the equivalent of about eighteen armoured divisions.

The actual expansion of the armoured formations did not, of course, keep pace with the plans. Moreover, the plans, however ambitious, did not require a corresponding increase in the total Army establishment or in the total requirements of war-stores, for the personnel of the armoured divisions was about twenty per cent. less than that of an infantry division with a corresponding economy in clothing, hutments, infantry weapons and transport. But it did necessitate a great rise in the demand for tanks—a rise which has already been mentioned and will be discussed again.[1]

Even more expansive turned out to be the needs of the Middle East. Acting in a mood of characteristic confidence and courage, the Government may have sent to Egypt reinforcements greater than those which in the summer of 1940 cautious men thought the country could safely spare. Nevertheless, the total forces engaged in Wavell's first campaign were not so heavy as to upset the strategic plan, and

[1] See pp. 117 and 131.

had the fighting continued on the same scale and remained equally successful, they could probably have been maintained—as the Government hoped they would be—without undue strain on the Army establishment or on its supply of munitions. But as it turned out, the needs of the campaign grew with every turn of military fortune. They were heavy enough at the time of Mr. Churchill's directive. In the spring of 1941 there were twelve divisions in the Middle East, of which three were from the United Kingdom. In Mr. Churchill's view three or four divisions were the most that could be sent from home and maintained in the Middle East. The main reinforcements would have to come from the other parts of the Empire, with later on munitions from the United States. Yet, by October 1941 the 'Army of the Nile' had swollen to sixteen divisions, of which six were from the United Kingdom, and it was intended to reinforce the Middle East with two more British divisions from the United Kingdom. And although by then the Middle East theatre was in appreciable measure supplied from North America (some thirty per cent. of its wheeled transport and some twenty per cent. of its tanks had come from there), the bulk of the equipment was still drawn from home.

Thus in the conditions of 1940 and 1941 the Army and its demands on war industry were bound to be greater than strict logic of the long-term strategy might appear to require. No wonder the formal statement of the War Office requirements under the post-Dunkirk programmes presented a great addition on earlier demands—how great will best be shown by comparing them with the War Office requirements as stated in April 1940.

War Office requirements under the pre-Dunkirk and post-Dunkirk programmes

TABLE 13 — Units

	Requirements as stated	
	April 1940	Aug.–Oct. 1940
Number of divisions for which required	36	55
Date by which delivery was to be completed	Z + 24 (31 Aug. 1941)	Z + 27 (30 Nov. 1941)
Tanks: medium, light and infantry	7,096	10,444
Carriers	11,647	14,568
Wheeled vehicles and motor cycles	376,299	575,008
Field, medium and anti-aircraft guns, including conversions: equipments	12,677	22,676
2-pdr. tank and anti-tank guns	13,561	20,670

Further additions were to come before long. Under a written arrangement between the War Office and the Ministry of Supply the

former undertook to provide every six months a revised set of requirements covering two full years ahead. In accordance with this arrangement revised programmes were submitted to the Ministry in the late spring of 1941 and these were followed by another revised programme in the autumn and winter of 1941–42.[1] At each of these stages the estimates for a number of stores (both cumulative totals and the monthly rates of supply at peak) were raised. As has already been suggested there were spectacular increases in the requirements of armoured fighting vehicles and of anti-tank guns to suit the expanding plans of armoured divisions. The number of cruiser and infantry tanks required by the end of November 1941 (Z + 27), as estimated in August 1940, was 10,444. As estimated in May 1941 the requirements to the end of that year (Z + 28) had risen to 17,501 and cumulative requirements to cover the 1942 programme to 19,700. In December 1941 it was estimated that requirements during 1942 and 1943 would be as high as 36,720.

War Office requirements of cruiser and infantry tanks

TABLE 14 Units

Date of estimate	August 1940	May 1941		December 1941–January 1942
Date by which delivery was to be completed	30th Nov. 1941 (Z + 27)	31st Dec. 1941 (Z + 28)	31st Dec. 1942 (Z + 40)	Total demand 1st Oct. 1941 to end 1943
Cruiser tanks	6,023	13,176	14,100	21,665
Infantry tanks	4,421	4,325	5,600	6,055
Provision for Russia and other Allies				9,000
TOTAL	10,444	17,501	19,700	36,720

The demands for other armoured fighting vehicles and for anti-tank guns were to match. A glance at Table 15 will also show that the War Office requirements for some other types of equipment were growing at very nearly the same rate.[2] But highest of all were the demands for ammunition, and it was on the figures of ammunition that the discussion of army programmes was largely to centre.

[1] These requirements did not reach the Ministry until January 1942. They nevertheless reflected the discussions of the previous two months and did not represent the new position created by America's entry into the war and the extension of the war to the Far East.

[2] This is indicated by a comparison between the figures in columns 4 and 5 of Table 15, but it should be noted that column 4 shows the gross requirements for the first forty months of the war as estimated in May 1941, whereas column 5 gives revised net requirements for the last fifteen months of that period, taking into account deliveries accepted by the Army up to 30th September 1941.

War Office requirements of certain war-stores, August 1940–December 1941

TABLE 15 — Units

Date of estimate	Aug. 1940	May 1941		Dec. 1941–Jan. 1942	
Date by which delivery was to be completed	30th Nov. 1941 (Z+27)	31st Dec. 1941 (Z+28)	31st Dec. 1942 (Z+40)	Between 1st Oct. 1941 and 31st Dec. 1942	During 1943[1]
Column 1	2	3	4	5	6
Tanks: medium, light and infantry	10,444	18,601	21,705	21,637[2]	7,270[2]
Carriers	14,568	28,500	35,550	57,100[3]	20,520[3]
Armoured and scout cars	5,132	7,300	9,250	10,000	3,500
Wheeled vehicles and motor cycles	575,008	567,145	688,970	498,300	169,316
Anti-aircraft guns: equipments	15,177	15,250	..	12,500	990
Medium artillery, including conversions: equipments	1,397	870	1,070	1,090	110
25 pdr.: equipments	6,102	5,900	6,800	3,800	900
2 pdr.: tank and anti-tank guns	20,670	19,400	25,100	5,650	650
Other tank and anti-tank guns	459	11,100	21,910	13,820	3,650

(.. not available)

One of the main reasons why the requirements of ammunition in the army programmes were so high was that the war-time programmes were not so exclusively devoted to 'initial' equipment as the narrow sense of the term might suggest. The anti-aircraft artillery was from the very first days of the Battle of Britain engaged in air warfare and was expending its ammunition and wearing out its guns. War-stores were also being expended in the Middle East in great and ever-growing quantities. But from the purely quantitative point of view even more important were the provisions for 'wastage' which were comprised in the 'initial' equipment of field divisions. The latter included large quantities of ammunition and other stores for immediate reserves and for stores in transit, and also reserves large enough to cover all operational wastage in the period between the outbreak of fighting and the complete deployment of war production.

However modestly estimated these various provisions for maintenance were bound to add up to a great deal; and it so happened that

[1] To be regarded as minimum maintenance requirements.

[2] Exclusive of provision of tanks for Russia and other Allies: 4,500 tanks in each period.

[3] Exclusive of provision of Bren carriers for Russia: 3,600 in each period.

the estimates were far from being modest. The expenditure rates for a number of stores like transport and clothing were very high, but the highest of all and the most burdensome were wastage requirements for bullets and shells. The War Office requirements for the maintenance of field guns including tank and anti-tank guns but excluding anti-aircraft guns, at the rate of 1,850 per month, or 22,200 per annum, were equivalent to the 'capital' equipment of some twenty-five divisions. Not counting the very high demands of the R.A.F. and the Navy, the requirements of small arms ammunition at November 1941 (Z + 27) stood at 277 million rounds per month. According to the Ministry of Supply forecast, in order to fulfil the requirements of gun ammunition, as stated in August 1940, 64 million shells would have to be provided for field guns by June 1941, and a monthly rate of 8 million rounds per month would have to be reached by December 1941. If maintained in 1942 this requirement would have necessitated an output of nearly 100 million shells in a year, or about twenty-five per cent. more than the total British output of gun ammunition for the B.E.F. in 1916, and some thirty-five per cent. more than in 1918.

These requirements were obviously impracticable. In the opinion of the Ministry of Supply they prejudiced the chances of the entire programme. Not only did the total requirements over the entire Z + 27 period (i.e. to 30th November 1941) represent a vast industrial task, but they were also so spaced out that for a year, or possibly two, the Ministry could not possibly avoid a large deficit; and the accumulated deficit of the earlier years would make it all but impossible to meet the final requirements in full. As early as the 7th August 1940 the Director General of Programmes in the Ministry of Supply had to warn his Minister that there would be substantial deficiencies on the Z + 24 programme, that further deficiencies were also very likely, and that unless some of the items in the War Office lists—and more especially ammunition scales—were cut, the Ministry's task would turn out to be impossible.

No sooner, therefore, were the 'August' programmes passed to the Ministry of Supply than the question of ammunition had to be examined more or less *ab initio*. The issues then raised are sufficiently important and went sufficiently far back into the history of war production to deserve a slight digression. The occasion for the first doubts about the ammunition programme occurred during the discussions of the Army plans in the autumn of 1939. The argument was Mr. Churchill's and was mainly tactical and strategic. It will be remembered that at that time the chief objection to a larger army rested on grounds of supply.[1] It was, therefore, inevitable that Mr.

[1] See p. 74.

Churchill's criticism should have been primarily directed against the War Office estimates of supply needs. In a note he submitted to the Military Co-ordination Committee of the War Cabinet on the 9th February 1940 he questioned the War Office assumption that an army of fifty-five divisions would require 66,000 guns and would 'consume' in the field some 25,000 guns. He observed that such a prodigious output of artillery would exceed the output of field, medium and heavy artillery in the whole of the first World War. At the peak of production in that war Britain was stated to have produced 8,500 guns of all calibres. How forlorn then must be the position of the German Army which aimed at having 240 divisions by August 1941. Under the War Office hypothesis, the Germans would have to produce some 290,000 guns of all calibres and maintain a supply of 108,000 guns per year. But Mr. Churchill's chief criticism was directed against the wastage rates of ammunition. The War Office, he said, derived its figures from the rates of fire of the new guns, which had greatly increased. But what had not increased was the means of conveying the ammunition from the rear to the guns, and this, Mr. Churchill proceeded, remained the limiting factor. The War Office, therefore, was not justified in assuming a greater expenditure of ammunition merely because of the greater rapidity of fire. The greater rapidity of discharge enabled a more intense burst of fire to be achieved for a short period. Economy of ammunition in accordance with the tactical and administrative conditions would have to be enforced now as formerly.[1]

These and similar arguments were on that occasion urged very strongly. If in the end the fifty-five-division plan was not at that time put into operation, it was largely because Mr. Churchill's arguments were not fully accepted. In August 1940, however, the issue was revived. A memorandum submitted by the Minister of Supply, Mr. Herbert Morrison, to the War Cabinet on 29th August 1940 officially reopened the discussions which were to continue all through the late autumn and winter. The discussions brought out most of the old arguments as well as a few new ones. The output of guns developed relatively slowly, and ammunition was being piled up for non-existing guns; the problems of storage and transport of ammunition would soon become unmanageable; above all, the ammunition scales put the rest of the army programme in jeopardy. This time the argument won the day. By the last week of February reduced rates were worked out. These and further reductions resulting from the Prime Minister's directive of 6th March 1941[2] were embodied in the

[1] The same arguments on transport had been used by Mr. Churchill in December 1939 in discussions on requirements of small arms ammunition.

[2] See p. 127.

War Office requirements as communicated to the Ministry of Supply in May 1941. How great the reductions were in comparison not only with the requirements of August 1940 but also with those of the pre-Dunkirk era will be seen from Table 16.

War Office requirements of principal types of ammunition, as communicated to the Ministry of Supply in April 1940, August 1940 and May 1941

TABLE 16 Thousand rounds

Type of Ammunition	April 1940[1]	August 1940[2]	May 1941[3]
FIELD AND MEDIUM			
25-pdr. H.E.	18,685	48,684	14,100
25-pdr. A.P.	564	1,608	600
25-pdr. Smoke and Gas	1,412	11,400	4,300
18-pdr. H.E. and Smoke	1,947	2,724	150
18-pdr. A.P.	56	72	170
4·5-inch gun H.E.	1,511	3,456	580
5·5-inch gun Howitzer H.E.	1,286	3,876	680
6-inch Howitzer H.E.	2,467	2,640	700
ANTI-AIRCRAFT			
40-mm. H.E.	3,360	6,000	7,570
3·7-inch H.E. and Shrapnel	3,638	4,632	6,086
4·5-inch H.E. and Shrapnel	230	432	1,052

In fact the only requirements of ammunition to increase were those for anti-tank and anti-aircraft types—a reflection of the emergency calls already described and of the growing emphasis on anti-aircraft and armoured formations. The reductions in gun ammunition were matched by other reductions, especially in reserves of guns and barrels and 'general stores' such as clothing, bedding, etc., but it was chiefly through the reduction in ammunition that the Ministry of Supply could contemplate the rising requirements for a number of weapons with some hope of fulfilling them. This should not be taken to mean that, even with the ammunition requirements reduced, the programmes for Z + 27 were capable of being fulfilled at their appointed date. The discussions within the Ministry of Supply and the information which that Ministry gave to the War Office and the Defence Committee (Supply) still reflected the general impression that the field forces would take longer to equip than the timetables of 1940 allowed. But what mattered was that the activities of the Minis-

[1] Total amount of ammunition required for the twelve months, September 1940 to August 1941.

[2] Figures shown in this column represent twelve times the monthly rate of maintenance to be covered by 30th November 1941, as on this occasion the War Office departed from its earlier procedure and did not fix the total amount of ammunition required by the final date of the programme but stipulated the monthly rate of maintenance it wanted to be covered by 31st May and 30th November 1941 respectively.

[3] Total amount of ammunition required during 1941.

try of Supply could now be planned on the assumption that sooner or later the programmes would be fulfilled and that sooner or later a peak point would be reached beyond which its operations might begin to contract. The assumption which always underlay War Office plans was that its requirements would come down as soon as the stores necessary to equip the entire complement of divisions had been delivered. The end of November 1941 (Z + 27) was the terminal date named in the summer of 1940; the subsequent additions to the programmes and the difficulties of industrial mobilisation put the date much later. But until the outbreak of hostilities in the Far East the Ministry of Supply could hope that the peak of its activities would be reached and the equipment of the Army be completed some time in 1942.

Thus, for all the fundamental changes in Britain's military position after Dunkirk, the general aims of war production and even the separate supply plans for the three Services did not undergo a radical transformation. The programmes of re-equipment expanded, but for the time being spectacular changes in individual Service programmes were ruled out by the economic and strategic position of the country. The continuity of the naval 'emergency' programmes was to be expected and was indeed planned for.[1] But the records of the other Services were almost equally continuous. The R.A.F.'s rank as the favoured arm was higher than ever before and stood in the way of any possible plans to expand the field forces beyond their essential minimum. Yet even the most essential minimum equipment of the Army turned out to be so large as to make it impossible to increase the Air Force as far as strategic plans demanded. And although industrial activity was now much greater than before, some of the increase resulted from earlier preparations; and for the rest, the growing scale of industrial activity reflected not so much the changed aims of the planners as the more rigorous execution of their plans.

(5)

The New Administration

After Dunkirk the execution of the Service demands altered more radically than the scale and structure of the demands themselves. What changed was the behaviour of the country: the spirit in which the people shouldered the burdens of the war and the resolution with which the Government imposed them. This may not be a subject to which a study of munitions can do justice. In an industrial and admin-

[1] See p. 59.

istrative study of this kind the spirit of the times must remain in the background and be taken more or less for granted. The behaviour of the Government on the other hand is an essential part of this history, even when the changes in government were also largely those of attitude and behaviour and were not solely concerned with administrative and institutional forms.

Administrative changes were bound to follow the great emergency of 1940 and the accession of the new Government.[1] In the administration of war production the earliest as well as the most conspicuous innovation was the formation on the 17th May of the Ministry of Aircraft Production.[2] The separate ministry symbolised the urgency which was now attached to the output of aircraft, but from a purely practical point of view its birth need not necessarily have been accompanied by any radical operation. In the course of the preceding ten months, the production department of the Air Ministry in Harrogate under Sir Wilfrid Freeman as the Air Member for Development and Production (A.M.D.P.)[3] and Sir Charles Craven as the recently appointed Civil Member for Development and Production (C.M.D.P.) had grown to rival in both size and authority the Ministry of Supply. It could easily be elevated to the rank of a fully-fledged ministry and be translated to London without great changes in its machinery. It is therefore not surprising that after the transfer the layout of the new Ministry remained for a time little different from what it had been in Harrogate.

If before long the Ministry appeared to break both with the men and the methods of Harrogate, this was not due to any lack of performance or administrative order in the production branches of the Air Ministry. On the contrary, the output of aircraft in the early months of 1940 was rising very fast and was ahead of programme: the first and very nearly the only period in the development of the war industry when this happened. The subsequent history of aircraft production also showed that the methods and attitudes of the planners and the industrial administrators active in the Air Ministry during that period were not deficient in either initiative or forethought. They did not however conform to what the new Minister of Aircraft Production thought was necessary in the exceptional circumstances of the summer of 1940. He did not believe that people he described generically as 'air marshals' were suited by temperament or training to the running of aircraft production. His intention was to make his department into a fast-growing enterprise run by men who knew how to make their enterprise grow fast. Another predilection of the Minister was for administrative methods more spontaneous and

[1] The forthcoming volume in this series on the Administration of War Production will deal with these changes in greater detail. (See also p. 77n.)

[2] S.R. & O. (1940), Nos. 747 and 762, 17th and 20th May 1940.

[3] See p. 20.

informal than the established practices of government departments. The latter spelt routine, paper work or, in general, 'organisation'; and as a poster in his private office proclaimed, 'organisation' was 'the enemy of improvisation'. So even if organised hierarchy and orderly procedure were allowed to continue at the lower levels of the official pyramid, the Ministry at the top was to an increasing extent run by an informal group of the Minister's personal advisers drawn from business. By degrees the group with Mr. Hennessy of Ford's at its head superseded both the A.M.D.P. and the C.M.D.P. In the autumn Air Chief Marshal Sir Wilfrid Freeman returned to the Air Staff and was, in part, replaced by Sir Henry Tizard; Sir Charles Craven returned to Vickers-Armstrongs and was not formally replaced. The Permanent Secretary was left alone in the Minister's entourage to represent the proprieties of a department of state. On paper the field of his official duties may have been narrow—consisting mainly of establishments and finance including contracts—but his authority was high, and his influence sufficiently great to enable him to preserve continuity in the affairs of the new Ministry as a whole.

The régime reflected the personality of the Minister and the critical urgency of the tasks he had to face in the summer of 1940. The urgency was more or less over by the winter of 1940–41, but it was not until the summer of 1941, when Lord Beaverbrook was translated to the Ministry of Supply and Colonel Moore-Brabazon, as he then was, became the Minister of Aircraft Production, that the administration of the department could be sorted out, re-defined and brought into line again with the methods of the other ministries. A number of Lord Beaverbrook's personal advisers left M.A.P.; Sir Charles Craven was persuaded to return as Controller General. Under him a network of directorates of production, under five directors general and deputy directors general, took shape. The Secretariat, under the Permanent Secretary, supplied the common administrative services of the Ministry as a whole, and its functions had by this time come to embrace such diverse tasks as labour, construction, regional services and aircraft distribution. And at the very top of the Ministry, the Aircraft Supply Council, comprising the Minister, the Parliamentary Secretary and the four or five heads of departments, established itself as the principal deliberative organ of the Ministry. Except for gradual changes in later years this was in principle to remain the structure of the Ministry for the rest of the war years.

The other production departments escaped most of the administrative experiences of M.A.P. They all had to undertake duties of industrial administration new and strange to the Civil Service; to tackle emergencies which required hustle and improvisation; and to choose recruits from among businessmen and dons. Yet compared with M.A.P. they took their new men and new methods in smaller

and perhaps more agreeable doses and thus escaped some of M.A.P.'s internal unsettlement.

The dosage of the Admiralty was indeed so small as to leave the organisation and method of the department almost unchanged. Naval construction between the two wars had been sufficient to keep in being a fully organised production department under the Third Sea Lord (the Controller of the Navy). The war and even Dunkirk did not bring with them an increase in naval construction great enough to require an expansion comparable with that of M.A.P. or the Ministry of Supply. The department therefore continued to be run more or less as before. Its main body at Bath was separated from Whitehall by a distance of more than a hundred miles, but it continued to be an integral part of the Admiralty organisation. Its various branches were often headed by naval officers; its high Civil Service members continued to look after matters of finance, contracts, secretariat and establishments; its recruits from outside were not as a rule given posts of great responsibility. The only exception was the newly-founded branch in charge of merchant shipbuilding and repair, whose head, Sir James Lithgow, and whose second-in-command, Sir Amos Ayre, were leaders of the British shipbuilding and ship-repairing industry, and whose higher personnel mostly came from the same source. To this extent, the department bore some resemblance to many branches of M.A.P.; yet the resemblance was largely superficial. Its production problems and the habits of its experts did not favour that post-haste improvisation which was so marked a feature of M.A.P. in the early stages of its development.

The administrative problems of the Ministry of Supply were equally difficult, for the Ministry was called upon to expand the production of an infinite variety of stores at rates which, measured by employment and expense, were little different from those of M.A.P. Yet its administrative record was unspectacular and to the uninformed might even appear uneventful.

Under Mr. Morrison[1] the department came up against a number of problems inherent in the original conception of the Ministry of Supply, but for none of these problems was a radical solution found or indeed sought. The most ambitious of the new appointments was perhaps that of Sir Walter Layton (later Lord Layton) as Director General of Programmes, with a seat on the Supply Council and in charge of the Statistics Branch. The Supply Council set up in September 1939 acted as a regular conference of departmental heads of the Ministry, but it was not destined to continue as the main directing committee within the Ministry. Before long it proved too cumbrous and even, in a sense, too representative a body to provide

[1] In May 1940, Mr. Herbert Morrison succeeded Dr. Leslie Burgin as Minister of Supply and was in turn succeeded in October by Sir Andrew Duncan.

a convenient place for regular discussion of the Ministry's problems, and its business largely passed into the hands of a much smaller Executive Committee which was set up in March 1941.

In July 1941 the advent of Lord Beaverbrook as Minister led to a more general reshuffle at the top.[1] Research and development of weapons were taken out of the competence of the production divisions and brought together under a centralised department, and placed under Mr. Oliver Lucas as Controller General of Research and Development. To match this appointment and perhaps to compensate for it the Director General of Munitions Production was raised to the position of Controller General with a general oversight over all the production divisions, including some not previously under his control. The appointment which was perhaps most characteristic of the Minister was that of Mr. (later Sir William) Rootes, head of the motor-car firm, as chairman of the 'Minister's Council' which consisted of the personal advisers of the Minister. The Supply Council, as hitherto understood, was put into suspense though not formally abolished.

More enduring than some of these personal and institutional innovations were the changes in the functions and the organisation of the Secretariat. Its principal duties in the early stages of the Ministry's history were little different from those which commonly fell to the secretariat branches in the Service and supply departments, i.e. establishments, finance and contracts, parliamentary business. On the other hand, the structure of the Secretariat and the distribution of duties within it was bound to be more complicated than elsewhere. Some of its functions were discharged by secretarial departments common to the Ministry as a whole and subject directly to the Permanent Secretary. Others were discharged by two autonomous branches of the Secretariat corresponding to the two-fold division of the Ministry: the secretariat of the Raw Materials Department and that of 'Supply', i.e. of the division responsible for the procurement of war-stores. Both branches were bound to grow in the early years of the war, but it was in the 'Supply' branch of the Secretariat that some of the most significant developments occurred. The original nucleus of the branch was the small secretarial branch ('M.P.C.'), which had been attached to the Director General of Munitions Production in the War Office and had migrated with him to the Ministry of Supply. Early in the life of the Ministry this branch had multiplied into a group of secretarial bodies each of which was attached to a director on the production side of the Ministry in the same way as the 'M.P.C.' was attached to the Director General of Munitions Production. This general system of 'bedding-out' civil servants helped to co-ordinate

[1] Lord Beaverbrook was Minister of Supply from 29th June 1941 to February 1942 Sir Andrew Duncan then returned as Minister, a position he retained until July 1945.

the activities of production directorates better than any formal machinery could have done. By May 1941 the branch had assumed responsibility for priorities, overseas activities and labour supply. But nothing was more characteristic of its growing importance than the functions it assumed in negotiating Service requirements: a development about which more will be said later.[1]

The changes in the central administration of war production at the War Cabinet offices were more general, though there too the significant changes resulted from the personal outlook of the Prime Minister. One of the most important institutional innovations was the replacement of the Ministerial Priority Committee by the Production Council. The entire system of committees was rearranged.[2] Previously under the Ministerial Priority Committee there had been two separate sub-committees for production and for materials;[3] the two were now combined into a single Joint Materials and Production Priority Committee. Two other new committees concerned with war production inherited their functions from their predecessors: the Manpower Priority Committee and the Works and Buildings Priority Committee. Later two other committees appeared in the field: the Industrial Capacity Committee which was set up in July 1940 and the *ad hoc* Manpower Requirements Committee set up in August to examine labour requirements.

In the course of the subsequent six months the machinery of the Production Council and its committees acquitted itself with varying degrees of success. The Industrial Capacity Committee succeeded in reorganising the Area Boards and did some useful work in considering and sometimes allocating surplus production capacity, in investigating the potential resources of industry and in establishing principles for the best use of capacity which was being set free for war production by the Limitation of Supplies Orders. The *ad hoc* Manpower Requirements Committee with Sir William Beveridge as chairman worked out the first approximation to a manpower budget, and, generally speaking, functioned as an investigating satellite of the Manpower Priority Committee. The Joint Materials and Production Priority Committee succeeded in a relatively short time in establishing a workable system for the allocation of raw materials between departments, about which more will be said presently.[4] The highest expectations, however, had been placed on the main ministerial committee, the Production Council, and it was that committee which drew upon itself most of the public interest.

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[1] See p. 457.

[2] The Committee reorganisation was announced in Parliament on 4th June 1940; see H. of C. Deb., Vol. 361, Cols. 769–771.

[3] See p. 79.

[4] See pp. 159–163.

The interest was apt to be kept alive by criticism in Parliament and the Press. Viewed in historical perspective some of the criticism might appear unjustifiable. The Council proved to be slow and unwieldy, but it was not wholly ineffective or inefficient. During its six months' existence it met thirteen times and was responsible for initiating the reorganisation of the Area Boards and for launching the Manpower Requirements Committee and its very important inquiries, and it will be shown further[1] that it played its part in the gradual transformation of the priority system which was taking place at the time. Yet to public opinion, even to so well-informed an opinion as that of the House of Commons and its Select Committees, the Production Council was bound to seem inadequate. At a time when war industry was still in the process of deployment and the needs of the Services were not yet fully satisfied a certain amount of public impatience was inevitable. And it was only too natural that the administrative feature to be singled out for criticism should have been the body nominally at the head of the machinery of war production. It was said to be incapable of stimulating and co-ordinating the activities of the three supply departments,[2] and it did not seem to function as an initiating and directing body. To all appearances the Council did not act at all unless departments made formal complaints, and its decisions about priorities and 'bottlenecks' invariably came as a result of applications by departments.

Various proposals to give the Council greater power and authority were made from time to time. In the summer of 1940 its secretary put forward a plan whereby all the common services of the three production departments would be brought together under a new Department of Raw Materials and Priorities somewhat on the lines of the pre-war blue-prints. A similar proposal was made by the Select Committee on National Expenditure in August.[3] In December Mr. Churchill himself, in answer to criticism in Parliament and the Press, drew up a scheme for the reform of the War Cabinet machinery which was later debated at length in Parliament[4] and carried into effect in the new year. A Production Executive, a smaller and more compact body than the Production Council, took the latter's place. It consisted of the three Supply Ministers and the President of the Board of Trade with the Minister of Labour as chairman, and the underlying idea was that the whole business of production and supply would now be

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[1] See p. 160.

[2] See, for example, H. of C. Deb., Vol. 364, Cols. 1303–04, 21st August 1940, Vol. 365, Cols. 1702–03, 13th November 1940; *Select Committee on National Expenditure*, Session 1939–40, Tenth Report dated 8th August 1940, para. 22.

[3] Tenth Report, *op. cit.*, para. 44 (iii).

[4] This scheme was announced in *The Times* on 7th January 1941 and discussed in the House of Commons, 21st and 22nd January 1941. See H. of C. Deb., Vol. 368, Cols. 81–150 and 209–270.

gripped at the top by a compact directing body consisting of ministers who would themselves be responsible for the necessary executive action. Under the Production Executive there was established a number of sub-committees which were largely the same as those which had taken shape under the Production Council, dealing respectively with materials,[1] industrial capacity, labour, works and buildings, and transport. The whole of this organisation was linked with the highest direction of economic policy through the Lord President (Sir John Anderson).

The reorganisation did not however meet the main points of public demand, for it did not establish a central department or a Ministry of War Production. Against these demands, it could still be argued that a super-department would merely duplicate departmental machinery, but the real reason was that Mr. Churchill did not think that the gap which the critics deplored in fact existed. Where supply problems were merely part of general economic policy, the Lord President's Committee and above all Sir John Anderson himself could be relied upon to lay down general principles and to reconcile departmental differences; and this they did with great and ever-growing efficiency. Where supply impinged upon the main conduct of the war or on questions of military policy, the co-ordinating and directing precepts came from the Defence Committee (Supply) or, to be more exact, from the Prime Minister in his capacity as Defence Minister. Indeed the Prime Minister's main argument against a Ministry of Production was that it would merely duplicate what he thought was one of his essential functions as Prime Minister and as Minister of Defence.

The argument agreed with facts more closely than public debate could reveal. Mr. Churchill was indeed performing many of the functions which the critics thought were not being performed, or were being performed badly. The Defence Committee of the War Cabinet, over which he presided and which he dominated, had no settled constitution and no hard and fast membership; but its 'supply' meetings often dealt with requirements of the Services and the quantities and qualities of weapons demanded by them; and it stimulated, instigated and criticised the plans and performances of the supply departments. This activity, being largely Mr. Churchill's, was irregular in procedure and sometimes unexpected in its results, but it was anything but laggard and, on matters of weapon policy, was more often right than wrong. Even his critics had to admit that Mr. Churchill knew a good weapon when he saw one, but unlike most experts he could appreciate the points of a weapon he had never seen.

[1] The former Joint Production and Materials Priority Committee became the Materials Committee concerned only with the allocation of scarce materials and with questions relating to the production and use of raw materials. The 'production' responsibilities of the former committee went to the Industrial Capacity Committee.

These personal qualities of the Prime Minister were responsible for one or two expensive adventures into unusual types of equipment; but they were also responsible for some of the highly successful instruments of war which were such a marked feature of the British war effort—the Mulberry among them. On questions of design, scales of equipment and current output Mr. Churchill never lacked advice, and was seldom wanting in information. Above all, he could always call upon the services of an organisation capable of carrying out independent exploration and investigation on his behalf.

That organisation functioned as a part of the secretariat at 10 Downing Street and was managed for the Prime Minister by Lord Cherwell, who in December 1942 was appointed Paymaster-General. From every point of view it was highly unorthodox. It had grown out of the statistical service which in the first eight months of the war Lord Cherwell (Professor F. A. Lindemann as he then was) had run in the Admiralty for the benefit of the First Lord. When fully deployed in association with the War Cabinet Secretariat, it consisted of a group of young men from the universities trained either as economists or scientists, who appeared to enjoy a roving commission over the entire field of war government and administration. Being what they were and doing what they did, Lord Cherwell and his 'boys' could not help becoming unpopular; in one or two fields their activities may also have turned out somewhat unremunerative. Yet, taken as a whole, their work meant a great accession to the Prime Minister's knowledge and grasp of what was going on in the departments and to his command over relevant facts and considerations. They may thereby have duplicated some of the work done by the other economic and scientific agencies of central government; they may sometimes have disturbed the orderly sequence of stages by which official advice normally comes to prime ministers. But to paraphrase a contemporary verdict, they helped to infuse logic into the Prime Minister's logistics. They certainly reinforced it with technical and statistical argument. To this extent they could claim some credit for the miracle of Britain's Government in the war: a Government which was largely personal and yet free from the intellectual limitations of an autocracy.

It was the energy and ubiquity of Mr. Churchill's activities rather than his failure to appreciate the uses of co-ordination that prevented the formation of a Ministry of Production until after the entry of the United States into the war. For the rest, the working of the War Cabinet machinery and the part the Prime Minister played in it exemplify the truism that the changes after Dunkirk affected the spirit of war policies more than their form; and the truism applies with equal relevance to other features of the administrative machinery in charge of war production. The proof of the new administrative

set-up was not so much in its design as in its functioning. Whereas the hierarchy of departments and committees differed little from that of old, many of the men and most of the measures were new. And newest of all was the general trend of policy. Rapidly, by a series of inevitable stages, the Government called into being a fully-fledged war economy wherein every interest, private or public, present or future, was utterly subordinated to the demands of the war. The change was one of attitude, but its practical effects were unmistakable. What with the new outlook of ministers and the accumulating experience of officials, the business of industrial mobilisation could now proceed more swiftly and with far greater efficiency than had been possible in the first six months of the war.

(6)

The Mobilisation of Labour

The field in which new attitudes and administrative devices were felt most was that of labour supplies. The political atmosphere had at last become favourable to comprehensive labour policies. Not only was the mood of the working people different, but the official representatives of labour, the Labour Party and the trade unions, were no longer in the position of anxious observers of a suspect Cabinet. Above all, the new Minister of Labour, Mr. Bevin, could be relied upon to win for the problem of labour, as well as for the Minister of Labour, a due share in the councils of the war. He fully realised that the military position and the spirit of the country dictated a radical and forceful labour policy; but his experience as a labour leader also taught him the dangers of precipitate action in the handling of working men; and the habits of his departmental officials were not such as to lead him into drastic action before he was ready for it. He therefore applied to the labour problems of the day that mixture of legislative audacity and administrative circumspection which was to be the hallmark of his régime. The Orders which he caused to be passed were more than sufficient to give the fullest possible advertisement to the authority he now possessed;[1] but in its daily routine his department made a sparing and unwilling use of the new powers and for a long time merely kept them in reserve.

In any case the labour situation was not yet so acute as to compel the Minister to draw on his entire reserve of powers. The problems with which the Ministry of Labour had to deal during this period did not at first differ fundamentally from labour problems of the first six

[1] See S.R. & O. (1940) 781, 22 May 1940, for the powers given to the Minister of Labour under the Emergency Powers Act of May 1940.

months of the war, and were still very largely those of skilled labour. Indeed until the end of 1940 the Ministry of Labour appeared to be less troubled by shortages in the general supply of labour than by lingering problems of local unemployment. The number of unemployed men stood near the half-million mark between July and November 1940 but rapidly dropped in the first half of 1941. By June 1941 there were only 158,000 men out of work,[1] but small as this figure was it happened to be made up of large local pockets of workless.

The pockets were partly due to the natural dislocation of civilian industry and partly caused by the Board of Trade restrictions on industries producing for the home market. Greatly as the production of munitions expanded in the summer months of 1940, it had not expanded far enough to absorb all the local unemployment. What is more, contracts and war factories were not being entirely confined to areas where the Ministry of Labour believed supplies of general labour to be most plentiful. Supply departments found it sometimes difficult to obey the Ministry of Labour's directives on location, for labour supply was not the only consideration they had to take into account in placing contracts or in sanctioning extensions.[2] They preferred their own lists of approved tenderers based on detailed knowledge of the manufacturing capacity, the technical qualifications and the industrial efficiency of individual firms. Their reluctance was all the more difficult to combat for the inevitable imperfections in Ministry of Labour forecasts. On several occasions in 1941 the Ministry of Supply was still able to find labour in areas in which, according to the Ministry of Labour classification, labour was or could soon be expected to be short.

Generally speaking, labour was still not very hard to find. Some shortages of unskilled workers were bound to appear from place to place and from time to time, and they were becoming more frequent in the course of 1941. But until quite late in that year they were mostly local and relatively easy to remedy. Aircraft production as yet suffered very little from lack of unskilled labour. In the shipbuilding industries only Barrow and Merseyside complained of many unskilled vacancies in the spring of 1941. The Ministry of Supply alone could justifiably complain of shortages of unskilled labour in the winter of 1940–41. It was responsible for several occupations of an unpleasant nature, such as iron ore mines, for which recruits were not forthcoming. Some of the heavier metal industries, like drop forging and non-ferrous metal plants, were concentrated in the Midlands where there was no reserve of unemployed labour, and where workers who had been with difficulty transferred from other

[1] See Cmd. 6564, Appendix A.
[2] See p. 98.

areas were apt to drift away to more attractive work in the many engineering and aircraft factories in the neighbourhood. Above all, the Ministry of Supply had to cope with the special problem of women for filling factories. Although at this time there was no shortage of women labour in the country as a whole, the filling factories were bound to present a problem of employment at the very outset owing to the nature of their work and their location away from inhabited places. The difficulties were from the beginning reflected in the high rate of labour turnover. At Chorley well over half the number who began work there left before production had been fully started, and quite early in the summer of 1941 officials complained that they were 'expending great energy in trying to fill a leaking tub'. Of the women sent by the employment exchanges at Preston and Blackburn to filling factories in November 1940 only half accepted employment. By the beginning of 1941 the shortage of ammunition threatened by insufficient labour in the filling factories had become so serious as to draw the attention of the Prime Minister. By the summer of 1941, however, the supplies had greatly improved. The reduction of hours following the introduction of three shifts, better travel facilities, canteens and hostels, as well as further releases from civilian industry, greatly eased the situation.

In general, the shortages of unskilled labour which were occurring in 1941 could still be overcome by a variety of local and *ad hoc* expedients, and such more general measures as were considered and passed at the time were largely preparatory. As part of the preparation the Government set afoot the Beveridge inquiry into labour supplies.[1] By the summer of 1940 the figures which were then available, those of Wolfe's report,[2] had become out of date. But the figures which the Beveridge report made available in December 1940, though much more conservative, foretold great shortages of unskilled labour. Not only were the demands of war industry bound to become higher within a year or so, but the demands of the Services also threatened to produce within the same period a famine in men of military age. The famine could only be met by withdrawing men from munitions industries and by recruiting women into munitions and the essential civil industries. According to Beveridge's estimates employment in munitions industries was to be increased within a year by 800,000 from the 1,450,000 employed in August 1940. In addition, to meet these requirements, about thirty-five per cent. of the male labour employed in non-munitions occupations would have to be transferred to munitions industries within two years. Some of the vacancies thus caused would have to be filled by women (the number was estimated

[1] An *ad hoc* Manpower Requirements Committee was set up under the chairmanship of Sir William Beveridge. See p. 141.

[2] See pp. 100–101.

at 750,000) and over one million additional women would also be required in munitions factories by August 1941.

The figures were thus very large, and the stringency they prophesied very great. Special preparations had, therefore, to be made to meet it. Limitation of Supplies Orders were from now on to be used not only to conserve raw materials but also to release labour and were soon to develop into the Concentration of Industry scheme.[1] More important still was the Registration for Employment Order which came into force in March 1941.[2] The Order as applied to men outside military age was not expected to achieve more than to mop up the few remaining reserves of male labour. Its chief object was the mobilisation of women.

The mobilisation of women was a drastic act of total war—more drastic than anything done in the war of 1914–18 or anything that even Hitler could contemplate. It was, therefore, not surprising to find the Ministry of Labour approaching it with the greatest caution. Until July 1941 the Ministry applied the Order only to women not already occupied in industry, and in doing so proceeded slowly and haltingly for fear that anything indiscriminate and swift might alienate public opinion. But by the early summer of 1941 it was seen that the number of 'unoccupied' women was very small; meanwhile demands for women for essential civil industries and for war production were increasing. The Ministry of Labour concluded that greater firmness and expedition were needed. More 'age groups' of women were called up for registration, and arrangements were made with certain industries to release young women for more essential work.[3] Even so, the total number of women transferred to war work or to vital civilian industries between the middle of April and November 1941 was rather less than 200,000. The control of the transfer of women became easier when early in 1942 as a result of the Employment of Women (Control of Engagement) Order[4] women between the ages of twenty and thirty years could obtain employment only through employment exchanges.

Before that, the Ministry of Labour could in justification of its hesitancy argue that the general problem of labour was not yet sufficiently acute. To repeat, the main problem, as well as the main preoccupation, of the Ministry was still that of skilled workers; and the problem was now much more acute than it had been before Dunkirk. Towards the end of 1940 and in the early months of 1941

[1] See Concentration of Industry White Paper: Cmd. 6258, issued March 1941; and p. 158.

[2] S.R. & O. (1941), No. 368, 15th March 1941.

[3] For example, an agreement was reached with retail distributors, other than food, for the withdrawal of women aged 20–25 years (M.L. Circ. 136/64, September 1941) and a similar agreement was made with the woollen and worsted industries (M.L. Circ. 136/65, 7th October 1941).

[4] S.R. & O. (1942), No. 100, 22nd January 1942.

new factories and expansions planned before Dunkirk were approaching their full rates of production. And most of them were now threatened with hold-ups through shortages of skilled labour.[1]

The full force of the Ministry of Supply demand for skilled labour came early in 1941, but there had already been serious difficulties in the R.O.F.s and among private contractors in the closing months of 1940. In the shipbuilding industry the supply of electricians, turners and fitters was becoming difficult at the end of 1940, and what made difficulties still worse was the continued drain on workmen in these trades from shipbuilding to other branches of the munitions industry. In the last six months of 1940 Cammell, Laird & Company, Birkenhead, had to record that far from increasing their skilled cadres they had lost 140 men, mostly electricians, to Napiers, Rootes and other firms.

The shortages intensified the evils of poaching and excessive turnover which were already in evidence in the first months of the war. To combat them the Ministry of Labour issued in June 1940 the Undertakings (Restriction on Engagement) Order[2] under which all new engagements in building, civil engineering and general engineering had to be made through employment exchanges or recognised employment agencies, so as to prevent poaching by 'advertisement'. But the Order could not prevent men from dismissing themselves. It was, for instance, alleged in July 1940 that the number of people who left the B.T.H. magneto factory each week was sometimes two-thirds as great as the number of people engaged. In the autumn a new problem arose with the German bombing, for a number of important firms situated in vulnerable areas found that some of their skilled men moved themselves and their families to places of greater safety. The Ministry of Labour tried to use against them its powers of direction, but was not very successful. There were difficulties in tracing the workers, and in addition neither the divisional controllers nor the representatives of the Amalgamated Engineering Union, who had been given the power to act for the Government, had the 'heart' to use compulsion against men who had evacuated themselves. The Ministry of Labour, therefore, tried to find some means of keeping skilled workers in their jobs which would avoid the defects and unpopularity of the leaving certificate system of the previous war. The Essential Work Order of 5th March 1941[3] was the result, and the procedure under the Order whereby the National Service Officer, and not the employer, was the judge of whether a man could leave, removed one source of workers' opposition. The necessary *quid pro quo*

[1] Shortages of toolmakers, setters and machinists were especially prominent at this time, and as mechanisation increased so did the demand for these types of skilled labour.

[2] S.R. & O. (1940), No. 877, 5th June 1940. Electrical installation industry was added March 1941. In general, the Order applied irrespective of age or sex.

[3] S.R. & O. (1941), No. 302, 5th March 1941.

for workers was found in the proposal that the employer receiving protection should be directed to keep all his workers subject to a week's notice to the employment exchange. Moreover, in accordance with the Ministry's general reluctance to force men to return to jobs where earnings were low or conditions unpleasant, the Essential Work Order was not to be applied to any establishment where conditions were unsatisfactory.

Keeping skilled workers in munitions jobs was, however, not the only labour problem the industry and the Government had to face. To overcome the shortage it was also necessary to transfer to munitions industry the skilled labour engaged in occupations not absolutely essential to home or export trades. When in August 1940 the registration of engineering labour was introduced[1] it revealed that there were 50,000 men formerly occupied in engineering and now engaged in other work, and 100,000 maintenance engineers in industries other than engineering. The Beveridge Committee estimated in November 1940 that 20,000 of each group could be transferred to munitions production, but it is difficult to say how many of them in fact moved into munitions industry in the course of the following year. The total figure of all labour—not just skilled—in the motor vehicle, aircraft and general engineering industries employed on work for the home and export markets fell between June 1940 and September 1941 from 252,000 to 152,000, and most of this reduction can be taken as an addition to the munitions industries. The transfer from other industries, however, was more difficult to trace and to measure, and the general impression was that there was not enough of it. Moreover, the transfers which were taking place did little to correct the uneven distribution of skilled labour between different areas. Disparities in local supplies were getting if anything worse. Thus in 1940–41 there was a permanent shortage of toolmakers and setters in the new factories and particularly in the engine 'shadow' factories in the North-West, while the Coventry and Birmingham districts remained the greatest potential source of skilled labour for transfer.

A demand for organised or even compulsory transfer was, therefore, bound to arise. But here again the Ministry, confronted as it was by a number of stubborn problems, proceeded with great circumspection. There was first of all the problem of travelling and lodging allowances which had to be paid by the Ministry. Even with these allowances there was the obstacle of differences in earnings. Thus the rates of earnings in shipbuilding were low relatively to other engineering and metal-working industries. In the iron and steel industries the highly-paid skilled workers from tin-plate mills, where work was contracting, were now being offered much lower earnings in drop forging plants. Within the aircraft industry the earnings for

[1] S.R. & O. (1940), No. 1459, 7th August 1940.

a forty-seven-hour week in October 1940 were £5 10s. 9d. at de Havillands in the Home Counties, £5 0s. 10d. at Napiers in the Home Counties, and £4 2s. 6d. at Napiers in the North-West. It was not until June 1941 that the knot could be cut by an agreement between the Amalgamated Engineering Union and the Engineering Employers' Federation whereby employers agreed to make up the difference in basic rates of earnings of workers transferred to areas where lower rates prevailed.

By that time the Ministry had tackled also the problem of compulsion. It had fought shy of compulsory measures throughout 1940 and early 1941. It would not use compulsion against the unemployed on the ground that it would be unjust to subject the unemployed to treatment from which their more fortunate fellows in employment were spared. In general the Ministry tried not to provoke opposition from the men. It would do nothing to force the unemployed electricians in London to go to Tyneside as they would have had to accept lower rates of pay and might make trouble. The threat so often employed in the war of 1914–18, that of revoking reservation, could not now be used very freely as the Services were anxious that the call-up should not be regarded as a penalty. In the spring of 1941 the Schedule of Reserved Occupations was amended so as to take into account the factories in which men were working as well as their occupations.[1] This made it possible to raise the reservation ages for the Army with the minimum of harm to munitions production. But although this measure also made it easier to apply the threat of military service it was very seldom thus used. Generally speaking, compulsion continued to be treated as an ultimate sanction—not to be invoked except in a few extreme cases.

To the problem of transfers between occupations and areas was added the purely administrative problem of allocating new labour among individual contractors. At the beginning of its career the Production Council assumed that priorities for labour would follow general priorities. The great industrial disturbances of midsummer 1940 following upon the production drive at M.A.P. and the overriding priorities which aircraft production then enjoyed brought out the defects of the priority system in relation to labour. A number of vital branches of the munitions industry, e.g. machine tools, were threatened with a dangerous hold-up, whereas firms with overriding priorities were found 'hoarding' skilled labour which they had acquired. At the end of September 1940 the War Cabinet decided in favour of the allocation principle. Priority lists were to remain but they were to be used simply as a guide to allocation. On 15th October the Prime Minister laid down that where M.A.P.'s demand for labour equalled the total supply of labour of that type, a special

[1] See W. K. Hancock and M. M. Gowing, *British War Economy*, *op. cit.*, p. 306.

allocation must be made for the minimum essential needs of other departments. From this time on priority no longer gave an exclusive right to all labour available, and in spite of lingering opposition from M.A.P. labour was as far as possible distributed with due regard to the indications of priority received.

The other problems to be tackled were those of dilution and upgrading. In November 1940 the Beveridge Committee had estimated that it was possible to dilute the skilled ranks in engineering and allied industries in the proportion of 1 in 4 by September 1941. The Committee was here thinking more of breaking down and deskilling the work than of upgrading the men. Even so, by December, the hope that dilution to this extent could be achieved was seen to be over-optimistic. The ease of dilution varied with the job and with the type of factory: for in new factories the layout and plant made possible a greater degree of dilution. In the summer of 1940 the Ministry of Labour departed from its previous attitude and was willing to accept the responsibility for pressing dilution; but progress was sometimes obstructed by opposition from both men and employers, and not all the supply departments appeared able to exercise the necessary pressure on their contractors. Considerable dilution took place in 1940–41 of shipwrights and electricians on Admiralty work, although little progress was made in the dilution of platers and riveters, which remained a stubborn problem throughout the war. Some of the new factories, such as the new engineering Royal Ordnance Factories, were economical in skilled labour from the very outset, but many engineering and aircraft factories still employed a high proportion of skilled labour in 1941. Throughout war industry variations in the proportion of skill in different firms persisted till the very end of the period. To a large extent they were inevitable for in no two firms were technical processes and the managerial practices the same. But they were to some extent also due to the failure to press dilution as far as possible. The position lightened itself by degrees in late 1941 and 1942.

(7)

Priority and Allocation

Important changes also took place in the flow of raw materials and in the ways by which they reached war industry.[1] Supplies were getting short or were about to get short, even though some of the shortages were so to speak local and 'particular' and were in the

[1] The volume in this series on The Control of Raw Materials by Mr. Hurstfield deals with these questions in detail. Most of the facts in this chapter are derived from the corresponding sections of Mr. Hurstfield's book.

nature of 'bottlenecks' reflecting a changed balance of requirements more than a general insufficiency of supplies. Of the special shortages the most acute and the most troublesome occurred in the provision of drop forgings. The demand for drop forgings was bound to grow with the rising production of aircraft and guns, and the threat of stringency had hung over the munitions industry since 1938, but the situation did not become critical until the summer of 1940. The 'crisis' was one of planning and distribution as well as one of supply. Orders had been allowed to accumulate far in excess of existing output, and by early July 1940 there was an accumulation of orders of 64,344 tons and a weekly deficiency in delivery of 3,500 tons. This in turn was due to a number of causes. Under the existing system the Iron and Steel Control did not possess a clear picture of specific requirements and was unable to differentiate between them. But even with fuller and better information at its disposal it would have found it difficult to introduce a general and rational scheme of distribution while government orders were still exempt from licence,[1] and while the newly-created Ministry of Aircraft Production, acting through a Drop Forgings Committee of its own, did all it could to obtain primacy for aircraft needs. In this M.A.P. was supported by the special Priority of Production Direction of 31st May 1940, which laid down that certain hammers should work exclusively for aircraft contracts. As long as it was in force this Direction threatened to play havoc with the whole munitions programme in general and with the tank programme in particular, and led other departments to place their orders as far ahead as possible, thus adding to the general congestion.

To resolve the crisis it was necessary to deal both with the requirements and with the supply. An interdepartmental Drop Forgings Sub-Committee of the Materials Committee was established in August 1940 'to examine and co-ordinate requirements' as well as to supervise the supply situation, including imports. At the same time the Drop Forgings Sub-Control was established at Birmingham to direct and expand production. This Sub-Control was given authority to check all requirements in collaboration with user departments, but it continued to be handicapped by the Priority Direction and by the activities of the internal Drop Forgings Committee of M.A.P. It was not until the spring of 1941 that the main Drop Forgings Sub-Committee established its authority over the M.A.P. Committee; and by this time arrangements for allocation were changed sufficiently to release the drop forgers from the plethora of priority certificates inflicted on them. The consuming departments were told to formulate, for a period of three months ahead, their requirements of various

[1] See p. 92.

types of drop forgings within the forging capacity allocated to them by the Drop Forgings Sub-Committee. Departments were also asked to replace drop forgings wherever possible by other components and to make their specifications less rigid so that the fullest advantage could be taken of available capacity and of semi-skilled and unskilled labour.

So much for requirements. The supply of forgings had to be tackled from several angles. Importation from the United States was an obvious remedy, but it could not bring quick relief. Between October 1940 and May 1941 orders were placed in the United States for drop forgings for various aircraft parts, vehicles and gun carriages, etc., to the value of approximately £5 millions, but the time-lag in delivery was expected to be about nine months, and proved even longer. In 1941 imported drop forgings represented only six per cent. of total deliveries to consumers; it was, therefore, from home production that the increased supplies had to be, and were, mainly found.

At home radical measures of the more obvious kind were adopted, but they too could not be expected to solve the problem at once. During 1940 and the first half of 1941 the Ministry of Supply put into operation a number of plans to increase total forging capacity in the United Kingdom, including plans for the building of specialised capacity, e.g. for Merlin and Bristol crankshafts, bearing-rings, etc. Most of these plans, however, were not expected to bear fruit until the latter half of 1941 or later. Increases in production which took place in the summer of 1941 must largely be attributed to the intensive use of existing capacity, to piecemeal extensions and to improvements in labour supply.

In this field as in others the first labour problem to arise was the scarcity of skilled workers. Before the war the occupation had not been attracting recruits, for physical conditions were unattractive and wages were low. The release of 200 skilled men from the Services in July 1940 alleviated the position somewhat, but the first attempts of the Sub-Control to recruit new workers was met by the reluctance of the Ministry of Labour to apply special direction without an improvement in wages. At the beginning of 1941 the rates of pay of trainees and workers were raised; and what with the new wage scales and with the new training schemes and hostels the position gradually improved. The problem of unskilled labour was solved by migration. The Ministry of Labour undertook to import unskilled workers, mainly from Ireland and South Wales, and the Ministry of Supply undertook to provide adequate accommodation. In January 1941 it was estimated that 4,600 additional men were required at the rate of 1,000 per quarter to ensure maximum shift-working on existing hammers, and the demand was met almost in full. The following

table shows the number of employees in drop forging works in 1940 and 1941 respectively:

	Male	*Female*	*Total*
1940	10,777	260	11,037
1941	12,786	1,070	13,856

By April 1941 the chairman of the Drop Forgings Sub-Committee was able to report the view of departments that 'while certain difficulties were still being experienced, the position had definitely improved during the last three months'. By May it could be claimed that the supply position showed a very great improvement. This was attributed to 'a considerable increase in substitution, a scaling down of requirements and an increased output from home sources'.

Other special shortages differed from those of drop forgings only in scale and were solved largely in the same manner. But as the special 'bottlenecks' appeared and disappeared the problem of raw materials in general, i.e. of the total supplies available for war production, was bound to intrude itself upon the attention of administrators. During this period a number of important strategic materials became scarce as a result of political and military events. The defeat in Norway in April 1940 deprived this country of some of her main peace-time sources of timber, paper-making material and iron ore. Later in the summer when the contacts with Europe and North Africa were virtually broken, Britain found herself deprived of a very large proportion of her imported steel-making materials, of phosphates, flax, hemp, pit props and a number of other commodities almost equally essential. The gradual closing of the Mediterranean route and the final interruption of trade with the Balkans removed yet another source of timber and minerals.

The growing scarcity of raw materials was not, however, wholly due to the cutting off of customary sources of supply and would in any case have developed with the increased requirements of war industry. Some such scarcity had been foreseen in the pre-war plans of rearmament, and its prospects had been frequently discussed during the first six months of the war. By June 1940 the production of war-stores had not yet developed sufficiently far to make the threat a reality, but the situation changed rapidly in the summer of 1940. While exports of finished products consuming raw materials began to decline, demands of the Services and of the munitions industry expanded very rapidly, and supplies became or were on the point of becoming tight over the entire range of raw materials, especially in steel and non-ferrous metals, timber and building materials.

The Ministry of Supply was thus called upon to remedy at short notice a series of shortages, some of which were immediate, others merely probable. One of the measures it now took was to extend the earlier schemes for developing domestic sources of supply and to improvise a number of new ones. Table 17 illustrates the changes in home production which took place as a result of the new measures.

Production of some essential raw materials, 1935–41

TABLE 17 — Thousand tons

	1935–38 average	1939	1940	1941
Iron ore[1]	12,417	14,486	17,702	18,974
Scrap for steel-making	5,800[2]	6,379	6,527	6,622
Hardwood	150[3]	310[4]	496	655
Softwood	180[3]	120[4]	444	701
Pitwood	120[3]	450[4]	1,527	1,441
Aluminium	18	25	19	23
Magnesium	2	5	6	11

Source: Cmd. 6564

Development of home sources inevitably created difficulties and problems for the users. The iron ore mined at home was, as a rule, of inferior grade, and especially of lower iron content than the imported ore. Home-grown hardwood was not always a good substitute for imported softwoods. Nevertheless, by the end of 1941 industry had adapted itself to the changes, and in this way the country became more self-sufficient in its supplies of raw materials than it had been in peace-time.

Additional home supplies alone could not, of course, meet the situation. In other circumstances the main remedy would have come from increased imports of strategic materials and, above all, from substitute sources of supply; and this remedy was not neglected in 1940. In spite of the approaching exhaustion of dollars much greater reliance had to be placed on supplies from the United States. In steel the requirements of imports from the United States had grown manifold overnight. Whereas in April 1940, when the policy of dollar economy was still being rigorously pursued, the total estimates of iron and steel requirements from the United States for the year amounted to £12·6 millions, the requirements for the second year of the war, as estimated in July 1940, came to £100 millions. A far greater

[1] Average ferrous content about thirty per cent.
[2] Estimated from statistics of consumption and imports.
[3] Production in 1930.
[4] Estimated production at beginning of the war, expressed as an annua rate.

proportion of raw materials was also expected from Canada (now the chief source of timber), from South Africa, Australasia and the Far East (now the chief source of steel-alloying materials).

This policy, however, could not be pursued regardless of other considerations. With the passing of the Lend-Lease Act on the 11th March 1941 currency difficulties (the Government had abandoned the policy of dollar rationing long before then) were no longer the obstacle they had been, but other difficulties and, above all, the shortage of shipping still prevented the country from making fuller use of the sources now opened to it. With shipping getting scarcer—both in fact and in prospect—the Government had to meet the raw materials problem not only by larger orders in regions yet untouched by war, but also by various measures of economy at home. In order to economise in shipping, the import programmes laid an ever greater stress on semi-finished and finished materials. Expenditure on raw materials from the United States between June 1940 and December 1941 was at an average monthly rate little more than half that of the first half of 1940, whereas the average monthly rate of expenditure on manufactured and semi-manufactured articles nearly trebled. But the main remedy was to reduce the total imports of raw materials. In the period July 1940 to March 1941 the United Kingdom import programme for raw materials was reduced from the optimistic 1939 estimate of 24 million tons per annum to programmes which ranged (the estimates rapidly changed) between 19 and 15 million tons per annum.

Thus, at the very time when war industry was at last approaching its full war-time rates of production, current supplies of some vital raw materials, such as steel ingots, timber and lead, were not only smaller than those assumed in the pre-war plans of war production but actually smaller than those available at the beginning of the war. Table 18, overleaf, shows that, with the possible exception of iron ore and aluminium, the supplies of a number of raw materials available in 1941 were less than those available at the end of the first year of the war. Even the supplies of iron ore, which were now swollen by much increased home production, were largely made up of low-grade ores and, measured by their metallic content, were if anything below the supplies available in 1939.

Hence the overwhelming need for greater economy in the use of raw materials and for more efficient distribution of available supplies. The Lord President's Committee had agreed on 21st June 1940 that steps should be taken as soon as possible to eliminate all unnecessary domestic consumption of materials which entered into the war effort. This decision was followed by more detailed directives from the Lord President's Committee. Emphasis was laid for example on the need to divert as much as possible of the declining supplies of wool left for

Supplies of certain raw materials in the United Kingdom

(*a*) Home production
(*b*) Imports
(*c*) Total

TABLE 18 — Thousand tons

	1939			1940			1941		
	(*a*)	(*b*)	(*c*)	(*a*)	(*b*)	(*c*)	(*a*)	(*b*)	(*c*)
Iron ore	14,486	5,240	19,726	17,702	4,549	22,251	18,974	2,283	21,257
Pig iron	7,980	354	8,334	8,205	676	8,881	7,392	971	8,363
Scrap	6,379	605	6,984	6,527	937	7,464	6,622	549	7,171
Steel ingots	13,221	24	13,245	12,975	488	13,463	12,312	562	12,874
Hardwood	310	836	1,146	496	683	1,179	655	365	1,020
Softwood	120	4,255	4,375	444	2,353	2,797	701	1,253	1,954
Pitwood	450	1,607	2,057	1,527	1,090	2,617	1,441	189	1,630
Aluminium[1]	25	58	83	19	66	85	23	138	161
Copper[2]	..	307	..	162	474	636	146	451	597
Lead[3]	17	334	351	14	336	350	8	139	147
Zinc[4]	51	345	396	56	431	487	67	412	479

(.. not available)
Sources: Cmd. 6564 and *Statistical Digest of the War*

civilian consumption to 'clothing of the cheaper kind'. Only very small quantities of flax required to meet essential demands were to be released for civilian home consumption, and steps were to be taken to economise in a number of non-essential uses of steel, copper and zinc. For example, certain direct steel exports were to be reduced and the consumption of copper and zinc was to be reviewed with the object of eliminating non-essential home uses.

In June 1940 came the first of the Limitation of Supplies (Miscellaneous) Orders[5] designed to reduce the consumption of raw materials in a number of civilian industries.[6] Restrictions had been imposed on sales of clothing since April 1940.[7] And economies were not to be confined to civilian requirements. At the end of 1940 the

[1] Home production of virgin aluminium; imports of aluminium and aluminium alloy ingots, blocks, slabs, billets, etc.

[2] Home production of refined copper; imports of copper, unwrought.

[3] Home production of lead concentrates; imports of lead, unwrought.

[4] Home production of virgin zinc; imports of zinc ore and concentrates, zinc or spelter, unwrought.

[5] S.R. & O. (1940), No. 874, 6th June 1940.

[6] Some of the restricting measures extended to scarce industrial capacity. To reduce civilian pressure on the engineering industry a system of machinery licensing was introduced (S.R. & O. (1940), No. 875, 6th June 1940), and in October 1940 building for civilian purposes was for the first time effectively restricted.

[7] S.R. & O. (1940), No. 561, 16th April 1940. For further details of restrictions imposed see W. K. Hancock and M. M. Gowing, *British War Economy*, *op. cit.*, pp. 117–18, 174–75, 321–22. This subject will also be dealt with in the forthcoming volume on Civil Industry and Commerce in the official civil histories series.

War Office was invited, when estimating steel requirements, to distinguish between the needs for vital points in defensive positions and those for the ordinary protection of military personnel, so that the needs of the latter should not make a call upon a scarce material greater than the reduced requirements for civilians. Early in 1941 the Lord President's Committee approved the proposal that for certain raw materials such as cotton, rubber, asbestos and calcium carbide the Services should accept cuts in supplies comparable with those imposed on civilians.

The various measures so far enumerated reflected the gradual expansion of government control over supplies of materials. But of the administrative processes now evolving none was more effective or more overdue than the changed methods of making raw materials available to industry. Towards the end of the period the priority system as it had functioned in the early stages of the war fell largely into disuse, and the existing system of allocations was extended more widely and more effectively. Order was thus brought into a field on which chaos had threatened to descend more than once.

The efficiency of the new system was to some extent due to accumulating knowledge and expertise. The Raw Materials Controls, the Raw Materials Department of the Ministry of Supply and with them the Materials Committee at the War Cabinet Office were by the end of 1941 able to obtain from consuming departments and sometimes from industry the information on which a more rational estimate of requirements could be founded. The consuming departments themselves knew better how to scrutinise the requirements of the contractors and how to differentiate between their various needs.

The improvement was, however, one of principle as well as one of routine, even though the improved principle—that of allocations—took a long time to establish itself. In this respect the problem of materials was no different from that of capacity, and was closely involved with it. In both fields the choice lay between the system of priorities as practised in the opening months of the war and the system of allocations. It has already been mentioned[1] that by the spring of 1940 the officials in charge of raw materials well understood the inadequacy of priorities and that by that time something in the nature of an alternative system was in use. Indeed, it looked as if the distribution of raw materials would be improved and rationalised there and then.

The summer of 1940, however, led to a sudden and probably an inescapable revival of the priority system in a form more extreme than was ever previously thought of. One of the earliest acts of Lord

[1] See pp. 92–93.

Beaverbrook's Ministry was to assert the prior claims of aircraft and to do so by direct action, mostly in the form of confidential telegrams to contractors instructing them to concentrate on aircraft orders even if this meant setting aside other urgent work. The effects were instantaneous, and most contractors proceeded to slow up work on munitions orders not included in the instructions from M.A.P.

In the form in which it was being applied the aircraft priority obviously could not continue. On the 27th May 1940 the Minister of Supply raised the issue with the Production Council proposing that anti-aircraft equipment and certain other army stores should be given equal priority with fighters and bombers. This was accepted in principle and led to the Priority of Production Direction of 31st May 1940. This Direction, which represented a new departure, legalised and also broadened Lord Beaverbrook's overriding priorities. Firms were instructed to give first priority to fighter or bomber aircraft, to instruments or equipment for such aircraft, to anti-aircraft equipment, especially Bofors guns, to small arms and small arms ammunition and to bombs. Tanks, anti-tank weapons, machine guns and corresponding classes of ammunition were given priority 1B. Two weeks later a revised Priority of Production Direction dated 14th June included trainer aircraft among the items to be given priority 1A and field artillery among those to be accorded priority 1B.

The system of priorities thus re-established was still so drastic as to endanger the entire flow of war production. Before long M.A.P. itself had to issue telegrams to remove causes of complaint. The Admiralty soon began to press for a review of priorities in favour of the naval repair programme and other needs. The execution of the War Cabinet's decision of 26th May giving priority to defence measures against invasion was creating acute shortages of cement and other building materials. The Ministry of Supply had to ask for high priority for tanks and other army equipment in its efforts to make good the losses of material in France. On the 16th August 1940 the War Cabinet refused an application by the Defence Committee (Supply) for priority 1A for tanks, but at the end of September it laid down that every effort was to be made to complete the programmes of the three Services by the due dates. Instructions were given that the available resources of labour, material and industrial capacity were to be allocated proportionately to the existing supply programmes, the basis of the allocation being determined in relation to strategic priority.

In principle, however, the issue was not yet resolved for Lord Beaverbrook was unable to part with the overriding priorities for aircraft as long as he continued at the head of M.A.P. All that could be done was to redefine the scope of priorities and to ameliorate their

administration. It would be out of place here to trace any but the main phases of that process.

The first phase was ushered in by a spate of wholly legitimate claims to preferential treatment such as those of factories and power stations damaged by bombing. It culminated in an agreement between the Minister of Supply and the Minister of Aircraft Production, to take effect from the 1st January 1941 to extend the Priority Direction of 14th June to cover fresh items, such as radar and machine tools.[1] The final phase was reached in June 1941 when the Committee of Principal Priority Officers[2] initiated a discussion which led to the new Priority Direction of 14th November 1941.[3] The new Direction reasserted the principle of priorities in relation to capacity but not in relation to raw materials. The use of industrial capacity was still to conform to priorities, but the priorities were to be laid down not by general instructions to manufacturers but by certificates. Special priorities served by certificates in the early stages included plant and machinery for balloon-barrages, decoy work for the Admiralty and Air Ministry, chemical shell, laggard elements in the production of cranes, pumps for fire-fighting, bomb-disposal equipment, plant for cordite, smoke generators and telegraphic network for defence.

Yet while the system of priorities was thus being redefined, the practice of allocation revived and grew. It re-established itself first in the administration of raw materials. In October 1940 at a meeting between the Prime Minister, the Minister of Aircraft Production and the Minister of Supply it was laid down that if each ministry kept within its own allocations priority was a matter for its own administration. Thereafter, materials were increasingly distributed by the method of allocations, a method of which officials were now gaining statistical knowledge and practical experience. Where in certain categories of materials 'bottlenecks' were threatened, e.g. in alloy steel, drop forgings and castings, special periodical allocations were made within the total allocation for the material as a whole. After the spring of 1941 priority directives for raw materials ceased to be issued and, as already said, the revised Priority of Production Direction of November 1941 specifically excluded materials from the field of priority.

In dealing with industrial capacity the Central Priority Com-

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[1] Machine tools had not been specifically mentioned in the Direction of 14th June, but had been covered by a further Direction issued on 27th June.

[2] Renamed, in July 1941, the Central Priority Committee.

[3] Issued under Regulation 55, Defence of the Realm, over signatures of the Secretaries of the three Supply departments, the Board of Trade, Ministry of Labour and Ministry of Works and Building and accompanied when sent to firms by an explanatory memorandum by the chairman of the Central Priority Committee.

mittee and the departments did away with priorities somewhat more slowly and more discreetly. Priority certificates were issued very sparingly and were slowly allowed to fall into disuse. Thirty certificates were issued in the first eleven weeks; but in the eight months after the date of the Direction only fifty-three were issued in all, often of limited or temporary validity; and none were issued from May 1942. In the memorandum issued with the Direction of November 1941[1] the chairman of the committee had looked forward to the time when planning and other interdepartmental arrangements would tend more and more to make priority ratings superfluous; and this forecast was justified by events. The Central Priority Committee consistently took the same line and refused to recommend the issue of special certificates where production was planned centrally, on the ground that under such planning the problem was more properly met by allocations. With the development of production planning by interdepartmental arrangement the importance of the Direction constantly diminished, and indeed hardly any meetings of the Central Priority Committee were held after June 1942.

The change-over was so discreet that for a long time the public and even the well-informed Select Committee on National Expenditure failed to notice it. Reporting at the end of April 1941 the committee thought it necessary to draw attention to difficulties still being experienced in relation to priorities and allocations at the factory level.[2] The reply of the Ministry of Supply was that, while there may have been minor difficulties at the factory level in particular cases, which had been resolved when brought to the notice of headquarters, the allocations system could now be said to be working satisfactorily over practically the whole range of capacity and materials.

Indeed there was some ground for satisfaction. Assisted by better estimates both of requirements and supply the officials had in the course of 1941 succeeded in fully organising the distribution of materials and capacity. Towards the end of the year allocations of materials generally took one of two forms. They could be made, as in the case of steel, cotton and timber, on a departmental basis, i.e. the Materials Committee would allocate to each department a certain tonnage and leave it to the department to determine whether or not the Control should issue the material to individual contractors; or else the material, such as rubber, paper and jute, would be allotted not to the department but to the 'end use', i.e. the store to be manufactured. In that case it was left to the Control itself to determine how far an application for a licence conformed to the Materials Com-

[1] See footnote (3) of p. 161.

[2] *Select Committee on National Expenditure*, Session 1940–41, Twelfth Report, dated 29th April 1941, para. 4.

mittee's allocation for that particular use. Allocation of capacity worked on roughly the same basis and, still in broad outline, conformed to the allocation of capacity worked out before the war by the Principal Supply Officers' Committee.[1]

Needless to say the system, like all systems, had its shortcomings and its blind spots. Some firms (on occasion entire branches of war industry) may have been over-provided while others went short, or at least shorter than they need have done had the system of allocations worked with unerring efficiency. But then no system, be it ever so perfect, not even the system of free markets in conditions of plenty and of perfect competition, could have adjusted the supplies and stocks of materials to needs with perfect foresight and precision at every point of war production. There were also other imperfections in the system of allocations as it emerged by the end of 1941. In moments of emergency, which the subsequent two or three years were to experience, urgent demands of the Services were not easy to accommodate within the orderly scheme of allocation, and more will be said about it later.[2] Above all, the system did not cover with equal efficiency the entire field of raw materials. The Materials Committee did not concern itself much with materials which were not yet scarce, with the result that stocks of rubber, tin and a few lesser commodities, plentiful in 1941, became perilously low on the morrow of Pearl Harbour. But it was not the duty and certainly not within the competence of the supply departments or the economic branches of the War Cabinet Office to plan the distribution of materials in 1941 with an eye to the strategic revolution which was to take place in 1942. That revolution was sufficiently great to upset many other things in addition to the supplies of raw materials.

(8)

The Bombers Delayed

The actual production of munitions—the output of war-stores and the build-up of productive resources—grew to match the rising intensity and efficiency of the national war effort. Some such growth would in any case have resulted from earlier preparations, and more especially from the rearmament programmes of 1938 and 1939, for most of the eve-of-war or early war plans for the production of aircraft and army weapons were so spaced out as to reach the peak rates of production some time during 1941 or at the turn of 1941 and

[1] See pp. 37 and 42.
[2] See p. 184.

1942.[1] But there is little doubt about the impetus which production received from the events and the policies of 1940 and 1941. The peak rates were now higher than before, and war industry was moving towards them with greater speed.

At the same time it would be too much to expect that production would everywhere advance at a uniform rate or that the entire chain of summits would be conquered on the dates laid down in the plans. Least of all could this be expected of aircraft production. The peaks of aircraft programmes proved to be so high as to be almost unscaleable; but what finally put them out of reach were the conditions under which the aircraft industry now worked. In moments of exceptional resolution and optimism, such as October 1940 when M.A.P. resumed its long-term plans, the planners tried to project into the future the steep trends of the summer of 1940. Events, however, soon proved that the midsummer spurt could not go on forever. People in factories who had been working hard in long shifts of twelve to fourteen hours (the average day shifts in the main airframe factories were 63·6 hours per week in July 1940 and the average night shifts were 64·9 hours) were by the end of the summer beginning to show obvious signs of fatigue. By the autumn the authorities in M.A.P. resigned themselves to some easing off in the factories and even advised the firms against excessive overtime and Sunday shifts. By that time the stocks of raw materials and components, which were so heavily drawn upon during the spurt, were reaching the point of exhaustion.

On top of all this came the bombing and the dispersal. The programme of 2nd October 1940[2] was initiated in the midst of Hitler's bombing attacks. The first to suffer was an engine repair organisation in Surrey. Then followed the destructive raids on Short's works on 9th and 15th August; the heavy day raid on a Vickers' factory in the Home Counties on 4th September; the heavy day raid on Bristol on 25th September, the effects of which were aggravated by an earlier night raid on the 22nd August; and finally the heavy day raid on the Supermarine Aviation Works on 26th September. The period of heavy night bombing began on 7th September. On 1st December the Supermarine works were badly bombed at night, on 14th November Coventry was 'blitzed', and from 19th to 22nd December there were heavy raids on Birmingham.

Bombing affected aircraft production in several ways. Some of its effects were immediate, others delayed and indirect. The direct destruction wrought by bombing, though by no means crippling, was somewhat greater than public reactions at the time made it appear.

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[1] See pp. 54 and 203.

[2] The so-called Hennessy scheme. See p. 184.

Here and there the destruction was quite damaging, and most damaging of all was the effect of the bombing on certain key plants, especially the B.T.H. (the British Thomson-Houston Company) works. As a result of this attack production of magnetos, and with it of engines, was retarded for several months, and the repercussions continued to be felt for very nearly a year. No wonder people in the Ministry were getting worried.

Lord Beaverbrook's answer to the danger of further destruction was dispersal, i.e. the removal of factories to alternative sites and the distribution among several small units of output hitherto concentrated in single large units. To begin with, the evacuation did not go much beyond the enforced removal of bombed factories. But in the early autumn the prophylactic dispersal of factories, hitherto carried out in special cases, became Lord Beaverbrook's general policy. There is no doubt that thereby the industry was saved from complete dislocation during the later and heavier raids of 1941. It is also certain that the effects on production were neither uniform nor permanent.

The branches most affected were those of engine and propeller production. They had been concentrated in a small number of large units and at the same time lent themselves comparatively easily to thoroughgoing dispersal. Most other branches either could not be easily dispersed or else were not greatly in need of dispersal. Thus the production of most items of equipment and of many components had, to a large extent, been dependent on numerous small factories and was thereby sufficiently immunised from effects of bombing. On the other hand, few of the main assembly shops could be distributed in smaller makeshift units, since the assembly of most types, and especially the assembly of bombers, demanded buildings of suitable height and floor space.[1]

In branches in which dispersal was carried very far, some permanent burdens were imposed upon the industry. The limited resources of management were strained by spreading them over a large number of units; the provision of labour and transport was made more difficult. On the other hand dispersal undoubtedly increased in the long run the potential capacity, for in many cases of dispersal it was necessary to provide some balancing plant in order to set up complete production lines in both the old factory and the dispersal point. When in 1941 the danger of bombing grew less and the policy was officially suspended, the factories previously emptied out by dispersal rapidly filled up again, and the dispersal points in many cases merely provided additional productive facilities. Judged by purely technical standards the additional capacity thus created was

[1] The assembly of Spitfires by Supermarine's could be, and was, dispersed.

not ideal and did not lead to the most economic employment of resources, but it was made available cheaply, quickly and with great economy of constructional labour.

Thus, in the long run dispersal, if not a blessing, was not the curse it had at one time threatened to be. Its 'short-term' effects, however, were most unsettling, and there is no doubt that for a time output suffered to a far greater extent than the public realised. Less acute but equally damaging to output were the recurrent shortages and 'bottlenecks' in the supply of raw materials (mostly light alloys) and components.

The difficulties in the supply of raw materials have already been discussed.[1] In addition, production throughout 1940 and 1941 was repeatedly held up by shortages in manufactured parts and components. These were 'bottlenecks' in the narrow sense of the term, for they were to a far greater extent due to accidents of industrial management than to real shortages of supplies. In a sample of over ten hold-ups due to absence of components between the outbreak of the war and the end of 1941, which has been assembled for the purpose of this study, eight were due to the absence of components or articles of equipment which, in the industry as a whole, were not at the time unduly scarce. They were mostly due to defects in the firms' planning, their progressing technique and their administration of stores. Some such defects occurred in peace-time in the best regulated of firms and were inevitable in war-time, but the general impression is that in 1940 and 1941 the incidence of self-inflicted shortages was higher than it need have been or, in fact, had been or was to be later. Not all the aircraft firms had as yet acquired either the knowledge or the people needed for the smooth administration of quantity production. While some firms either inherited the necessary technique from their peace-time experience or were quick to learn it, other firms were continually struggling with sudden shortages which were largely of their own making.[2]

'Bottlenecks' in the narrowest sense of the term did not, however, account for most of the recurrent shortages. At least as important were the deficiencies of components of a more general kind, which were due to production difficulties or to faulty planning or to both. The best-known examples are perhaps the engines and the propellers. Throughout 1939, 1940 and 1941 the aircraft industry laboured under a gathering shadow of engine shortage. The menace had two aspects—one general and one special. The menace of the general shortage was due to chronic under-provisioning of engines which

[1] See pp. 152-157.

[2] In the early stages of the war the firms with previous experience in large-scale production, even if they happened to be new to aircraft production, found it relatively easy to organise serial production of airframes. See pp. 394-395.

characterised all the aircraft programmes before 1942. The menace was recognised in 1939, was implied in the plan for the 'war potential' and deplored at least once by the Director General of Production. But until the estimates of requirements were put on a new footing in 1942 and until the Merlins began to come in from the United States, the chronic shortage of engines had a depressing effect on both programmes and output.

The special shortages were those of certain types. These were due to a very great number of causes, but chiefly to hazards of engine development and to the independent status of engine firms. A number of engines of which much had been hoped either failed altogether or were available for operational use much later than originally scheduled. The Peregrine, the Vulture, the Sabre, the Hercules VI, the Centaurus, the Griffon are outstanding examples of hopes either disappointed or deferred. And every time an engine failed to appear, or was late in coming forward, a type or mark of aircraft had to be scrapped, modified or postponed, and a gap appeared between programme and output. The difficulties of planning future production will be discussed later:[1] here it will suffice to mention that the complete autonomy which a firm like Rolls-Royce enjoyed over their policy of development, and to some extent over their production —an autonomy which in the case of Rolls-Royce may well have been necessary to sustain the remarkable progress of their engines—made it difficult for the Ministry to lay down well in advance which type would be available and at what time.

The propellers were also a 'hardy perennial'. If the threatening shortages did not all materialise it was only because the demand was often eased by failures in the output of airframes and engines. Moreover, the absence of propellers did not delay production in the sense in which other shortages did, and should not perhaps be described as a deficiency. They could be fitted after the aircraft had left the assembly line and been 'ferried' with borrowed propellers to storage units. Shortages there nevertheless were. The supply of electric propellers was especially precarious, chiefly through difficulties in the parent firm (Rotol), and in 1941 the shortage seriously affected supplies of aircraft to the R.A.F.

Other shortages, in components like under-carriages, in instruments and in armaments, were apt to recur at frequent intervals, and the record of aircraft production was beset by them. The irregular and inevitable character of the shortages as well as the other difficulties of the time must be borne in mind in considering the achievements of the Ministry.

The achievement was most complete and the targets were

[1] See Chapter IX, section (4).

approached nearest in what, for want of a better term, has been referred to as the 'build-up' of resources. As a result of five years of continuous preparation the productive capacity of the industry in 1941 stood very high. Towards the end of the year Lord Beaverbrook formed a settled conviction that the aircraft industry—more especially its airframe and aero-engine firms—possessed all the plant and machinery it needed to satisfy the planned demands and even to meet the Prime Minister's recent request for more bombers.[1] Put as baldly as Lord Beaverbrook was in the habit of putting it, this estimate was not generally acceptable either to officials in M.A.P. or to observers outside, but, broadly speaking, it was not far out. Throughout the preceding five years the industry had greatly added to its floor space and equipment and had accumulated great reserves of productive capacity. Lord Beaverbrook had therefore some reason for thinking that by the end of 1941 not all the reserves had been fully taken up. Some such reserve capacity had indeed been inherent in the peace-time planning of production and was part and parcel of the Air Ministry's schemes under Lord Swinton and Sir Wilfrid Freeman. The general assumption of the pre-war plans was that at the outbreak of war, production would be raised to the scales of the 'war potential' by working the existing capacity with several shifts. This assumption was not borne out by the first year of the war. Under the conditions of late 1939 and early 1940 continuous shifts and shift-working of assembly plant proved very difficult. The increases in war-time output had, therefore, to be based on additions to factory space rather than on fuller use of the existing capacity.

In this way much of the reserve of buildings and plant originally created for the purpose of the 'war potential' continued to be carried and added to in war-time, and its existence was only partly concealed by the somewhat haphazard way in which it was allowed to grow up. Before the end of 1942 it was not even measured; indeed, accurate estimates of the floor space or of machining capacity in the aircraft industry as a whole were not to be had at any time, and were not even available for the purposes of this study. Moreover the reserve was not a fully balanced one and could not have been easily drawn on in time of emergency without some supplementary provisions. Thus, when in the autumn of 1941 the Ministry had to meet the Prime Minister's demands for bombers, it found that four additional factories for heavy bombers would be needed unless shift-working were substantially extended, and that it could not make use of existing capacity without recommending extensions in almost every firm making bombers. But allowing for the additions, the experts in the Ministry were, on the whole, acting on the broad assumption that

[1] See p. 125.

by the beginning of 1942 the aircraft industry would, in terms of floor space and plant, more or less have reached the limit of its expansion. The best evidence of the generous provision which at that time existed is that to the very end of 1942 multiple shift-working was very exceptional in the assembly plant and was not general even in the machine shops or in the engine plant.

This verdict applies not only to buildings and plant but also to that part of productive capacity about which the pre-war planners had been most pessimistic, i.e. machine tools. It will be shown[1] that local shortages in special types of machine tools were apt to occur throughout 1942 and later. But shortages of machine tools in general were overcome or were on the point of being overcome by 1942, and the story of how this was done will, when told, disclose an industrial achievement second to none. In the aircraft industry the general problem of machine tools had lost most of its terrors by the middle of 1941 or even earlier. Even after 1941 it may still have limited the ambitions of the programme makers and circumscribed some of the future plans, but the actual flow of machine tools was more than sufficient to support the rate of expansion in most fields of aircraft production.[2]

So much for the growth of capacity. Still more spectacular, even though disappointing to the Air Staff and at times to the Prime Minister, was the output of aircraft. Measured in units of complete aircraft, the total produced between Dunkirk and Pearl Harbour reached 29,000: monthly deliveries of new aircraft are shown in Appendix 4. There was thus a continuous growth of mere numbers. The average monthly production in the first six months of 1941 was fifty per cent. above that of the first six months of 1940, and it was to rise by another twenty-five per cent. in the subsequent six months.

Needless to say that, measured in real terms, i.e. in terms fully representing the industrial effort, the output rose even more steeply and reached an even higher level than the monthly figures of aircraft would suggest. For in the meantime the unit of account itself, the finished aircraft, increased in weight and complexity. The new fighters which were beginning to come in early in 1942 and which were, in fact, occupying the production line at the end of 1941, the Typhoon and Spitfire IX, were heavier and more complicated structures than the fighters which were turned out early in 1940. Above all, the four-engined bombers which were now coming into production were very complex and embodied an amount of raw materials and man-hours much greater than the lighter bombers they

[1] See p. 208.

[2] A fuller account of machine tools in war industry is given in Section 2(*a*) of Chapter V.

displaced. The airframe structure weight of the Manchester at 16,130 lb. exceeded that of the Wellington and the Whitley by about 5,000 lb. The Halifax at 17,925 lb., the Lancaster (which was not however available in numbers until the second quarter of 1942) at 18,000 lb. and the Stirling at 22,250 lb. were still heavier.

In theory the ideal direct measurement could have been found in the man-hour equivalents of aircraft and spares produced. Unfortunately in the unstable conditions of war production the man-hour figures available to M.A.P. did not provide a wholly satisfactory unit of account. They measured not only the objective value added to raw materials by the aircraft industry, but also the varying efficiencies in the utilisation of labour from firm to firm and from time to time. There were also other statistical objections to man-hour figures about which more will be said later.[1] For what they were worth, the figures of man-hours of airframe production appeared to rise after the beginning of the war by the following stages:

Date	*Man-hours per month in 000's*
September 1939	13,485
July 1940	28,702
February 1941	29,312
Average for March–July 1941	30,440
Average for August–December 1941	34,610
Average for January–May 1942	41,153

For purposes of general demonstration the Deputy Directorate General of Statistics and Programmes employed the measurement of structure weight which brought out a rise of production far more striking than that suggested by the number of aircraft or the figures of man-hours.

The figures are as follows:

Year	*Approximate structure weight of aircraft in million lb.*
1939	29
1940	59
1941	87
1942	134

Needless to mention errors are also implicit in a measurement based on weight. Ordinary commonsense would suggest that the amount of productive effort, i.e. economic value added per pound of weight, does not rise proportionately to the total weight of aircraft. Whereas in 1940 the weight of the Stirling was eleven times that of the Spitfire, their man-hour equivalents differed only in the ratio

[1] See pp. 464–466.

of 5 : 1.[1] This means that a ton of heavy aircraft represented less added value and a smaller industrial effort than a ton of lighter aircraft. And this also means that, with the rising proportion of heavy aircraft in the programme, the index based on structure weight carried the danger of over-estimating the 'real' output.

To meet this objection the statisticians in M.A.P. attempted in 1943 an index of production based on structure weight figures corrected for each of the three main classes of aircraft by their corresponding man-hour equivalent for 100 lb. of weight. Thus corrected, the index of production probably approaches nearest to real measurement of aircraft output, and the monthly figures reflect very closely the fluctuations in industrial achievement. (See Table 19.)

These figures are well supported by indirect indices of production: the financial turnover, the throughput of raw materials, the labour force. The average annual cost of aircraft purchased from the industry by the Air Ministry and M.A.P. is represented in the figures of the so-called production expenditure.[2] These figures as shown in Table 20 reveal nearly an eighty-fold growth between 1934 and the end of 1941 and an increase of nearly fifty-five per cent. from 1940 to 1941.

[1] As early as January 1940 when the first war-time programme embodying the heavy bombers was settled, it was reckoned that ratios of weight to man-hours would, for the principal types, work out as follows:

	Airframe structure weight	Average man-hours	lb. structure weight per 1,000 man-hours
FIGHTERS	lb.	thousands	
Spitfire	2,055	15·2	135
Hurricane	2,468	10·3	240
Whirlwind	3,461	26·6	130
Tornado	3,600	15·5	233
BOMBERS			
Battle	4,466	24	186
Whitley	9,557	52	184
Wellington	10,117	38	266
Manchester	15,650	52·1	300
Halifax	16,157	76	213
Stirling	23,630	75	314

The actual figures, especially those for man-hours, were modified in the course of the subsequent three years, but the basic relations between weight and man-hours remained the same, and the heavier aircraft continued to require much less manpower per pound of weight than the lighter ones.

[2] The production-expenditure figures of the Air Ministry, and later of the Ministry of Aircraft Production, are not an accurate statement of the money values of aircraft production, for they include expenditure on a number of other stores consumed by the R.A.F., such as bombs, ammunition, ground equipment, as well as the sums spent on research and development and the assembly of American aircraft, and numerous other items. But the cost of aircraft accounted for the bulk of the outlay and, moreover, the expenditure on most ancillary stores moved with the size of the R.A.F. and with the volume of aircraft production. The figures, therefore, exhibit the trend of aircraft production even if they do not measure its magnitude.

Structure weight index of aircraft production corrected by man-hour equivalents

(Production in January 1942 = 1,000)

TABLE 19

	1940	1941
January	333	527
February	300	748
March	373	807
April	463	721
May	569	810
June	736	792
July	735	808
August	731	857
September	581	930
October	609	915
November	635	897
December	563	829

United Kingdom production-expenditure on aircraft, 1934–42

TABLE 20 £ thousands

Year	*Production-expenditure*
1934	7,531
1935	12,070
1936	26,886
1937	44,700
1938	76,718
1939	147,009
1940	344,200
1941	530,824
1942	690,000 (estimated)

The other indirect indices—materials and labour—expanded in roughly the same proportion as money costs. The volume of fabricated alloys produced in the country under the Ministry's control and allocated for the production of aircraft rose from about 4,000 tons in September 1939 to 10,300 tons in December 1940, and to about 14,500 tons in December 1941. The total labour force in the various trades engaged in aircraft production rose from approximately 840,000 in August 1940 to 1,015,000 in January 1941, and to 1,326,100 in December 1941.

The measurements, whether direct or indirect, thus make it abundantly clear that over the period as a whole production expanded at a striking rate. The different indices may exhibit different rates of growth, but even the most conservative measurements, such as those of complete aircraft or of man-hours, cannot obscure the achievements of aircraft production. From the point of view of the Ministry the achievement appears all the more remarkable for its other activities. It had to conduct a vast amount of research and experimentation, the results of which were not directly reflected in

the quantitative measurement of output. It had to equip whole factories for aircraft so advanced as to be wholly outside programmes. It had to organise the repair of aircraft on an unprecedented scale, to run emergency services in connection with air raids and defence and to supply a vast amount of ancillary R.A.F. equipment—everything from bombs to balloons. In addition, it placed orders in the United States and the Empire for which productive capacity had not only to be found but also to be created anew.

The achievement was thus truly outstanding; yet, great as it was, it was less than the plans. Throughout the period there were wide gaps between expectations as reflected in programmes and achievement as measured by current output. At certain periods gaps between programmes and output were fully expected and were, in a sense, even intended. The 'Harrogate' programme of January 1940 was perhaps the last fully realistic programme which its makers expected to be achieved in full. After that time the whole conception of programmes appeared to change. They came to be regarded as 'targets', i.e. as points set sufficiently high to prompt the industry to greater efforts. This was certainly Lord Beaverbrook's theory.[1] In so far as he had any use for programmes he employed them as stimulants to performance. He believed that an object outside the industry's reach would set it straining at the leash and would also reveal the weak points and the potential 'bottlenecks' for the civil servants and the industrialists to clear. It was on this theory that the 'Hennessy' programme of the autumn of 1940 was constructed. With the downward revision of the programme in March 1941 the more optimistic of Mr. Hennessy's margins were reduced, but they were not cut out altogether. And before long the administrators in M.A.P. began to take the unrealistic margins for granted. During the discussions on the Prime Minister's bomber programme the Ministry officially informed the War Cabinet that fifteen per cent. of the programme would, as a matter of course, remain unrealised. Indeed, it was not until the days of Sir Stafford Cripps and the so-called 'realistic' programme of January 1943[2] that a definite attempt was again made to plan aircraft production without fictitious margins.

As long as the optimistic margins were there[1] the lag between programmes and production was unavoidable and need not have bothered the observers any more than it worried informed people in the Ministry. What was worrying was that now and again the lag was far wider than the mere doctrine of optimistic programming allowed, and that it was, as a rule, widest at the points at which the fulfilment of programmes was most vital.

Over the entire field of aircraft production the leeway may seldom

[1] See p. 124.

[2] See p. 307.

have exceeded the conventional fifteen per cent. but frequently, and more especially in the second half of 1941, the 'overall' gap of fifteen per cent. concealed larger and obviously unpremeditated 'shortfalls' of the aircraft types most in demand, and principally of naval types and heavy bombers. Whereas the easy and well-established types of fighters and reconnaissance aircraft kept up with the forecasts, the bombers, especially the new and heavy ones, fell behind sometimes by as much as forty-five per cent. The drag in the bomber output became most pronounced and most disturbing in 1942 and 1943. Its significance and its causes will, therefore, be more conveniently discussed in a later chapter.[1]

(9)

The Shells and the Guns

The output of war-stores for which the Ministry of Supply was responsible had also been mounting very fast. The combined index of production worked out by the Statistical Department of the Ministry of Supply showed that total output during the period between May 1940 and December 1941 rose by more than 100 per cent. The movements from month to month are shown in Table 21.

Index of Ministry of Supply output of war-stores,[2] *May 1940–December 1941*

(Average of four months September to December 1939 = 100)

TABLE 21

1940	
May	206
June	256
July	253
August	245
September	217
October	245
November	242
December	239
1941	
January	244
February	266
March	303
April	284
May	319
June	319
July	327
August	347
September	387
October	404
November	429
December	431

[1] See Chapter VI, Section (4).

[2] Includes total completed warlike stores, engineering and allied stores, clothing and equipment.

This index was based on the money value of output calculated at fixed prices and gives a good indication of the actual volume of deliveries. It reflects very closely the other indices of industrial effort. Thus the number of operatives employed on Ministry of Supply work in engineering and allied, explosive and chemical industries grew from 774,900 in January 1941 to 1,206,400 in December 1941, a rise of fifty-six per cent. There was thus a steep and general rise.

The Ministry of Supply's general index, however, greatly oversimplified the actual movements of production. Like all indices of this kind it aggregated a large assortment of trends, and it so happened that the output of the Ministry of Supply was much more varied than that of M.A.P., and the stores it produced could not in the end be expressed in terms of a single equipment like the aircraft. It is, therefore, not surprising to find that behind the trend of growth extending over twenty months lay concealed achievements both higher and lower than the aggregate trend. The detailed record of the principal stores taken individually is shown on Table 22.

Individual stores lagged behind the programmes in varying measures. As in the previous period, production of most 'general stores' was buoyant even though their total output did not grow as fast as it had done in the earlier months. This was partly due to cuts in army requirements and partly to the very success with which earlier requirements had been met.[1] Much more uneven was the record of the three main classes of munitions: of ammunition, artillery and tanks.

The ammunition programme presented the greatest difficulties. From the outset it was in the output of ammunition and, above all, in filling that deficits were greatest. When in the winter of 1939–40 the Military Co-ordination Committee of the War Cabinet surveyed the requirements of the B.E.F. in France, ammunition of almost every class was included in the highest or the 'worst found' category of deficiencies. And right until the end of 1940 the deficits of the earlier requirements added to the Ministry's liabilities under current programmes weighed on the Ministry like a millstone.

The difficulties and delays arose from the very nature of ammunition regarded as an industrial product. The making of small arms ammunition, and most of all the filling of shells, had *ex hypothesi* been regarded by the planners as a task for which the greatest and most difficult preparations would have to be made. Not all branches of ammunition production were equally 'difficult'. In the manufacture of 'empties' and of most other components the fruits of preparatory planning could be reaped quite early. By means of new technical

[1] For example, with the rapid expansion in the manufacture of army clothing and the greater economy in Service requirements, actual production of greatcoats and battledress could be scaled down after the spring of 1941.

Ministry of Supply: deliveries of important groups of stores, May 1940–December 1941

TABLE 22

Units unless otherwise stated

Month and year	TANKS	GUNS			RIFLES	GUN AMMUNITION[1]	SMALL ARMS AMMUNITION[2]	WHEELED VEHICLES: ARMY[3]	CLOTHING	
	medium and heavy	25-pdr.	3·7-in. A.A.	Other guns: 2-pdr. Bofors and over	·303 in.	(all filled shell)	·303 in.		Army battle-dress trousers (Deliveries during four- or five-week periods)	Army and R.A.F. greatcoats (Deliveries during four- or five-week periods)
1	2	3	4	5	6	7	8	9	10	11
						Thousands	Millions		Thousands	Thousands
1940										
May	113	42	125	221	9,618	999	66·3	27,210[4]	898	406
June	115	42	136	303	7,387	1,199	67·8		702	176
July	129	60	183	357	8,722	1,369	56·7	9,624	803	178
August	126	72	136	297	8,919	1,217	49·4	8,779	1,394	216
September	122	78	148	301	8,676	971	38·0	8,444	756	206
October	144	108	104	349	6,197	1,285	41·2	8,154	861	333
November	113	120	92	266	5,003	1,310	50·8	7,322	1,041	471
December	170	153	115	343	4,549	1,366	53·5	6,145	888	446
1941										
January	201	193	125	496	3,311	1,498	63·4	6,428	950	538
February	203	196	113	451	1,983	1,634	70·5	8,163	924	482
March	249	234	142	572	3,160	1,608	87·8	8,370	1,317	501
April	247	287	106	547	2,387	1,534	83·8	8,259	1,406	383
May	332	408	124	647	5,493	1,934	99·3	8,280	1,195	263
June	337	310	119	884	4,034	1,848	96·2	7,313	807	201
July	360	337	91	950	3,278	2,376	116·1	7,261	857	207
August	460	439	158	1,045	3,408	2,784	99·5	6,489	399	136
September	528	466	171	1,368	5,900	2,978	95·0	6,167	445	143
October	595	523	196	1,695	10,930	3,139	113·1	6,273	397	190
November	610	582	153	1,820	13,749	3,915	110·7	5,822	173	98
December	649	452	177	2,025	16,324	4,333	124·6	5,484	109	74

[1] Excluding naval.
[2] Factory production.
[3] Lorries, trucks, ambulances and heavy cars.
[4] Deliveries during the quarter, April to June 1940.

methods and with the help of specialised plant ordered and installed during the years of rearmament it was possible to use the manufacturing capacity of 'outside' firms[1] in the engineering and other industries and thus to avoid the delays and expense of brand-new factories. Similarly, the manufacture of explosives could at least in part be planned as an extension of the peace-time activities of the chemical industry. New factories for the making of explosives had, however, to be planned and erected, and at least eleven new explosives factories were approved for construction between 1936 and the end of 1939. But the work of technical preparation and the responsibility for the erection of factories and their managements could be shared with chemical firms in the country, and in the first place with I.C.I. From 1929 onwards I.C.I. and the Royal Ordnance Factories collaborated over the technical problems of explosives production, and from 1936 onwards their collaboration extended to the design and construction of explosives factories.

The ability of private industry to share in the work doubtless facilitated the smooth and early completion of the explosives programme. By the end of 1941 almost the entire programme of explosives factories was completed (only one R.O.F. in the North-West was still under construction and that factory was completed by the middle of 1942). This does not mean, of course, that production in 1940 and 1941 was sufficient for all needs, present and future. The scale on which new capacity was provided fell short of what the War Office considered necessary for the full war potential. But such gaps as appeared between 1939 and 1941 were met by developing further capacity in North America; and, in general, the output of explosives and of the chemicals needed for them at no time fell below the demand of the filling factories.

The crux of the problem was in the filling of gun ammunition. The experience of the last war showed that the expansion of filling capacity was fraught with many difficulties. There was no private industrial experience on which to draw, very little peace-time equipment to serve as a nucleus and no peace-time buildings capable of being adapted for filling. From the very beginning of pre-war planning it was, therefore, assumed that filling would have to be done in the Royal Ordnance Factories and that responsibility for the erection and management of the factories would be entirely in the hands of the Ministry of Supply, or, to be more exact, of the Directorate of the R.O.F.s within the Ministry.

A large network of filling factories was in fact planned, though the size of the new capacity provided under the earlier programmes was, from the point of view of the War Office, insufficient for the needs of

[1] See p. 399.

the war potential.[1] Under the pre-1939 plans R.O.F. Hereford had been reconstructed, R.O.F. Chorley and two other large filling factories had been commenced, and, when in the spring of 1939 the thirty-two-division plan was formulated, six more filling factories had to be planned. Of these, three were laid down in the autumn and winter of 1939–40, and in the spring of 1940 two more were laid down. When in April 1940 the final war-time scales for the thirty-six divisions at Z + 24 (31st August 1941) reached the Ministry of Supply, another ten small (half-size) factories were designed, of which six were actually laid down. The scales of August 1940[2] were met in November and December 1940 by plans to erect sixteen additional factories, of which six were mainly to meet the new demand for anti-aircraft rockets (U.P.) and aircraft bombs.

Whether a programme of nearly forty filling factories (by November 1940 some thirty-six factories to employ 287,200 workers on a two-shift basis had been projected) could have been completed and manned in time for the programme is very doubtful. Fortunately, by the early summer of 1941 the Ministry of Supply found itself in the enviable position of having its programme of current output of filled ammunition approaching fulfilment, without the necessity of completing its factory programme in its entirety. Some incidents of this 'success' story have already been told;[3] others will be dealt with later,[4] but most of them deserve re-telling here. For one thing they suggest an interesting comparison with contemporary developments in the aircraft industry.

The filling factories had by the summer of 1941 accumulated a reserve capacity which was, if anything, greater than that in aircraft firms. Some of the excess capacity was intentional in so far as it had been planned as an insurance against various contingencies, and in the first place against attack from the air. Generally speaking, it had been assumed that the filling capacity overseas, situated principally in Canada and equal to fifteen to twenty-five per cent. of the total, should be regarded as an insurance for the home programme. But filling capacity abroad was itself subject to risks, chiefly those of transport. Consequently some extra capacity for insurance had to be provided in this country, and in at least one case was specially asked for by the 'user' Service (the Admiralty).

Even greater excess was bound to result from the conservative planning of the R.O.F.s. In computing the numbers and the layout of filling factories the technicians at Woolwich had to assume efficiency per square foot of floor and per worker lower than that

[1] See p. 46 and p. 112.
[2] See p. 135.
[3] See pp. 134–36.
[4] See pp. 352–53.

theoretically possible. Hand labour had to be planned for and unskilled hand labour at that. It is not that the processes could not be, or were not in fact, successfully mechanised. A committee, with the chief mechanical engineer of the Woolwich factories, had worked out various ways of mechanisation as early as 1936, and the subject had been periodically raised on several occasions in the intervening years. But mechanisation in filling factories had many and obvious limits. Some of the processes, especially those of multiple filling, lent themselves badly to mechanised mass production, while those processes, which in theory were capable of being mechanised, proved difficult to standardise owing to continuous changes in specifications. In any case the layout of factories would have made it impossible to employ much large-scale machinery. In spite of the immense scale of the first ten R.O.F.s, the individual units within them had, for safety reasons, to be kept small in scale and much dispersed. Production was therefore seldom concentrated in single blocks large enough to allow the use of large-scale machinery and, above all, conveyor belts. Factories were therefore planned very largely as 'manufactories' in which the operations, done mostly by hand or by small tools, would be carried out by large masses of hand workers.

In addition, the technicians at Woolwich had to assume that the labour force available to them would be of low average quality. Not only had they to make an allowance for the difficulties of recruitment, but they also knew that trained labour in the country was very scarce and that the skilled cadres in Woolwich capable of training new labour were very exiguous. They therefore planned on the assumption that future production per head would start very low and that it would take as long as eighteen months to reach the pre-war levels of output at Woolwich. Nor did they think it safe to count on the introduction of all the possible incentives and efficiency devices or on the working of continuous shifts. Two shifts were considered a practical maximum, and this alone was bound to lead to a margin of capacity above the minimum required under three-shift working.[1]

In these respects the record of the R.O.F.s in the first two years of the war was somewhat different from that of the aircraft factories. The latter had been planned on the assumption that their productivity would grow much faster and that continuous shift-working would be introduced more generally than in fact proved possible in 1940 and 1941. On the other hand, the R.O.F.s succeeded in introducing all the efficiency schemes on which the Woolwich planners in their caution had refused to bank. In the first place, continuous

[1] Equally inevitable and even less clearly foreseen was excess capacity which accumulated as a result of continuous modifications in the technical specifications of the Services. As a result of these changes capacity created for the type no longer required was frequently reduced to a temporary or permanent unemployment.

shifts proved practicable. In response to tentative promptings from various quarters—from the War Cabinet and the Prime Minister personally, as well as from within the Ministry itself—the Director General of the R.O.F.s decided at the end of January 1941 to reorganise the work in all the factories on the basis of three shifts. The transition was quickly carried out, and, as a result, the output of the existing factories was expected to rise by at least thirty-three per cent., and in fact rose higher, as shown on Table 23; and this alone was sufficient to make the latest provision of sixteen factories, and even some of the 'second ten' factories, redundant.

Both before and after this decision other marked changes in efficiency were taking place in nearly all the ordnance factories. The work of the factories was not greatly interrupted or disturbed by air-raids, the managerial staff were becoming more expert, the workers more skilled. But the most powerful impetus to higher output came from the various efficiency measures adopted in several of them on the initiative of the headquarters of the R.O.F.s themselves. Between January and the summer of 1941 piece rates and output bonuses were introduced. 'Time and motion' studies, statistical controls of quality, improvements in welfare and in background conditions followed. In January 1941 when the policy of incentives was first adopted its sponsors expected a rise of from ten to fifteen per cent., but subsequent experience may well have exceeded their expectations. It is, of course, difficult to assign to each factor its right share in the growing efficiency of labour. The fact, however, remains that by the end of 1941 the Ministry could plan with the knowledge that the efficiency of filling labour was fully forty per cent. above its level eighteen months previously.

This in itself would have made much of the planned capacity redundant; and when in the summer and autumn of 1941 the Ministry agreed on a lower scale of ammunition requirements, this redundancy became still greater. The Ministry was now able to concentrate filling in a much smaller number of factories, most of which were already in operation and all of which could be, and in fact were, fully manned and working in the summer of 1942. Of the ten filling factories in the second batch, i.e. those planned under the thirty-two-division programme of 1939, three were cancelled. The sixteen small factories planned in the summer of 1940[1] were not proceeded with at all.

Needless to say, the effect of the situation on the numbers of people employed was relatively small, since the whole purpose of the reorganisation was to enable the existing factories to carry a greater amount of manpower. Nevertheless the higher efficiency of labour

[1] See p. 178.

made it possible to plan for a much smaller intake. In a note circulated in May 1941 the Director General of Programmes could report with obvious satisfaction that, whereas the rate of filling in 1942 would be two-and-a-half times as great as in the second half of 1941, the labour force would grow from about 125,000 to 175,000. Thus 150 per cent. more output would be coming from fifty per cent. more labour.[1] In the event, the additions to the labour force turned out to be even smaller than the D.G.P.'s note assumed. Employment in the filling factories which had risen from about 70,000 at the end of March 1941 to 145,000 at the end of December, rose only slightly above that level in the subsequent six months and remained at the level of approximately 155,000 for the remainder of the year. With this labour force the Ministry was able to fulfil by the summer of 1942 the planned supply of ammunition as well as some requirements for special types of ammunition which had been added to the programmes in the meantime. By then the problem of filling factories as it figured in a report of the Select Committee on National Expenditure and in Parliamentary debates[2] had ceased to be one of deficiency and had become one of over-fulfilment. There soon grew up an impression that as a result of faulty planning the country was overprovided with manufacturing capacity. The Ministry had no difficulty in rebutting the argument. For by the time the programme of filling factories was suitably reduced and reorganised, i.e. by the spring of 1942, productive capacity for ammunition was not much in excess of 40 per cent. above current requirements. And this proved to be not too wide a margin to be kept in hand for the time when fighting should flare up.

The supply of small arms ammunition was another difficult problem.[3] It had always been assumed that the nature of small arms ammunition was such as to necessitate special and largely self-contained factories for its manufacture. But before 1939 the demands of the Services were not yet very great, and the vast war-time programmes of small arms ammunition were still a thing of the future. Compared with existing demand and with current expectations of future demand the potential capacity available in peace-time at Woolwich, Imperial Chemical Industries and Greenwood and Batley was quite large. There was thus little need for additional factories until the summer of 1939 when the requirements of the Army and of the Air Force were reassessed. By January 1941 some

[1] The D.G.P.'s figures somewhat overstated the position. The rates of filling for 1942 were barely twice those planned early in 1941 for the second half of that year.

[2] *Select Committee on National Expenditure*, Session 1941–42, Eleventh Report, dated 17th July 1942, paras. 3–7; H. of C. Deb., Vol. 382, Cols. 1071–1154, 5th August 1942.

[3] The difficulties applied in equal measure to the making of cartridge cases, other components and to filling. Unlike filling factories most small arms ammunition factories manufactured components as well as undertaking the bulk of their own filling.

eleven new small arms ammunition factories had been approved. As at least twelve months had to elapse before production in the new factories could begin and at least eighteen months before it could be brought up to peak, it is not surprising that output of small arms ammunition appeared to lag. Maximum planned rates were not achieved until well into 1943; for 20-mm. ammunition not until 1944. Yet considering the late start, the expansion of production by the end of 1941 was very rapid. That thereafter the insatiable appetites of the Air Force and the Army for small arms ammunition could be satisfied was a remarkable achievement.

Production of ammunition during 1941

TABLE 23

	Gun ammunition	Small arms ammunition
	Thousand rounds	Million rounds
1941		
January–March	4,569	239·3
April–June	5,185	318·7
July–September	7,758	356·2
October–December	10,660	384·2

Source: Statistical Digest of the Second World War, Tables 123 and 125

Ammunition was an instance of a difficult problem solved. Of the other difficult items some were in a position almost equally good, others were not. The teething problems of the 25-pounder and its carriage were solved, and by the turn of 1941 and 1942 the makers (R.O.F.s and private firms) had reached the peak rates of production.[1] The makers of some small arms were approaching their peak rates of production; rifles were still coming through slowly, but Sten guns began to be turned out in large and growing quantities once the production line was equipped and set up at the R.O.F.s in the North-West and in a number of private firms.[2] The production of anti-aircraft equipment developed more slowly, but in the end caught up with the programmes. The production of the 3·7-inch medium anti-aircraft gun was one of the first production jobs tackled by the Ministry in the early years of expansion, and the first of the new engineering R.O.F.s was mainly devoted to this task. But so complicated was the equipment and so great were the requirements for it

[1] The peak rate of production of the 25-pounder gun had been reached in November 1941 at 582 units a month. The peak rate of production of the 25-pounder carriage had been reached in October 1941 at 405 units a month.

[2] The home production of Sten guns was:

1941:	November 250	*1942:*	January 5,337
	December 6,068		February 27,234
			March 96,889

that the output, although high,[1] lagged well behind requirements. The Bofors gun, on the other hand, which took a long time to get into mass production, was at last beginning to be turned out at a really good pace, and output promised to catch up with programmes in the course of 1942.

Production of Bofors guns, tank and anti-tank guns, May 1940–December 1941

TABLE 24 Units

Year and month	Bofors guns	2-pdr. T. and A.T. guns	Year and month	Bofors guns	2-pdr. T. and A.T. guns	6-pdr. T. and A.T. guns
1940			*1941*			
May .	81	126	January .	155	281	nil
June .	119	169	February .	144	246	nil
July . .	128	200	March .	213	319	nil
August .	124	148	April .	176	325	nil
September.	116	150	May .	190	392	nil
October .	138	211	June .	250	567	2
November.	104	157	July .	225	674	1
December .	119	215	August .	233	721	4
			September	270	985	1
			October .	301	1,262	13
			November.	260	1,393	32
			December .	295	1,382	146

If the record of the anti-tank and tank gun did not appear in quite as favourable a light, the explanation was to be sought not so much in industrial difficulties as in the policy of the departments and in the uncertain and constantly changing requirements of the War Office. From this point of view the problem of the anti-tank and tank gun was closely bound with the tank itself.

(10)

The Tank and its Gun

By the summer of 1941, largely under the influence of Rommel's first offensive in Libya, the public suddenly woke up to the deficiencies of British tanks. The problems of tank design and production had been exercising the Prime Minister, the War Office and the Ministry of Supply for some time, but now criticism in Parliament and in the Press, combined with alarming reports from the field of battle, made the production of tanks appear as the sore spot of the munitions industry. A sore spot it was to remain until the later stages of the European battle in 1944.

[1] The peak monthly rate of production of 3·7-inch anti-aircraft guns was reached in March 1942 at 228 guns.

The making of tanks was of course fraught with very great difficulties. On the eve of rearmament the country possessed hardly any of the equipment or experience needed to make up-to-date tanks. Between the two wars the manufacture of armoured fighting vehicles fell into desuetude, and Vickers-Armstrongs alone had some of the necessary plant and skill. New capacity had therefore to be created and educated, and by no means all the capacity drawn into the production of tanks at that stage turned out to be as suitable as had once seemed probable.

Production of tanks in quantity did not begin until several months after the outbreak of the war, and no sooner had it begun than the difficulties common to all war industry, above all shortages of skilled labour and materials, piled up. To overcome them sooner than they were being overcome in other branches of war industry, tank production needed preferential treatment. But the general priority direction of 14th June 1940 did not give tanks the highest priority, and certainly not the overriding priority which was enjoyed by aircraft production.[1] On 22nd July 1940 the Minister of Supply formally drew the attention of the Defence Committee (Supply) to the fact that the production of tanks did not figure in Priority 1A, whereupon the Committee on the Prime Minister's recommendation invited the Production Council to consider the inclusion in Priority 1A of the manufacture of tanks. The Battle of Britain, however, prevented this instruction from bearing fruit,[2] and throughout the subsequent six to eight months the Ministry of Supply continued to complain that tank production was suffering from the overriding claims of aircraft production, especially in the matter of stampings and drop forgings. It may well be—as it was at one time alleged—that the chief effect of the absence of highest priority was psychological; but some of the effects were more material than that. Even though the system of priorities was soon superseded by the fixing of allocations between the different branches of war industry, higher priority was still accorded to aircraft, and the old system was still exercising a drag on tank production. At the first Tank Parliament—a name given to a series of conferences on tank production convened in 1941[3]—it was made clear that the two branches of production clashed in machine tools, gauges, tool-making capacity, and, to a certain extent, skilled labour. It was not until 9th July 1941 that the Production Executive decided to put on record at once for the guidance of departments, committees, etc., that the production of tanks (including spares), 2-pounder and 6-pounder guns and armour-piercing ammunition should be treated as on a footing with the production of articles to

[1] See p. 160.
[2] *Ibid.*
[3] Under the chairmanship of the Prime Minister and attended by representatives of the supply ministries and the Services.

which first priority was given under the General Priority Direction of 14th June 1940.

Production was, nevertheless, rising all the time, though very slowly at first. In the pre-Dunkirk period of the war, i.e. from the beginning of September 1939 to 1st June of the following year, 739 tanks were produced and the average monthly rate was about 82. By the end of 1940 the total produced since the beginning of the war rose to 1,713 and the average monthly rate in the last quarter of the year approached 150. A year later still, at the end of December 1941, the total produced since the beginning of the war was 6,554 and the average monthly rate in the last quarter was 626. This total was within about twenty per cent. of the full Z+27 requirements as defined in August 1940 (see Table 25).

Thus, judged by figures of production alone, the supply of tanks at the end of 1941, or even in the early summer of that year, would not have justified the prevailing sense of great inferiority to the enemy. The evidence which has since come to light shows that German production of tanks in 1941 measured by numbers was not superior to the British. But the supply of tanks was not, and could not have been, judged by numbers, even had the British and the German numbers been known at the time to the critics in the Army and in the Press. The success of British tank production was judged by performance in the field, and thus judged the British tanks were unequal to all the battle requirements at that time and were to remain unequal for at least another two or three years. This should not, of course, be taken to mean that British tanks were in every respect inferior to the German tanks encountered in the early years of the war; but there is little doubt that, except for armour, the inferiority of British tanks became more marked in this period.

Of the various characteristics that determine the quality of the tank as a weapon—armour, armament, speed and reliability—armour was, to begin with, and remained for a long time fully equal to the demands of battle. Ever since the decision taken in 1938 to provide an armoured force for operations in France,[1] the General Staff had laid continual stress on heavy armour. The British infantry tanks, including the Matilda and the Valentine, carried armour capable of resisting such artillery and anti-tank weapons as the Germans were known to possess at the beginning of the war. When, early in 1940, it was realised that the Germans were developing a better anti-tank gun (the 50-mm.), the War Office specification for armour rose accordingly. In the design of the A.22 (the future Churchill), 3-inch armour for the more vulnerable parts was laid down in the original specification; this was, on the insistence of the War Office, increased to 3½-inch to safeguard against the anticipated developments in German

[1] See p. 70.

Production of tanks to December 1941

TABLE 25

Units

	Total	Cruiser	Infantry	Light
Pre-war	1,148	79	67	1,002
1939: September–December	314	71	63	180
1940: January–March	218	92	46	80
April–June	340	159	121	60
July–September	392	147	227	18
October–December	449	78	354	17
Total deliveries September 1939 to December 1940	1,713			
1941: January–March	653	184	469	nil
April–June	943	347	566	30
July–September	1,368	406	942	20
October–December	1,877	479	1,375	23
Total deliveries September 1939 to December 1941	6,554			
Total deliveries including pre-war	7,702			
Total required by 30th November 1941 (Z+27) — as estimated August 1940	9,926[1]			

[1] Exclusive of 518 cruiser close-supports shown in Tables 13 and 15.

anti-tank weapons. The cruiser tanks operating in the Desert were, of course, relatively lightly armoured, but the design of the Cromwell, as defined in the second half of 1941, was based on the assumption that it would be as heavily armoured as the infantry tanks of 1940.

As a result of the General Staff's emphasis on adequate armour, British tanks were in this respect equal to the demands of battle until the German Tiger tanks appeared in the battle of Normandy. The bulk of the tanks with which the Germans overran Poland were apparently of the thinly-armoured light type. They had relatively few heavy tanks in France, and those they had did not carry heavier armour than the infantry types with which the British Army was at that time being supplied. Nor were Rommel's heavy tanks more thickly armoured than the British types which they confronted in the Desert. The bulk of the German heavy vehicles in Libya, KW.3 and KW.4, carried armour which in its more heavily protected parts did not exceed 65 mm. In comparison, the armour in the vulnerable front parts of the Matilda was 75 mm. in the turret and 78 mm. in the hull, and in the Valentine 65 mm. and 60 mm. respectively. The corresponding figures for the Cromwell were 76 mm. and 63 mm.; the Churchill carried an armour of 88 mm. in the turret and 101 mm. in the hull.

Much less satisfactory was the relative speed of British tanks. Until the arrival of the Cromwell, engined by a Rolls-Royce Meteor, most British tanks suffered from an unfavourable weight-to-power ratio. This was in part a penalty paid for their defensive qualities, for all attempts to increase armoured protection invariably made inroads on speed. The Infantry Mark I (Matilda I) tank was the outstanding example of encroachment of armour on speed, but the speeds of the Mark II (Matilda II) at 15 m.p.h. and of the Valentine (Infantry Mark III) at 13 m.p.h. also proved inadequate for operational requirements, and the explanation in each case was the weight of armour relative to the power of the engine. As a compromise, the War Office had accepted in 1938 the low speed for the Valentine and Matilda tanks; but the Battle of Flanders was to reveal how unsatisfactory the compromise was. Although the British tanks were, type for type, superior in armoured protection and fire power, some of them, particularly the infantry tanks, were outmatched by the speed and manœuvrability of the German tanks.

For this in the final resort the engines were mainly to blame. In this respect more than any other, British tank production paid the price for the neglect in development between the two wars. German tank designers were able to draw upon well-developed tank engines of high power; in Great Britain tank designers had, until 1940, to use in infantry tanks engines which did not much exceed 150 horse-power and which had been designed for commercial vehicles. The only

engine of greater power specially designed for infantry tanks was the Vauxhall which was used in the Churchill, but it unfortunately proved to be insufficient for the ever-growing weight of that tank. The two highest powered engines to be used in British tanks—the Liberty and the Meteor—were adaptations of aircraft engines. The former, dating back to the 1914–18 war and adopted in British cruiser tanks in 1938, provided adequate power, but proved in many ways unreliable and difficult to maintain. The Meteor—at over 600 horse-power it was by far the highest-powered tank engine—was not to be available in quantity until much later.

The design and development of the Cromwell (a tank which was to form the backbone of the British armoured formations in the battles of 1944) hinged upon the supply of an engine of very high power. Two such engines were considered and developed. One was the Ford V.12 which was being developed in the United States, and the other (it became in the end the standard engine for the tank) was the Meteor, an adaptation for tank purposes of the Rolls-Royce Merlin aircraft engine. But unfortunately the Cromwell programme had to be launched with the supplies of Meteors not yet fully secured, and the deficiency of Meteors had for the time being to be made up by the Liberty engine. It was not until late in 1942 that the supplies of Meteors became sufficiently assured to solve for the time being the problem of tank engines.

The point at which the British tanks of 1941 suffered most in comparison with the German, and which drew to itself most criticism, both amateur and professional, was their fire-power. The problem of the tank gun on British tanks was, however, closely interwoven with that of the anti-tank gun, for both were fundamentally the same and differed only in their respective mountings and operational uses. The story of the anti-tank gun will be discussed below.

The various shortcomings of British tanks could be accounted for by a number of causes both old and new. The most fundamental cause was the gap in development after the 1914–18 war. During that period design and development of tanks was confined to what Vickers-Armstrongs were able to do in conditions of peace and to the very restricted activities of the rudimentary design department at Woolwich. The rearmament period saw some improvement. The cruisers Marks I to VI and the infantry tanks, Matilda and Valentine, were developed and brought into production.[1] Additional firms, in-

[1] The following table shows the date of the first production of each type of tank:

Cruiser I	August 1937	Infantry I	April 1937
Cruiser II	July 1938	Infantry II	May 1938
Cruiser III	January 1938	Infantry III	July 1939
Cruiser IV	January 1939		
Cruiser V	April 1939		
Cruiser VI	July 1939		

cluding Nuffield Mechanizations, were employed on the design and development of tanks. Nevertheless, when the Ministry of Supply took over from the War Office responsibility for the manufacture of tanks, there were no advanced designs on the drawing-board, no prototype suitable for future development and very limited experience of the practical difficulties of tank design.

The earlier neglect of tank design and development made itself felt in the difficult years of 1940 and 1941; and despite the subsequent efforts of the Ministry of Supply it continued to affect tank development throughout the war. The very few fundamental advances in design—mainly in steering and transmission—evolved in the immediate pre-war and early war periods were achieved mainly by drawing on the skill and ingenuity of individual engineers rather than on accumulated experience in tank development. In the absence of proved designs, tanks had to be developed and produced more or less simultaneously and had to be supplied to troops long before all their shortcomings had revealed themselves in tests and had been eliminated. As a result, not only was production continuously held up by teething troubles, but tanks in service with the Army were apt to be imperfect in performance and unreliable in service.

The lingering effects of the pre-war gap in design were aggravated by the conditions under which tanks had to be designed in war-time. In 1941 (for that matter in 1942 and 1943 as well) the task of the designers was not made easier by the ideas of the General Staff about the use and composition of tank forces and about the desirable qualities of a tank. For a long time the General Staff insisted on tanks conforming to a number of features cramping to the designer. There was the insistence on the transport of the tank by railway which limited its width; there was the insistence on the tank being built to cross standard bridges which limited its weight; there was the insistence on a low silhouette which limited its height. These requirements were backed by tactical and 'logistic' arguments reasonable enough. But by the end of 1941 it became apparent that the General Staff requirements in these matters need not have been laid down as *sine qua non* of tank design. For by then the War Office was ready to welcome the delivery in Libya of American tanks with a high silhouette, while the Ministry of Supply was staking out claims in America for transporters capable of taking tanks by road, and beginning to design special bridging equipment (some of it tank-borne) capable of supporting tanks much heavier than the old War Office minimum. In the end the latest British tank to be designed during the war broke nearly every one of the limitations imposed upon tank design by the General Staff in 1940 and 1941.

Even more important was the influence on tank design of the fluctuating notions about the tactical use of tanks. For the ideas of the

General Staff fluctuated at frequent intervals, and when they finally became stabilised they had to be embodied in a compromise design which presented a number of engineering difficulties. In order to understand the nature of the early vacillations and the eventual compromise it is necessary to bear in mind that in the early years of rearmament the War Office clearly distinguished between two functions of the tank in battle and between two corresponding types of tank: the slower and heavier tank for 'infantry' and 'assault' duties, and the faster and lighter 'cruiser' tank for cavalry action. But even though the distinction was clearly drawn, the preferences of the General Staff were apt to alternate. At first (i.e. in the last years of peace) the possibility of a clash with Italy in the Middle East dominated the War Office plans and stimulated the demand for light and fast tanks of the cavalry or cruiser type. In this period the only representative of the 'assault' or 'infantry' type was the Infantry Tank Mark I, a slow and heavy vehicle armed with a machine gun. With the approach of the war with Germany and the prospect of an expeditionary force in France, the emphasis was shifted to tanks capable of acting against troops in fortified positions. The two infantry types, the Mark II, later known as the Matilda II, and the Mark III, the Valentine, were developed, the former in 1938 and the latter in 1939.[1] In November 1939 specifications were issued for the heavier A.20, out of which the A.22 (the Churchill) was later to grow. The 'deficiency' programme for the Army, as agreed on 21st April 1939,[2] not only raised the total requirements of tanks from 997 to 2,172, but also increased the proportion of infantry tanks from thirty-six per cent. to fifty-one per cent. of the total requirements. As a result, in the early stages of the Ministry of Supply new production of tanks was largely devoted to the Infantry Mark II. The policy of the Ministry at that period was best summarised in a memorandum by the Minister of Supply to the Military Requirements Committee on 7th March 1940. The memorandum makes it clear that the Ministry put into production intermediate models of cruiser tanks halfway to the real programme, all with 2-pounder guns (cruiser A.10 Mark I and cruiser A.13 Mark II), as soon as it was realised that conditions were changed and that heavier arming was essential, but that it was the shortage of infantry tanks which had given the greatest concern and where the greatest effort was being made to increase and accelerate production.

Ideas changed again after the evacuation of Dunkirk. The part which the German panzer divisions played in the defeat of France, their speed and mobility, led not only to an increased demand for tanks, but also to a far greater stress on cruiser tanks. The current army programme was expanded to one of nine armoured divisions

[1] See p. 188, footnote (2).

[2] See p. 72.

and six army tank brigades.[1] This alteration involved a great increase in cruisers and a reduction in infantry tanks which had previously been regarded as the most important requirement. Out of a total of 10,441 tanks stated as requirements by the War Office on 30th July 1940, 4,699, or forty-five per cent., were to be cruisers. In the programme of December 1940 the proportion of cruisers was raised to seventy-eight per cent. of the total and that of infantry tanks was reduced from fifty-five per cent. to twenty-two per cent. A radical change of this nature was impossible without unsettling the entire scheme of production. It was therefore agreed that in practice no immediate alteration should be made to capacity which would involve any loss in gross production, and that until an adequate supply of cruisers could be produced a certain number of armoured divisions would be equipped with infantry tanks.

The requirements of the General Staff began to change again in 1941 largely as a result of the fighting in the Middle East. The campaigns in Libya, and especially the second campaign in the winter of 1941, created a demand for a tank force composed of vehicles more mobile than the infantry tanks, but equally well protected. The immediate effect was to raise the Army demand for infantry tanks to thirty per cent. of the total. But the final result of the new ideas was to bring the operational requirements of the two types of vehicles so close as to make it possible to satisfy both with the same design. The demand on the Ministry of Supply was to produce a vehicle with power of attack and defence greater than that of the current models of the cruiser tank, but with a speed far greater than the infantry tanks then in service, i.e. the Valentine and Matilda. This requirement was eventually met by the design of the Cromwell, a more heavily armed and armoured version of the basic cruiser design, embodying an engine of great power, and thus capable of high speed. Its initial development was carried out early in 1941 and it was expected that it would be in production later in the same year. Snags and pitfalls, however, beset its development and greatly delayed delivery to the troops. Engineering difficulties were inevitable in a compromise design of this kind; and in the first place the difficulty of mounting on a standard suspension a tank so heavy and so fast. It was not until 1943 that the Cromwell was in service with the troops in a reliable version. By the end of that year it was to prove itself by far the best tank designed and produced in Britain during the war, and later it acquitted itself well in the pursuit of the enemy across Europe. But it was essentially a design based on the experience of the Western Desert and was possibly in some ways unsuited to the close-range battles of Normandy.

So much for the evolution of General Staff ideas and their effects

[1] See p. 129.

on the design of tanks. The quality of the tanks turned out by industry was also affected for a time by the 'foreshortening' of design and development on the morrow of Dunkirk. The Ministry was driven to concentrate on achieving the highest possible output of tanks. Technical development, improvements of existing types and the introduction of new ones, had to be reduced to the minimum so as not to interfere with output. It must be remembered that the country entered the war with only a small proportion of its estimated requirements of tanks available. Under the Army 'deficiency' programme of 21st April 1939 the requirements of cruiser and infantry tanks were 2,172, but by 1st September 1939 the Army did not possess more than 146 of both. In the eight months between the outbreak of war and Dunkirk 437 cruiser and infantry tanks were produced, but of these 210 were lost in France.

With the country facing, almost without tanks, the dangers of invasion, the Ministry had to concentrate on the production of existing types. The overwhelming need for tanks and more tanks of existing types had to be reaffirmed by the Prime Minister and continually reinforced throughout 1940 and most of 1941. At the meeting of the Defence Committee (Supply) on 11th June 1940 the Prime Minister recommended that every effort should be made to press on with the production of existing types, and that no modification should be accepted which would delay in the slightest degree their production. On another occasion, in July, the Prime Minister again laid down that there was no time to try and improve existing types and specifications, that the choice which had to be made was not between a good tank and a better one, but between a fairly good tank and no tank at all. The same theme occurred over and over again in the Prime Minister's pronouncements and in the minutes of the Ministry of Supply. The concentration on the production of existing types was apparently intended to continue throughout 1941, so that new types could not be expected before 1942. On 17th January 1941 the Minister told the Tank Board that the Prime Minister, as Minister of Defence, had instructed that 'for 1941 the department must concentrate on securing the maximum production of existing known models and there must be the minimum of interference with production by changes of design. At the same time the Board must give close attention to design and development with a view to a different programme for the year 1942'.

There is thus no wonder that the one tank which was designed and developed in 1940—the A.22, better known to the public as the Churchill tank—suffered from haste in design and development. This tank was needed mainly for home defence against invasion, and in 1940 and 1941 the danger of invasion was too near to allow designers the necessary time for the normal procedure of tests and

trials. The War Office specification was ready in the middle of June. On 1st July 1940 the Prime Minister issued an instruction to proceed with a view to producing, as a minimum, 500 by March 1941. The time allowed for tests, development and tooling-up was less than nine months, or about one-half of what is usually regarded as the minimum period for a new type. Most unorthodox measures had to be taken to speed up development. The tank was ordered 'off the drawing-board', and Vauxhall Motors were entrusted with detailed design and manufacture. The first pilot was running in December 1940; fourteen tanks were delivered by 30th June 1941; and by the autumn 400 were available for battle.[1] But by that time it had also become abundantly clear that the tank was most unreliable in use. The initial batches of the tank had to be re-worked, further production had for a time to be suspended, and much time had to elapse before the main defects could be bred out of the tank. Improved versions were delivered in 1942 and acquitted themselves well in the landings at Dieppe (August) and at El Alamein (October). By 1943 the latest version of the Churchill had been developed into a sound and effective heavy fighting vehicle, capable of adaptation to many uses and of great service to the British Army in Tunisia and in Europe. But in 1941 the qualities of the tank and its prospects were still problematic, and for the time being the only major adventure in design and development failed to produce the heavy armoured tank which was then so urgently needed to repel the threatened invasion.

Largely the same causes—neglect of design in the twenties and early thirties and inability to sacrifice immediate production—produced in 1941 the notorious crisis in anti-tank and tank guns. It has already been mentioned that the worst deficiency of British tanks revealed by the battles of 1941 was that of fire-power.[2] This deficiency was relatively recent. The standard anti-tank weapon installed in the tank at the outbreak of war, the 2-pounder, was at that time superior to the 37-mm. gun carried on German tanks, and acquitted itself very well in the first Libyan campaign. This initial advantage was, however, soon lost: mostly through delays in the supplies of more advanced types and the over-cautious piecemeal advance of the War Office specifications. As mentioned above,[3] by the summer of 1940 the Germans were known to be developing a new tank gun of 50 mm. with greater range and penetrative power than that of the British 2-pounder. The British reply to that gun was the 6-pounder, but unfortunately the reply was not made early enough.

The British 6-pounder gun was a weapon of pre-war conception.

[1] See the Prime Minister's statement on the A.22 (Churchill) tank, H. of C. Deb., Vol. 385, Cols. 1772–1774, 15th December 1942.

[2] See p. 188.

[3] See p. 185.

It had apparently been discussed in the War Office in April 1938, but the design was not pursued owing to the urgency of other design work. The matter was taken up again in the summer of 1939. On 30th June the D.C.I.G.S. put forward a provisional specification for a new 6-pounder tank gun and a corresponding design was produced by the Director of Artillery without much delay. A complete 6-pounder anti-tank equipment was available for trials in the spring of 1940, and on 10th June the Ministry of Supply asked the War Office to agree to an order for 400 6-pounder guns. Yet although on 20th June the General Staff reaffirmed its desire for a more powerful gun than the 2-pounder, the order for the 400 guns was not forthcoming. In August the War Office notified the Ministry of Supply that the number of 6-pounder guns was to be governed by the effect on 2-pounder production, which was poor. This turned out to be the crucial issue in the evolution of the problem. An earlier order for a few pilot models was now increased to fifty in order to get production under way, and in December 1940 the Ministry of Supply, on its own initiative, though in agreement with the War Office, increased the order from fifty to 500.[1] The War Office, however, was still anxious not to prejudice the prospective output of 2-pounders through increased orders for the 6-pounder. It had been informed that the production of 100 complete 6-pounders in the year would entail a loss of 600 2-pounders.[2] The alternative was presented to the Defence Committee (Supply) which discussed it in February 1941 and decided that a diversion of capacity from 2-pounders to 6-pounders could not be afforded and that the urgently necessary acceleration of 6-pounder production must at the outset be solely from new capacity. This was in fact the decision which the Ministry of Supply had itself taken in August 1940 in response to the War Office view that the number of 6-pounder guns was to be governed by the effect on 2-pounder production. The subsequent production of the gun was thus entirely dependent upon new capacity coming into production. The first guns in any quantity were turned out in November 1941 when thirty-two were produced: 146 came out in December, and 341 in January 1942. The output in May 1942 rose to 1,517.

The installation of the 6-pounder gun on tanks could not therefore effectively begin until the spring of 1942, and in its anti-tank role the gun appeared in the Desert in time to contribute to the turn of fortune there in the autumn of that year. As soon as supplies of the gun were available it was installed in Crusader and Churchill tanks. In 1943 it was installed also in the Cromwell, and in that year about eighty per cent. of all tanks produced in the United Kingdom were equipped with the 6-pounder.

[1] See Cmd. 6865, p. 5.
[2] See H. of C. Deb., Vol. 381, Col. 254, 1st July 1942.

The later history of the 6-pounder and its successors falls outside the chronological limit of this chapter. In so far as they ceased to figure as major production issues, the tank and anti-tank guns of 1943 and 1944 may fall outside the range of this study altogether. But before taking leave of the subject it should perhaps be noted that the problem of 'quality', as distinct from that of production, was not completely wound up by the arrival of the 6-pounder. In 1944 the 6-pounder was to be almost entirely superseded by the 17-pounder tank and anti-tank gun and the 75-mm. tank gun. Yet this should not be taken to mean that the race against the Germans in the fire-power of tank and anti-tank weapons was thereby won. For before long both guns had to compete in range and penetrating power with later versions of the German 88-mm. gun. By then, however, the whole question of fire-power in tanks had become greatly complicated by the use in tanks of a variety of auxiliary equipment not primarily designed to fire armour-piercing shells of high velocity. But, to repeat, this part of the story is not closely linked up with the success or failure of munitions production and will more appropriately be told in a study of design and development.[1]

[1] i.e. in the forthcoming volume in this series on the Design and Development of Weapons, by M. M. Postan, D. Hay and J. D. Scott.

CHAPTER V

FROM PEARL HARBOUR TO VICTORY IN EUROPE:

I. THE OFFENSIVE STRATEGY

(1)

Introductory: The Two Summits

In Mr. Churchill's famous phrase the year 1942 saw 'the end of the beginning'.[1] The time of preparation was nearly over, and the country could begin to plan how to deploy the Forces it had gathered and equipped in the preceding three years. That a moment like this would come some time in 1942 had always been foreseen, though the precise date may for a long time have remained indefinite. The strategic and industrial hypotheses underlying the successive Service programmes of 1939, 1940 and 1941 implied a turning point in the conduct of the war soon after the end of 1941. The armed forces could by then be expected to reach their planned strength and to receive the final instalment of their 'capital equipment'. The terminal point of the Army plans could not, of course, be reached in December 1941 as required by the strict timetable of the 1940 requirements for Z+27;[2] but, in spite of all the postponements, the War Office and the Ministry of Supply continued to act on the assumption that the equipment of the field forces would be more or less completed by the end of the year. Similarly, the first comprehensive war-time programme of aircraft construction (the 'Harrogate' programme of September 1939),[3] and the programmes of 1940 and 1941 derived from it, all reflected the intention to achieve the output of 2,550 aircraft per month—the peak rate—during 1942. Even in the Admiralty the planners looked forward to 1942 as the year when the supply of small vessels under the 'emergency' programmes would reach the point beyond which exclusive concentration on the 'emergency' programmes themselves could stop.[4]

[1] Broadcast speech at the Lord Mayor's Day luncheon at the Mansion House, London, 10th November 1942.

[2] See p. 136.

[3] See p. 69.

[4] The story of the 'emergency' programmes up to Pearl Harbour has been told in Chapter III, Section (2).

From these expectations obvious strategic and economic consequences followed. Now that weapons were in more plentiful supply more could be spared for offensive action, even if the delays over bombers made it difficult to launch full-scale bombing attacks for at least another year. The economic consequences were, if anything, even more immediate. War industry was absorbing ever-growing volumes of productive resources as it approached its final targets. The year 1942 was therefore destined to bring the country to the very verge of the fullest possible industrial mobilisation.

In this way, on the eve of Pearl Harbour the twin summits of the war, strategic and economic, were rapidly coming into view. The strategic and political situation had been transformed by the German attack on Russia in June 1941, though the effects of German involvement in the East on British strategic planning did not become apparent until the strength of Russian resistance revealed itself in full, as it did during 1942. More directly relevant to Britain's economic and strategic plans was the evolving attitude of the United States. On the eve of Pearl Harbour American aid was already great, and prospects of further aid were rapidly rising. The events of the winter of 1941 —Pearl Harbour, the entry of the United States and Japan into the war—greatly amplified both the prejudice and the promise of 1941, and thereby intensified the crises to which the country was in any case moving. They brought immense accretion to Allied strength and a firm assurance of victory, but they also raised the height of the peaks yet to be scaled and probably also the length of time which this country would have to stay at topmost levels. It suddenly became possible to embark upon offensives greater and more far-reaching than any which Britain could have undertaken alone; and it also became necessary to raise military output and economic mobilisation to limits even higher than those which the pre-1942 programmes had forecast. At the same time the offensive action could not be planned to reach its *dénouement* for at least another eighteen months or two years; nor were the strains of industrial mobilisation expected to ease off in the meantime.

The sustained height of the war effort during those years and, above all, the combination of full industrial mobilisation with mounting military offensives, must be borne in mind if the story of war production in this period is to be properly understood. War industry was called upon to continue its movement towards the inherited targets of its earlier plans; it was also called upon to respond to the successive stimuli of the offensive strategy; and all this had to be done at a time when the productive resources and, above all, the manpower of the country were stretched to the furthest possible limits.

(2)

The Offensive Strategy

The changing emphasis of war production reflected not only the growing shortage of manpower but also the constant and unremitting pressure for expansion—a pressure to which the country found it increasingly difficult to respond, but which strategic necessity made it equally difficult to deny. It would be a truism to insist that between 1942 and 1944 the demand for supplies was bound to expand with every step of the unfolding offensive. Somewhat less obvious and familiar are the effects on supply programmes of the slow and necessarily circuitous progress of the offensive plans. With the entry of America into the war the military prospects underwent a transformation as profound as most contemporaries wished it to be. Eventual victory now appeared to be assured and the road towards it more or less open. Yet the military position did not alter at all suddenly. While future horizons were lightening and spirits were rising, the immediate prospects remained for a while gloomy. Until the very eve of Alamein and Stalingrad the Allies continued to suffer reverses in every field of battle—in the Philippines, in Malaya, in the Western Desert, in the Atlantic and in the approaches to the Caucasus.

No comparable reverses were likely on the supply front, but enough has already been said here to show that 1942 was bound to be a year of great difficulties and shortages. Indeed the first phase of the Anglo-American alliance turned out to be one of unrelieved stringency. At the end of 1941 American war industry was still in the early stages of expansion and was not to be fully employed or to be working at maximum rates until well into 1943. There was even some deterioration in the immediate outlook, for weapons manufactured for British use in the United States were being diverted to the American Army, and the vast ambitions of American war industry were threatening the supply of critical raw materials. In these conditions it was obviously impossible for Britain and the United States to come to grips with the main forces of the enemy at once. However certain the victory, the road towards it was turning out to be both longer and more roundabout than it may at first have appeared to some Allied leaders. Its true length and direction were not to be revealed until most of its distance had been traversed.

The mapping of the road began immediately after Pearl Harbour. Within three weeks of America's entry into the war Mr. Churchill and Mr. Roosevelt met in Washington to consider the broad strategy of the war.[1] They had no difficulty in agreeing on the strategic

[1] The Arcadia Conference.

priorities. As Germany was the predominant member of the Axis powers, the Atlantic and the European area was to be considered the decisive theatre of the war, and only the minimum of force necessary to safeguard vital interests in other theatres was to be diverted from operations against Germany.

The date and direction of the main attack were not, however, and could not be settled at once. In the spring of 1942 General Marshall came to London with a plan for an early and even an immediate offensive in Western Europe. He proposed that Allied troops should invade Europe and establish a bridgehead there as soon as possible, indeed in the autumn of 1942. This operation if successful was to lead in 1943 to a full-dress invasion of Europe (Operation 'Round-up'). These dates, however, proved too early and too definite. In general, the British leaders were prepared to accept the American proposal for an offensive in Western Europe in the spring of 1943. In a manner still more general, they agreed that the Allies might be compelled to launch an attack, however limited, in 1942 or might be induced to do so if a favourable opening occurred. Before long, however, both the date and the point of the attack were revised. At a further conference between the President and the Prime Minister in Washington in June 1942[1] the Allies decided to push forward with all speed and energy the building up of American forces in the United Kingdom for an early offensive. But, at the same time, they laid it down that if detailed examination were to show that a successful invasion of France and the Low Countries was as yet impracticable, the Allies must be ready with an alternative plan for an early operation against German land forces. As an alternative, a landing in North Africa —Operation 'Torch'—appeared to be most promising and desirable.

When in the following month, July 1942, the United States Chiefs of Staff visited England to investigate the possibilities of offensive action during 1942, the decision to postpone the invasion of the Continent followed almost inevitably. The bomber offensive had not yet developed sufficiently to prepare the ground for an Allied landing; the technique of such landings had not been worked out; the United States did not yet dispose of large bodies of battle-trained troops, nor did their war industry turn out supplies in the necessary quantities. The smaller and purely preliminary alternative in North Africa had therefore to be launched first.

The invasion of North Africa took place as planned; yet even after it had been completed—in the early summer of 1943[2]—the culminating point of the offensive was still far off. While preparations for the North African campaign were in full swing, attention and re-

[1] The Argonaut Conference.

[2] All organised Axis resistance in Tunisia came to an end on 12th May 1943. (Royal Institute of International Affairs: *Chronology of the Second World War*, 1947, p. 182.)

sources had to be diverted to other military objectives. The German advance into Egypt was a strategic threat of the greatest gravity, and the preparations to repulse it, which had been going on throughout 1942, could not be held up. Nor was it possible to stop or even to reduce the assistance to Russia. Measures purely military, such as help for the defence of the Caucasus or the invasion of northern Norway, were seriously considered but proved impracticable. On the other hand, supplies to White Sea ports were absorbing an ever-mounting volume of resources, and were not allowed to slacken off. At the same time an assault on Madagascar had to be planned and was executed in May 1942. Above all the Allies, more especially the Americans, had to do all that was possible to prevent the position in the Pacific from becoming even more critical than it was. In this country there was also the ever-present, and at times overshadowing, threat to Atlantic sea-lanes, where throughout 1942 and the first half of 1943 the German U-boats were levying a heavy toll.

For these and the more general reasons of strategy and supplies (which in the main were still those of 1942) the success in North Africa was not to be followed by an immediate switch-over to France. The Prime Minister and the President met at Casablanca in January 1943[1] and decided to follow up the successes in Tunisia with an attack on Sicily, to be launched in June or July.[2] The invasion of Sicily was followed by other moves in the encircling offensive. The Italian mainland was invaded on 3rd September, and when Mussolini fled and Italian resistance collapsed in the autumn of 1943, the British military leaders were anxious to complete the campaign in the south, even at the cost of some further postponement of the invasion of France. The problem occupied the Allied leaders at the Quebec Conference of August 1943, and at the Cairo discussions in November 1943; and it was only at Teheran[3], where Stalin joined the President and the Prime Minister for the first time, that the 'Overlord' operation in Northern France and the accompanying invasion of Southern France were fixed for May 1944 with the clear understanding that no other operation would be allowed to interfere with their date and success.

In these final decisions the argument of supply played a decisive part. Hitherto it had been possible to contend that, although the long-term objectives of military equipment were nearly attained, there still remained the task of preparing the specialised equipment without which the final offensive in France could not be launched, and, in the first place, the all-important landing-craft. The reason why the summer of 1944 could at last be fixed as the final date for 'Overlord' was not only that the preliminary phases of the encircling offensive had

[1] The Symbol Conference.

[2] The first Allied landings in Sicily took place on 10th July 1943.

[3] The Quadrant, Sextant and Eureka Conferences respectively.

been successfully carried out and that the bombing attacks on Germany were approaching the point of highest intensity, but also that the preliminary supply tasks appeared capable of being completed in time.

The strategic plans of the Allies in their turn had profound economic and, more especially, industrial effects. Not only was war industry called upon to supply very large quantities of special equipment for the coming offensive, but it was also subjected to a heavy and at the same time irregular pressure from the so-to-speak intermediate strategic needs. The offensive strategy developed over a period so long and was compounded of preparatory activities so dispersed and so divergent that the flow of offensive weapons had to be kept not only high but also very elastic. Incidents, all of them critical, came in quick succession: the bombing offensive, the massing of troops and supplies for the battles in Libya and Tunisia, the critical stage in the Battle of the Atlantic, the mounting of the landings in Sicily and Italy, and the maintenance of the armies there. They all raised urgent demands which had to be satisfied rapidly, and sometimes concurrently, before final concentration on 'Overlord' could be decreed at the end of 1943. And no sooner was the landing launched than urgent demands began to come in from the armies in the fields of battle and from the air force over them. At the end of the period, while the prospects of victory in Europe were drawing near, the requirements of war in the Far East were coming to the forefront.

Is there then any wonder that the progress of war production during those years was irregular as well as great? Requirements had to be constantly reassessed in the order of military urgency, and the course of war production was therefore bound to be highly unstable. Yet the general tendency towards expansion, though repeatedly checked, was never arrested. In so far as additional demands merged into the periodic Service programmes (as the bulk of them did) they will be recounted again later;[1] but it is not necessary to catalogue them in order to account for the growing industrial tasks. The growth reflected itself in every direction: in the higher demands for munitions, the rising requirements of raw materials, and, above all, in the ever-larger demands for labour.

(3)

The Economic Strains

(*a*) MACHINE TOOLS[2]

The culminating point in the military preparations, i.e. the opening up of the offensive and the inevitably heightened pressure of

[1] See Chapter VI.

[2] The story of machine tools in war industries will be told in more detail in the forthcoming volume in this series on Factories and Plant by W. C. Hornby.

requirements for munitions, coincided with the final stages in the industrial mobilisation. These stages were bound to be fraught with difficulty. As the peaks of industrial activity were coming into view the concomitant stresses were becoming more pronounced and more difficult to relieve. The 'limiting' factors of war-time industries as they figured in all the rearmament plans—machine tools, raw materials, labour—were now beginning to exercise to the full their limiting effect. At the same time not all the productive resources were equally strained, and the various shortages did not constrict war industry in equal measure. What is more, the worst strains were not those which had done most to hold back industrial expansion in the early phases of rearmament.

Capacity—factories and machines—was ceasing to be the pacemaker of war industry. If, until 1942, the output of munitions did not grow—and indeed was not expected to grow—much faster than it did, the main reason was that the country was still 'tooling up'. And if, in its turn, this process dragged on for several long and impatient years, the obvious (though, of course, not the only) explanation was that demands for fixed capital were so great that they could not possibly be met any sooner. Factory buildings took a long time to erect (on the whole much longer than in the war of 1914–18),[1] while the supply of plant and machine tools, not only in this country but also in the United States, was for a long time unequal to the need. By the end of 1942, however, the general position had greatly changed. Capital equipment was ceasing to be short; supply had caught up with demand, and in 1943 the demand itself dropped well below the peak.

That the demand should have decreased at this stage of the war was, of course, in the nature of the industrial build-up. Hitherto the whole timetable of British rearmament had largely depended on the rate at which new factories could be brought into production or other factories be converted to munitions; and this meant that some time before the highest levels of war production were reached the making of fixed capital equipment should have begun to slow down. The turning-point under the programmes of 1939 and 1940 would have come some time before Pearl Harbour, and soonest of all in the aircraft industry. Throughout the greater part of 1941 the Ministry of Aircraft Production was still engaged on the original programme of 2,550 aircraft per month. The programme had been approved in general terms in September 1939,[2] and between that date and August 1941 orders had been placed for the bulk of the necessary Government expenditure on plant and buildings—£97 millions out of about £110 millions. Had the programme been allowed to run its

[1] See also p. 393.
[2] See p. 69.

course, the requirements of capital equipment would probably have begun to diminish in the autumn of 1941. In the Ministry of Supply the turning-point was expected to come later, somewhere early in 1942, for it was in the course of 1942 that production under the Z+27 programme[1] was due to reach its zenith. In the Admiralty the capital schemes launched in the first two years of the war were mainly to expand capacity for armaments and ammunition, and these were also expected to mature at the end of 1941 or early in 1942.

Thus, according to the original production plans, the process of industrial re-equipment would have culminated at the turn of 1941 and 1942. The process was not, however, allowed to run according to plan. Even before the date of completion arrived, the supply departments had to sponsor additions to factory programmes and to extend the period of 'tooling up'. Greatest of all were the additions to the aircraft factories resulting from the bomber programmes of the late autumn of 1941. It will be recalled[2] that the Prime Minister's wishes for additional bombers could not be met even half-way without additional factory construction. There were also to be changes in plant and machines and additions to the machining capacity in general in a number of existing factories. Hence there was a very large increase in orders for plant and machine tools at the end of 1941 and during 1942. Indeed so large was the increase that the approved financial commitments for additional plant and machinery sanctioned for engines, airframes and propellers from September 1941 to December 1942, at nearly £48 millions, were more than twice that of the comparable commitments between December 1939 and the end of August 1941, and only £6·5 millions less than the total commitment for the provision of plant and machinery, at Government ex-

Commitments approved for machine tools and plant

TABLE 26 £ millions

	1936–39	Dec. 1939 to 31st Aug. 1941 (20 months)	Sept. 1941 to 31st Dec. 1942 (16 months)
Engines	26·4	10·0	28·1
Airframes	5·9	9·5	12·9
Propellers	0·9	1·7	6·9
	33·2	21·2	47·9
All aircraft products[3]	45·2	37·5	62·0

[1] See p. 136.

[2] See p. 168.

[3] Including all aircraft components, equipment, instruments, armament and fabrication of light metals, but not raw materials or fuel.

pense, for this section of the aircraft industry in the five years since 1936. The increase in plant and machinery requirements over the whole field of aircraft production was only slightly less severe. The peak requirements of the Ministry of Aircraft Production for capital goods were thus inevitably put off to some point in 1943.

Important additions to capital, though on a much smaller scale, also took place in the shipbuilding industry. It will be shown later[1] that in the middle of 1942 the Admiralty reached an impasse in its endeavours to force out of the shipbuilding industry a large increase in output. This led to a technical inquiry which, in its turn, led to an ambitious plan for a State-assisted renovation of capital equipment in the shipyards. Large and costly machine tools were to be provided as well as shipyard plant and welding equipment. In consequence the total value of major capital schemes for naval shipbuilding and marine engineering for the two years 1942 and 1943 exceeded £4½ millions, compared with less than £1 million for the two years 1940 and 1941. In addition a further large scheme for torpedo production was approved in 1942. The large increase in capital equipment for naval construction and marine engineering which followed the 1942 inquiry is reflected in the Admiralty expenditure on this account (Table 27).

Admiralty expenditure on plant and machine tools for naval shipbuilding and marine engineering contractors

TABLE 27 — £ millions

1940	1941	1942	1943	1944
0·259	0·869	1·245	4·002	4·090

In the Ministry of Supply alone the additions were not sufficiently large to lead to a great postponement of the decline, which in any case was planned to come later there than elsewhere. In the capital schemes approved in 1942 provision of plant and machine tools at more than £26 millions was only £2 millions lower than in 1941, though more than £16 millions higher than the figure to which it was to drop in the course of 1943. The 1941 level of demand for capital was thus prolonged throughout the greater part of 1942 but fell sharply in 1943. But for the further schemes for the tank programme and for the increasing demand for 20-mm. weapons and ammunition the 1943 figure would have been lower still, and the drop might have come earlier.

The compilation of total requirements of machine tools for delivery in each year was undertaken by the Machine Tool Control from 1941

[1] See p. 297.

onwards. The process was subject to much uncertainty, and figures computed at the beginning of the year were subject to drastic changes in the course of the year. The actual demands for machine tools, on which orders for delivery were issued, frequently differed widely from these estimated requirements. Requirements were related almost entirely to demands arising out of financial projects of capital expenditure financed and subsidised from Government sources, but there was also a smaller flow of orders emanating directly from private firms and financed wholly by them. Outside the official lists were also the machine tools required for the production of other machine tools and small tools and gauges, for labour training schemes, for export and for replacement of worn-out and of war-damaged machines. In 1940 and 1941 the annual total requirement was estimated at 100,000 machine tools. In 1942, when returns became more complete, the estimate reached 111,000. Reckoned in numbers the estimated decline in 1943 and 1944 was remarkably small, but the needs of these years were for a larger proportion of low-cost machines and for a larger number of machines to replace worn-out machinery in factories.[1]

Estimated requirements and actual supplies of machine tools to supply departments[2]

TABLE 28 Number of machine tools

	Ministry of Aircraft Production		Ministry of Supply		Admiralty	
	Requirements	Supplies	Requirements	Supplies	Requirements	Supplies
September 1939 to December 1940	40,000[3]	30,000[3]	45,000[3]	33,000[3]	6,000[3]	3,500[3]
1941	38,611[4]	32,000[3]	27,723	29,000[3]	6,063	4,500[3]
1942[5]	32,928	30,631	38,000[6]	38,154	2,400[7]	5,478
1943[5]	24,650	21,498	25,560[6]	23,641	6,000	6,644
1944[5]	16,363	15,790	24,180[6]	15,514	7,000	5,987

[1] For the total requirements of machine tools, 1942–45, see Appendix 5.

[2] This table does *not* include requirements and supplies for private purchases, exports and machine-tool production. The scope of these is indicated in Appendix 5.

[3] Approximate retrospective estimate.

[4] This figure includes some of the requirements under the 1942 bomber programme. Before September 1941 the requirements ran at a monthly rate of about 2,500 per month.

[5] From 1942, all estimated requirements are first month of year estimates except for Ministry of Supply (1942) where a later estimate including a large War Office demand is used.

[6] A large part of the Ministry of Supply requirements for 1942 onwards were for machine tools for the Army. These were mainly different from those in demand for munitions production and a very large proportion were portable low-cost machines.

[7] This figure was much increased in the course of the year.

The turning-point in the total demand for plant and machine tools was thus postponed; but it was bound to come before long. Allowing for the interval between the date at which expenditure was sanctioned and the date at which orders could be placed, the end of 1942 might be regarded as the time when the pressure of demand for capital equipment in war industry as a whole would begin to fall off.

The general position, however, improved some time before that point was reached. Although the total demand had been fast approaching the highest point, the supplies of machine tools and plant were growing faster still. For this, American deliveries were partly responsible. During 1940 and 1941 the number of machine tools supplied to the United Kingdom from the United States was at a record level of four times the number supplied from the United States in 1939, and at least three and a half times the 1939 tonnage. The main source, however, was not American supplies but the ever-expanding production at home. Indeed, the growth of the British machine-tool industry during the war was very remarkable. From less than 20,000 machines in 1935 and about 35,000 machines in 1939 the British output of machine tools approached 100,000 by 1942.

For the early stages of the expansion the pre-war planners may claim some credit. In the war of 1914–18 the shortage of machine tools, jigs and gauges was one of the main limiting factors of war production. The machine-tool and gauge problem consequently figured very prominently in the inter-war discussions of industrial mobilisation and in the investigations conducted by the Supply Board.[1] As a result a good deal had been achieved by 1939. The output of standard machines to meet rearmament requirements and to maintain exports had expanded, and new capacity[2] had also been developed for gauges and for special machines for gun and shell production. But much more was needed, and in the end much more was done. In the early years of the war the output of machine tools directed by the Machine Tool Control in the Ministry of Supply grew from month to month and reached by the end of 1942 a point far beyond the scope of pre-war expectations. There was also a commensurate expansion in the output of the supply of small tools—cutting tools and equipment, gauges and measuring instruments.

This achievement was one of the great industrial successes of the war. What made it possible was the remarkable response of the established machine-tool firms, but one of the most important features of the growing output was the contribution made by undertakings not previously engaged in the manufacture of machine tools. In the end about a third of the output came from a large number of 'general'

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[1] See p. 35.
[2] Including important shell plant capacity in Canada.

engineering firms. The manufacture of many types of machine tools was, of course, well suited to the qualities and limitations of medium-sized and small firms in the British engineering industry. Yet even so, their contribution revealed reserves of skill and adaptability out of the ordinary.

Supplies of machine tools

TABLE 29 Number of machine tools

	1939	1940	1941	1942	1943	1944
United Kingdom production	37,000[1]	62,000[1]	80,927	95,788	76,208	59,125
United States supplies[2]	8,364	33,111	32,044	24,023	20,514	8,516

Supplies of small tools

TABLE 30 £ thousands

	1940	1941	1942	1943	1944
United Kingdom production[3]	17,000	25,047	35,837	42,172	38,600
Imports	764	2,595	6,160	8,030	..

(.. not available)

Thus, after Pearl Harbour domestic production was able to meet the bulk of British requirements for machine tools, and dependence on American supplies was increasingly confined to machine tools of certain sizes and of highly specialised design. But even in this field the country was becoming less dependent on imports. Successful endeavours to replace continental types and some United States types with United Kingdom products go back to 1940 and beyond. In 1941, with the growing stringency of supplies from the United States, the Machine Tool Control arranged for further new types to be introduced to replace some United States designs, including gear-cutting and specialised milling machines. As a result, the range of types not manufactured in the United Kingdom was narrowed down, and the need for foreign tools was correspondingly reduced.

It goes without saying that however fast and however successfully

[1] Estimated figure.

[2] United States supplies in 1939 were, by tonnage, sixty-two per cent. of the total United Kingdom imports of machine tools; in 1940, ninety per cent.; in 1941, ninety-five per cent.; and in 1942–44, ninety-nine per cent. After 1939 Canada supplied the greater part, by tonnage, of the remaining imports of machine tools.

[3] Tools, gauges, etc., made by the users themselves are not included. The quantity of some tools thus provided was very considerable.

the general problem of plant and machinery was being solved, local shortages and difficulties continued to occur. Throughout 1942, and even in 1943 and 1944, delays and failures in production could still, more or less justly, be blamed on non-delivery of plant and tools. Small as the arrears were now becoming, even small arrears were capable of delaying production, especially if they happened to include critical key tools. The Ministry of Aircraft Production was especially difficult to satisfy. Not only was its demand for machine tools at a very high level in 1942, but it was especially sensitive to unbalancing effects of production 'shortfalls'. For the M.A.P. requirements contained a high proportion of 'difficult' tools and, in addition, were to a great extent made up of large production units, sometimes whole factories, which took on the average not less than twelve months and sometimes as many as eighteen months to complete. For this and other reasons it is not surprising to find M.A.P. complaining about arrears in the supply of machine tools in May 1942 and again in October of that year and at the beginning of 1943. The Machine Tool Control was reassuring about the prospects and could claim that by the end of 1942 not more than 2,300 machine tools, or about seven per cent. of the requirements, remained undelivered. But improvements were all very recent—mostly in the last months of 1942—and among the machines still in arrears were large plano-millers essential for the manufacture of the long spars of airframes and certain specially-designed machines vital for the manufacture of engines and propellers.

M.A.P. could thus claim that delays in delivery of machines not only upset the timing of major programmes but also impeded necessary changes of types. Thus, in December 1942 when a change-over from Stirlings and Wellingtons to Lancasters was considered for Austin's, Short's and Vickers', it was found that the change-over could only be made at either Short's or Vickers' but not at both, through lack of sufficient specially-designed plano-millers of large size. In December 1942 eleven more of these machine tools were required for existing Lancaster production; twelve more were required for the change-over at Short's and eighteen more at Vickers'. Against this total of forty-one plano-millers the best delivery was twelve in nine months and four per month to follow. Thus, whilst the general statistics showed the requirements as fully or almost fully met, serious delays in the supply of key machines could still be held responsible for failures in production.

Needless to say, this argument was not accepted in full, and was often met by the arguments that the M.A.P. demands were inflated, that the existing machine-tool capacity was not fully worked, and that in any case the industry did not possess the labour necessary to work the new machines. The labour argument was of course double-

edged, for machines were often needed to economise in labour and also to train new cadres. But the argument that the requirements were exaggerated could not be dismissed by a mere denial. That by the end of 1941 the industry had accumulated a great deal of redundant plant and machinery appeared very probable. In the summer of 1941 the Controller General of the Machine Tool Control could refer without fear of contradiction to the surplus of machine tools in certain M.A.P. factories as something generally known; and a few weeks later the M.A.P. Director of Machine Tools reported to the Supply Board that in his estimate some 10,000–12,000 machine tools were idle through shortage of labour and equipment or for other reasons and that some 50,000 were inefficiently operated through lack of skilled labour. The same view was to be expressed in a manner characteristically unambiguous by Lord Beaverbrook, now Minister of Supply. In a memorandum to the Defence Committee (Supply) relating to the Prime Minister's bomber programme, Lord Beaverbrook stated categorically that for the bomber programme:

> no more machine tools are needed, over 30,000 new tools were directed to M.A.P. factories in 1941. The machine-tool plant must be worked night and day. Some special-purpose machine tools must be provided. The flow of replenishments and renewals must be maintained. But the main jobs are all completed and in fact some consignments of tools remain unused and even unpacked.

The categorical opening of this memorandum was qualified in its later sections, but its main argument still implied that at least half of the 30,000 machine tools asked for were unnecessary.

Lord Beaverbrook's criticisms of M.A.P. demands or the more moderately expressed criticisms by the Machine Tool Control could be neither generally disproved nor upheld until after April 1942, when M.A.P. at last agreed to have its machine-tool demands examined by technical experts of the Machine Tool Control. The object of the examination was to check the requirements of new machine tools as stated by M.A.P. against the Machine Tool Control's own calculation of what would be needed if the most suitable machine tools were most efficiently used. As a result of the inquiry the utilisation of tools may or may not have improved, but M.A.P. requirements lost some of the controversial aura which had hitherto surrounded them. It is very probable that even then the industry continued to possess a reserve of machining capacity. When in the earlier stages of discussion Lord Beaverbrook and others had tried to apply to the M.A.P. requirements the test of double-shift working, M.A.P. insisted that the only realistic level for measuring utilisation of tools was by assuming that machines would be worked to the extent of not more than 165 per cent., i.e. 65 per cent. above their hypothetical full utilisation in a single shift. It is, nevertheless, doubtful whether even

165 per cent. of utilisation was attained in machining shops throughout the aircraft industry, and it is more or less certain that the coefficient of utilisation in some of the branches of aircraft production remained considerably lower than that.

The hang-over of the machine-tool problem also continued to be felt in the branches of production controlled by the Admiralty and the Ministry of Supply, but in neither department did it appear as troublesome or as persistent as in M.A.P. Their demands—especially those of the Ministry of Supply—were not linked to a single large production scheme like the 'bomber programme', capable of being delayed in its entirety by local shortages of vital machines. The Ministry of Supply also enjoyed the advantages of fairly interchangeable industrial capacity and of somewhat less exacting requirements.

In so far as the Ministry of Supply requirements contained large and specialised machines, or were made up of complete production complements, delays continued for some time after the general problem of supplies appeared to be solved. Thus, the factory programme for production of the Meteor tank engine, involving some 850 machines, both British and American, took eighteen months to complete; it was approved early in 1943, but the delivery of machine tools for full production was not completed until November 1944. Generally speaking, 'critical' machines, i.e. those of special design or otherwise in short supply, could not be made available in under twelve months except by transfer of existing orders. Fortunately, from 1942 onwards the Ministry asked for relatively few 'difficult' machines. And even when machines were required in complete production units, as for 20-mm. ammunition, fuses and small arms, or for tank engines, the units were usually much smaller than those required by M.A.P. In general, new machine tools in the Ministry's programme were to an increasing extent required not to tool up new capacity but to convert existing munitions capacity for the production of new types of weapons and ammunition.

Increases in the demand for general tools such as there were (a large part consisted of workshop tools of smaller and portable type for the Army) did not raise serious difficulties. By the end of 1942 they could be supplied within six to nine months, and in the course of that year many machines were being delivered at a rate which kept pace with the rate of requirements. From 1943 onwards a rapidly increasing number of machines on the Ministry of Supply list were becoming redundant and were passing into the Machine Tool Control pool; private orders for replacement of worn-out machines were increasing and in many instances were easily met.

There was, however, some delay in the delivery of machines under the Admiralty scheme of shipyard renovation.[1] The delivery dates

[1] See p. 297.

for the heavier and more specialised machine tools for shipyards and engine-makers, such as hydraulic presses, joggling and flanging machines, riveting machines and special horizontal boring machines, were invariably long—indeed in some cases so long as to extend the period of re-equipment for about eight to nine months beyond the end of 1943 which was the planned date of completion. There was some feeling in the Admiralty that the delays were in part due to interference by Russian orders for similar machinery, though the Machine Tool Control did not admit that Russian orders had any great effect. Difficulties may also have been caused by lack of finality and definition in the technical requirements of the shipbuilding firms. Yet great as these difficulties were, they were not such as to upset the programme as a whole. In general, the requirements of the yards were filled more or less on time. Thus, in the supply of welding machines, which formed a crucial part of the modernisation scheme, the measures taken by the Machine Tool Control to standardise a large percentage of the welding machines and to scrutinise the Admiralty demands for machines above a certain size made it possible to fulfil the programme without delay. Some ninety per cent. of the welding schemes were completed by the autumn of 1943, at least a couple of months before the terminal date of the renovation scheme as a whole.

(*b*) RAW MATERIALS[1]

The shortage which on the morrow of Pearl Harbour appeared most dangerous and most immediate was that of raw materials. It was to prove much less crippling in the event than it appeared in anticipation; there is, however, no doubt that until well into 1943 the anticipations were very disturbing. From May 1941 imports of raw materials increased to a rate which was sufficiently well above current consumption to raise the stocks of materials subject to import programmes by several million tons above what in 1942 was to be regarded as the minimum of 'distribution' stocks required to keep the flow of production uninterrupted. In the autumn of 1941 the prospects for a short time appeared still brighter, and the Government hoped that imports of raw materials would be higher in the course of 1942 than in 1941. Even when, by the middle of November, the import programmes had to be reduced to allow for the mounting demands of Russia and of the Middle East and for the slowing down of American shipping assistance, the expected imports of raw materials in 1942 were still planned at approximately the same levels as the actual imports of 1941.

These hopes did not survive Pearl Harbour. The Japanese con-

[1] Further details on raw materials import programmes and stocks will be given in the forthcoming volume in this series on the Control of Raw Materials. The facts in this chapter are largely based on the corresponding sections in Mr. Hurstfield's book.

quests in the Far East removed several sources of important raw materials. Malaya, the Netherlands East Indies and the neighbouring territories had produced ninety per cent. of the world's rubber supplies, sixty per cent. of the world's tin and also quantities of sisal. In the Philippines the Allies lost the only source of manila hemp, and elsewhere in the Far East they lost supplies of tungsten, chromite, antimony and hardwood. Not all these losses were wholly and permanently irreplaceable. There were hopes of expanding rubber production elsewhere, especially in Ceylon, and the production of synthetic rubber was due to develop on a large scale in the United States. The mining of tin could be expanded in Nigeria, the Belgian Congo and Bolivia, and the loss of tin-smelting capacity was to be made good by the new American smelter already in process of erection in Texas. Yet all these schemes could not mature at once, and even when mature they could not be expected to make good the entire deficiency.

In addition, the immediate prospects of supplies for Britain were, for the time being, dimmed by the inevitable increase in America's own demands arising mainly out of her immense armament plans. Most serious of all was the threat to the allocations of steel and non-ferrous metals, especially copper; and in this respect the situation remained dangerous until late in 1942, i.e. until the United States' munitions programmes had been pruned sufficiently to revive, at least in part, hopes of continued American supplies to Britain.

More important still, indeed much more important, was the new shipping situation. In 1942 the U-boat activities in the Atlantic raised the rate of sinkings to new and alarming peaks. At the same time the demand for shipping was greatly swollen by the military needs of the Eastern and the Middle-Eastern theatres of war and by the gradual development of the Allied counter-offensive. America's own need of ships in the Far East and elsewhere reduced the immediate help she could give. Merchant shipping construction, especially in America, was originally expected to replace losses and overtake demands by the end of 1942, but in June it became clear that American shipping assistance would not greatly increase until the second half of 1943. As a result, the total tonnage to serve British imports not only failed to grow but was in danger of a continued decline for at least another year or eighteen months. Added to the shortages of shipping tonnage, both present and future, was also the difficulty of suiting military shipping to the needs of the import programme. In theory ships carrying supplies to the Far East or to the Mediterranean were available to bring back imports, but in practice the available cargoes did not necessarily fit into the pattern of military sailings, and ships homeward bound were sometimes compelled to sail not fully laden and generally to bring imports in proportions not strictly corresponding to the import programmes.

It is, therefore, no wonder that the expectations of raw materials imports had to be drastically reduced. By February 1942 the high expectations of the autumn of 1941 were cut by more than a quarter. In the new conditions, supplies of materials had to be planned on assumptions involving not only far greater economy than before, but also much greater risks. In considering the import programme in February 1942 the Lord President decided that the time had come to reduce expectations of raw materials to the absolute minimum needed for the war effort, and in so doing to assume that stocks would be reduced by the end of the year to the safety line. On that basis the Raw Materials Department of the Ministry of Supply had drastically to reduce the total volume of requirements and some of the most essential items in it. Above all, iron and steel and non-ferrous metals were to be cut to an extent which threatened to reduce the stocks of pig iron, steel and scrap by a very large figure. Stocks of other imported raw materials[1] were also to be drawn upon.

Yet, even at this level, expectations of imports appeared to be higher than the shipping situation justified. At the invitation of the Lord President the Raw Materials Department of the Ministry of Supply submitted in February 1942 two programmes of imports both smaller than the previous much reduced expectations, and in March the Department had to act on the dismal assumption that the quantity of materials to be received by sea would be only seventy-five per cent. of the forecast in November 1941. At this level imports would be considerably less than the amount below which, it was thought, they could not fall without creating a serious situation. As planned production was expected to rise in the course of 1943 to its topmost peak and consumption of raw materials to grow in proportion, the accumulated deficiency over the eighteen months from January 1942 to July 1943 looked as if it might exceed the safety figure by a wide margin.

It will be shown presently that, in fact, the situation in the second half of 1942 did not deteriorate quite so badly and that no serious shortages developed. This, however, was not sufficient to relieve the fears for the still more distant future. Even though in the course of 1943 American assistance was expected greatly to relieve the shipping position, the authorities expected that further dislocation of the import programmes would result from the offensive campaigns of the Allies. At the same time consumption was due to rise in keeping with earlier plans, and the munitions industries alone were due to consume 12·5 per cent. more raw materials in 1943 than in 1942. The prospect was very disturbing, and what made it still more disturbing was that in the last quarter of 1942 the rate of sinkings rose and the amount of

[1] Mainly timber, raw wool, raw cotton and pyrites.

tonnage diverted to military preparations was greater than expected. At the level of imports that could now be expected, reserves set aside to meet unforeseen emergencies might at the end of the year be reduced to three to four weeks' supply.

Indeed, so dangerous appeared the position and prospects of stocks that the Prime Minister was obliged in December 1942 to intervene with a direction that stocks should not be allowed to drop to a level which would leave this country without 'elbow room' for possible contingencies. This meant cancelling the assumption on which the current programmes were based, i.e. that this country would run down its stocks of imported raw materials to the level of 'distribution' stocks. The new 'elbow room' was set by the Minister of Production at a figure which was near the level at which stocks of imported raw materials had stood at the end of 1942. The estimates of consumption in 1943 had therefore to be reduced accordingly, and above all, heroic measures had to be taken to maintain the rate of imports. And nothing was more 'heroic' than the Prime Minister's decision to sanction the withdrawal of ships from military uses. In accordance with his direction, fifty-two out of every ninety-two ships which it had been planned to use for the carrying of military stores to the Indian Ocean during the first six months of 1943 were to be diverted to bring imports to the United Kingdom.

For a few months in 1943 the position appeared to deteriorate still further, partly through a sharp fall in the amount of shipping space allocated from the United States, but also through severe weather. The position was expected to improve in the second half of 1943; yet, allowing for all possible improvements, the Minister of Production unofficially estimated in the spring that it would not be possible to import during 1943 anything like the amounts budgeted for. A grave deficiency thus appeared inevitable. The requirements of the production departments had been pruned in January 1943 to a level which was below that of 1942, but as the consumption of raw materials in general had been running at a relatively high rate during the last three quarters of 1942, it was difficult to cut it sufficiently to satisfy the Prime Minister's expressed wish for 'elbow room' over and above the minimum distribution stocks. There was indeed a danger that distribution stocks themselves might have to be raided, and if so, the flow of production would not be sustained.

Sustained it nevertheless was. At no time during the period was munitions production in the country interrupted or even slowed down by a failure in the supply of raw materials. Such shortages as may have appeared in aircraft production and elsewhere were purely local and were confined not to raw materials in the narrow sense of the term but to the 'fabricated' materials—rolled products, castings, forgings, etc.—and were due not so much to difficulties of import as

to problems of fabrication in this country. At no time were stocks of imported raw materials in general drawn upon to the extent which the Lord President of the Council and the Raw Materials Department had been forced to contemplate at the beginning of 1942. This was due in part to a decline in munitions requirements, but also to the steps which the Ministry of Production took in April 1943 to restrict consumption.

The cumulative reductions of stocks over the eighteen months January 1942 to June 1943 are difficult to compute with any exactitude, but they were certainly nowhere near the figure which once seemed inevitable, and what is more, total stocks of raw materials began to rise again by midsummer 1943. In the three months June to August 1943 they rose by nearly 1·5 million tons.

The relatively satisfactory condition of stocks and supplies was partly due to a flow of imports better than at one time seemed probable. In the first six months of 1942 and again at the turn of 1942 and 1943, imports were below programme, but, with the possible exception of the opening months of 1943, they never dropped below the safety line. Over the period as a whole the actual flow of imports was above the minimum programmes, and from late spring 1943 onwards the position improved very rapidly. The early months of the year saw a decisive turn in the Battle of the Atlantic, and a little later the military success in North Africa and Italy opened the Mediterranean to Allied shipping. As a result, more goods arrived than forecast; and the American promises of shipping assistance also proved easier to fulfil. No doubt supplies of individual commodities still remained very difficult. Above all, as more shipping was made available, so did the difficulty of finding appropriate cargoes in foreign ports grow.[1] Nevertheless, by June 1943 the total of non-tanker imports reached the highest level since October 1941, and, as mentioned above, stocks of imported raw materials were beginning to rise. By the end of 1943 they were higher than at the beginning of the year and well above the 'distribution' minimum.

Mutatis mutandis, the situation in 1943, with imports and stocks higher than the more pessimistic forecasts, was recreated in 1944. Although the year began with hopes higher than ever before, certain dangers were to be anticipated. The needs of the offensive on the Continent were expected to put a strain on shipping, and inland transport was also heavily burdened. Nevertheless, imports in the first half of 1944 ran higher than even the more hopeful versions of the programmes allowed.

The higher rate of imports in 1943 and 1944 was not the only, and

[1] See p. 212.

perhaps not even the main, cause of the satisfactory state of supplies. Domestic sources also proved very buoyant. The production of iron ore had reached its peak in 1942 when nearly 20 million tons were produced, eight million tons more than in 1938,[1] and, what is more important, one million tons more than in 1941. In 1943 3·7 million tons of domestic timber had been felled, slightly more than had been assumed in earlier discussions.

Production of some essential raw materials[2]

TABLE 31 — Thousand tons

	1942	1943	1944
Iron ore[3] . . .	19,540	18,487	15,496
Pig iron . . .	7,604	7,187	6,760
Scrap for steel-making .	7,688	7,782	7,349
Steel ingots and castings	12,764	13,031	12,116
Hardwood . . .	1,025	1,251	1,163
Softwood . . .	861	805	560
Pitwood . . .	1,574	1,765	1,506

Source: Cmd. 6564

The main relief, however, came neither from the better rate of imports nor from the higher output from domestic sources, but from a much reduced consumption. Consumption would in any case have run below estimates. The expected demands for raw materials, like all other estimates of requirements for war production, were computed on the assumption that all other factors of production would be available in planned proportions at the right times and in the proper places, and that production of munitions would run at full programme rates. This assumption was, of course, highly unreal and inevitably led to over-estimates in every individual item of the programmes. In addition, most estimates in the programmes contained insurance margins against contingencies and sometimes against possible cuts. It is, therefore, no wonder that the demand for raw materials in 1942, as anticipated in February 1942, turned out to be nearly twenty per cent. higher than the actual intake of raw materials by industry in that year. The estimates were revised in the middle of the year; yet even in their June version they were about nine per cent. higher than actual consumption. The over-estimates were especially marked in programmes for steel, non-ferrous metals and softwood—all of them materials where shortages were expected to be most serious.

This tendency to over-estimate, inherent in the nature of war-time programmes, did not cease, but in general the margins of over-

[1] The metallic content of the ore had, however, declined.

[2] See p. 156 for production, 1935–41.

[3] Average ferrous content about thirty per cent.

estimates were themselves becoming smaller. In the same period, however, the gap between supply and requirements narrowed down to an extent far greater than improved estimates alone can explain. A further and more potent cause will be found in further reductions of requirements which were forced upon the Ministries by economic circumstances. This time what was being reduced was not only the requirements of raw materials based on current production programmes, but the current production programmes themselves. In December 1942 the Prime Minister, in his endeavours to protect stocks, enjoined upon the Ministries drastic reductions in their requirements of imported raw materials.[1] But even before these economies could be carried into effect the supply departments, and in the first place the Ministry of Supply, had to cut down most of their forward plans for expansion. For in the meantime the shortage of manpower became so pronounced that it made general retrenchment in economic effort inevitable. Consumption of raw materials was bound to follow suit. The peak demands were reached earlier than originally planned, somewhere in the middle of 1943, and ran at lower levels. In short, the main reason why the deficiency of raw materials was not very great was that the deficiency of labour was far greater.

(c) THE LABOUR FAMINE

The growing shortage of labour was rapidly becoming the main obstacle to continued expansion, the one limiting factor to which all others were being rapidly reduced. The difficulties of labour supplies had been, of course, the inescapable accompaniment of industrial progress from the earliest days of rearmament.[2] But whereas before the end of 1941 the labour problems were mostly local and were largely confined to skilled workers, by 1942 the labour problem had become that of manpower in general.

It is not that the shortages of skilled labour were no longer felt. Dilution and training had much progressed and the total number of skilled operatives, more especially of skilled engineers, was now very much greater than it had been at the beginning of the war. By the middle of 1942 one and a quarter million people in the engineering industry alone were drawing skilled rates of pay as compared with about half that number in June 1940 in the 'engineering and allied industries'.[3] But skilled men's wages did not always go to wholly skilled men. Managers now frequently complained that the quality of

[1] See p. 214.

[2] The story of Labour in Munitions Industries will be told in the forthcoming volume in this series by P. Inman.

[3] This category includes engineering, construction of vehicles and other metal industries, but not shipbuilding, ship-repairing or the manufacture of metals.

skilled labour was much lower, even if the quantity was higher. What is more, even the quantity, high as it was, was not equal to the demand. For in spite of up-grading, dilution and concentration of production[1] the demand was growing with the general expansion of war industry and also with the development of new techniques requiring special training and aptitude. Welding was probably the most insatiable of the new skilled grades. In the course of 1942, 1943 and 1944 welding came to be adopted in almost every branch of metal-working. The change in shipbuilding was perhaps the most abrupt, and more will be said about it later,[2] but welded construction had also made great headway in the manufacture of aircraft, gun carriages, engineering stores and tanks. Fortunately it did not take as long to train a welder as it did a skilled worker in alternative processes—a riveter or a skilled foundryman. It was also fortunate that women often proved well fitted to the delicate and painstaking character of the work and were trained in very large numbers, more especially in the engineering Royal Ordnance Factories. Nevertheless, the demand for highly skilled welders always exceeded the supply. Equally unsatisfied remained the demand for shipwrights, platers and riveters in the shipyards, toolmakers, electricians, fitters, draughtsmen and some other higher categories of industrial skill. In general, shortages of skilled labour were still sufficiently real to be used as convenient alibi for recurrent production problems in the aircraft industry and elsewhere. But the shortage was especially acute in the shipbuilding industry where, in spite of the technical transformation which was to take place in the course of 1943, skilled labour was still needed in proportions higher than those which prevailed in other branches of war industry.

All these difficulties, however, were now merged into the rapidly growing shortage of labour of every kind and the gradual exhaustion of manpower resources. The exhaustion was not, of course, unexpected or unheralded. Manpower was the ultimate limit of the war effort of 1914–18, and ever since the beginning of rearmament the planners and the administrators of war industry always assumed that if another war were to come the industrial effort would again be limited by manpower. This was the obvious postulate of the arguments for and against a large field army at the beginning of the war, and a rough notion of an eventual limit of manpower reserves also underlay the later discussions of the Army intake which were to lead to Mr. Churchill's directive of March 1941.[3]

The size of the manpower reserves or the time when they would give out could not, of course, be determined in advance with any

[1] See p. 148.

[2] See pp. 297–98.

[3] See p. 127.

accuracy. Full and reliable manpower budgets were not available until the last eighteen months of the war, and in the meantime it was impossible to measure with any accuracy either the actual needs or the future requirements of the Services and of war industries. Rough estimates were, however, made, and were sufficient to foretell a general labour shortage some time in 1941 or 1942. Though in its report of May 1940 Lord Stamp's Survey of Economic and Financial Plans was mainly concerned with the period over which the current programme of war effort could be achieved, its implied prediction was that manpower resources would be wholly taken up by the end of the current programme.

On the other hand, the Beveridge Committee of the autumn and winter of 1940[1] was, as its name shows, primarily concerned with the future supplies of men and women for the Services and war industries, and its findings were not only more definite and precise than anything hitherto available, but they were also more strictly relevant to the main problem of labour resources. On the strength of the evidence available to it the committee calculated that by the end of 1941 the personnel of the Forces and of war industries would under their current plans be some 9·5 millions strong, 3·5 millions more than in mid-1940. The needs of the fighting Services (including civil defence) would have to be met largely by drafting into the Services some 1·7 million men, previously excluded from call-up or shielded from military service by reserved occupations or otherwise retained by civil occupations or even in war industry. As a result of these measures the munitions industry stood to lose some 300,000 men, whereas its estimated needs by the autumn of 1941 were for an additional 1,465,000 workers. The shortage in the munitions industry would thus be very great—far greater than transfer of men from other occupations could cover. The committee reckoned that by getting hold of youths below military age, of older men, and of men physically unfit, war industry might scrape up a million or so. This would still leave a deficit of men—300,000 or thereabouts—in the munitions industry as well as a further deficit of some 700,000 caused by the withdrawal of men from the non-munitions industries and services. The deficits, as well as the additional demands of the Forces and civil defence, could be covered only by recruiting some 1,690,000 women, and in the opinion of the committee this number could not be found without impinging upon population groups not normally reckoned as 'employable', and in the first place upon married women. This, by implication, would be the country's last reserve of labour.

The estimates of the Beveridge inquiry were not, and could not, be borne out in detail, for future demands of both the Forces and war

[1] See pp. 85 and 147.

industry could not be measured in advance with any precision; but the general prophecy proved only too true. When in July 1941 the War Cabinet asked for a survey of demands and of resources and the Ministry of Labour presented its first Manpower Survey based on its midsummer count of employment books, the state of the country's manpower resources appeared not far different from the Beveridge forecast. The total in the Forces and the munitions industries was about eight millions, not 9·5 millions as anticipated by the Beveridge Committee, but then the year was not yet up,[1] and much of the Services' demand to the end of the year was still to be met. Moreover, new and far-reaching demands for the year ending June 1942 were now forecast—just under 1·5 million more for the armed forces and civil defence and some further 775,000 men and women for munitions and other essential industries, such as mining and timber. And no sooner were these figures published than the autumn bomber programmes presented the Ministry of Labour with additional demands from the Ministry of Aircraft Production to the tune of 850,000 men and women.[2]

The country was thus entering 1942 with demands for labour for that year at least 1·5 million higher than the figure on which the Beveridge Committee had based its dismal prophecy and its drastic recommendations. In other words, even before Pearl Harbour and the extension of the war to the Far East the country was faced with the near prospect of a labour famine. The events following Pearl Harbour brought the prospect of the famine nearer still. Throughout 1942 and 1943 the Services and the supply ministries, responding to the rising needs of the war, presented a series of ever-growing demands for manpower which far outstripped the possible yield of the country's reservoirs of men and women.

The reservoirs were in any case being drawn on to the full. The transfer from other fields of employment had by 1942 gone as far as it could go, for apart from distributive trades, civil engineering and building, from which some further transfers were still possible, the civilian industries and services no longer possessed any big residues of transferable labour. In order to reinforce the Services the Government introduced individual deferment in the place of the system of reservation hitherto in force under the Schedule of Reserved Occupations.[3] This change was designed not to disturb production at its most essential points, but war industry was now bound to lose some of the men previously shielded from enlistment by the reservation of entire occupations. The extension of the age of conscription to fifty-

[1] The Manpower Requirements Committee's estimate of the intake of the Forces was to the end of 1941.

[2] See p. 304.

[3] See pp. 96 and 151; also W. K. Hancock and M. M. Gowing, *British War Economy*, *op. cit.*, pp. 313 and 456.

one years also impinged on the supplies of males still available for industrial employment: supplies which had in any case been attenuated to a mere trickle. There was a small intake of men invalided from the Services and of older men, of immigrant labour from Ireland, of timber-workers from Canada and Honduras; later came also prisoners-of-war. But the contribution which most of these sources could make was not great, and, from the point of view of war industry, it was mostly indirect. Prisoners replaced in various outdoor occupations men drawn into the Services or into war production, but their main spheres of employment were agriculture and navvying. Irish labour was more generally available for industrial employment and, on one occasion early in 1942, a single large batch of Irish labour, shepherded into this country by the Ministry of Labour, helped to clear a difficult 'bottleneck' in drop-forging labour. Over the period as a whole the direct contribution from Ireland reached quite a sizeable figure. During 1940 and 1941 the total number of Irish immigrants who took up employment in this country exceeded 60,000, and a further 100,000 came in during 1942 and 1943, but by no means all the immigrants sought employment in war production or in other essential occupations.

New supplies of labour commensurate with new demands could come from the only domestic source not yet exhausted by the beginning of 1942, i.e. women; and the Government proceeded to mobilise all the women that could possibly be mobilised. In his early approaches to the problem of the employment of women, Mr. Bevin may have given the impression of holding back. But now that all other domestic sources had given out, and the demands of the war machine were high and urgent, he was prepared to proceed quickly and to go very far. In the end the Minister of Labour and the War Cabinet in general went farther in this direction than the war governments of any other country, not excluding Germany and Russia, and even farther than the advocates of drastic mobilisation in 1940 had anticipated. The net cast by the Registration for Employment Order of March 1941 had by October 1942 been spread to take in the bulk of the young and middle-aged women of the country; by then all women between the ages of 18 and 45½ had registered at employment exchanges. When in the summer of 1943 an urgent call for labour for aircraft production had to be answered, another 20,000 women or thereabouts were scraped up by extending the registration to 'grandmothers'—the women of 50.

Extension of the age limits was not, of course, in itself the main instrument of mobilisation. What brought women in was the growing vigour with which the Orders were applied, the wider use of official powers, and, above all, the gradual paring down of the definitions of 'immobility' and 'domestic responsibilities' by which a large group of

women had originally been shielded from mobilisation. In March 1941 when the registration of women was first introduced, the measure was directed at 'unoccupied' women.[1] Only later in the year did it aim largely at identifying women in 'less essential' occupations, and even then its immediate object was not so much to compel women to move to more essential occupations as to measure and to locate the supplies immediately available for transfer. But in the course of 1942 and 1943 the emphasis gradually changed. Inducement and, in the end, compulsion had to be used to enforce transfers. Powers of direction were extended to mobile women already in employment and then, by degrees, the definitions of mobility and the grounds for exemption were tightened. In the spring of 1942 exemption from work on grounds of 'household responsibilities' was confined to women looking after at least one other person. In practice, the immunity was narrowed down still further to women who looked after children living at home; all other women with 'household responsibilities' were to be regarded as available for work, full-time or part-time. And if, at the time, women, deemed available only for part-time work, were not yet subjected to compulsory direction, within a year this last exemption was also removed.

By these measures the Ministry of Labour succeeded in decanting into the Forces and into war industry the entire supply of the country's employable women. Thereby the level of employment in the country was lifted to an exceptionally high peak. By the middle of 1943 the total employment in the country (including the Forces) reached 22 millions, which was at least a million more than in June 1941.[2] More men and women were now drawn into the Services and war industry than in the war of 1914–18. Not only was the total number at the beginning of 1944 some three to four millions more than at the peak of manpower mobilisation in 1918, but it also formed a larger proportion of the total population—thirty-two per cent. compared with twenty-eight per cent. The actual number of people directly drawn into service was even greater than the statistics of mobilisation at first sight indicate. For in the statistical computation two part-time workers counted as one whole-time person, and there were, at the end of 1943, the equivalent of 750,000 whole-time workers (mostly women) engaged in part-time work.[3] There were also large numbers of men and, above all, women outside the registration, foreigners, men and women of sixty-five years of age and over. In addition, there were a million voluntary workers, mostly women, whose contribution to the national effort was difficult to measure, but who

[1] See p. 148.
[2] Cmd. 7225, pp. 350–51.
[3] *Ibid*, p. 351.

undoubtedly replaced in the national life a large amount of paid labour.

The supply of manpower for the war was thus greatly expanded, but the expansion could not go on much longer. The inflow of manpower was bound to slacken, and the time was bound to arrive when the human reserves would be exhausted, and industry and the Services would have to reduce their establishments. The coming of the exhaustion point had been long foreseen and even dated. In September 1942 the Joint War Production Staff foresaw in their Report that the time would come when the essential needs of the Forces for men would have to be met by cutting the munitions programmes. Although precise estimates of future industrial needs could not be formed, approximate compilations showed that between April 1942 and December 1943 the current programmes of the Services and of war industry would require for their fulfilment another two million men or women, which was out of all proportion to what could be scraped up by further measures of mobilisation. They therefore foresaw that the Service demands might have to be reduced, and that the munitions industry would have to obtain higher output not from additional bodies but from higher productivity of the bodies they already employed. In October, almost before the warning of the Joint War Production Staff had had time to sink in, the Ministry of Labour's Survey of Manpower covering the twelve months mid-June 1942 to mid-June 1943 (the first Manpower Budget in the proper sense of the term) revealed the full length to which the demand for manpower was outrunning the supply.

With manpower resources exhausted and total employment about to recede, it was no longer possible for the War Cabinet to plan for continued and uninterrupted expansion along the entire front of the war effort. The need for retrenching the demand for manpower was brought home to the War Cabinet by the Lord President in his report of November of the same year. The Prime Minister had requested him to consider the labour prospect to the end of 1943 and to lay before the War Cabinet the issues which emerged from the Ministry of Labour's Survey. His verdict was that the additional requirements of the Services and of the munitions industries would by that date approach 2·7 millions or thereabouts. On the assumption that the remaining reserves of 'unoccupied' women could yield up as much as half a million, and that 'less essential' occupations could be made to give up another half a million, there would still remain a deficit of well over a million. Allowing for every possible exaggeration in the demands of the supply departments (the Lord President put them at 150,000), the gap between supply and demand still remained perilously near the figure of a million. The Lord President's conclusion, therefore, was that the Government must face the fact that manpower

resources did not match the current programmes. The country could not at the same time meet the essential needs of the Navy, provide for an Army of 100 divisions[1] and expand the Air Force to a total of over 600 operational squadrons. The total calls on manpower would have to be cut and further adjustments be made.

The Lord President and his immediate advisers on manpower problems based their conclusions on the assumption that if 1944 were to see the peak of the military effort, and if victory were to be achieved by the end of that year, the peak of industrial effort and of employment would have to come in 1943. After 1943 war industry would have to contract in order to provide men for a final military effort in 1944. The alternative, i.e. that of continuing to put equal weight into both sides of the war effort would mean a gradual loss of efficiency in both.[2]

However unwelcome, the conclusion was not unexpected, for by the end of 1942 the labour deficit had ceased to be a mere accounting forecast. Hitherto, it had been possible to provide for excesses of demand over immediate supply by mobilising additional categories of men and women, and by contracting still further the less essential fields of employment. There were now few prospects of fresh supplies from either source. By the end of 1942 most civilian industries and services had contracted as far as the maintenance of communal life on these islands would allow. Indeed in some civilian industries, such as transport and laundries, it had gone too far, and now that American forces were arriving in the country these and some other civilian occupations had to be reinforced with new recruits. Nor could further measures of registration and mobilisation of women be expected to yield much result.[3] The British Government, and Mr. Churchill in particular, had no difficulty in recognising that the limit of British mobilisation was near.

From the end of 1942 periodical cuts in supply programmes had to be made and manpower additions had to be doled out at much reduced rates; additions at some points had to be matched by subtractions at others. The Prime Minister's first set of proposals for reductions in the Service and munitions programmes were made very shortly after the Lord President's report:[4] their effects on labour allocations to the supply departments are shown on Table 32.

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[1] See p. 345 for the plan of May 1942.

[2] The significance of the manpower position in Anglo-American negotiations had already been emphasised by the Minister of Production. See p. 242.

[3] See p. 221.

[4] The Prime Minister's directive was issued on 28th November, but it was preceded by a meeting of ministers on 26th November at which the main principles of the forthcoming directive were discussed. The figures were subsequently discussed and modified, and the final conclusions on cuts were reached at the War Cabinet meeting of 11th December.

Manpower allocations to the end of 1943 as authorised in December 1942

TABLE 32 Thousands

	The demands in July 1942	Cuts	Allocations authorised
Admiralty (Supply)	186	75	111
Ministry of Supply	148	226	− 78
Ministry of Aircraft Production	603	100	503
TOTAL	937	401	536

The requirements were thus drastically cut, and the Ministry of Supply was for the first time asked to reduce its total labour force, but the demands of the bomber programmes[1] and of naval construction[2] were still sufficiently insistent to receive between them an additional allocation of some 614,000 workers by the end of 1943. The position did not materially change in the course of that year. When in the spring of 1943 the Ministry of Labour presented an interim survey of manpower, the labour intake of the supply departments was still increasing. The Ministry of Aircraft Production may not have been getting all the workers to which it was entitled, but the Ministry of Supply had not yet succeeded in reducing its labour force and was still adding to its establishment. The survey was followed by further endeavours to bring down the manpower 'targets' of the Services and of the supply departments. The extent to which labour demands had been exaggerated had by now become apparent, and cuts could be correspondingly more severe. Table 33 shows the numbers to be allotted to the supply departments by the end of the year under the revised allocations of July 1943.

Manpower allocations to the end of 1943 as revised in July 1943

TABLE 33 Thousands

	Allocations of December 1942	Revised allocations of July 1943
Admiralty (Supply)	111	111
Ministry of Supply	−78	−165
Ministry of Aircraft Production	503	259
TOTAL	536	205

[1] See p. 220 and p. 304.

[2] The Admiralty had presented a bill for 34,000 additional workers, of whom forty per cent. were to be skilled, as a prerequisite for the fulfilment of the large programme of escort and anti-submarine vessels recently approved.

Thus, on paper at least, the additional supply of labour to war industry was reduced to little more than 200,000. Yet when the 1943 Manpower Survey appeared in the autumn of that year it revealed new and still higher demands for 1944. The total requirement for additional men and women for the Services and industry came to 1,190,000.[1] In December 1943 the three supply departments tabled urgent demands for at least 114,000 men and women in addition to the numbers they employed at that time.[2] The Ministry of Supply needed an additional 31,000, the Admiralty 71,000, the Ministry of Aircraft Production 12,000, and the other branches of production participating in the preparation for the invasion claimed another 6,000.

The full incidence of these demands will be realised if it is remembered that under the previous cuts, those of December 1942 and July 1943, the planned size of the armed forces had to be curtailed to relieve pressure on manpower. The reductions had involved a cut of four divisions in the planned strength of the Army, of fifty-seven squadrons in the R.A.F.'s programme for 1943 and of eighty-nine squadrons in the programme to the end of June 1944. In addition, owing to the cut in the labour intake of the Ministry of Aircraft Production, a loss of fourteen heavy bomber squadrons in 1943 and of nineteen heavy bomber squadrons by mid-1944 was expected. No such further cuts were possible at the beginning of 1944 when preparations for final battle were in hand. At the same time natural wastage alone, not counting battle casualties, was expected to reduce in the course of the year the total number of the employed population in the country by 150,000.

Hence the continued endeavours of the Government to prune the supply programmes. Hence also the continuous regimen of stringent though shifting priorities. Of the three supply departments, the Ministry of Aircraft Production had enjoyed at the turn of 1941 and 1942 the first claim on resources, mainly by virtue of its all-important bomber programme. In April 1942, however, the War Cabinet approved a high programme of naval construction to deal with the mounting attacks on shipping, and no sooner had this urgency passed away than the need for landing-craft became acute. From May 1942 the Admiralty accordingly acquired the highest priority for important items of its programmes, a priority which it continued to enjoy until the preparations for D-Day began to overshadow all other military objectives. In the final months of preparation the bomber had again to be singled out for preferential treatment, and so also were the special offensive projects on which the Ministry of Supply were engaged. Since the middle of 1942 that Ministry had been cutting its programmes and its manpower in order to facilitate the general reduc-

[1] 776,000 for the Services, 174,000 for supply departments, 240,000 for basic industries.
[2] See Table 34.

tions in war industry, and also in order to make possible continued additions to labour in the Ministries enjoying higher priority. Now the emphasis shifted to it again. In the summer of 1944 the needs of the British armies on the Continent reacted again on its programmes, and the Ministry of Supply had to be allowed to add somewhat to its labour force in spite of the far-reaching cuts which had by then been introduced into the munitions industry as a whole (see Table 34).

Manpower allocations for 1944

TABLE 34 Thousands

	Original demands	Allocations of December 1943	Revised allocations: September 1944
Admiralty (Supply)	71	− 13	− 68
Ministry of Supply	31	−220	−170
Ministry of Aircraft Production	12	− 69	−198
TOTAL	114	−302	−436

The actual emphasis of war production shifted even more frequently and irregularly than the alternating priorities of the three supply departments indicated, for within each of the three main programmes the weight attaching to individual weapons and stores rose and fell with military events. These changes will be recounted in somewhat greater detail further on;[1] but they must be borne in mind in tracing the course which the war economy was compelled to take under the double compulsion of expanding requirements and diminishing resources. The progress of war production had to be 're-tailored', hemmed in at some points, released at others, in accordance with the changing emphasis of strategic necessity and with the dwindling reserves of productive resources. But even thus 're-tailored' it might not have been sufficient to meet the most essential requirements of British forces without much greater American assistance.

(4)

The American Munitions

(*a*) THE NEW NEED

New importance now attached to American supplies. A history of British war production may not, of course, be the right place in which to tell the story of American supplies in all its aspects. But the two themes were closely interwoven, and the weave got closer as the war

[1] See Chapter VI.

was approaching its end. If in the earlier period, i.e. before the middle or the end of 1941, British expectations of 'finished' munitions were not greatly dependent upon the output of American factories, by 1942 and thereafter they had more and more to be adjusted to what could or could not be obtained from the United States. With its economic resources engaged to the full Britain found herself unable to meet the additional demands for munitions in the same proportion as before. As it was, some cuts in individual programmes had to be made. It was only the rising scale of American assistance that prevented the cuts from being still greater. Without it the most essential preparations for the offensive employment of the British forces and for their needs in the field of battle would have had to be sacrificed; indeed the whole problem of Britain's war effort and the scale of her combatant action would have had to be radically recast. By 1944 reliance on American supplies went so far as to enforce what amounted to a division of labour between the war industries in the two countries. But long before then the American supplies figured so prominently in British calculations that the size and the character of the home-produced deliveries could not be understood without taking note of what had come to be expected and in fact was being received from the United States.

(*b*) SELF-SUFFICIENCY

It has already been explained that in the early stages of the war the British war effort was more or less self-sufficient. The size of the British forces, the scale of British war production, the pace of rearmament and presumably the scale of military preparations were for the time being determined by the manpower and economic resources directly available to the United Kingdom. Britain had been producing at home the bulk of her weapons and building up her Forces to an establishment capable of being supplied out of domestic production. This does not of course mean that the British Government was making a deliberate choice between alternative plans resting on a statistical or military argument. Its general attitude was much more opportunist and less articulate than that. While American support was uncertain and the British resources not yet fully taken up, there appeared to be no other way of planning the war effort than by taking the self-sufficiency of the war effort more or less for granted. Not until the American alliance had become a reality and British manpower was on the point of being fully mobilised did it become necessary or possible to conceive a different distribution of resources.

The assumption of self-sufficiency was of course from the outset tempered by a number of factors which did not directly concern British relations with the United States. From the very beginning of

the war Canada, a member of the Commonwealth, figured in British calculations of combatant strength as well as in British programmes of supplies. At first she may not have figured very largely. Half-hearted attempts had been made before the war to prepare the ground for munitions production in Canada, but apart from a modest aircraft programme the only significant results had been small orders for Bren guns and field artillery. The 1st Canadian Division was equipped almost entirely in the United Kingdom. Nor was the position much altered by the outbreak of war. Doubts about the ability of Canadian industry to deliver the goods quickly and shortage of dollars combined to keep the British munitions programme in Canada before Dunkirk within very narrow bounds—ten corvettes, small quantities of gun barrels, ammunition and explosives, and capacity for an eventual output of 250 aircraft a month, mostly trainers. Even so, up to June 1940 a more important role in the supply of munitions, other than aircraft, was allotted to Canada than to the United States.

These assumptions, however, were bound to be influenced by the growing numbers of overseas troops to be armed. Whereas the planned establishment of the field army to be raised at home seldom exceeded the equivalent of fifty divisions, Britain's responsibility for arming and equipping troops under her command had by the end of 1942 extended to a large number of allied and colonial divisions (at one time that accretion was expected to reach the equivalent of more than seventy-five divisions).[1] The rough and ready assumption of self-sufficiency which may have underlain the planned distribution of resources in 1939 was obviously untenable in the conditions of swollen liabilities of 1942.

The demands on American supplies—not only their size but their very *raison d'être*—changed accordingly.[2] To begin with they were very modest, and their modesty reflected not only the scale of the war as it was conceived in Britain but also a number of factors more specifically American. Most important of all was the difficulty of payment. As long as the rule of 'cash and carry' applied, dollar payments in the United States were severely rationed; and the total ration, in itself small, was in its turn mainly given over to non-munitions goods—food, raw materials and machine tools. Dependence on American and Canadian raw materials was great and it grew greater as the war advanced. Dependence on American machine tools was never again to be as great as it had been in the years 1939 to 1941:[3] the time when the main network of British war

[1] See p. 345, footnote 2.

[2] The problems and achievements of Anglo-American supply relationships will be dealt with in more detail in the forthcoming volume in this series on North American Supply by H. Duncan Hall.

[3] See pp. 206–207.

factories was being equipped. So even if American industry had been capable of delivering large quantities of munitions (it will be shown presently that with the possible exception of aircraft American output was as yet small even by British standards)[1] the dollar ration would not have allowed them to be bought in any quantity.

From this point of view the situation changed in the summer of 1940. With the dreadful prospect of defeat and invasion so near there was no sense in keeping within the limits of the dollar allocation calculated on a three-year basis. There was in any case no question of Mr. Churchill's Government doing so; and one of the first manifestations of the 'reckless abandon' with which the war was now to be waged was the decision no longer to refrain from ordering American supplies through lack of dollars.

The decision had an immediate effect on the scale of British purchases in the United States; yet it made little difference to the 'make-up' of British requirements. The need for American raw materials and machine tools was even greater after Dunkirk than it had been before. When on the morrow of Dunkirk there occurred the chance of acquiring the large quantities of machine tools ordered in the United States by the French, it was eagerly seized by the supply departments, and indeed the initiative came from the Ministry of Supply. The need for American machine tools was acutely felt all through 1941, and the demand for special-purpose tools of American make and design remained high and unsatisfied to the very end of the war.[2] As for raw materials, the expanding output of munitions, the loss of several European sources of raw materials and the mounting difficulty of shipping continued to raise the volume of raw materials obtained from the United States.

On the other hand, the flow of munitions across the Atlantic was for the time being bound to be scanty; and it was so made up as to leave little scope for the purchase of standard weapons in common use and least of all for the army weapons in the Ministry of Supply programmes. The main claim on American supplies was from the outset conceded to the R.A.F. The United States possessed in peacetime a sizeable aircraft industry, and the early British orders for aircraft could therefore be cast on a larger scale and stood a better chance of early delivery than those of the other Services. In midsummer 1940 while the Battle of Britain was being fought Lord Beaverbrook made it clear that in addition to current contracts he would be prepared to take all the aircraft which could be produced up to 3,000 a month. The figure was of course hyperbolic: in spite of the rising rate of deliveries, the average monthly exports of American

[1] See p. 233.

[2] See p. 207 on the narrowing down in the range of types of machine tools needed from abroad.

aircraft in the second half of 1941 ran at about 270.[1] But in general Lord Beaverbrook was as good as his word and throughout 1940 and 1941 pressed for as many aircraft as America could possibly yield, thereby greatly outweighing the volume and the value of American supplies to the other Services.

By comparison, the volume and value of what the Navy and Army received from the United States in 1940–41 (not counting the weapons from old stocks which the President dispatched in the summer of 1940 or the old destroyers ceded later in the year) was exceedingly small. The total value of Admiralty contracts at the height of the naval crisis of 1940–41 stood at about £33 millions; they included orders for munitions amounting to about £20 millions, for engines including motor-boat engines to about £9 millions and for small vessels, other than warships, and motor boats for about £600,000. With the exception of small ships, no naval vessels properly speaking were to be ordered in the United States until the middle of 1941. The main demand was for merchant vessels, for even the authors of the pre-war plans had assumed that the Merchant Navy would have to draw on American shipbuilding resources. Yet the first Kaiser-Todd contract for Liberty ships—sixty in all—was not concluded until December 1940; the great Kaiser organisation for prefabricated shipbuilding was not set going until the spring of 1941, and the first Kaiser ships were not launched for at least another six months.

The Ministry of Supply orders were almost entirely confined to so-called 'deficiencies', i.e. urgent items which British industry could not for the time being supply in sufficient numbers, and to so-called 'insurance' orders against possible losses in output through bombing or other causes. Even at their highest the deficiencies did not form a large proportion of the British programmes. On occasions the Ministry of Supply were anxious to get from the United States relatively large quantities of certain exceptional weapons. Thus in August 1940 the Ministry of Supply authorised the placing of contracts in the United States for 3,000 cruiser tanks, about thirty per cent. of total tank requirements. The list of deficiencies which in September 1940 Sir Walter Layton, as he then was, took with him to Washington included 1,600 heavy anti-aircraft guns, or just over thirty per cent. of the total requirements to the end of 1941; a million rifles, about forty per cent. of total requirements;[2] 1,800 field guns, nearly thirty per cent. of requirements and 1,250 anti-tank guns, twelve per cent. of requirements. The other deficiencies on his list were less than ten per cent. of requirements and most of the Ministry

[1] See E. R. Stettinius, Jr., *Lend-Lease*, 1944. Chapter VIII: '2,400 aircraft were exported to Britain and to British forces in Egypt from March to December 1941.'

[2] This represented about sixty-five per cent. of requirements from new production.

of Supply's stores were not on the list at all. A rough computation of the total deficiencies then listed represented rather less than five per cent. of the Ministry's current programmes at Z + 27 (30th November 1941) measured by values. Even this estimate exaggerated the real need, for the deficiencies were computed on the assumption that the initial equipment of the Army would have to be completed by the end of 1941. Had a later and more realistic date been chosen the figures of deficiencies would have been put still lower.

Insurance orders were calculated on a scale which appeared to be but was not more ambitious. When an 'Army Insurance Policy' was worked out in June/July 1940 the margin to be insured was reckoned at twenty to thirty-five per cent. of the total requirements of the more important military stores. Nevertheless the total orders which the Ministry of Supply placed in the United States during 1940 and 1941 covering both 'deficiencies' and 'insurance' were well below fifteen per cent. of the British programmes, and actual deliveries were lower still. A later estimate put the British purchases of 'finished' munitions in the United States from September 1939 to the end of 1940 at rather less than $515 millions or about 5·6 per cent. of the total British Empire supplies of munitions from all sources; and yet this figure included the greatly increased outlay on ships, aircraft and weapons which followed the military events of the early summer. According to the same computation the value of munitions obtained from America in 1941 was not more than $1,490 millions or 11·5 per cent. of the supplies from all sources; and that in spite of the coming of Lend-Lease in the spring of that year.[1]

The low levels were a matter of both choice and necessity. In the Admiralty and more still in the Ministry of Supply a doctrine of self-sufficiency prevailed, and neither department appeared to be willing to run the risks of an alternative policy. The alternative did not of course remain unformulated. Throughout 1940 and 1941 some of the leading British representatives in the United States, men like Mr. Purvis and M. Monnet, and Sir Arthur Salter, then chairman of the North American Supplies Committee in London, repeatedly criticised British policy in matters of supply as not sufficiently imaginative or audacious. The war could not be won as long as the Americans were merely asked to make good the worst deficiencies in the existing British programmes or to cover modest insurance margins. For one thing the British programmes, drawn up as they were to the scale of British resources, were far below the German war potential and therefore insufficient to ensure final victory. In order to make victory certain it was necessary to launch a single Anglo-American programme of production large enough to outstrip the potential out-

[1] See R. G. D. Allen, Mutual Aid between the United States and the British Empire, 1941–1945, *Journal of the Royal Statistical Society*, Vol. CIX, Part III, 1946.

put of German Europe and, therefore, large enough to engage the entire economic strength of the United States.[1]

This was the Purvis-Monnet-Salter argument. In the long run, i.e. in the closing years of the war, events appeared to vindicate it, for Britain's dependence on American industry became very great. But in 1940, when the argument was first formulated, the policy of the great industrial alliance was still little more than a hope. It made occasional and somewhat unsubstantial appearances among the more distant objectives of British war strategy, and on one or two occasions in 1940 and early 1941 it entered into the Prime Minister's communications to the President. It was also adopted by Sir Walter Layton as a directive for his negotiations in the United States in September 1940. He did not, however, press it very hard during the negotiations and would not have been fully supported by his own department if he had. For it necessitated a number of assumptions and hopes which in the London of 1940 and 1941 did not appear at all certain.

The grounds of uncertainty were several. To begin with, there was the uncertainty (which the supply departments themselves were in no position to weigh and measure) whether the United States would remain neutral or become involved in the war. If they did become involved in the war, it was uncertain how much of their munitions output they would retain for their own armed forces (whose size was quite beyond prediction): the munitions assignment system, which in the event assured to the United Kingdom a substantial proportion of American production, was still a thing of the future. The 'targets' of American production were, as yet, a matter of aspiration or, for some, of faith; in 1940 British supply departments had no firm ground for believing that American industry would in fact achieve the vast output of which theoretically it was capable. The American shipbuilding industry had not yet fully emerged from the great inter-war slump and was expanding very slowly. In 1940, the second year of war expansion, it was still unable to turn out more than fifty-three ocean-going ships, and in 1939 little more than half that number had been built. No medium or heavy tanks were produced in the United States in 1939 or 1940; and in 1941, with an output of 3,900 medium and heavy tanks, American production was still twenty per cent. below the corresponding figure of British output. The number of guns of 2-pounder and above produced in the United States in 1940 was 340, and in 1941 6,720—about thirty to forty per cent. of the corresponding figure of British output in that year. Until the very end of the first quarter of 1942 the volume of American output of munitions as a whole was below that of British production.

[1] The correspondence and the exchange of telegrams between British representatives in the United States and the War Cabinet Office in London in the summer of 1940 contain a number of messages representing this point of view.

There were also persistent doubts about American designs and specifications. The bulk of American munitions was intended for American forces and was made to their own orders and design and appeared unsuited to British requirements. The orders placed in the United States including those for 'insurance' were therefore for British types. The American Army authorities on their part disliked orders which might divert resources to the production of weapons which the American forces did not use. In the summer of 1940 the British representatives tried to persuade the American soldiers to adopt for their own use some of the British types of weapons. Travelling teams of British experts demonstrated, or believed they demonstrated, the ability of the British 25-pounder and 3·7-inch anti-aircraft gun to outshoot the corresponding American weapons. But the American Army authorities remained unconverted, and their Government continued to classify weapons of British type as 'non-common' stores. With the battle of the types thus lost, the Ministry of Supply gave up such little hopes as it may have had of covering a large proportion of its needs from the output which the Americans were developing for their own Army.

This must not be taken to mean that no weapons of American types were ordered. Thus American-designed tanks were asked for and supplied from the end of 1940 onwards; and on one or two occasions in 1940 and 1941 the British Government placed large and spectacular orders for weapons of American type. In October 1940 Sir Walter Layton, urged on by the Prime Minister, accepted—and perhaps even instigated—the offer of the American authorities to supply American-type munitions sufficient to equip ten divisions. This ten-division programme also figured prominently as 'List B' in the negotiations with the United States throughout 1941. The significance of this order must not, however, be misunderstood. At the time of the ordering there was a possibility of arming with American-designed weapons some Empire contingents in outlying theatres of war, but the real object of the offer, understood by the British, was to use British orders to develop American capacity for the production of weapons. American Army authorities needed that capacity, and the weapons produced under the ten-division order were eventually diverted to the American Army in 1942.

When, after Dunkirk, the British Government turned its eyes across the Atlantic it was, of course, looking for help from the Dominion of Canada as well as from the still neutral United States. The arguments which made for restraint in the ordering of American munitions applied with much less force to Canada. There was no 'battle of the types', for Canadian forces were equipped with British weapons and the Canadians were generally content to follow the British lead in design. There was less fear of the 'vagaries of allo-

cation': Canada had defence needs of her own, but they did not constitute a serious threat to the delivery of munitions on British account. There was a problem of payment, but it was never allowed to impede the flow of war material. Thus, while progress in the United States was held up by long-drawn-out financial, technical and political negotiations, the Canadians went ahead to build up an armaments industry, the greater part of which was directly at British service. One-third of the original Army 'insurance' programme was allotted to them and as time went on their share became steadily larger. Canadian-built escort vessels played a great part in the Battle of the Atlantic; most of the Eighth Army's transport came from Canada; Canadian factories contributed more than those of the United States to British supplies of anti-aircraft guns and the lighter varieties of armoured fighting vehicles. On the other hand the industrial resources of Canada were very much smaller than those of the United States, and in the nature of things Canadian munitions production could never reach sufficient volume, least of all in the crucial categories of tanks and aircraft, to alter the basic assumptions of British war production planning.

For all these reasons the supply departments, and in the first place the Ministry of Supply, went on assuming that the whole or nearly the whole burden of military requirements would have to be borne by British war industry; and for the time being it was so borne. National resources were not yet fully mobilised, the armed forces and war industry were still capable of simultaneous expansion; and as long as this situation lasted the limited certainties of domestic output could still appear preferable to the unlimited but uncertain potentialities of American production and allocation. Indeed, granted the determination to remain independent of American output, there was even some ground for fearing that America's war industry might attempt too much. As long as the progress of British war production depended on American machine tools and raw materials, there was some reason for fearing lest American expansion should become so great as to absorb the raw materials and the tools which British industry badly needed. As early as mid-1940 Lord Beaverbrook's high appetite for aeroplanes had to be satisfied by sacrificing to American manufacturers some of the French machine tools acquired after the fall of France.[1] Throughout late 1940 and 1941 the supply of machine tools for Britain suffered from the overwhelming requirements of the American munitions industry; and it has already been shown that the immense plans on the morrow of Pearl Harbour created a sudden stringency in the supply of critical raw materials.[2]

[1] See p. 230.
[2] See p. 212.

(*c*) TOWARDS A MERGER

The supplies of munitions from the United States, their volume, their importance to the British war effort, and indeed the entire policy behind them, were to change in later years. From the British point of view the decisive factor was to be the growing shortage of manpower, but the mutual involvement of the British and American production programmes had begun some time before the labour shortage in Britain became pressing. The road towards it was opened by the passing of the Lend-Lease Act in March 1941, even though progress along it was not very rapid for a while. The general effect of the new financial dispensation on supplies of munitions was bound to be gradual. The dollar value of lend-lease supplies actually received during the remainder of 1941 was estimated at £1,082 millions, about one-seventh of the annual average for the next four years;[1] and the bulk of the allocation under lend-lease continued as before to be devoted to food and raw materials. If anything, this country put an even greater reliance on American supplies of raw materials than before, for Britain was now able to switch to the United States her purchases of raw materials without fear of exhausting the stocks of dollars. After Pearl Harbour strategic needs led to further switches to the United States, and considerations of shipping economy continued to influence the British import policy in the same direction. To save shipping space and labour Britain also began to buy from America larger quantities of semi-finished industrial products—mild steel instead of iron ore, non-ferrous metals in semi-manufactured condition, crude chemicals.

On the other hand some time had to pass before finished munitions began to come through under the Lend-Lease Act in large quantities. For not only had the American industry not yet reached its high level of production, but weapons immediately available were still those produced to British cash orders. Of the 2,400 aircraft exported between the passing of the Act and the end of the year, 2,300 had been ordered by March 1941 and paid for in cash. The same is true of 165 out of 951 tanks supplied in the same period, and of 8,000 out of 13,000 lorries.[2] It was not until the second quarter of 1942 that the bulk of the munitions accruing to this country and to the other 'British' theatres of war had been appropriated under the Lend-Lease Act.

The sluggish progress of American supplies to Britain was nevertheless deceptive. While exports of munitions still seemed to grow very slowly, if at all, determined attempts were made on both sides of the Atlantic to lift American assistance above its pre-lend-lease levels. The needs of the British Navy and Army still continued to be

[1] See Table 14 in R. G. D. Allen's article, *op. cit.*

[2] See Stettinius: *Lend-Lease*, *op. cit.*, Chapter VIII.

expressed as 'deficiencies' and 'insurance margins'. But the actual quantities were becoming so great as to involve the main strength of American industry; until the time came when the whole strategic assumptions of the British and American supply programmes had to be adjusted to the conditions of full mobilisation in Britain and the approaching offensive on the Continent.

The first important step in this direction was more symbolic than practical, and moreover appeared to outpace opinion in London. It was connected with the 'Purvis Balance Sheet',[1] compiled with the avowed object of enabling the United States Government to estimate the dollar appropriations which might be necessary to cover the total British requirements under the projected Lend-Lease Bill. It was to be used as a basis for British claims under the new American methods of allocating their output. In form at least the 'balance sheet' was so arranged as to imply that the United States would not be expected to do more than cover the deficiencies in the existing British programmes. But the programmes themselves were stated in terms so broad and so generous that, had the Americans accepted them, they would have found themselves charged with the provision of a very large part of British requirements. The demands on America, listed in the 'balance sheet', included some 7,000 tanks, some 3,300 field guns, some 23,000 tank and anti-tank guns, some 9,000 anti-aircraft guns and some 86 million shells, all to be delivered before the end of 1942.

The figures turned out to be in advance of opinion at home. One of their main objects was to demonstrate to the American authorities and the American public the true scale of military needs. To that extent they were a contribution to America's own plans of rearmament; and by all appearances they played their part in educating American opinion and may even have helped the President to carry through his vast programmes of munitions. This purpose, however, appeared irrelevant to the immediate preoccupation of the supply departments at home, which took the figures at their face value. And taken at their face value they appeared too ambitious. Above all, the Ministry of Supply was not prepared to involve itself with American industry to the extent envisaged in the 'balance sheet'. In the words of the Ministry of Supply telegram to Washington it desired

> to make clear that the statement provided to Purvis was a rough estimate based on many broad assumptions for the main purpose of dramatisation of a situation and was never intended to be used as a precise programme or as a basis for contract action. . . . So far as military requirements were concerned . . . we should not at this stage regard provision on so high a scale as justified. . . .

[1] This 'Balance Sheet' of December 1940 was presented to the President on 5th January 1941. It set down, firstly, British requirements of munitions for 1941–42, secondly, estimates of British production, and, thirdly, the deficiencies that would remain.

As a broad indication, the Ministry of Supply suggested that the requirements for the main army equipments for 1942 should be discounted by fifteen per cent.; for ammunition items the discount should be substantially higher. In the end the British Supply Council[1] itself explained that the figures were not intended to form a basis for immediate orders and were only designed as the first bid in the anticipated haggle over the allocation of American production.

A still more ambitious attempt at unified production plans was to be made some six months later in connection with the so-called Victory Programme of September and October 1941. By the summer of that year Anglo-American relations had reached a state of intimacy in which victory over Germany could be officially acknowledged as a joint concern of the two nations. Though still non-belligerent, the United States Government was now fully prepared to accept the duty of providing Britain with the tools necessary to finish the job. As the United States Government had also undertaken to participate in supplies to Russia, the time became ripe for a survey of the responsibilities now shared between the two countries and for some sort of a 'Victory Programme'.[2]

The principle of a 'Victory Programme' had been urged by various persons throughout 1940 and the first part of 1941. But the issue came to a head in the late summer of 1941. In July the Prime Minister, acting on the request of the Chiefs of Staff, asked the President to arrange for a joint study for a combined strategy for winning the war. Independently of this move Mr. Stimson sent to this country in August 1941 a representative, Mr. Stacy May, to explore the munitions problem. Mr. May's principal concern was the scale of American war industry. In his words 'he felt strongly, and others in high positions in America felt the same, that the present schedule was much too low'. He therefore hoped to obtain an indication of 'ultimate requirements' in order to 'jolt the American production men'.

The figures which Mr. May was able to take back to Washington were very tentative, but they were sufficiently high to strengthen the case for a joint survey of victory requirements. Before long preparations for a victory conference were put in hand on both sides of the Atlantic. Early in September the President asked the American Chiefs of Staff to make an estimate of the armament production

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[1] A committee of heads of the British Supply Missions in North America set up in December 1940 under the chairmanship of Mr. Purvis.

[2] This account of the 'Victory Programme' is based on information in the forthcoming volume in this series on North American Supply, *op. cit.* For the American side of the programme see M. S. Watson, Pre-War Plans and Preparations, in the series *The United States Army in World War II*, sub-series *The War Department* (Washington, D.C., 1950), pp. 331–55. For an American account of the growing Anglo-American intimacy and frequent consultations in the first half of 1941, see *ibid*, pp. 371 *et seq.*

required for victory in the war, and requested that the information should be available for the forthcoming conference in London. At about the same time the British Government formulated the general strategic assumptions and assembled from the Service and supply ministries their 'production requirements for victory', covering the period between the 1st July 1941 and the end of March 1943. These schedules showed increases in most stores, and were indeed so high that they could not possibly be met except by American assistance far greater than had ever been contemplated before. The figures for army weapons finally submitted to the conference were as shown in Table 35.

United Kingdom requirements of army weapons as submitted to the Victory Conference, September 1941

TABLE 35

	Required from the United States (Units)	Percentage of total British requirements %
Tanks	11,500	41
Medium artillery	700	47
Heavy artillery	100	33
Anti-tank guns (6-pdr. and over)	4,000	36
Anti-aircraft guns (light)	1,700	14
Anti-aircraft guns (heavy)	3,400	47
Rifles	1,650,000	60

The conference met on 15th September and the British requirements submitted to it reflected the hopeful mood which had by then come to pervade relations between Britain and the United States. The decisions of the conference were not, however, capable of being translated into immediate orders or assignments. In the early autumn of 1941 future American action in fields both military and diplomatic was as yet too uncertain to provide clear guidance of military requirements. In the absence of American data, all the conference could do was to survey the general strategic situation and to register the British requirements for the period between July 1941 and June 1943. The only definite decision was about supplies to Russia, and for a time it even looked as if supplies to Britain would have to be slightly reduced in the immediate future in order to allow their diversion to the Russians. The more distant British requirements were apparently accepted without much questioning, but also without any definite confirmation. They were to be subjected to further study in Washington where they were to be correlated with the new production plans and with the requirements of the American Army if and when the latter were fixed. But long before that point

arrived the Japanese struck at Pearl Harbour and the United States entered the war.

The merger was bound to become more real after America's entry into the war. The institutions necessary to give it effect were in fact founded without delay. The Conference of Allied Leaders held in Washington from December 1941 to January 1942 decided to set up a number of agencies to serve the common purpose of the Allies. The Combined Chiefs of Staff were to be charged with the discussion and the working out of common strategic plans; a Combined Raw Materials Board was to plan the development, expansion and use of the raw materials required for the combined war effort. But from the point of view of this study, the most important of the new committees was to be the Combined Munitions Assignment Board to operate under the Combined Chiefs of Staff as the chief agency for the allocation of weapons, in accordance with strategic priorities.[1] For purposes of allocation the entire munitions resources of the two countries 'were deemed to be in a common pool'.

For the time being, however, both the pool and the machinery devised for drawing supplies from it were still little more than projects. The combined strategic plans were not yet there, nor were the munitions to serve them; even the blue-prints of institutions were still incomplete. For if the industrial efforts of the two countries were to serve a common strategy and to feed a common pool, industrial plans had to be co-ordinated as intimately as the strategic plans. A body responsible for some such co-ordination was in the minds of the British representatives at the Washington conference, but it was not to be established for another six months—on the occasion of Mr. Oliver Lyttelton's visit to the United States in the spring of 1942.

The visit, its purpose and achievements, revealed the distance which still separated the plans of combined war production from its reality. In the months immediately following Pearl Harbour hopes of co-ordination ran high, but the immediate allocation of raw materials and munitions to Britain was greatly jeopardised by the direct repercussions of America's entry into the war. The requirements of the Ministry of Supply in particular stood in great danger of being jettisoned to make room for the demands of the American Services and, to some extent, for the urgent British calls for ships and aircraft. This very danger, however, proved the necessity of completing and carrying into effect the Washington decisions of the previous winter. So, although the immediate pretext of Mr. Lyttelton's visit was to ward off the cuts in British supplies, the preliminary discussion in London and the subsequent conversations in Washington inevitably raised the more permanent problem. In order to place

[1] The Washington Conference also set up a Combined Shipping Adjustment Board. The constitution of the new bodies was set out in Cmd. 6332, dated January 1942.

British requirements on a stable and rational basis it was necessary to relate them to common strategic objects; and that meant concerting not only strategic plans but also production plans.

In this Mr. Lyttelton succeeded fully in form and not quite so fully in substance. A joint organisation for supply came into existence similar and parallel to the joint machinery of military staffs already in existence—a Combined Production and Resources Board (C.P.R.B.) with Mr. Donald Nelson[1] as the United States' representative and Mr. Lyttelton as the representative of the United Kingdom. A body was thus created for working out a unified plan of production based on a common strategic hypothesis. The plan itself, however, was not yet there. On the British side every preparation was made: the Chiefs of Staff had worked out an Order of Battle for April 1943 to serve as a basis for joint production plans, and the supply ministries submitted estimates of their total requirements. On the American side, however, preparations were not yet equally advanced. In spite of their general willingness to relate production to joint strategy, the American Service Chiefs were not yet prepared to subject their requirements to a test of comparative strategic urgency side by side with the British needs. In these circumstances all the British negotiators could hope to achieve was to place the British requirements on the same plane of urgency as the corresponding American requirements. At the first meeting of the C.P.R.B. on 20th June a general decision was taken that 'priority ratings should be allotted to those items of equipment equivalent to the United States' weapons for Forces of equivalent strategic importance'. In accordance with this decision the most urgent British requirements for stores like 3·7-inch predictors, rifles, tank transporters, 10-ton lorries, universal carriers, tank components and explosives were to be given the highest priority to the extent of about half the quantities asked for.

Mr. Lyttelton's next visit led to further acts of 'mutual interference'. In the late autumn of 1942 he had to travel again to Washington, and the pretext as before was provided by the danger of reduced allocations to Britain as a result of threatened reductions in American war production plans. By the early autumn of that year it had become clear that American ambitions in the industrial field were over-inflated and would have to contract. Whereas the original objective for 1943 had been $97·9 billions, the War Production Board now came to the conclusion that production in 1943 would probably be somewhere about $75 billions. In this event it looked as

[1] Mr. Nelson was chairman of the United States War Production Board, the agency set up by the President to supervise and co-ordinate the various production programmes in the United States. The work of the C.P.R.B. will be described in the volume on North American Supply, *op. cit.*

if Britain would receive during 1943 not much more than sixty per cent. of what the British authorities had been led to expect. What is more, the cuts which America at first proposed bore little relation to the balance of strategic needs as they were felt in this country. There was no objection to the American proposals to increase the 'target' for operational aircraft from 80,000 to 100,000 and to cut the tank programme by forty per cent. But the Americans also proposed to reduce the 'target' for merchant ships in 1943 from 20 million dead-weight tons to 16 million, and there was a feeling in this country that with the Battle of the Atlantic at its height the shipping effort would have to be redoubled.[1]

These were all urgent and crying needs; yet the real issue went further than the immediate threat to British supplies or the detailed composition of American programmes. More than ever before, the future of the war appeared to depend on a thorough unification of the strategic and economic plans of the two countries. British representatives believed that under any unified plan of strategy and production the needs of British forces in the various theatres of war would be met more fully than they in fact were in the face of the competing claims of American forces. And, overriding these eminently practical considerations, a fundamental principle of the British war effort for the first time revealed itself for what it was—an essentially Anglo-American problem. This country was now anxious to discuss the entire distribution of its own resources between the fighting Services and war production in relation to American supplies.

The argument was well summarised in a communication from the Minister of Production to the Prime Minister. He reminded the Prime Minister that changes of American plans played havoc with British plans,

> . . . as we must allocate almost all the remaining reserves of our manpower within the next few months, we must reach some understanding with the Americans. Without such an understanding, we cannot risk increasing the manpower in the Services on a scale involving substantial dependence on United States for equipment. If we cannot reach it we must adjust the balance between our industrial effort and the intake into the Services. This would mean, in fact, that, given the need for expansion both of the naval and air production programmes, there must be a limitation on the size of the Army.

In this way the threatened exhaustion of the labour reserves brought to the surface the latent issue of an Anglo-American 'division

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[1] For the American debate on the feasibility of the current programmes which preceded the reductions of autumn 1942 see *The United States at War: Development and Administration of the War Program by the Federal Government*, Historical Reports on War Administration, No. 1 (Washington, D.C.), pp. 107–17; also J. E. Brigante, *The Feasibility Dispute: Determination of War Production Objectives for 1942 and 1943* (Washington, 1950).

of labour'. It has already been stressed that hitherto the issue had not presented itself as a clear-cut dilemma. But by the autumn of 1942 Mr. Churchill's Government was about to take far-reaching decisions on the size of the armed forces and of the munitions industries, and the choice of possibilities was clearly dependent upon the scale of American assistance. Mr. Churchill was of course determined to trim excessive ambition of the Services, and especially of the Army, but the planned strength of the Forces, even after trimming, was greater than British war industry alone could supply. It now became clear that, left to her own production, Britain would be compelled to make drastic reductions in her combatant forces and thus to resign herself to a much smaller part in the coming battle than all previous strategic plans assigned to her. This Mr. Churchill and his Government would not willingly do. What they therefore hoped for and expected was that from now on American war industry would be able to cover a large part of the British Service programmes and, above all, to meet the needs for new or unusual weapons for which capacity in this country was not available and for which new capacity could not be created or manned.

These were the issues which underlay approaches to the United States in the autumn of 1942 and the subsequent negotiations in Washington. What this country now wanted and badly needed was a true pool of munitions, and within a year or so of Mr. Lyttelton's second visit that pooling was to all intents and purposes achieved.

(*d*) A COMMON POOL

It was very fortunate that at the turn of 1942–43, i.e. at the time when shortage of manpower compelled this country to place on America the main weight of the additional demands for munitions, most of the other arguments against this course should also have gone. In spite of their magnitude and generosity the American assignments of munitions under the lend-lease procedure could still at times be subjected to strong pressures from their own Services. As a rule the pressures sprang from motives wholly legitimate, for they had the interests of common victory in view. They were, however, something the British Government was unable to control, and they were therefore from the British point of view unmanageable and unaccountable. To that extent people still found it possible in 1942 to speak of the 'vagaries' of American allocations. But in later years this note was sounded very rarely, for, the 'vagaries' notwithstanding, the volume of munitions assigned and delivered to British forces grew very fast.

Generally speaking, such scepticism as still lingered about the potential volume of American supplies had by 1943 all but evaporated. The very reasons which earlier in the war delayed the full

deployment of American production resources now led to a remarkable outburst of industrial activity. The Americans, not yet confronted with direct demands from the field of battle, were able to draw on the habits of their pre-war economy and to tackle the problem of war-time production with methods of mass production.[1] Mass production required elaborate and extensive tooling up of war plants, and while it lasted the immediate output was bound to be meagre; but once completed it produced a veritable flood of munitions. In the second quarter of 1942 the American output caught up the British; by early autumn the weighted average of American output was more than twice that of British munitions; airframe weight was twice, army weapons two and three-quarter times, merchant shipping nearly six times as great as the corresponding British production. And yet American war industry was less than halfway towards its targets and employed less than seven million people, compared with the British 5·1 millions. The productivity of labour was already estimated to be seventy per cent. higher than in Britain and promised to be 140 per cent. higher in the first quarter of 1943. Thereafter the total output was to grow even faster. By the end of 1943 it was about four times that of Great Britain, and the ratio in 1944 approached 6 to 1.

This remarkable expansion of output was not accompanied by that lack of pliability which some of the sceptics had prophesied. One objection to the adoption of mass-production methods in British war industry was the fear that lines of production elaborately tooled up would be very difficult to adapt to the continuous evolution of military needs and that the quality of weapons would suffer. But American factories did not appear to be afflicted with rigidities of standardised production to the extent sometimes foretold in this country. They were helped by their experience in designing and equipping industrial layouts, by the great capacities of their machine-tool industry, and by the aptitude of workers and managers for emergency spurts—much in evidence in both countries. Thus endowed, they were able in the later years of the war to equip and re-equip new lines of production in remarkably short time. Also the scale of their industry was so vast that it enabled them to establish and to run special factories where standardised products could be modified in accordance with the changing requirements of the Services without interfering with the main flow of production.

Needless to say the quality of American weapons was also proving fully equal to the demands of the war. The suitability of American aircraft was never in question. American fighters, even those of earlier vintage—the Tomahawk and the Kittyhawk—gave an excellent account of themselves in the Middle East and were highly

[1] See pp. 365, 390–91, 406.

welcomed at the height of the Libyan battle. Equally valuable proved to be the Catalina flying-boat, which entered British service in 1940 and continued to be usefully employed in the Battle of the Atlantic. And if the number of Flying Fortresses and Liberators in service with the R.A.F. was very small, it was not for want of asking. Indeed, so anxious was the Air Ministry to get a large number of American 'heavies' in time for the great bombing attack on Germany in 1942 and 1943 that the diversion of the promised bombers to American use after Pearl Harbour was received in the Air Ministry as a heavy blow.

American army weapons were still open to the objection that they were different from the British; but they could not be spurned for being inferior or even for being impervious to British lessons. Though reluctant to adopt the British army weapons or naval weapons in their entirety, the American designers were prepared to accept proved British ideas. It was very largely on British advice that the inferior features of the United States M.3 medium tank, above all its turret, were dispensed with in favour of a British-inspired design. British ideas, as embodied in a tank designed by the Canadian General Staff, also influenced the development of the American Sherman tank,[1] Before long American Services and designers had accumulated sufficient experience to forge ahead of this country at several points. In the field of tank armament the American 75-mm. and 76-mm. dual-purpose tank guns won the acknowledgement of British tank experts, and so did the miscellaneous infantry equipment which American industry was turning out by the end of 1943. The excellence of American transport vehicles had come to be accepted much earlier and was to form the basis of the entire vehicle policy of the War Office.

In naval arms quality of American design and production eventually asserted itself. The Admiralty always rested on the proud assurance of the great qualities of British naval architecture and naval armament; and temptations to follow American examples were very few. Yet in the later phases of the war American naval architects and engineers were developing designs and methods of construction and were using prime movers (mainly turbines employing higher temperatures and pressures) which were well in advance of British practice. Even in the design of aircraft, where British standards and achievements stood very high throughout the war, the marriage of American airframes with Rolls-Royce engines, as in the Mustang fighter, was capable of producing aircraft of quality second to none.

[1] The Canadian General Staff, on the advice of United Kingdom tank representatives, built a development of the United States medium M.3 mounting the 6-pdr. This machine, the Ram, in its turn influenced the United States project for the M.4 tank which became the Sherman.

The American engine-makers may still have been unable to rival the Rolls-Royce liquid-cooled engine; and the Rolls-Royce Merlin, produced in America by Packards, was still the best American-made engine of this type. But the American designers and makers were now producing air-cooled engines of great size and power especially suited for installation in bombers. The coming of the B.29, the Superfortress, in the closing year of the war marked another and a very remarkable advance in a branch of aircraft production where British types had hitherto stood highest.

Thus no argument of general application stood in the way of ever larger requests for American munitions of every kind; and the requests in the end came to cover a very wide range of stores and weapons. Now that the 'capital equipment' of the field army was nearly complete, standard infantry weapons or guns of American type were not required. But individual articles of proved quality, capable of being fitted into the armament of British divisions, or air squadrons, or naval vessels, were requested and allotted, even though some had subsequently to be modified to suit British ideas. A British gun might be fitted into the Sherman tank,[1] British instruments might be installed on American aircraft, and the labour expended in adaptations appeared to be well worth while. The bulk of British requirements, however, were for weapons outside the conventional range of standard equipment. The rough-and-ready principle on which the Service departments and the supply departments now acted was that the United States would be expected to cover British requirements for certain classes of weapons for which the requirements matured or greatly increased in the later stages of the war.

What these requirements were or were going to be was already becoming clear by the end of 1942. The strategic plans as they emerged from the Washington conversations in the autumn of 1942 assumed that nearly 100 per cent. of the Allied requirements for transport aircraft, nearly 100 per cent. of their self-propelled guns and of 40-ton tank transporters, and a very high proportion of landing craft, light bombers, tanks and army transport would come from American sources. In addition, the Allied needs of merchant shipping over and above the 800,000 to a million tons produced in British yards were to be covered by the United States, and so was a large proportion of the combatant vessels such as the auxiliary aircraft carriers, which could be made by modifying or adapting merchant vessels.[2]

[1] See p. 426.

[2] Total receipts of warships from the United States by the end of the war included 38 auxiliary carriers, 99 escort vessels, 132 landing-ships, 2,395 landing craft, 22 fleet minesweepers, 150 motor minesweepers (small craft), 113 motor torpedo boats, and 9 submarines.

Supplies of groups of certain war-stores from the United States and production in the United Kingdom and Empire September 1939–August 1945.

TABLE 36

	Production in:				United States supplies for War Office and Empire requirements	United States supplies as percentage of:	
	United Kingdom	Canada	Eastern Group	Total cols. 2, 3 and 4		United Kingdom production (i.e. col. 2)	Total supplies (i.e. col. 5 + col. 6)
Column 1	2	3	4	5	6	7	8
			Thousands			%	%
Tanks[1]	24·8	3·6	nil	28·4	25·6	104	47
Artillery, anti-aircraft equipments, tank and anti-tank guns	132·1	13·4	5·9	151·4	10·3	8	6
Small arms (for Army only)	7,598	1,450	1,124	10,172	2,757[2]	36	21
Military vehicles:[3]							
(*a*) Propelled vehicles[4]	682	582	1·6	1,265·6	264	39	17
(*b*) Tank transporters (included under (*a*) above)	1·3	nil	nil	1·3	4·8	362	78
Aircraft:							
(*a*) Combat aircraft[5]	96·1	5·4	1·1	102·6	23·0[6]	24	18
(*b*) Transport (and A.S.R.) aircraft	1·8	nil	nil	1·8	2·7[6]	150	60
Landing craft and ships	4·3	nil	nil	4·3	2·6	60	38
			Million rounds				
Small arms ammunition	11,094	4,520	3,790	19,404	7,453	67	28

[1] To 30th June, 1944 only and excluding tank chassis for S.P. artillery.
[2] Special release of rifles from stock in 1940–41 *not* included.
[3] For all armed Services.

[4] Excluding	*Production in: U.K.*	*Canada*	*Supplies from U.S.A.*
	Thousands		
(i) Trailers	151	1·8	11·7
(ii) Motor cycles	421	—	15·9

[5] Heavy, medium and light bombers, general reconnaissance, naval types and fighters.
[6] Deliveries from North America.

These expectations were to determine the composition of British requirements for American weapons during the subsequent two or three years, although the exact quantities and priorities were bound to change from time to time. Thus a higher proportion of landing craft was in the end supplied from home resources, and the proportion of American light bombers delivered or used was smaller than originally planned. On the other hand, American productive capacity had to be drawn on to an ever-increasing extent for the making of such new instruments of war as radar (especially valves), new sights for bombers and remote-control gear, even though most of those instruments happened to be wholly or mainly of British design. As the battle in Europe progressed British forces received large quantities of miscellaneous stores and equipment. Standard infantry weapons or guns of American type were not supplied in any considerable quantity, but miscellaneous army equipment, e.g. transport and some ammunition, came from the United States in larger quantities than ever before. The relative importance of American deliveries in the total supplies of the British forces is illustrated in Table 36.

(5)

The Ministry of Production

(*a*) THE 'GAP'

The war industry at the summit of its effort made new and exacting demands on Government machinery. Readjustments in the machinery were accordingly made. There were changes, mostly small, in the organisation of the supply departments and there were important innovations at the centre, i.e. at and around the War Cabinet offices, and among them the setting up of the office of the Minister of Production. Contrary to the Prime Minister's recent arguments in Parliament and contrary also to earlier opinion in other official quarters, a Minister of Production now replaced the somewhat dispersed authority of the co-ordinating committees. To begin with, the change may not have been as radical in substance as it appeared to be in name; but in the end, i.e. by 1944, the powers and the usefulness of the new office had grown sufficiently to give the country the essence as well as the form of a co-ordinating department of state in charge of war industry.

At a time when the war finally passed out of its passive phase and the military needs both grew and changed in emphasis, a close and continuous link between strategy and production was needed, and the new Ministry supplied it. With industrial mobilisation at its peak

it was no longer possible to expand industrial effort all along the line, and expansion at some points had to be matched by contraction at others. It was therefore very fortunate that the shifts of resources from one supply department to another and, eventually, the gradual demobilisation of industry could now be done under the ægis of a 'neutral' and co-ordinating Ministry of Production. At a time when the British war effort was rapidly ceasing to be self-sufficient, and an ever-greater proportion of munitions was coming from the United States, the negotiations with American authorities were at last in the hands of a Minister who could speak for the three Services and the three supply departments, and do so with the authority of a member of the War Cabinet. In addition, the Ministry was able to provide a unified direction for a number of essential administrative activities which no single supply department could run alone: allocation of machine tools, regional organisation, exceptional claims to labour.

Some of the needs the Ministry eventually met had been felt more or less from the very beginning of rearmament. Above all, the old 'gap', i.e. that between requirements and production, had been noticed and criticised even before the need for filling it became really urgent. Some of the other functions of the Ministry grew up as new interdepartmental 'gaps' opened. The Ministry's usefulness and authority were therefore bound to grow more or less gradually, according as old needs were met and new needs appeared. For the same reasons the Ministry could not have obtained at the outset the authority and the position it eventually acquired. At the time of its creation, in the early months of 1942, the tasks of war production appeared to be fully shared between the supply departments, and the crevices between them were filled, or at least papered over, by various interdepartmental devices. The usefulness of the Ministry of Production, though for a long time apparent to opinion outside the Government, had still to be proved to the people who manned the administrative machine. In the end the proof was provided by events.

At the time when the office of the Minister of Production was first created, i.e. in February 1942, the shortcomings of the existing system, though often admitted, did not appear to call for radical remedies. In the course of two years of war the supply departments and the other ministries concerned with munitions had worked out a rough and ready routine of co-operation. The routine may have been incomplete and unsystematic, but it prevented much friction and delay in the lower ranges of interdepartmental business. On higher levels there was the Production Executive and its committees, to say nothing of the Defence Committee (Supply) and the Lord President of the Council;[1] and at the end of 1941 the opinion

[1] See pp. 142–43.

generally held in official quarters was that the Production Executive with its system of committees had not worked badly. During its brief lifetime it had performed a considerable number of essential tasks. In so far as it was responsible for the Materials Committee, whose decisions it ratified, it succeeded in establishing an efficient system of allocating materials. It tackled the problems of building-labour and materials and thereby helped to overcome the difficulties of the building programme, which was then a burning issue. It also discussed and settled a large number of small interdepartmental problems. It also invariably succeeded in adjusting claims and policies of departments, and its decisions were for the most part loyally accepted by the Ministers.[1]

At the same time the Production Executive did not and could not fill important gaps in the conduct of war industry. Being a mere interdepartmental committee it did no more than provide ministers with opportunities for negotiation and agreement. It could not act in the absence of agreement, and it could not enforce its decisions against the wishes of sovereign ministries. What is even more important was that it could not provide any lead or take any initiative in production matters. The matters it discussed were as a rule referred to it by other departments or by its own committees. Much of its business arose on reports of the Materials Committee and the Industrial Capacity Committee. In its two other committees, those of Manpower and Works and Building, the initiative lay with the respective ministers. Occasionally subjects were brought up by Regional Boards, but it would be an exaggeration to say that the Production Executive exercised a constant or efficient supervision over the regional organisation. In general, the Production Executive found few opportunities for watching the development of war production as a whole. It was officially responsible for the so-called Series D of the Statistical Digest, prepared by the Central Statistical Office, in which the main returns of the munitions industry were summarised. But although the Chairman of the Production Executive (Mr. Bevin) recognised that the chief use of production statistics was to compare them with requirements, the full requirements of the Services and the production programmes based on them did not as a rule come before the Executive.

These gaps were not of course apparent except when viewed against an idealised image of a 'streamlined' administration. But so viewed they frequently were; and not in irresponsible quarters alone. It was perhaps symptomatic of the changing official attitude that as early as October 1941 the Admiralty circulated a proposal for the establishment of a Production General Staff. What was even more symptomatic was the impression which articles on 'Brakes on

[1] On only one occasion did a Minister appeal against an important decision of the Production Executive.

Production' in *The Times* of 2nd and 3rd January 1942 appeared to create. The articles argued that 'a Production Executive which does not function as such, with Regional Boards which are almost wholly advisory and . . . have not authority' was 'a fundamental hindrance to full production' and that there was imperative need for 'a supreme informed body to plan and control production to the advantage of the war machine as a whole'. Counter-arguments were not of course lacking and could be easily assembled for the Prime Minister's guidance. There was in the first place the obvious contention that the planning of production in relation to strategic needs could not be done by anyone except the Minister of Defence and the Defence Committee of the War Cabinet. It appeared equally obvious that failings in execution of production programmes could not be tackled by anybody except the supply ministries. Nor did local problems and difficulties necessarily call for radical remedies. The Regional Boards, it was said, were doing all that could be done. What they failed to do was not due to any lack of authority but to the difficulties and complexities of the task itself. In general the imperfections in the work of production were due to human fallibility and were not to be cured by the setting up of a centralised production department.

It is difficult to say how far this apologia was accepted in its entirety even in the government departments. A note by the Ministry of Labour on the Admiralty memorandum of October admitted that although the Defence Committee (Supply) to some extent kept under control the requirements of the Forces, there was no centralised control of what the Forces were in fact receiving and there was an obvious gap between the Production Executive and the Defence Committee (Supply). But, on the whole, the failings of the Production Executive were not thought to be so great as to jeopardise the war effort. There is therefore little doubt that had the issue been decided solely in relation to domestic war production, no major change would have taken place, at any rate not in 1942.

What finally made the change inevitable and what converted the Prime Minister to its necessity was not so much the domestic aspect of the problem as its international implications. Discussions with both Russia and the United States about allocations of weapons had to be conducted through a single channel and, if possible, by a minister capable of representing the interests of British war production as a whole. From that point of view the new office can be said to have been germinated in Moscow or somewhere between Moscow and Washington.[1] When at the turn of 1941 and 1942 British and American aid to Russia came up for general review, something in the nature of a joint account with the United States had to be established. Lord

[1] See H. of L. Deb., Vol. 121, Col. 799, 12th February 1942.

Beaverbrook, who represented this country in the Moscow negotiations, had to speak and act with the same authority as his American counterpart, Mr. Harriman. The need for a similar concentration of authority became even greater in the next few months when the two countries took steps to pool their resources. With the machinery of the Combined Boards in operation[1] it was becoming obvious that an office corresponding to Mr. Nelson's would have to be set up in this country. The need was not only for creating a satisfactory symmetry in the official representation of the two countries, but for seeing that British representatives on the Combined Boards possessed knowledge and authority sufficient to match that of their American counterparts.

This, indeed, became the main pretext, if not the sole justification, for appointing a Minister of Production. In the words of Lord Beaverbrook setting out his views on the duties of the Minister of Production:[2]

> The very first duty of the Minister of Production will be to journey abroad. Not only will it be necessary to go to Washington, but also to Moscow, because only by such means can decisions be reached on the questions that will now arise as the result of the Joint Board sitting in Washington.

(*b*) THE PERSONAL OFFICE

Lord Beaverbrook's appointment to the new office was announced on 10th February 1942.[3] He did not, however, remain in the office for any length of time. His appointment met with criticism from certain quarters, but probably Lord Beaverbrook's own doubts about the functions and powers of the new office were more decisive. On 24th February 1942 he was succeeded by Mr. Oliver Lyttelton,[4] who was to remain the Minister of Production until the end of the war. During the three and a half years of Mr. Lyttelton's office the Ministry[5] enlarged its scope and extended its usefulness into almost every field of war production. But the timing and the circumstances of its birth made it certain that, however much it grew, it could never become a Ministry of Munitions supplanting the separate production departments. From the very outset all extensions of its authority in that direction were watched with distrust. In the end it found itself wielding an authority far larger than that with which it had started, but the enlargements had taken place piecemeal and in fields which individual supply departments had not previously appropriated.

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[1] For the formation of the Combined Boards see pp. 240–41.

[2] H. of L. Deb., Vol. 121, Col. 800, 12th February 1942.

[3] H. of C. Deb., Vol. 377, Cols. 1403–1405, 10th February 1942.

[4] *Ibid.* Vol. 378, Col. 38, 24th February 1942.

[5] On 13th July 1942, by an Order under 2 & 3 Geo. 6, c. 77, the office of the Minister of Production became the Ministry of Production. S.R. & O. (1942), No. 1383.

In its first version, as set out in a White Paper of February 1942[1] and re-stated by the Prime Minister in Parliament on Mr. Lyttelton's appointment,[2] the conception of the Ministry was that of a largely personal office. There was no intention of establishing a new government department or of encroaching upon the existing departments. The co-ordinating functions which had previously been, so to speak, put into commission, were now entrusted to a single minister, but the functions themselves were to remain substantially the same. Of his various duties, liaison with the United States was the only one not previously borne by the Production Executive and its committees. His powers over allocations of raw materials and over imports in general were to that extent more direct than those of the Production Executive. But in all other respects the position of the supply departments remained unaltered. They were expected to bear the full constitutional responsibility for the business of their departments as heretofore, and were to continue to enjoy the same sovereign authority within their allotted spheres.

It goes without saying that a definition of duties thus conceived could not wholly satisfy the advocates of a Ministry of Production, and did not at first appear to satisfy the Minister of Production himself. On the one hand, the Minister showed his wish to act as a co-ordinator and to be a mere *primus inter pares* among other supply ministers, a position he enjoyed by virtue of his status as a member of the War Cabinet. One of his earliest acts was to set up the Minister of Production's Council, a periodic meeting of the permanent heads of the supply ministries presided over by the Minister of Production. Its first meeting took place on 6th April, and from the outset it functioned as a deliberating and negotiating body, to which the Minister invariably committed all major projects of interdepartmental control and administration.

On the other hand, the Minister made no secret of his intention of giving his office greater substance and definition than it appeared to possess at the outset. The weeks between Mr. Lyttelton's appointment as the Minister of Production (24th February) and the Prime Minister's statement in the House (12th March) on the functions of the Minister were filled with argument and counter-argument about the insufficiency of the proposed powers. Mr. Lyttelton's own *desideratum* was for a Ministry whose co-ordinating powers would be based not only on the authority derived from his membership of the War

[1] Cmd. 6337.

[2] The White Paper defining Lord Beaverbrook's functions was soon withdrawn (H. of C. Deb., Vol. 378, Col. 38, 24th February 1942). The terms of the document had been subject to a careful scrutiny by Mr. Lyttelton and his immediate advisers and a revised version formed the basis of the Prime Minister's statement in the House of Commons on 12th March. (H. of C. Deb., Vol. 378, Cols. 1205–1207). The main principles of the White Paper were not, however, affected by the revisions. No White Paper was issued on the appointment of Mr. Lyttelton.

Cabinet but on his effective power over the use and disposal of 'common factors'. Some such power he was expected to derive from his general authority over allocations and import programmes;[1] but in the opinion of Mr. Lyttelton and his advisers it was both illogical and impracticable to entrust him with the supervision of allocations and import programmes and to leave to the Ministry of Supply and to the Ministry of Aircraft Production the administration of controls. The alternative (it had previously been adumbrated by Sir Walter Layton) was that the 'Raw Materials Departments and the Machine Tool Control and possibly the allocation of labour as thrown up by the Ministry of Labour' should be concentrated in a separate Ministry of Raw Materials and Industrial Capacity under a Minister responsible to the Minister of Production.

Very little came of this and of other similar proposals. The transfer of control over labour was in any case out of the question. The functions of the Minister as expounded in Parliament by the Prime Minister and Mr. Lyttelton[2] included the duty of settling in conjunction with the Minister of Labour the allocation, distribution and efficient use of labour within the field of war production. But the emphasis was on the 'conjunction', and there was no suggestion that the Minister of Production would settle interdepartmental labour problems, either by taking over the Labour Preference Committee or by establishing a similar body under his own authority. A body of this kind may have looked right in one or two of the tentative administration charts of the new office, but nobody 'in the know' could seriously argue that the control of manpower had been unduly dispersed and needed greater concentration than the Minister of Labour had been able to give it. In any case so weighty was Mr. Bevin's personality and so great was his authority in the War Cabinet as to place outside the realm of practical politics any project for taking away from the Ministry of Labour control of the allocation and distribution of manpower. The proposal was not in fact seriously pursued and dropped out of discussion almost at once. No labour allocation department was set up, and nothing was done to establish direct administrative contacts with the labour departments of the supply ministries. The Ministry of Labour appointed a liaison officer, and that officer sat on the Labour Preference Committee with a working brief for the Minister of Production. It will be seen later[3] that

[1] In the original version of his functions a slight clash appeared possible over the import programmes, for the functions assigned to the Minister of Production appeared to overlap the duties of the Import Executive. Eventually the clash was avoided by replacing the Import Executive by an interdepartmental Shipping Committee, an arrangement that was completed on 1st May 1942.

[2] H. of C. Deb., Vol. 378, Cols. 1205–1206, 12th March, and Cols. 1837–1851, 24th March 1942 respectively.

[3] See pp. 265–69.

when in the closing stages of the war the Ministry of Production came to play an important part in the allocation of marginal labour, it did so not by virtue of any special authority in labour matters, but as a result of its growing preoccupation with industrial priorities.

A more determined attempt was to be made to vest in the Ministry of Production control over raw materials and machine tools. There were protracted consultations between the new Minister of Production and the Minister of Supply, but in the end the division of functions agreed between them was to remain largely as originally conceived. The Minister of Production was to exercise his powers over raw materials at the highest level, and that presumably meant that he would confine himself to the broad issues of general policy. He was, of course, to be in charge of the import programmes of raw materials, and the staff administering the import programmes was therefore to be transferred to the Ministry of Production. It was his business to direct negotiations with the Combined Raw Materials Board and the lend-lease authorities in Washington, to control the interdepartmental allocations and releases of United Kingdom materials, the levels of United Kingdom stocks, the development of domestic sources and the purchasing policy in the United Kingdom and the Empire. The administration of all the controls and the determination of prices was to be in the hands of the Minister of Supply and no orders to the Controllers were to be given except through him; but the most essential functions of allocations and priorities were now within the sphere of authority of the Minister of Production. For the all-important Materials Committee of the Production Executive,[1] with its highly-experienced staff under Professor Plant, was now transferred to the Minister of Production's organisation. It could be expected to function as effectively as hitherto, dealing with the individual controls and with ministries as it had done when the Committee was still a semi-independent body in the War Cabinet offices.

The agreement on machine tools resulted in a somewhat similar division of responsibility. General control over the procurement and allocation of machine tools among the supply departments was to be transferred to the Ministry of Production, but the Ministry of Supply retained the administration of the Machine Tool Control and with it the current contact with the machine-tool makers and the detailed supervision of orders and their execution. In the event, the division of responsibility turned out to be less clear-cut than it appeared on paper. Sir Percy Mills, the Controller of Machine Tools at the Ministry of Supply, was appointed head of the Machine Tools Allocation and Utilisation Division at the Ministry of Production, thus ensuring not only a direct continuity with the Machine Tool Control, but also

[1] See p. 143.

the continued exercise of his personal authority in all the important problems of machine tools. The arrangement worked all the smoother for the fortunate fact that the supply of machine tools was now rapidly improving. Machine tools were getting more plentiful as the year 1942 was drawing to its end, and before long machine tools in general ceased to be an important limitation on war production.[1] It is not therefore altogether surprising that the general tendency in the Machine Tools Division was to claim greater influence over the utilisation of tools. This was essentially an 'industrial' function, as the term came to be understood in the Ministry of Supply; and Sir Percy Mills himself figured prominently in the subsequent plans to give the Ministry of Production greater power over the actual production of munitions.

(*c*) THE PRODUCTION STAFF

Greater success was to crown the Minister's endeavours to extend the functions of the Ministry over future plans of munitions production broadly conceived. Before the Ministry of Production was formed the advocacy of a central production department had frequently carried with it the notion that war production should be subject to the same 'drill' as military strategy, i.e. that it should be discussed and co-ordinated at the highest level by a body organised and functioning in the same manner as the committee of the Chiefs of Staff. The idea that there was a real gap, which only a 'general staff' could fill, made an occasional appearance in official discussions of the problems, such as in the memorandum of the Ministry of Labour, to which reference has already been made.[2] Some such idea was also inherent in the first blue-print of the Ministry of Production. Sir Walter Layton had for some time advocated the establishment of a central planning body which could relate the main strategic decisions to the current industrial plans, i.e. express strategic decisions in terms of material resources, and perhaps even bring the accurate assessment of industrial problems to bear upon strategic discussions.

The idea was eventually accepted by the Prime Minister, espoused by Mr. Lyttelton and carried into effect by Sir Walter Layton's appointment to the Ministry of Production. One of the earliest administrative acts of Mr. Lyttelton was the setting up of a Joint War Production Staff (J.W.P.S.) made up of the chief advisers to the Ministry of Production on programmes and planning, the chief technical officers of the Ministry of Supply and the Ministry of Aircraft Production, the Controller of the Navy, and representatives of the Chiefs of Staff. It was expected to advise the Minister on changes in programmes necessitated by strategic needs, to keep the Chiefs of

[1] See pp. 206–11.

[2] See p. 251.

Staff informed on the state of production, to discuss and reconcile demands for overseas supplies and to feed with information the Ministry's representatives on combined Anglo-American bodies.

This part of the project worked out very nearly as planned. The Joint War Planning Group, an inner body, directed for the first twelve months by Sir Walter Layton and staffed by a small group of distinguished and energetic economists, soon succeeded in focusing official discussion on the really essential industrial issues. The discussions and findings of the J.W.P.S. were not, of course, more authoritative than it was in its power to make them. In spite of its official links it could not command all the information in the hands of the departments. The urgency of its reports, the speed with which they had to be prepared and their all-embracing scope meant that their evidence and their conclusions were no more than preliminary and were apt to be superseded by more detailed and better-informed departmental studies. It is also possible that the ideas emanating from the J.W.P.S. had greater effect within the Ministry than they had outside. Yet, read after the event, they present a remarkable record of accurate and timely appreciation. The very first report of the J.W.P.S., that of 13th April 1942, marked a real turning-point in the official notions about the relations between strategy, war industry and manpower in that it brought the prospects of manpower and production into clear relation with the strategic plan.

For a year or two, however, the relative success of the J.W.P.S. was not to be matched by similar successes in other branches of central planning. The J.W.P.S. and the Joint War Planning Group within it concerned themselves with future plans and programmes of munitions, but neither their powers nor their composition suited all the purposes which a planning authority was expected to serve. In Sir Walter Layton's proposals for a production general staff a special department in the Ministry was expected to engage 'in the continuous study of programmes with a view to their better co-ordination' as well as with 'the study of common production problems and difficulties and the direction of the production departments'. There were thus two functions—a higher and a lower one; and both implied more than general discussion of the economic problems and policies underlying the Service programmes. The planning function in the 'higher' sense of the term would have led the Minister to play a major part in the discussion and settlement of future requirements of munitions as they sprang from successive changes in strategic plans. The second and the 'lower' function would have made it necessary for the Minister to control the manner in which production plans were put into operation by the supply departments.

Of the two activities the second and the humbler function of planning presented the greater difficulty in that it promised (or

threatened) to lead the Minister into detailed supervision of war industry. Some supervision was implied in the original definition of the Minister of Production's functions, but it was to be very general and did not require the assumption of new and special authority. In the words of the Prime Minister's statement in Parliament,[1] the Minister of Production 'was to concert and supervise the activities of the production departments', and this he could be expected to do by means of his influence on Anglo-American bodies and by means of the various instruments which he was due to inherit from the Production Executive.

In the mind of the Prime Minister these instruments were sufficient to enable the Minister to supervise and to concert with some effect. They fell, however, short of what a number of people in and round the Minister of Production had in mind and of what, to begin with, may even have been in the mind of Mr. Lyttelton himself. In his first statement to Parliament he spoke of his responsibility for the utilisation of the real resources in the most effective manner, and this could easily be interpreted as the right to control the execution of programmes by war industries. It was very largely with this intention in view that the Minister's official advisers propounded a whole succession of administrative projects designed for the purpose of industrial control.

The first to be proposed and in part to be realised was the project for an Industrial Division. In his statement in Parliament on 24th March[2] Mr. Lyttelton appeared to foresee in his office a division staffed with technical officers from the various production departments. Its function in the industrial field would, however, be confined to the fundamental problems of industrial policy which no single production minister could tackle alone. An example he mentioned was that of changing over factories from one type of munition to another. This proposal, coupled with an advisory body of industrialists (Industrial Panel), was approved by the Minister of Production's Council on 16th April, and a new branch of the Minister's office to be known as the Industrial Division came into existence. It acquired at once a specialised administrative nucleus by taking over from the Ministry of Supply the entire personnel of the Capacity Register or List 392,[3] and from October 1942 it also functioned as the secretariat of the Location of Industry Committee. Yet its activities turned out to be somewhat humble. It performed several useful interdepartmental tasks; it played an important part in overcoming the shortages of ball-bearings; it helped to establish an effective control in the

[1] See p. 254.

[2] H. of C. Deb., Vol. 378, Col. 1847, 24th March 1942.

[3] See p. 42. The officer in charge of the list became the chief executive officer of the Industrial Division of the Ministry of Production.

distribution of small tools; and it handled numerous smaller inter-departmental problems. But it did not exercise anything in the nature of a central authority in industrial matters, and was largely ignored in all subsequent projects to give the Minister of Production an effective machinery of industrial control.

These projects succeeded each other at frequent intervals, though they largely failed to bear fruit. Among them was a scheme, proposed in July 1942, which envisaged the creation of a Production Council with authority over all the committees taken over by the Ministry,[1] and the appointment of a Chief Adviser on Production. The scheme was, however, too ambitious and too symmetrical to find sufficient support within the new department. It would certainly not have survived the scrutiny of other departments, for that scrutiny proved to be all but lethal even to the less ambitious proposals of the following September.[2] The latter included a project for a Joint Industrial Staff and a Joint Production Committee to take charge of the Minister's responsibilities in industrial matters. This time the proposals were framed to meet in advance the objections from other departments. The Industrial Staff was to be a small and a somewhat informal body, a counterpart of Sir Walter Layton's planning group; the Joint Production Committee was to consist almost entirely of representatives of the supply departments. Above all, the scheme as a whole rested on the principle that the Minister's functions in the field of production should be exercised jointly by supply departments and the Minister of Production and that the new bodies would be not so much branches of the new Ministry as instruments of interdepartmental authority. The interdepartmental character of the plan was to be further emphasised by the setting up of a Committee of the Chief Executives of the supply departments.

Nevertheless, the proposals offered sufficient pretexts for associating the Minister of Production (or worse still, the Permanent Secretary) with the effective control of current production to provoke the opposition of the supply departments. By now the opposition was firmly established. It will be recalled that from the very outset, indeed while the Industrial Division was being set up, the supply departments made it clear that it was their own business to see that production of munitions proceeded according to plan. Above all, the Ministry of Supply was anxious not to sponsor official bodies capable of duplicating its own functions. The same fears and objections were to be

[1] i.e. the Central Priority Committee, the Materials Committee, the Industrial Capacity Committee and the Manpower Priority Committee.

[2] These were based on the suggestions of Sir Henry Self who had joined the Ministry a short time previously. They were discussed in the Ministry and between the departments throughout the autumn, mostly during Mr. Oliver Lyttelton's absence in the United States.

raised in the autumn of 1942 by the plan for a Joint Industrial Staff and Joint Production Committee. At an interdepartmental meeting on 13th November 1942 the representatives of the supply departments put it on record that in their view the existing machinery for facilitating the execution of production programmes was as fully developed as it need be and suffered from no visible gaps. There was therefore no case for a Joint Industrial Staff or for any interdepartmental machinery proposed by the Ministry of Production. If the Ministry felt a gap in the working of its own organisation it could fill it by action within its department. This admission and the decision that *ad hoc* meetings of Chief Executives might be useful, exhausted all that by now could be salvaged from the Ministry's plans.

Thus ended the earliest endeavours to provide the Minister of Production with a full complement of officers and committees for effective control over the execution of the munitions programmes. This does not, however, mean that the Minister remained utterly unprovided with administrative devices for industrial control. It will be recalled that in addition to the somewhat inconspicuous Industrial Division there was an Industrial Panel.[1] By the end of the year the Minister set up, with the agreement of the supply departments, a Progress Division within his department—a project salvaged from the ill-fated plans of September to December. At about the same time he also set up the Munitions Management and Labour Efficiency Committee ('Five Man Board').

These bodies were, of course, modest in both promise and achievement. The Industrial Panel was, as its name showed, not an administrative body acting collectively, but a list of names, mostly those of industrialists and trade-union leaders capable of undertaking investigations on behalf of the supply departments. Up to the end of 1942 the members of the Panel carried out twelve inquiries; and its chairman, Mr. R. Barlow, was very frequently called in to advise the Minister of Production himself on industrial questions. After 1942, however, the Panel ceased to be used at all frequently.

Equally uneventful was the career of the Munitions Management and Labour Efficiency Committee. A decision to set it up was taken in September 1942 following recommendations of the J.W.P.S. for increasing production. But what with the delays in obtaining the concurrence of the supply departments and with the Minister absent abroad the Committee did not begin operations till mid-December.[2] By the end of March 1943 it had tackled only one large industrial topic—the production problems of David Brown (Huddersfield). Although the Ministry of Labour appeared to take a hopeful view of the

[1] See p. 258.

[2] Sir Charles Craven, hitherto Controller General of M.A.P., was the first chairman and Sir Percy Mills was the Minister of Production's representative.

Committee's future tasks, its agenda was destined to remain very light.

Somewhat more ambitious and more effective were the activities of the Progress Division. As mentioned above,[1] the same meeting of the permanent heads of supply departments on 13th November which refused to admit that there was a gap between the conception of munitions plans and their execution, also pointed out that if any such gap appeared to exist in the Ministry of Production it was the Ministry's own business to fill it. The hint was taken and early in December the Minister decided to establish a progressing division within his Ministry. This was a more authoritative and perhaps a more effective body than any other so far available within the Ministry for purely industrial tasks, yet it too fell short of its original purposes. The idea of a progressing division had in the first place been worked out by Sir Ernest Lemon, a pre-war Director of Production in the Air Ministry. His notion of progressing was not far removed from that version of industrial control which his directorate had before the war tried to establish in the Air Ministry.[2] It was mainly concerned with the planning and phasing of production in the factories, and involved direct collaboration with firms in the actual operations in workshops.

The new division was not, and could not be, designed to 'progress' production in this manner. Sir Ernest Lemon himself realised that the task required full access to the production plans of the supply departments and to their first-hand progress reports. It also assumed a direct and continuous contact with factories and their managers. But as none of these facilities was to be offered by the supply departments, the Progress Division had to be designed to act on the strength of the information available at the Ministry of Production itself, i.e. the figures of the programme divisions. These could disclose discrepancies between forecasts and output and thus reveal the lack of balance in programmes as a whole; but they could do little to help in locating industrial flows at factory level. The Division as eventually established had therefore to cut its ambition to suit its information. The progressing it could undertake was no more than 'notation of failures in actual deliveries', or broad recommendations of industrial policy to remedy the failures; and this was certainly not what Sir Ernest Lemon had in mind. Under Sir Percy Mills as its first head and Sir Charles Craven as the Minister's Industrial Adviser, the Division proved to be of considerable use,[3] but it never became a major influence in the conduct of war industry.

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[1] See p. 260.

[2] See p. 21.

[3] The regular work of the Progress Division was in the hands of the Secretariat, which also acted as the Secretariat for the 'Five Man Board'.

(*d*) THE GROWING AUTHORITY

Thus, by the end of the first year of its existence and some six months after its formal transformation into a ministry,[1] the office of the Minister of Production acquired some machinery for co-ordinating the execution of programmes. But enough has been said about its different elements to show that by itself it was incapable of raising the Ministry to a predominant position in the conduct of war industry. It was not through machinery expressly designed for the purpose that the Ministry's competence in this field was destined to grow. The authority which it had in fact acquired by the end of the war came to it by ways which had been open to it at the very inception of the office: by virtue of the Minister's position as a member of the War Cabinet, his command over Anglo-American relations, his power over imports and allocations, his position at the head of a *congérie* of co-ordination committees and his responsibility for regional organisation.

In all these directions the Ministry gradually asserted its usefulness and importance. This it did with sufficient tact and caution to lay the spectre of an imperialist Ministry of Munitions which had haunted official discussions in 1942. It was also helped by changes in its senior ranks which did much to banish the earlier suspicions of the Ministry and its officials.[2] For all these reasons the Ministry was able from mid-1943 until the end of the war to penetrate into fields of industrial administration which had been heavily barricaded against it a year or two earlier. Above all, co-operation between the departments was greatly facilitated by meetings of the executive heads[3] under the chairmanship of the Chief Executive of the Ministry of Production. Numerous problems, mostly immediate and concrete, were discussed and settled at these meetings with great advantage.

Thus, through his personal position in the War Cabinet, the Minister found himself charged with tackling, at the Prime Minister's request, the difficulties of the tank at the turn of 1942 and 1943, the problem of the landing craft, and the timetable of the offensive weapons. The problems were all, to say the least, 'ticklish', and in handling them the Minister of Production may therefore have acted with caution. But act he did: and thereby he helped to confer upon his department some of that adjudicating authority which it had un-

[1] See footnote (5) on p. 252.

[2] In June 1943 a new Permanent Secretary of the Ministry was appointed and Sir Robert Sinclair became the Chief Executive. Sir Robert Sinclair's previous functions included the headship of the British Supply Mission in Washington and before then membership of the Army Council and the Supply Council and in that capacity liaison with the Ministry of Supply.

[3] i.e. the Controller of the Navy; Controller General of Munitions Production, Ministry of Supply; Chief Executive, Ministry of Aircraft Production; Permanent Secretaries, Ministries of Labour, War Transport, Fuel and Power; Deputy Chief of General Staff, War Office, and on occasion equivalents from the Admiralty and the Air Ministry.

doubtedly acquired by the last year of the war—an authority to be appealed to in all moments of crisis in the field of production.

This authority grew with the increase in the relative importance of American supplies and the complexities of the import programmes. Above all, the industrial stringency of 1943 and 1944, with its recurrent cuts and adjustments in the munitions programmes and its constant shifts of priorities, was bound to engage the Minister very heavily. For not only did the Joint War Production Staff and the Programmes and Planning Division play a major part in anticipating the need for the successive cuts and adjustments, but it also fell to the Ministry to pilot through the supply departments the War Cabinet decisions on cuts in manpower and to help to reconcile the consequential changes in programmes.

The growing preoccupation with interdepartmental production problems at the highest level was to be matched by a growing involvement with the daily operations of industry through the machinery of the regional organisation. The story how an effective regional organisation gradually emerged will be told in greater detail elsewhere.[1] When told, it may well present its early history as one of both promise and frustration. The Area Boards (twelve in number) had been set up in January 1940 by the Ministry of Supply in agreement with the Admiralty, the Air Ministry and the Ministry of Labour. Their main object was then defined as that of co-ordinating the activities of the local representatives of the supply departments, and of helping to find additional capacity in the areas. The Industrial Capacity Committee established by the Production Council in July 1940 took over the supervision of the Area Boards, and in August 1940 it tried to strengthen them by adding to their permanent membership representatives of employers and trade unions.

For a long time, however, the Area Boards could not be counted upon to do more than offer facilities for consultation between local officials. When in April 1941 the Parliamentary Secretary to the Ministry of Supply, Mr. Harold Macmillan, then at the head of the Industrial Capacity Committee of the Production Executive, toured the areas, he found the members of the Boards, especially the unofficial ones, suffering from a sense of frustration. There was a feeling that the industrial resources in the areas were not yet fully tapped, and that the Area Boards were not doing what they should to mobilise them. On Mr. Macmillan's advice the Area Boards were renamed Regional Boards and somewhat reorganised in the process. Above all, they were given to understand that their chief duties would be to help the main contractors and sub-contractors in the task of finding additional capacity. They were accordingly empowered to set up 'capacity

[1] i.e. in the forthcoming volume in this series on the Administration of War Production; see also p. 77n.

clearing centres', somewhat on the lines of the centre which had existed in the London and South-Eastern region since August 1940. From then on the Industrial Capacity Committee and the supply departments did much to breathe life into the regional organisation. In October 1941 the Boards were given an important part in the redistribution of skilled labour. They were instructed to set up sub-committees for labour supply to assist the Minister of Labour in meeting local demands, especially those for skilled civilian labour. The sub-committees were also expected to hear disputed cases of transfer, of grading, dilution, training and employment of women.

A wide field of activity was thus opened up; it was soon to be matched by the operations of the machine-tool committees, which had been established a few months earlier[1] to help in the supply and exchange of cutting tools urgently needed to relieve 'bottlenecks' in production. Of still greater importance were to prove the 'capacity clearing centres', of which over thirty-six had been set up by the spring of 1942.

In this way, when in February 1942 Lord Beaverbrook became Minister of Production, the regional organisation had grown into an administrative instrument of some importance, and in the course of the subsequent two years its usefulness and importance continued to grow. Inquiry into the work and efficiency of the Boards which Lord Beaverbrook had decreed in February 1942 showed that some useful work had been done by all, and much by some; but the report[2] also showed that more still remained to be done in drawing into war production industrial capacity which was still found to exist in small and dispersed fragments all over the country.

It was in these three fields—local labour problems, the supply and utilisation of tools and, above all, the full mobilisation of industrial capacity—that the regional organisation of the Ministry of Production pursued its activities. Now and again the plans of the men in charge of the regional organisation appeared to transgress the limits of what regional bodies could do or would be allowed to do. Thus, at one time, the department tried to organise its records and census-like surveys into something in the nature of a central register of industrial capacity—a potential instrument of unified control over the disposition of industrial resources on a national scale. At one time in 1944 it may even have seemed as if the regional organisation would fall heir to the hopes which had a year or two previously been pinned on the various versions of a Central Production Staff. But though none of the higher ambitions could be given full play, the regional bodies had by the end of the war become powerful instruments of administration. Especially valuable were their services in settling the detailed

[1] In July 1941.
[2] Cmd. 6360, May 1942.

and highly-complicated priorities of labour, in facilitating the transfers of capacity and in helping the demobilisation of industry in the closing year of the war. And through its regional organisation the Ministry as a whole asserted itself as an indispensable source of policy and authority.

(e) THE DESIGNATION OF WORK

It has already been indicated that in the end the Ministry of Production also acquired important functions in the filling of industrial demands for labour. The need for any such intervention would not have been admitted in the first two years of the Ministry's life. The functioning of the Ministry of Labour as a single department of state in charge of all manpower problems in itself guaranteed unity of policy and administration. In so far as interdepartmental committees had to be created for convenience of negotiation and consultation, they were closely linked with the Ministry of Labour or else were part of the War Cabinet machinery and functioned under the ægis of the Lord President of the Council. The Manpower Committee of the Production Executive had the Parliamentary Secretary of the Ministry of Labour as its chairman. It was, of course, mainly concerned with details of interdepartmental business (deferments, call-ups, etc.), but it was also called upon to play a part in the preparation of the manpower survey of July 1941.[1] Most of the discussions relating to this and subsequent manpower surveys were from the outset in the hands of the Lord President, his Committee and his immediate official assistants.[2] After his appointment as Chancellor of the Exchequer in September 1943, Sir John Anderson continued to handle these questions as chairman of a new Manpower Committee. This Committee with its ministerial and official sections was to remain the principal government organ for the discussion and the working out of the implications of successive manpower budgets.

In addition, two other committees, the Labour Co-ordinating Committee and the Headquarters Preference Committee, looked after the administrative problems of labour supply and allocation, but these bodies also functioned not so much as controlling and arbitrating agencies as administrative aids to the Ministry of Labour. The Labour Co-ordinating Committee came into existence in March 1941 to deal with those labour problems on which the viewpoints of supply departments happened to diverge. It was composed of specialists in labour administration in the supply departments and the Board of Trade, and it was mainly preoccupied with the practical details of labour requirements and supply. But its function and useful-

[1] See p. 220.

[2] See pp. 223–24.

ness reached far beyond the current administration of labour controls. It was sometimes asked to consider in detail the data assembled for the purposes of the labour budget and often found itself drawn into the discussion of labour policies. Thus, in April 1942, the Ministry of Supply and the Admiralty, acting on the request of the Ministry of Labour, submitted to the Labour Co-ordinating Committee their estimates of needs for 1942. After the War Cabinet's decision of December 1942 on manpower allocations[1]—and even before the War Cabinet reached its final conclusions—the Ministry of Labour and the supply departments used the Labour Co-ordinating Committee as a clearing house for their problems. It was as a rule on this committee that the representatives of departments discussed the labour aspects of the cuts in munitions programmes.

To begin with, there was similar continuity in the work of the other committee concerned with labour matters, i.e. the Headquarters Preference Committee. The composition and the functions of this body were severely practical.[2] Its function was to provide a collective representation at the headquarters of the Ministry of Labour for the labour departments of the Ministry of Supply, the Ministry of Aircraft Production, and the Admiralty; and its main preoccupation was with the growing practice of labour preferences, about which more will be said later.

This system of interdepartmental labour committees worked smoothly and on the whole successfully, and there appeared to be no ground for dissatisfaction among government departments with the existing system of consultations on labour matters. It is therefore not surprising that very little came from the suggestion of the Minister of Production at the end of 1942 that an interdepartmental mechanism should be created to guide adjustments of munitions programmes to labour supply. The proposal was opposed by the Ministry of Labour and received little backing in the Labour Co-ordinating Committee. As a compromise, an interdepartmental group was formed to keep in touch with the changes in programmes and to report from time to time to the J.W.P.S.; but in practice it only reported once.

In this way the working of the labour policy and administration remained unaffected by the creation of the Ministry of Production and by the resulting changes in the structure of War Cabinet committees. The change which eventually came resulted from the gradual evolution of the labour preference procedure and from the important part which the Ministry of Production eventually played in it.

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[1] See p. 224.

[2] Although the Labour Co-ordinating Committee was established several months before the Preference Committee, it was before long attached to it for reasons of policy and convenience.

The system of labour preferences had been growing up during 1941 and was becoming more important as well as more complex as labour supplies were being exhausted. Grants of special priorities by the Minister of Labour to laggard elements in production go back to the turn of 1940 and 1941, the somewhat chaotic period when the War Cabinet directive on the general priorities of production had begun to be whittled down by exemptions and additions. But the most important move towards a régime of labour preferences was probably that of June 1941 when, following a demand for 100,000 heavy unskilled workers, the Ministry of Labour proposed that the demand should be met by attaching graded priorities to individual industries. The Labour Co-ordinating Committee did not accept the proposal as a whole, but agreed that priority for supplies of heavy labour should be given to the production of iron ore, marine engineering products, non-ferrous metals and cruiser tanks—four industries called upon to meet demands of great urgency. In September of the same year special labour priorities were accorded to the radio industry and to the manufacture of chemical defence equipment, and priorities of second order to a number of other industries. Experience had by then shown that priorities offered the best means of meeting the most urgent demands for labour at the most crucial points of war production. By that time also the Labour Preference Committee, grown out of the fortnightly meetings of the representatives of the supply departments, had finally established itself in charge of the new system.

It was in the next stage that the difficulties and complexities of the preference system revealed themselves. By then the list of preferences had become very long, and to that extent indiscriminate. The list had to be shortened and made more selective, but this in its turn raised problems of procedure and principle. At the beginning of November 1941 the Defence Committee (Supply) decided that factories producing aero engines, airscrews, carburettors and fabricated light alloys should be manned to full capacity. In giving effect to this decision the Preference Committee granted labour preferences to individual firms in the respective industries. This meant that individual firms were singled out from an industry for preferential treatment, leaving the rest of the industry to fend for itself. The innovation was helpful in that it enabled a greater discrimination to be made in the treatment of over-loaded areas and compelled a continuous scrutiny of the requirements and operation of the principal munitions firms. But it also placed upon the Ministry of Labour and the Labour Preference Committee the power and onus of judging the relative urgency of individual weapons and the relative contributions of individual firms. True, at a special meeting of the Preference Committee on the 5th November 1942, at which the problem of singling out the most urgent items was discussed, the representatives

of the departments appeared to think the existing procedure workable. The difficulties, however, were real and threatened to get worse. A comb-out of the list was then carried out, but the list thus shortened soon began to grow once more, and alarm at the number of current preferences was again evident in the spring of 1943. Nor was the problem of competence solved. By 1943 even the Ministry of Labour appeared to feel that the Labour Preference Committee in its attempts to keep the list down was involving itself in a discussion of subjects which were clearly beyond its competence.

At this point the Ministry of Production was bound to be drawn in. It was the proper authority for deciding the relative urgencies of weapons and stores. It was also responsible for the regional organisation, and regional bodies had by then come to play an essential part in the procedure of labour preferences. They sometimes initiated the proposals for preference; they were invariably asked to explore the circumstances of individual applications, and it invariably fell to them to carry out on the spot the decisions involved in a grant of labour preference.

The issues matured by midsummer 1943. In July of that year the War Cabinet, having revised the 1943 Manpower Budget, instructed the Minister of Production to keep supply and demand of munitions labour under continual review. One of the implied objects of the review was to ensure that the Ministry of Aircraft Production should not suffer from a labour deficit in the total budget, if such a deficit turned out to be inevitable by the end of 1943. This meant conferring on M.A.P. a special and overriding priority for labour, safe even from prior 'vetting' by the Preference Committee. But once the principle of super-priority was admitted it was impossible to refuse it to other branches of munitions production of urgent importance. Super-priority equal to that of M.A.P. soon had to be given to such items as ball-bearings, tools and steel tubes which, although needed for the production of aircraft, were in fact made by contractors of the Ministry of Supply. But the Ministry of Production was pressing for an even wider application of the principle to cover the most urgent work for the Army and the Navy. After a discussion of the whole question at a meeting of the Joint War Production Staff in the autumn of 1943 the War Cabinet agreed that it should be the task of the Minister of Production to 'designate' as being of equal importance with aircraft those products or services which he considered to be vital to the war effort. Henceforth meetings under the chairmanship of the Chief Executive of the Ministry of Production considered and made recommendations as to labour preference policy. By agreement between the departments much discretion was given to the Deputy Secretary of the Ministry of Labour and the Chief Executive of the Ministry of Production to resolve these questions as operational needs demanded.

Thus a highly important method of allotting supplies of scarce labour had come to be worked out. When the overriding preference to aircraft production was withdrawn at the beginning of 1944 it remained the business of the Ministry of Production to 'designate' the products which were sufficiently 'vital' to entitle the industries and firms making them to a super-preference in the filling of labour vacancies. The Ministry of Labour was of course closely associated with the Ministry of Production in controlling the composition of the list of designations, but it was issued on the Minister of Production's sole authority, and his department became the main instrument in its preparation and working.[1] In this way the difficult and highly complex problems of labour control, at the time when the stringency was at its highest, came to be matched by an efficient administrative device; and the Ministry of Production received an important accession to its functions and authority.

(*f*) THE 'MIGHT HAVE BEEN'

Thus, in the closing years of the war the growth of the Ministry of Production completed the administrative structure of war production. The old and much discussed 'gap' between strategic and industrial plans was at last filled, and so were the more recent gaps between American supplies and British production, between central plans and regional action, between declining employment and rising demands from the field of battle, and, finally, between the military and civilian requirements in the period of reconversion. These gaps might not have been filled equally well or equally quickly by the alternative means of interdepartmental consultation. For, although the habits and the machinery of co-ordination had been well developed before the Ministry of Production came into existence, there was bound to be greater expedition and efficiency under a prominent member of the War Cabinet served by the administrative facilities of a fully-fledged department of state.

The solution, however, was historical, not rational. It was a satisfactory resolution of the administrative issues which had arisen in the course of the war, and was not necessarily an ideal recipe for administering the production of munitions *de novo*. The Ministry was called upon to complete and strengthen the system of departments in charge of war production; but the particular configuration in 1942—three separate supply departments catering for three respective fighting Services, but one of them also in charge of raw materials—was in itself a product of *ad hoc* decisions and of gradual evolution. Indeed, it was not the configuration envisaged in most of the pre-

[1] Once a product was designated it was still the responsibility of the Headquarters Preference Committee to decide which individual firms manufacturing it needed 'headquarters' preference to assist in filling their vacancies. A lower degree of preference was accorded by interdepartmental committees in the regions.

war plans or at first intended by the pre-war Governments. It will be remembered that according to most of the pre-war plans the Ministry of Supply was to consist of a single department catering for the three Services and matched by a Ministry of Resources, or at least by a Ministry of Raw Materials.[1] Three independent supply departments emerged as a result of the Admiralty's refusal to part with the design and production of ships, followed by a similar refusal from the Air Ministry to give up responsibility for the supply of aircraft. But for this double refusal there would have been a single Ministry of Supply, and the problem of interdepartmental co-ordination in its 1942 version might never have arisen.

The separate existence of three supply departments, each narrowed down to the needs of one fighting Service, was not, however, the only characteristic feature of the system. The field in which the supply departments, taken separately, now operated may have been narrower than that of the Ministry of Supply of the pre-war blue-prints, but within their fields they were expected to perform more functions than a single ministry might have done. For the Ministry of Supply and Ministry of Aircraft Production were concerned not only with the quantity of weapons but also with their quality, and administered not only the munitions industries but also the technical and scientific effort that went into the design and development of weapons.

The reasons for which this particular combination of functions was chosen in 1939, when the Ministry of Supply was created, and was repeated in 1940, when the Ministry of Aircraft Production was formed, were partly contingent and accidental, and partly prompted by a rational argument. The contingent factor was the existence within the Service ministries on the eve of the war of branches which in fact combined control of production with responsibility for development of weapons—that of the Director General of Munitions Production in the War Office and that of the Air Member for Development and Production in the Air Ministry. The two departments were the embryos of the future supply ministries and were bodily taken over when those ministries were formed.

This solution was also backed by an argument. Again and again in Parliament and in official papers warnings were made against a 'divorce' between design and production. There was the suspicion that left to themselves the technicians in the Service departments might design weapons difficult to produce or might insist on modifications and improvements which would disrupt production. On more than one occasion before the war British designs were criticised as being too elaborate or too 'perfect'. This note was repeatedly sounded in parliamentary debates during the years of rearmament, and now and again it crept even into the papers emanating from

[1] See p. 77.

government departments themselves. Thus on the eve of the war the British experts who visited France to inspect French armaments noted with a somewhat envious admiration how successfully the designers of French weapons adapted them for ease and economy of production. Much later similar opinions were passed on some German and on all the Russian equipment. In these implied comparisons no reference was made to the administration of design in France, Germany or Russia (in all these countries design was in fact administered by the Service ministries), but in discussing the situation at home people commonly assumed that a close administrative link between design and production would solve the problem. The arrangements within the Service departments themselves appeared to lend support to the view.

Between the authority which the supply departments were now given over design, and their existence as separate ministries there was an obvious connection. Once it was decided to entrust the design of weapons to the Ministry of Supply a single Munitions Ministry became impossible. For a ministry supervising the design, development and production of weapons for the three Services would have been too large to be run by the most efficient of ministers or civil servants. It would probably have in fact functioned as a federation of three largely independent sub-ministries; and the same problems of co-ordination which faced the three supply departments in the war would have had to be faced within the ministry itself. In short, the true alternative to the organisation which emerged in the war was not a mammoth ministry of munitions engulfing the three supply departments, but a supply ministry conceived purely as a ministry of production, i.e. concerned with production alone.

This was not the solution adopted in the war, and it was therefore spared the criticisms it would have drawn upon itself had it been attempted. What was criticised was the system in operation, and the criticisms were of course directed at both its principles—the division of the field between the ministries and the powers of the supply ministries over design and development. In this study main attention has to be given to a discussion of interdepartmental co-ordination, for this discussion was most relevant to the history of production. But had design and development been a major theme of this book, equal attention would have been paid to the other criticism. It came mostly from Service circles, and was therefore less vocal than the discussions of co-ordination which were largely 'civilian'. It was, however, to be heard in various places and at different points of time. A Director of Artillery might be heard regretting his exile in the Ministry of Supply away from daily contacts with the activities and opinions of the War Office. The critics of the tanks might deplore the difficulty of bringing the experiences of tank battles to bear upon

the business of design. Now and again the representatives of the Air Ministry might treat some of the shortcomings of war-time production as penalties for the removal of design of aircraft from the Air Ministry. And it goes without saying that the Admiralty was able to blame the Ministry of Aircraft Production 'set-up' for the trials and tribulations which beset the evolution of naval aircraft.

Some such criticisms were of course inevitable. By decreeing that design should not be separated from production the Government did not remove the dangers of an administrative hiatus, but merely transferred them to another link in the chain of decisions. The reputedly weak link was now between the formulation of Staff requirements and the control of actual design. And as long as a weak link was assumed to exist, criticism was bound to focus on it.

Yet although inevitable, the criticism was not built up into a fully argued case. Both the relevant evidence and the conclusions drawn from it remained somewhat uncertain to the very end of the war; indeed they were less certain at the end of the war than at the beginning. Was it ever agreed that the naval vessels, designed as they were within the Admiralty, proved more satisfactory in action or more advanced technically than contemporaneous aircraft, designed in the Ministry of Aircraft Production, or than the guns designed in the Ministry of Supply? Nor was foreign experience much drawn upon. On the occasions when decisions were not taken by the Führer himself, the design of German aircraft was administered by the Services; but it was not argued, nor indeed admitted, in this country that the German system resulted in better aircraft. The American Army and Navy also had a greater administrative hold over the design of their weapons (including aircraft) than the British Services had over the design of theirs. But this fact was not much cited either in the earlier criticisms or in the later praise of American weapons.

Above all, the width of the gap at home was never properly measured. How wide in fact was the gap between operational experience and the control of design? There was, or should have been, none in the Admiralty. As to the relations between the Air Ministry and the Ministry of Aircraft Production, various devices were adopted for bridging the gap between the 'user' and 'supplier' at the topmost level:[1] but even more important than formal devices were the

[1] For five months after the formation of the Ministry of Aircraft Production and the separation from the Air Ministry of the A.M.D.P.'s department, the regular meetings between representatives of design and development and of the operational side, which had been held since early in 1939, continued as interdepartmental meetings, but the exploratory and tentative character of the discussions was increasingly emphasised. From the autumn of 1940 to early in 1941 there were no formal contacts between the two Ministries. In February 1941 the Joint Production and Development Committee, under the chairmanship of Sir Henry Tizard, was established. Meetings of this committee were attended by representatives of the Air Staff, and in this way a link was forged between

personal contacts between men. Design and development in the Ministry of Aircraft Production were as a rule controlled by high serving officers, sharing common experiences and outlook with the heads of the Air Staff and in constant touch with them. More especially, from 1943 the Chief Executive of the Ministry, Sir Wilfrid Freeman, just back from the Office of Vice-Chief of Air Staff, took special pains to maintain regular contacts both formal and informal with his former colleagues. In the Ministry of Supply high-level contacts over matters of design and development were perhaps not so centralised or so continuous as in the Ministry of Aircraft Production. But there, too, close high-level contacts over questions of design were available in the person of Engineer Vice-Admiral Sir Harold Brown, Controller General of Munitions Production until 1942 and Senior Supply Officer for the rest of the war period, and in the persons of the several generals who either headed various branches of the Ministry or represented the General Staff of the War Office in discussions with the Ministry.

It was not these links, however, that the critics desired and the absence of which they deplored. What they had in mind was a daily contact at lower level, access to common experience, and ease of informal approach at all times. More than anything else they wished to throw open government departments and firms' offices to direct impressions from the field and sky of battle. It is not, however, certain that direct operational lessons were wholly denied to the men in industry and in the supply ministries. In the Air Ministry the business of collecting operational experiences and embodying them in 'operational requirements' was well organised and elaborately canalised; yet it could not prevent manufacturers (to say nothing of the technical branches of the Ministry of Aircraft Production) from cultivating contacts with serving officers and guiding their design policy accordingly. The success of an important breed of aircraft turrets has been partly ascribed to informal links of this kind; and almost every large aircraft firm maintained a similar private channel —one is tempted to call it a service. In the sadder moments of tank history both sides, the War Office and the Ministry of Supply, suspected each other of failing to meet the needs of battle. But in 1942 the Ministry of Supply had its own mission in Libya collecting the lessons of battle, and both before and after that date direct reports— and messengers—from Africa were not spurned. In other fields, especially in the study of gunfire, the lessons were gathered for the

requirements on the one hand and design and development on the other. On the suspension of the committee in June 1941, attempts at organised contacts were not altogether given up, and in December 1941 a series of fortnightly meetings between the Air Ministry and Ministry of Aircraft Production were inaugurated, attended at their own request by the Permanent Under-Secretary of the Air Ministry, and the Permanent Secretary of the Ministry of Aircraft Production.

Ministry of Supply by operational research groups specially set up for the purpose.

Thus it is probably true that in matters of design the gap between the 'user' and the 'supplier' was not quite as wide as was sometimes pictured. At any rate it was probably not allowed to remain for long at its widest. Therein lies, of course, both the virtue of British constitutional methods and also the vice of purely constitutional judgements. For in Britain, during the war, the formal conventions of constitutions and the symmetry of administrative charts seldom represented the real methods of government or the real division of functions between officials. The necessities of war led to a number of working arrangements, which largely remedied the division of the field into three supply departments and later culminated in the Ministry of Production. The same necessities of war greatly mollified the rigour of the separation between the men in the fighting Services and the designers of weapons.

CHAPTER VI

FROM PEARL HARBOUR TO VICTORY IN EUROPE:

II. THE EBB AND FLOW OF MUNITIONS

(1)

Ebb and Flow

In the strategic and economic conditions of 1942, 1943 and 1944 the flow of supplies was bound to be both highly expansive and unstable. The strategy of the time assumed and demanded increasing supplies. Offensive plans necessitated special offensive weapons; more especially the final landing on the Continent required a large quantity of miscellaneous equipment specially designed for that purpose, such as Mulberry and landing craft. Disseminated all over the main supply programmes were many other items of equipment of the same origin, ranging from additional engineers' equipment and amphibious or waterproof tanks for the Army to special radar instruments for 'tactical' bombing.

As a rule, the new weapons for the offensive were so interlocked with war-stores in current supply that neither at the time nor in retrospect could they be easily isolated from the main stream of Service requirements. The main burdens of the new demands on the supply departments came in that way: as further instalments of Service programmes. Yet from the point of view of the supply departments the period was marked not only by an expansion of Service programmes but also by their fluidity. The expansion threatened to pass beyond the bounds of the possible, and before long cuts became inevitable. But the cuts themselves added to that uncertainty and instability which was in any case bound to result from the shifting emphasis of the offensive campaigns.

In the ordinary course of events the sights of production programmes would have risen, and were, in fact, in the process of being lifted at the end of 1941. Some rises were resulting from the progressive changes in weapons which were taking place all the while but which were expected to reach their maximum by 1942. In the

course of that year the new four-engined bombers were to replace the older types and to lead to vastly increased requirements of materials, components and labour. The fighters of the Battle of Britain were beginning to be replaced by more advanced types—the Typhoon, the Tempest and the new marks of Spitfires. A large and brand-new field of military supplies was being opened up by the development of radar. Less revolutionary, but almost equally expansive, were the coming changes in the army weapons. The 6-pounder gun which generally replaced the 2-pounder gun in the course of late 1941 and early 1942 was to be supplemented, and in part replaced, by the still heavier 17-pounder tank gun and anti-tank equipment. The anti-aircraft artillery was to be supplemented by a new version of the 3·7-inch, by the 4·5-inch, by the much heavier and more complicated 5·25-inch, and by the medium-light twin 6-pounder. Important changes were envisaged in ammunition, both for tank and anti-tank guns and for anti-aircraft guns (proximity fuses). Finally, tanks of the new cruiser type (Cavalier-Centaur) and of the new heavily-armed types (Cromwell, A.30 and A.32) were expected to come into production in replacement of the Matilda, the Crusader, the Valentine and, to some extent, the Churchill. There were also some changes in army organisation leading to demands for special weapons, the outstanding example of which was the formation of air-borne troops.

Additions to military programmes also resulted from the growing allocations to the Allies. The Polish Prisoners' Divisions, which arrived in the Middle East from Russia in 1942, had to be equipped from British sources, and there was, of course, the continued drain of supplies to the U.S.S.R. The supplies which Britain undertook to provide under the 'Second Protocol' of June 1942 were to run at roughly the same monthly rates as under the 'First Protocol' of October 1941[1]—200 aircraft per month, 250 tanks per month, etc. And even although the interruptions to the convoys to North Russia which occurred in the late summer and early autumn of 1942 prevented the supplies under the Second Protocol from being delivered in full within the year, the actual burden of the allocations to the U.S.S.R. continued to weigh heavily upon the supply programmes and upon the industrial efforts of this country.

These increments, whether emanating from recent offensive plans or inherited from earlier commitments, were all to be superimposed on current programmes. What is more, current programmes themselves were in process of rapid expansion. Planned production was due to be raised in 1942 to reach the culminating rates of output; and the rates themselves were on the point of being expanded in keeping with the wider strategic responsibilities after Pearl Harbour.

The expansion had in fact begun some time before America's entry

[1] See p. 119.

into the war. The British strategic hypotheses and programmes discussed at the Anglo-American Conference in the autumn of 1941[1] necessitated additions of about ten per cent. to the current rates of Service requirements. The Americans did not, for the time being, make clear forecasts of their own, but before long high targets were set up in Washington. As soon as the United States entered the war the American objectives were enlarged further still, far above all earlier estimates of supplies necessary for victory. In his famous pronouncement to Congress on 6th January 1942 the President set before American war industry aims so immense as to appear fabulous: 185,000 aeroplanes, 120,000 tanks, 55,000 anti-aircraft guns, 18 million tons of merchant shipping—all within two years.[2]

Industrial ambitions in Britain could not, of course, be expanded to anything approaching the same height; yet they had already been rising and were to continue to rise with the further progress of current programmes, with the more recent increases in the strength of the Forces and with the mounting demands of the developing offensive. Large and on the whole increasing supplies had to be produced in accordance with programmes, and, in addition, special equipment outside the regular Service programmes continued to be asked for and turned out in ever-increasing quantities.

(2)

The Offensive Tools

(*a*) BOLERO

Obvious accretions to military demands were bound to result from the purely tactical requirements of the offensive strategy. The demands for 'tools' specially designed for the attack and the urgent needs of various offensive enterprises had begun to mount long before full concentration on 'Overlord' was decreed. Indeed, heavy calls on the economic resources of this country came from the very undertaking which inaugurated the offensive schemes of the Allies: the so-called operation 'Bolero' for the reception and maintenance of American forces in Britain. At the time when 'Bolero' was planned, i.e. at the beginning of 1942, the Battle of the Atlantic was at its height[3] and the shortage of which the planners were most conscious was that of shipping. They therefore laid down that for greater

[1] See p. 239.

[2] How high these targets appeared even in some American eyes is shown by the press comments quoted in *The United States at War*, *op. cit.*, p. 103.

[3] The shipping crisis lasted for approximately fifteen months, January 1942 to March 1943. For further details see W. K. Hancock and M. M. Gowing, *British War Economy*, *op. cit.*, pp. 417–435.

economy in shipping the stores required by the American forces in Britain should, as far as possible, be found from British production. Needless to say, the burden of 'Bolero' was not to be borne wholly by the supply departments and by war industry. Much of the strain was taken by civil industries of every kind. Some of the burden had to be shouldered by transport services; provision also had to be made for suitable development of the harbours and possibly of the railways of southern England; above all, the operation required a very large allocation of building labour for the construction of aerodromes and camps. In 1943 it was estimated that some 500,000 workers were engaged, directly or indirectly, in providing goods and services of all kinds for United States forces in the United Kingdom, and that of these, thirty per cent. were engaged in services including transport, thirty per cent. in building, ten per cent. in other civil occupations and only thirty per cent. in providing weapons.

Nevertheless the actual burden on war industries was probably greater than a mere third of the total, for the additional demands now placed on the so-called civil industries made it more difficult to reduce the margin of non-essential labour and materials from which the requirements of war industry could be drawn. It was not until 1944, when the shortage of manpower had come to be felt more acutely than the lack of shipping, that the principle of 'Bolero' was revised, and the needs of American forces in Britain had to a far greater extent than before to be covered by imports from the United States.[1]

Other supplies directly related to the coming offensive were too many and too miscellaneous to be listed and described here. They included, however, in addition to the all-important landing craft, one or two items so novel in conception and so spectacular in size as to draw to themselves a great deal of well-deserved publicity. One of them was the famous Mulberry, a series of prefabricated harbours designed to facilitate the landing of supplies on unsheltered beaches; another was 'Pluto', an oil pipe to the armies across the Channel. Measured against the total volume of war production the two projects may not appear very great, but coming, as they did, when resources were stretched to their limit, they were bound to raise production problems out of proportion to their size. Moreover, they had to be fitted to the opening dates of the operation without much time to spare.

(*b*) PLUTO

Operation Pluto was strategically important, tactically adventurous and, from the industrial point of view, strenuous, but it did not engage any considerable proportion of British resources. More than

[1] The adjustments were greatly eased by the work of the Combined Munitions Assignment Board (C.M.A.B.). See p. 240.

a year's experimental work on the project had been organised by the Petroleum Warfare Department and the Combined Operations Experimental Directorate before the operational stage was reached in June 1943.[1] Some time before then a joint effort of an oil company, a submarine cable company and a steel company, working in conjunction with rival commercial firms, resulted in two novel types of oil pipe—the Hais (Hartley-Anglo-Iranian-Siemens) cable made of lead and the Hamel (Hammick-Ellis) steel pipe.[2] By the summer of 1943 both types were being made in large quantities and arrangements were also made for lengths of the cable to be produced in the United States.[3] All preparations for the operation were completed some weeks before D-day.

The carrying out of the project necessitated close co-operation between companies, firms, government departments and the Services,[4] and gave rise to complex problems of organisation, but measured in materials and manpower it did not by itself impose too heavy a burden on war industry. In June 1943 it was estimated that comparatively small quantities of such scarce raw materials as steel, lead and rubber would be required.[5] The labour needed was estimated to include an unspecified number of workers for the erection of pumping houses, pumps, pipes, tanks, etc., at the English terminal; approximately 600 men for the extension of a land-line to the coast; and some 600 workers, of whom 112 would be skilled, for the execution of the rest of the operation. Indeed, the main burden of the operation was felt not by industry but by the Services. The resources of the Navy were strained,[6] though in the end the project helped to save valuable tanker tonnage needed in the Far East. Both the Navy and the Army also felt the drain on their personnel. In July 1945 the War Office stated that the six or seven thousand engineers employed in connection with Pluto were urgently needed elsewhere. As soon, therefore, as reliable alternative supplies of petroleum became available in sufficient quantities, i.e. from the end of July 1945, the operation was closed down.

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[1] The Navy then assumed responsibility for the laying of the main section of the submarine line, the Army for the distribution end on the Continent and the Petroleum Warfare Department, in collaboration with the Petroleum Division, for the supply unit at the home end.

[2] In spite of the lack of previous experience in the use of bare steel pipe on the bottom of the sea, construction work had proceeded on the Hamel as it was by no means certain that there would be sufficient supplies of lead available to produce all the Hais cable required.

[3] Of the 710 nautical miles of Hais cable produced for the operation, 570 miles were made by various firms in the United Kingdom, 140 miles came from the United States.

[4] For a detailed account of the industrial effort, see A. C. Hartley, 'Operation Pluto', *Proc. I. Mech.E.*, Vol. 154, 1946, p. 433.

[5] 15,000 tons steel, 6,500 tons lead alloy, 25 tons other non-ferrous metals, 1 ton rubber.

[6] By mid-December 1941 the operation employed, among other naval resources, four cable-layers, five ocean-going tugs, nine motor barges and six motor fishing vessels.

(*c*) MULBERRY

Of the two projects, the Mulberry harbour was the larger and the more complicated. Fortunately, the equipment which made it up was highly heterogeneous in conception and construction, and the task could be spread between several ministries and a large number of industries. One of its main components (in the end it turned out to be the most effective of all), the booms of blockships comprising the five 'Gooseberries', entailed little additional effort. The thirty-odd blockships, which formed the British contribution, came out of scarce and fully-employed resources of the Merchant Navy, but at least one-third of the ships provided by the Ministry of War Transport were so old and decrepit as to be no longer usable.[1] The remainder, although also old, could not be easily spared from British shipping resources, but at the time when they were being mustered for D-day, it was no longer thought necessary or possible to make special provision for replacing them with new shipping tonnage, and no additions to the current shipbuilding programmes thus resulted. The other main components however—the concrete caissons to form the main breakwater (the 'Phoenix'), the pierheads and other equipment making up the main system of jetties and floating roadways (the 'Whale'), and the steel floats composing the outer breakwater (the 'Bombardon')—all had to be designed and produced anew.

Fortunately, a little of the preliminary work had been done some time before the requirement for the prefabricated harbours took shape. In May 1942 the Prime Minister had drawn the attention of the Chief of Combined Operations to the need for piers specially designed for use on beaches, and the discussions which followed had led to the design of a pier-head capable of floating to its site under its own power and of being held there in position by power-operated legs or 'spuds'.[2] The first prototype was ordered from the Ministry of Supply in September 1942 and, very providentially, the Ministry took this opportunity to make certain templates and jigs and to work out a special welding technique in expectation of a bulk order. Similarly, the Department of Special Weapon Development at the Admiralty had for some months been considering a project for a floating breakwater out of which the 'Bombardon' was to develop.

On the other hand, the other components were not designed and could not be ordered until the entire project of the Mulberry was ready, and the latter did not take shape until the early autumn of 1943. It had been under discussion at the headquarters of Combined Operations and of the Chiefs of Staff of the Supreme Allied

[1] Some old warships were also dedicated to the purpose.

[2] This incorporated some still earlier ideas of the Directorate of Transportation at the War Office, and indirectly derived from the highly successful 'Lucayan' dredger designed and manufactured in 1923 by Lobnitz & Co., of Renfrew.

Command, for since the Dieppe landing in August 1942 operations on the Continent had to be planned on the assumption that large ports would not be available in the initial stages of the landing and that troops and supplies would have to be discharged on open beaches. The plan of artificial harbours did not crystallise into a definite requirement until August 1943 when the Chief of Staff to the Supreme Allied Commander was at last able to notify the Chiefs of Staff that in his view two artificial ports would be indispensable for the landing on the Continent. The requirement was finally approved by the Combined Chiefs of Staff at their Quebec meeting on the 15th August, but the design of the Phoenix breakwater could not be made ready and the order could not be placed until October.[1] Similarly the construction of the Bombardon units could not be begun until November. Most of the secondary components of the piers and floating roadways were designed and ordered at the turn of 1943 and 1944. And as the plan of operations made it necessary for the harbour to be ready for erection in the following spring, there were not more than five or six months in which to do the work. The problem was not made easier by continual changes in detailed design and by the later decision to enlarge the project in order to land two divisions more than was originally planned.

The main weight of the project fell upon the Ministry of Supply and the Admiralty, for by an agreement with the Allies the designing and construction of the harbour was to be carried out in the United Kingdom. The Admiralty undertook to supply 115 units of the 'Bombardon', of about 200 tons of steel each,[2] in addition to a great deal of minor equipment and modifications required for the block-ships. The Ministry of Supply undertook to produce for erection before D-day 167 Phoenix caissons of various sizes, ranging in weight from 1,600 tons to 5,780 tons (the latter was said to be equal in size and weight to a concrete building five storeys high), twenty-three pier-heads and other elements of the 'Whale' piers, including eight collapsible steel extensions to pier-heads (the so-called Baker Floating Dolphins of 100 tons each), ten miles of bridging to form floating roadways and a very large number of floating pontoons to support the roadway as well as a quantity of secondary and subsidiary material. Additional components were ordered after D-day: some to repair the damage caused by the disastrous storms of the 19th–24th

[1] The timetable was as follows: on 31st August 1943 the project of the Mulberry was approved by the Joint Staff Mission in Washington and on 2nd September it was commended by the Combined Advisory Committee to the Chiefs of Staff; on 6th September the Chiefs of Staff officially instructed the War Office to take steps to ensure the design and construction of the two harbours. The final stages in the design of the 'Phoenix' were carried out in the War Office by the end of September; on 27th September the Ministry of Supply established the special department in charge of the 'Phoenix'.

[2] This number was reduced to ninety-three in February 1944. The total weight of each Bombardon was 1,000–1,500 tons.

June, others to reinforce the surviving Mulberry harbour for use in winter.

The enterprise thus turned out to be large as well as complicated and urgent. No wonder it was watched and helped along by everybody concerned, including the Prime Minister and General Eisenhower, with solicitude not unmixed with anxiety. But, except for a few critical days in April when the timetable hung fire, the project proceeded speedily and smoothly and was completed on time. The caissons for the 'Phoenix' were all but completed by the 16th May, and the last was delivered on the 23rd; the 'Bombardon' was assembled in Portland by the 16th May; the bulk of the 'Whale' order sufficient for the minimum operational requirements was ready on the 27th May. The entire armada was ready to sail on the dates originally scheduled—the 6th, 7th and 8th June—and reached the Normandy beaches in several instalments by the 9th June.

The renown which soon attached itself to the name of Mulberry may have led the public to exaggerate not only the part which the artificial harbours as a whole played in the success of D-day operations, but also the magnitude of the production task it represented. On the other hand, the speed with which it was manufactured in the difficult conditions of the spring of 1944 may belie the true magnitude of the achievement. The total cost in money of manufacturing the Mulberry components was somewhere about £25 millions, or rather less than five per cent. of the estimated value of the total output of the Ministry of Supply and the Admiralty in the six months in which the Mulberry was under construction. The labour force directly employed was not at any time much in excess of 45,000 (in the week ending the 15th March 1944 the labour force engaged on 'Phoenix' was about 22,000, while the peak labour load on the 'Whale' was estimated at about 15,000 workers and that on the 'Bombardon' at about 8,000 workers). In all, the direct labour requirements of the project did not exceed about two per cent. of the total labour engaged in munitions production by the two departments at the time. The material used for the 'Phoenix' was mainly ballast, sand and cement, and the total amount of steel required for the Mulberry did not exceed 90,000 tons.

Yet behind these relatively modest figures lay an effort of great complexity and difficulty. The project matured at a time when a demand for even 45,000 extra men was bound to impose a great strain on the labour market, especially as in that number were included categories of workers which were exceedingly scarce. The 1,200 scaffolders required for the 'Phoenix' were more than the total supply available in the country. The welders and steel erectors for the 'Whale' components were equally difficult to find, and a special emergency scheme for training welders had to be instituted to satisfy

the demand. The difficulties in the supply of materials were of the same kind. Although only 60,000 tons of steel were required for the 'Whale', it had to be fashioned into 200 completely interchangeable components, and the problem of fabrication was very great. Even the 30,000 reinforcing steel bars required for the 'Phoenix' caissons involved a concentrated effort and a change-over of a number of rolling mills from other work.

When at the end of 1944 Sir Walter Monckton was appointed by the Prime Minister to inquire into the results achieved by the Mulberry harbour and to estimate its cost to the war effort, he was able to report that, according to the evidence he received, the work of constructing the Mulberries in the United Kingdom did not seriously interfere with other important production programmes. This verdict must be read more as a tribute to the manner in which the supply departments succeeded in fitting the Mulberry project into their current programmes than as an estimate of the industrial and administrative effort it called forth. Easiest of all was the provision of labour and material (though not of manufacturing capacity and building sites) for the concrete caissons. Their construction was essentially a building operation, and it fortunately coincided with the time when employment of building labour and materials on aerodromes and factories had slackened.[1] For the making of other components no such easements were available, for the main burden fell on the heavily engaged engineering and metal-working industries. In order to prevent too great a disturbance in the manufacture of weapons, the Ministry of Supply had to spread the prefabrication of the pier-heads of the 'Whale' between 300 firms and the prefabrication of the floating roadways among 250 firms. Thus spread, the orders required a great deal of guiding and programming. At the end of the year, looking back on its experience over 'Mulberry', the Ministry of Supply had to report that 'a great deal of work which had to be carried out to meet these programmes was only found possible by the granting of a real overriding priority which was used in some cases ruthlessly'. The report goes on to say that, by any ordinary methods, the task could not have been met and the deliveries to arranged dates could not have been achieved.

No wonder other production had to be sacrificed, even if the industrial effort as a whole was not in any way set back. The war-stores which suffered most were gun carriages, tanks, jerricans, steam-boilers, ammunition boxes, and, above all, Bailey bridges. At one time the making of the floating-bridge units for the piers represented as much as fifty per cent. of the total production of military bridging. In addition, the fabrication of the pier-heads led to some

[1] It did, however, interfere with civil building, especially with the repair of bombed buildings.

delay in ship construction and repair, although no interference in landing craft was permitted. That these losses did no harm is perhaps due to the healthy condition of British supplies and stocks on the eve of D-day; that the losses were no greater is evidence of the efficiency and elasticity of British war production in the fifth year of the war.

(*d*) LANDING CRAFT

More burdensome still, and from the point of view of the coming operation much more essential, was the demand for landing craft. On the eve of the landing on the Continent the landing craft had become the most urgent and the most absorbing of the Admiralty's tasks, but the history of the landing boats—their design and provision—reaches back to the early months of the war or even earlier. The need for assault vessels had been realised long before the war, and a few had been included in the Admiralty's small vessel programmes of 1937–39 and were ready to take part in operations in Norway early in 1940 as well as in those at Dunkirk. But the quantity of the boats was small, their operational quality very modest, and demand for more and better assault vessels was bound to grow in 1940 and 1941.[1] When early in June 1940 Mr. Churchill first urged his plans for Commando raids on enemy-held territories, he also foresaw that the raiding parties would have to be carried by special craft, lightly armoured and capable of landing on beaches.[2] His request brought forth the earliest version of the tank landing craft (L.C.T.) of 226 tons light displacement. Twenty of these craft were ordered in July 1940 and a further ten in October. By the end of 1941 they had all been delivered and some had taken part in raiding operations on the Continent as well as in the operations at Tobruk in Libya.

In the course of time the demand for landing craft was to be steeply raised in preparation for the offensive enterprises. The landing of armies on sea coasts required a number of landing craft very much greater than the earlier programmes of naval construction had ever contemplated, and among them ships of larger size and of more elaborate design than the landing-boats of 1940. The main need was for vessels capable of transporting and landing tanks and assault craft. In the end several specialised types of such vessels were evolved, and requirements had come to include larger vessels like the L.S.T.s (tank landing ships) capable of ocean voyages. The second and improved version of the L.S.T. (the L.S.T.2), played a prominent part in the shipping armada required for the Normandy

[1] See Appendix 1, Table C.

[2] Mr. Churchill traces this suggestion to the bullet-proof lighters and tank-landing lighters which he suggested in 1917 as part of a proposal for an amphibious operation against Borkum and Sylt. *The Second World War*, Vol. II, pp. 215–17. The Inter-Service Training and Development Centre (I.S.T.D.C.) was experimenting with light assault boats in 1938 and 1939. See Rear-Admiral L. E. H. Maund, *Assault from the Sea*, Chapter I.

landing. By the end of 1943 there had also emerged a design for a still more advanced landing ship of great endurance, the L.S.T.3, conceived largely in preparation for landings in the Far East. Meanwhile a number of specialised types had also budded off from the basic design of both the landing craft and the assault craft.[1]

It was, however, the tank landing craft, not the tank landing ship, that was to form the backbone of the British programmes of 1942 and 1943. British production of landing vessels had perforce to be concentrated on smaller types—the small assault craft and above all the tank landing craft—for landing ships could only be built in shipyards at the expense of mercantile tonnage. It was therefore necessary to rely from the outset on the rapidly developing shipbuilding facilities of the United States for future supplies of L.S.T.s. At the time when the United States entered the war no more than six such vessels were available, of which three were makeshift adaptations of older shallow-draught ships, and further supplies of these and other landing craft could only come in sufficient numbers from the United States. During the months immediately preceding the landing on the Continent efforts had to be made to supply a number of the ships from British sources,[2] but in the end most of the landing ships taking part in the operations on the Normandy beaches were American-built.

On the other hand, various types of tank landing craft and of smaller vessels with numerous specialised variations were to be built in this country. Both the requirements and the orders for them grew throughout the war years, though it was not until the second half of 1943 that their building could go forward on a scale and at a pace suited to the needs of the imminent landing on the Continent.[3] The programme was drastically scaled up a few months after America's entry into the war, when, for a time, it appeared possible that an invasion of the Continent might have to be staged in 1943. Eventually the programme of 1942 rose to a level as high as 1,168 vessels to be completed by May 1943 as against 662 vessels outstanding under the old programme. The expectations of actual deliveries never ran as high as that, and the main hopes rested on the 2,500 craft of various types which were to be delivered from the

[1] The types of landing craft with which British production was concerned in 1942 were Tank Landing Craft (L.C.T.), Mechanised Landing Craft (L.C.M.), Assault Landing Craft (L.C.A.), Heavy Support Craft, Beach Protection Vessels, Coble Raiding Craft, and Second Flight Craft. Mechanised Landing Craft were small vessels which could be carried on the decks of ships. Assault Landing Craft and Coble Raiding Craft were infantry-carrying vessels, as were Second Flight Craft. Heavy Support Craft and Beach Protection Vessels were armoured craft with anti-aircraft guns. Further specialised types were designed in 1943 and 1944, but few of them were ready for operations in Europe.

[2] See p. 293.

[3] The first sizeable programme for landing craft was put in hand in the spring of 1940, and the numbers under construction gradually rose from 128 in the second quarter of 1940 to 348 in the last quarter of 1941. The rate of progress was thus satisfactory while Britain was alone and large-scale offensives on the continent of Europe were not yet in view.

United States. Requirements nevertheless continued to mount in spite of the fact that the actual production of landing craft, like all other branches of naval construction, had to concede first place to escort vessels. In the spring of 1943 the programme of British construction of landing craft was for 1,050 units, about equally divided between small assault craft and various other types of landing craft. Later in the year additional orders were placed for about 850 landing craft.

By that time plans for landing on the Continent had taken shape, and requirements of landing craft rose to their peak. The campaigns in the Mediterranean had fully demonstrated the crucial importance of landing craft and had brought out the part which supplies of them were bound to play in the timetable of the Allied offensive. The plans for landing on the Continent, as they were then maturing, were based on the clear assumption that the size of the landing fleet available would not only decide the ability to mount the operations on the appointed day but would also determine the size of the landing armies.[1] As soon as the date and the general dimensions of the coming operation were definitely decided (in October 1943) the Admiralty was instructed to concentrate on landing craft to the uttermost limit of shipbuilding capacities and at the expense, if necessary, of all other forms of naval construction. The orders and the output soared sufficiently to provide, by May 1944, the British contingent of the landing fleet almost in full. By that time some 3,000 units, of which two-thirds were landing craft of various types, had been made available.

The effort which went into the building of landing craft and the difficulties encountered will be told later as part of the general story of naval construction. Here it will be sufficient to note that the effort was sufficiently great not only to require the grant of overriding priority over all other branches of naval shipbuilding, but also to make big inroads into current output. Fortunately for the naval programmes as a whole, the great rise in the demand for landing craft at the end of 1943 coincided with the falling demand for escort vessels. Yet even then the strain was great and some dislocation was inevitable.

Bolero, Pluto, Mulberry and landing craft have been singled out for special treatment as examples of the urgent additions resulting from the offensive, but in terms of productive resources they represented a mere fraction of the additional burdens which resulted from the new needs of the offensive campaigns abroad. Above all there were

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[1] For the crucial part which the supply of landing craft played in the strategic decisions of 1943 and 1944 see W. S. Churchill, *The Second World War*, Vol. IV, pp. 282, 298, 430.

vast increases in requirements for engineering stores, transport and 'general stores' in preparation for D-day. There were great increases in the demand for ammunition throughout the twelve months of active fighting. But these various additions are even more difficult to separate from the main stream of regular Army demands than were such 'freak' enterprises as the Mulberry.

(3)

Naval Construction and Shipbuilding

(*a*) ESCORTS AND LANDING CRAFT

Viewed from the point of view of the anxieties it caused, the priorities it enjoyed, and the successes it scored, naval construction was almost as typical of the conditions of war production in 1942 and 1943 as aircraft was of the conditions of 1940 and 1941. Throughout the greater part of the period it was under a constant pressure of expanding requirements; and until the second half of 1943 the preference which the War Cabinet gave to parts of the naval programmes helped to sustain the pressure.[1] Naval programmes and naval output accordingly expanded throughout 1942 and 1943. Indeed 1943 was the year in which the naval shipbuilding effort in the United Kingdom was at its highest. The average amount of naval tonnage under construction throughout the year was over 1·7 million tons, a far higher figure than that reached during the previous war years. The general cut in munitions programmes in December 1943 was bound to lead to a decline in naval construction, but the decline was neither steep nor sudden. Production continued throughout 1944 on a level no more than ten per cent. lower than that of 1943.[2]

On the other hand neither output nor authorised requirements could grow at the same pace over the entire range of naval needs. In conditions of industrial stringency naval construction had to be concentrated on the parts of programmes which accorded best with the strategic exigencies of the time. And the exigencies varied sufficiently frequently to make a stable scale of preferences within the naval programmes impossible. It is therefore no wonder that behind a trend seemingly stable it is only too easy to discover an ever-changing distribution of industrial effort.

The period opens with the battleship in the forefront. The programmes inherited from the previous period were almost exclusively

[1] See pp. 290–92. In July 1943 super-priority was given to the bomber programme. See p. 305.

[2] Naval tonnage actually completed was 316,000 tons in 1943 and 286,700 tons in 1944.

devoted to the emergency output of small vessels, but in the last quarter of 1941 hopes of being able to shift back to a more balanced programme of naval construction were again running high. The number of small vessels requisitioned from the United States had been growing, and it therefore appeared probable that, if American deliveries continued to come up to expectations, shipbuilding labour and materials might at last be available for other types of ships. Before long hopes were further strengthened by what appeared to be obvious necessity.

The first effect of Pearl Harbour and the war in the Far East was to make the need for 'other types' more urgent than before. Now that the depots and bases at Singapore, Rangoon and Hong Kong had been lost, the Navy had to be supplied with additional facilities for servicing and maintenance to enable it to operate for long periods at long distances away from the fully-equipped bases still available to it. But above all it had to be given battleships. In accordance with the Prime Minister's directive of 26th March 1941,[1] construction of all vessels, except the *Vanguard*, that could not be completed within two years had been suspended. Outside the George V class the *Vanguard* was therefore the only battleship being built at the end of 1941. It might well be that with the completion of the *Duke of York* and with the entry into the war of the United States, the Allies had a superiority over Japan in capital ships which even the loss of the *Prince of Wales* and the *Repulse* in Malaya, of the *Hood* in the Atlantic and of the *Barham* in the Mediterranean could not wipe out. Yet considering the dispersal of ships of the Royal Navy over the oceans, the margin of superiority was small, and might have disappeared altogether if the French fleet were to fall into the hands of the enemy.

Needless to say, events in the Far East had also strengthened the doubts about the efficacy of the battleship, but battleships were still demanded to give the fleet striking power in all conditions of geographical position, weather and light. Above all, it was thought that so long as the enemy possessed heavy ships the battleships would be necessary to counter them. The demand for battleships was therefore maintained and had to be met, though it could not of course be satisfied to the extent of reviving all the capital ship programmes previously sanctioned and suspended. The shortage of materials, men, armaments and instruments was too great for that. The Naval Staff was nevertheless anxious to proceed with at least two new battleships, and to go as fast as possible with the *Vanguard*.

The emphasis on battleships was not, however, destined to last. At the beginning of 1943 the battleship position no longer appeared disturbing. The danger of French battleships falling into German hands

[1] See p. 63.

had gone; the *Anson* and the *Howe* had been completed during 1942; and with the British capital ship strength at fifteen the Naval Staff were better prepared to agree again to the postponement of the *Lion* and of the other battleships on order for the sake of new demands which were becoming urgent.

Some of the urgency had passed to the aircraft carriers. If the construction of carriers had hitherto been somewhat neglected, the neglect was due not so much to lingering doubts about the importance of ship-borne aircraft as to the Admiralty's reluctance to lay down new aircraft carriers until their designs could embody the lessons of the loss of the *Ark Royal*. By mid-1942 the new design was available, and above all the strategic and tactical value of the aircraft carrier had been strikingly demonstrated in the six months of war in the eastern oceans. Not only had carriers proved a most powerful weapon of naval warfare, but they were also proving very effective in convoy service. Naval opinion was therefore running very strongly in their favour—so strongly that the Naval Staff was now prepared to set its aims as high as an eventual force of fifty-five to sixty-two carriers of all types and sizes.

In the new conception of the Fleet Air Arm large fleet carriers were, to begin with, to play a predominant part, and the mid-1942 plans envisaged a force of some thirteen to twenty fleet carriers, or seven to fourteen more than were at that time in service or under construction.[1] Industrial conditions however made it impossible to contemplate an immediate addition of very large ships, while military considerations were against undue concentration on ships that might take five to six years to build and would not be ready in time for operations in the war. So in the end, of the 1942 programme only one large carrier, the *Audacious*, was laid down, to be completed in April 1946. Two other aircraft carriers, the *Implacable* and the *Indefatigable*, due to be completed in 1943 and 1944 respectively, were now to be given high priority, while the two remaining fleet carriers of the 1942 programme, the *Eagle* and the *Ark Royal*, though ordered, were not laid down. Four more were included in the 1943 programme, but the Naval Staff took it more or less for granted that they would not be laid down in 1943 or the following year.

The need for aircraft carriers was to be mainly satisfied by auxiliary and, above all, by light fleet carriers. The former—essentially escort vessels—were little more than fast merchantmen converted to carry a small number of aircraft. Their provision therefore depended very largely on the supplies of fast merchantmen, and they were mostly to come from the United States. In so far as they

[1] In mid-1942 the fleet carriers in service were the *Illustrious*, the *Formidable*, the *Victorious*, and the *Indomitable*, and two more, the *Implacable* and the *Indefatigable*, were due for completion in 1943-44.

were to be provided from British sources their story is closely interwoven with that of the repair and conversion of merchant ships, and will be mentioned again later.[1] On the other hand, the light fleet carriers were specially designed and fully-equipped aircraft carriers suitable both for escort duty and for service with the fleet. They were sometimes described as 'intermediate' in that they were less slow and helpless in combat than the auxiliary carriers but smaller than the large fleet carriers and therefore enjoyed the advantage of easier and speedier construction. The minimum period they took to build was two years compared with the minimum of three years for a large fleet carrier. They were therefore to form a large and ever-increasing part of naval programmes for the rest of the war and were to be given priority over cruisers, battleships and even over large carriers.[2] Four light fleet carriers were ordered in the spring of 1942, and twelve more by the end of the year. Of these sixteen, ten were actually laid down by January 1943 and were expected to come into service in late 1944 and 1945.[3]

The shipyard capacity for larger ships thus came to be mainly engaged on aircraft carriers. There was however no question now of enlarging it at the expense of smaller ships as had seemed possible at the turn of 1941 and 1942. In the course of 1942 the need for escort and anti-submarine ships of every kind was becoming more and not less urgent than before. In June the enemy attacks on shipping in the Atlantic reached their highest point, and losses of merchant shipping and of escort vessels were exceptionally and alarmingly large. Moreover the expectations of American supplies had to be drastically lowered. Now that the United States were at war and their shipping routes were everywhere under direct attack, they proceeded to divert to their own use most of the escort ships they were building for Britain. The War Cabinet and the Admiralty were thus compelled to revive and to reinforce the earlier emphasis on Britain's own output of small vessels. Towards the end of the summer of 1942 the Naval Staff estimated the minimum requirements of ocean-going escort vessels at 1,050, but in October of that year only 445 such vessels were available and of these about 100 were old destroyers of 1914-15 vintage. The deficiency was great, and at current rates of production and losses it threatened to be persistent as well as high; it was estimated at 352 by the end of 1944 even if American assignments were honoured in full. Additions therefore had to be made to British production programmes for every type of small vessel capable of

[1] See pp. 301–302.

[2] The *Indefatigable* was at last handed over by the spring of 1944, but the speedy completion of the *Implacable* had to be sacrificed; the three carriers of the 1942 programme so far laid down were not expected to be completed before November 1946 and 1947, and none of the carriers of the 1943 programme was laid down.

[3] In fact only six light carriers were in service by the end of the war in Europe.

escorting merchant ships or of fighting the submarine—minesweepers, sloops, corvettes, frigates, and, above all, destroyers.

The building of destroyers was to be continued to the limit of capacity. But even at its maximum the supply of destroyers could make a relatively small contribution to the problem as a whole. Under the war-time 'emergency' programmes there were by the end of 1941 some 118 destroyers in various stages of construction. To these in the course of 1942 there were added forty-two, of which sixteen were larger fleet destroyers of new design and of much increased anti-aircraft fire power. During 1942, seventy-five destroyers were completed and some 107 were still in hand at the beginning of 1943. An additional forty-three were authorised, even though the capacity of the shipyards was so fully engaged that there was very little chance of their being laid down or being completed before the end of the war.

The main needs of the escort programme thus continued to be covered by the output of vessels which were easier to build than destroyers: minesweepers, trawlers, and, above all, ships of the corvette type.[1] The corvette, unlike the trawler, was a true escort vessel, but it was less elaborately armed and was easier and quicker to construct than the destroyer. It is therefore no wonder that the Admiralty was determined to continue the building of corvettes to capacity and even to forgo its hopes of a wholesale switch to the improved twin-screw type—the frigate. The latter had a greater endurance and were more habitable than the corvettes, but their construction impinged more on the capacity which now had to be diverted to the intermediate carrier. Above all they could not be expected to come in as quickly as the corvettes. So corvettes, as well as frigates, had both to be built in Britain and ordered abroad to meet the urgent needs of the time.

The supply of corvettes did not at first respond to the urgency of the demand in spite of every advantage of overriding priority, and the output in 1942 and early 1943 was badly behind the ever-mounting requirements. Worst of all were the American supplies. In the course of 1942 the American authorities had made it clear that out of the 150 on order 100 or so would not be made in time owing to shortage of steel plate. So great was the American need for small escort vessels that in the course of that year ten corvettes which were being completed in Britain had to be turned over to the American Navy; the latter was also allowed to buy from Canada the twenty-five corvettes that were being made for Great Britain. Only twenty-eight

[1] There were more minesweepers and trawlers on order at the end of 1942 than in any previous year: 229 in the United Kingdom and 167 abroad; further orders were placed in 1942, mostly abroad. Yet fewer were building in 1943 than the minimum demands of the Navy, and of those building fewer were coming from British yards than the Admiralty had hoped, even though the American supplies were improving.

British-built and twelve American vessels were added to the Royal Navy by the autumn of 1943, and yet somehow 200 additional vessels were expected between November 1942 and January 1945.

Heroic measures to expand production at home were therefore necessary. Out of these measures the first large-scale schemes of prefabrication and industrial reorganisation were to be undertaken by the Admiralty, and more about the changes will be said later. Reorganisation however took time, and less than fifty corvettes and frigates were completed during 1943. In the meantime the extreme urgency had passed and the emphasis in the naval programme shifted again, this time from escort vessels to landing craft.

The brief story of the evolving design and the rising requirements of landing craft has already been told.[1] That story with its successful dénouement on D-day is apt to belie the difficulties encountered in the course of production and the extraordinary measures which had to be taken to achieve the rate of output which the plan of the landing required. One of the causes of the delay—the priority which had been assigned in 1942 and early 1943 to escort vessels—has already been mentioned. In the conditions of 1942 and 1943 the winning of the Battle of the Atlantic ranked in order of time well before the preparations for the landing on the Continent. In so far as the delays in launching the offensive could be attributed to an insufficient supply of landing craft they were in the last resort due to the high strategic and industrial priority which the Allied leaders assigned to the defence of the shipping lanes.

That priority prevented a great expansion in output of landing craft; it did not result in actual reduction of output. It will be shown later[2] that a high rate of production could be maintained in spite of the higher preference now given to escort vessels. An even higher rate might have been achieved but for the resistances which the more ambitious landing craft programmes generated in the Admiralty. It was not that the importance of landing craft was not understood or that measures to increase their production were not taken. But throughout 1942 and 1943 the Admiralty worked under great pressure and was faced with a rapid succession of urgent tasks. Above all, so great had now become the difficulty of recruiting and maintaining the labour force and so precarious was the balance of labour supplies and of wage rates that the Controller of the Navy and his department went about in fear lest a sudden spate of orders for landing craft should throw into chaos the entire labour system in the shipyards. The main danger was that a great increase in construction in inland centres of fabrication, where labour was highly paid, would disturb

[1] See pp. 284–86.

[2] See p. 293.

the settled conditions of employment in the shipyards and would also set up uncontrollable movements of labour.

Substantial as these fears were for a time and great as was the resistance they generated, they had completely vanished in the months of active preparation and above all in the spring of 1944. In these months the output of landing craft developed very fast indeed —probably faster than any branch of naval programmes had ever developed in the past. The output of landing craft in 1942, 1943 and 1944 moved as shown in Table 37.

Landing craft: number and tonnage under construction (quarterly averages)

TABLE 37

Period	Number	Tonnage (thousand tons)
1942: First quarter	518	104·4
Second quarter	846	167·2
Third quarter	1,215	250·6
Fourth quarter	1,361	270·6
1943: First quarter	1,364	290·8
Second quarter	1,336	291·2
Third quarter	1,338	327·3
Fourth quarter	1,360	361·2
1944: First quarter	1,270	328·8
Second quarter	1,381	363·2

The figures for the first six months of 1944 are even more creditable than it might at first sight appear from the table. For in the months immediately preceding D-day the demands had grown so high and had to be met with such haste that production of hulls again began to give trouble. The capacity in constructional engineering firms was insufficient to cope with it, and a large proportion of the programme had to be brought back to the shipbuilding yards and forced ahead at the expense of other ships.[1] The newly-introduced 'landing craft gun' (L.C.G.) proved most troublesome. It was more complicated than the L.C.T.s, it entailed much preliminary work, especially in the drawing stage, and occupied a great deal of fitting-out capacity. Equally troublesome, though in a different way, were the landing ships (L.S.T.s) which, contrary to an earlier understanding with the United States, had now to be introduced into the British programme. There was not enough space in the shipyards to allow boats as large as the L.S.T. to be laid down, and in order to make space, the Admiralty was compelled to remove the keels of naval vessels which

[1] The big ships were to suffer most, and carriers, like the *Ark Royal*, the *Leviathan*, the *Triumph*, and the *Hawke*, had to be delayed in the early months of the year so that landing ships and craft might be hastened. The destroyers building at Swan Hunter's and at Hawthorn Leslie's and, in at least one instance, trawlers were also held up.

had already been laid down. This was done with one of the battle-class destroyers, with the aircraft carrier *Eagle*, and with two submarines.

The demand for landing vessels slumped somewhat after D-day, as was only to be expected, but it did not cease altogether. It was maintained as part of the preparations for war against Japan and in some respects was even more exacting than the larger demands of 1943 and 1944. The landing vessels did not however monopolise the attention of the Admiralty, for in the meantime another change of emphasis occurred within the naval programme. This time the most urgent demand was for the so-called Fleet Train—a change connected with the war in the Far East which will best be described elsewhere.[1] With it the record of changing priorities in naval programmes came to its final conclusion.

(*b*) BUOYANT OUTPUT

The changing balance within the naval programmes must be borne in mind in considering the ups and downs of output. It imposed additional strains at a time when the prospects of raw materials were precarious, labour short and the supply of components and equipment irregular. Special problems—mostly local shortages and failures in synchronising supplies—arose in quick succession as one naval type after another was singled out for preferential treatment. It is therefore not surprising that delays in construction were becoming troublesome and even disturbing during 1942. The completions by April 1942 were from ten to thirty per cent. behind the forecasts of July 1941 in all classes of most urgently needed vessels. Whereas the expected production of battleships, carriers and cruisers had been cut down sufficiently low for production to be running fully up to forecasts, the output of smaller ships ran as shown in Table 38.

Smaller naval vessels: production forecasts in July 1941 and actual production to April 1942

TABLE 38 — Numbers

	Forecasts, July 1941	Actual production to April 1942
Destroyers	61	38
Convoy escorts	50	42
Submarines	21	17
Landing craft	171	142

Minesweepers, anti-submarine vessels and other miscellaneous craft were about fifteen per cent. below forecast.

[1] See Chapter VII.

What is more surprising than the delays in 1942 is that in 1943 the rate of completion rose, delays shortened and output improved in spite of the withdrawal of preference. Work in hand rose sharply as the year 1942 drew to its close, and continued to rise in 1943. The increase was most marked in types of ships for which hulls could be prefabricated—L.C.T.s and corvettes. But the general trend of output also reached its highest point during 1943. Tonnage in hand rose from 1,525,000 tons in January to a peak of 1,953,000 tons in December. The tonnage of naval vessels completed rose to 316,000 tons, and the disparity between expectations and fulfilment was now narrower than ever before.

Naval tonnage completing between January 1941 and June 1944 (down to and including trawlers)

TABLE 39

	Tonnage expected to complete by end of period	Tonnage actually completed by end of period	Percentage
			%
1941: January to June .	252,433	171,755	68
July to December.	230,970	179,850	78
1942: January to June .	192,302	157,257	82
July to December.	189,227	162,340	86
1943: January to June .	134,582	124,257	92
July to December.	208,080	191,855	92
1944: January to June .	218,532	157,944	72

These improvements can to some extent be ascribed to the priority which naval construction as a whole or parts of it enjoyed during the greater part of 1943. It made it easier to obtain materials and more especially labour, for the employment of labour in Admiralty industries steadily rose during this period and in December 1943 stood at 918,000, the highest point it was ever to reach. But the high rate of production continued even after the overriding priorities had been taken away, thus revealing what probably was the most important cause of rising output, i.e. improvements in the efficiency of the industry. In naval construction the improvements mostly came as a result of new methods adopted in the manufacture of smaller vessels and also in the technical re-equipment of the shipbuilding industry as a whole. Of the new methods, the most important one—prefabrication—has already been mentioned. It was mainly to be employed in the making of corvettes and landing craft, but in this

special field its effects were all but revolutionary. Without it neither the large programme of escort vessels of 1942 and 1943 nor the still greater programme of landing craft of 1943–44 could have been achieved.

The first steps to introduce prefabrication had been taken in 1940, but the whole of 1941 and a great part of 1942 passed before the scheme was in full working order. Its main principle, as it then worked, was to entrust constructional engineering firms with welding large units out of which hulls could be assembled in the dockyards. This division of labour economised a great deal of time in the slips and of dockyard labour, and the economies grew as the scheme was getting into its stride. At first the prefabricated parts were limited to five tons, but by degrees cramped dockyards were cleared, more powerful cranes were provided, and the dimensions and weights of prefabricated units were increased far above earlier limits. In the first half of 1943 some firms were producing prefabricated L.C.T.s in two or two and a half months as against the six months they had taken previously. Unfortunately for the landing-craft programme, but fortunately for the escort programmes, the need for frigates flared up just at the time when the system of prefabrication was at last working at full efficiency. But the system was again to prove of immense value seven or eight months later when L.C.T.s again replaced the corvettes in the engineering shops and on the slips.

Considering how meagre was the pre-war experience of prefabrication—it had been chiefly confined to the manufacture and assembly of certain types of ancillary equipment—the scheme was remarkably successful. Firms were of course able to draw on American experience; they caught the sense of urgency which animated the preparations for the final offensive; but they also undoubtedly benefited from the various re-equipment schemes which the Admiralty sponsored in the course of 1943.

The purpose of the re-equipment was not so much to develop facilities outside the main shipbuilding centres as to re-equip and to modernise the main processes in the shipyards themselves and in marine engineering firms. Their modernisation had to be tackled sooner or later. Whereas some firms, like Vickers, had re-equipped on the eve of the war or in the early years of the war, the industry as a whole continued until well into 1942 to suffer from general obsolescence. In the shipyards machine tools, heavy plant, especially cranes and power supplies were generally deficient, and provisions for welding were very meagre. Most of the marine engineers worked with old machines; a large proportion were twenty to thirty years old and were debilitated by war-time working speeds for which they were not designed. The technical processes, especially in coppersmiths' and blacksmiths' shops, were slow and old-fashioned. All these

facts were well known both in the industry and in the Admiralty, but in the earlier years of the war the pressure of immediate production tasks left the firms no time for a comprehensive survey and a drastic reform; and in any case their capital resources were not such as to enable them to embark on a wholesale reconstruction out of their own means.

It was left to the Government to take the initiative. In the course of 1942 the difficulty of expanding output in the shipyards was becoming manifest, and the impression that their equipment was at fault gained ground in the Admiralty and elsewhere. In July 1942 the Barlow Committee[1] reported to the Minister of Production that in its view the industry was in urgent need of re-equipment and modernisation. This view was to be reinforced in detail by an inquiry which an engineer outside the shipbuilding industry carried out on behalf of the Machine Tool Controller.[2] In accordance with his recommendations the Admiralty undertook to instigate the re-equipment and to shoulder its main cost. A Shipyard Development Committee was set up inside the Admiralty in November 1942 'to consider proposals and where necessary to initiate action for the improvement of equipment, re-equipment and/or extension of shipyards and marine engineering works with a view to achieving maximum economic production and ensuring that such steps are consistent with the most economical use of manpower'. In all, schemes of capital development were approved at about a hundred contractors' works at a total cost of about £6·9 millions, of which £5 millions were to be borne by the Government. They were designed to provide the industry with new machine tools, cranes, power supplies and certain other improvements of a structural kind. Above all, rapid steps were to be taken to equip the industry for the use of welding.

The early history of welding in British shipbuilding was marked by much scepticism and inertia. Although some welding processes had been in use for years, the foreign successes in producing welded constructions were watched with interest mixed with distrust. There were, to begin with, technical doubts whether welded structures would withstand the special stresses and strains to which ships in general and naval ships especially were subjected, and there were also reasons both economic and social, not to say sentimental, for continued preference both in the Admiralty and in the industry for riveted construction. There was however no doubt about the economies of welded construction in war-time, for supplies of riveters

[1] This committee, under the chairmanship of Mr. Robert Barlow, had been appointed to report on the use of labour, dilution, payment by results, etc., in the shipyards; it interpreted its terms of reference in sufficiently broad terms to cover the organisation and re-equipment of the shipyards themselves.

[2] See p. 204.

were short and difficult to expand, while fabrication by welding was proving quicker and cheaper than any other alternative method. Before long the accumulating experiences both in naval vessels and elsewhere (especially in tanks) were to prove the technical qualities of welded seams. By 1942 opinion in favour of general adoption of welding was sufficiently ripe for the Admiralty to take the initiative in equipping the yards for a very wide use of welding. Between July 1942 and July 1943 the number of welders employed by the main naval shipbuilding firms grew by almost forty per cent., and work could be begun on the first all-welded pressure hulls for submarines and on the first all-welded destroyer.

This and other improvements were carried into effect very quickly. By August 1943 the Shipyard Development Committee was able to report that the bulk of the development scheme would be completed by the end of the year and that the welding scheme would be finished earlier still, by September. And it was very largely by these means that the output of hulls was progressively expanded in the course of the year.

The increase in the output of hulls was of course to bring with it its own problems. As elsewhere in war production, accelerated output in any one direction was bound to bring out shortages in others. The industries supplying the shipyards with materials found themselves at the turn of 1943 and 1944 under additional strain. Heavy castings and forgings threatened to become scarce in 1944, and the light carrier *Majestic* was actually held up on that account.

More serious still and more chronic was the shortage of equipment. The very success of prefabrication in the making of hulls for landing vessels created in the course of 1943 the problem of finding the necessary engines. Admiralty requirements for diesels had reached a peak of 500 per month, for even though minor landing craft were engined from American sources, larger craft had to be equipped by engines made in the United Kingdom. There was particular difficulty over supplying sufficient big oil engines (Paxman T.P.12). An additional factory which had been given over to this work started production early in the year, but a shortage of supplies continued, and it was reported in the summer that though output would meet current production it was insufficient to make up arrears or to provide spares. The position, however, never became desperate and had rectified itself by the spring of 1944.

More stubborn were some of the other shortages of equipment, most of which resulted from more recent and above all more exacting requirements. The ships which were being built with a view to possible use in the Far East necessitated improved living conditions, and consequently a large increase in electrical installations of a 'non-combatant' kind, such as laundries and kitchens, and thus added to

the chronic shortage of electrical equipment. The continued development of radar created difficulties in the supply of wireless telegraphy and direction-finding apparatus. In the design of engines there was a marked tendency towards increased heat and pressure, and the standards were rising just when the burdens of productive capacity were at their heaviest.

Worst of all was the supply of fire control gear. Not only was the productive capacity barely sufficient to meet the total volume of requirements, but the requirements themselves were changing as a result of the rapid progress of design. Especially troublesome was the provision of fire control gear for light anti-aircraft guns. The production of modern equipment for the 40-mm. gun (there were two such equipments in production) was giving trouble during 1943, and early in that year the design department brought forward the so-called BUSTER, a twin self-controlled mounting developed from a previous design, which it was to supersede. A successor also had to be found to the pom-pom director, which had not proved a successful equipment at sea; the result was the Close Range Blind Fire Director based on the same principle of control as the BUSTER.[1]

The industrial situation in 1943 and 1944 prevented these ideas from being fully realised. Much was however done to expand production. Owing to the specialised and complex nature of the products, it was not easy to draw on capacity not specially created for the purpose. So, to begin with, the Admiralty went on entrusting the expansion to firms which possessed sufficient experience to be able to produce work up to the required standard. In the end the Admiralty adopted the 'group system', in which orders were placed with inexperienced firms which were co-ordinated in groups led by an experienced firm. But although the groups were quickly formed, difficulties in making the system work persisted until the end of the war, and production was not expanded as hoped for. Ships were still being equipped with the multiple pom-pom and its out-of-date control, though experience of Japanese bomber attacks had shown the combination to be inadequate. A large number of ships continued to reach the fitting-out stage with the probability that the equipment in general and fire control in particular would not be ready in time.

Generally speaking, the last year of war in Europe was marked by recurring anxieties about a large variety of supplies: no sooner had shortages in one direction been done away with than, owing to the generally overloaded state of industry, they appeared in another. Wireless items, including the main switchgear, continued to be

[1] In the design of the BUSTER special care was taken not to compete for production capacity with a somewhat earlier type of fire control equipment for 40-mm. guns, and the Close Range Blind Fire Director was designed to embody most of the control components of the same fire control for the 40-mm. guns. This alleviated but did not remove the industrial difficulties of transition.

difficult. There was a shortage of wireless valves so serious that steps had to be taken to obtain supplies from the United States and from the Air Ministry. Flying-bomb attacks added to production difficulties in this field and helped to create a shortage of dry batteries which continued for several months. At the end of the year it was reported that renewed difficulties were expected over these items, mainly as a result of new designs. But for these and the earlier shortages the achievements of naval construction in the closing years of the war in Europe would have been even greater than the total output shows them to have been.

(*c*) THE MERCHANT SHIPS

The record of merchant shipbuilding reflected and recapitulated the general trend of naval construction. It benefited from the increased efficiency of the industry, suffered from changes of emphasis in requirements, and in the end it contracted to fit the falling labour supplies. At the time of Pearl Harbour merchant shipbuilding appeared in a position remarkably and unexpectedly prosperous. It will be recalled that early in 1941 the supply of merchant shipping had gone through a depression.[1] Two and a half million tons of damaged merchant shipping lay immobilised in ports and shipyards at a time when the Battle of the Atlantic was entering one of its intense phases. In March of that year the Prime Minister was compelled to seek a way out of the conflicting claims of repairs, merchant shipbuilding and naval construction by decreeing a general scaling-down in the construction of new vessels. In addition to calling a halt to the construction of heavy warships, he laid it down that the output of new merchant ships in 1942 should be reduced from the 'target' of 1·25 million tons previously fixed to 1·1 million tons, and that the Admiralty should not for the time being proceed with any merchant vessels which could not be completed by the end of 1941. The Prime Minister's object was to set 10,000 men—5,000 from merchant ship construction and 5,000 from naval construction—free to deal with the enormous arrears of repairs to merchant ships and their escorts.

In the event, the change of policy did not result in reductions quite as drastic as the Prime Minister was ready to face. The large-scale transfer of labour proved difficult to carry out, and the Admiralty disregarded the direction to suspend work on merchant ships not expected to complete within the year. It did so in the expectation that the accumulated repairs, largely seasonal in origin, could shortly be worked off without recourse to so drastic a step, and that most of the men required for the repair of merchant shipping could be (as they were to be) drawn from long-term naval repair work.

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[1] See p. 62.

Thus, paradoxically, the prospects of improving the output of new merchant ships were better in 1941, following the lowering of the target figure, than they had been for a long time. Between February and June the number of men engaged on merchant shipbuilding increased owing to a rise in the rate of recruitment, and the increase continued to the end of the year and beyond. Earlier difficulties in the manufacture of propelling machinery were also being resolved. By the autumn the numbers of workers engaged in the construction of marine engines had increased sufficiently to remove the worst shortages, and the supply of engines and boilers for merchant ships had practically ceased to cause anxiety. In addition, the Government's policy of concentrating upon the production of the simplest classes of merchant ships and upon economical and semi-standardised individual types was beginning to take full effect. Before the end of the year considerable progress had also been made in the prefabrication of hulls. The difficulties of riveting and fitting-out still persisted in the shipyards, but they did not arrest the general advance in output. During the second half of 1941 production was at the annual rate of 1·4 million tons. Since March, tonnage immobilised in repair yards had been halved and the production of new merchant ships in the course of the year exceeded by 50,000 tons the target figure of 1·1 million tons then fixed.

Indeed, so favourable did the state of production appear at the end of 1941 that the Prime Minister and his advisers thought it possible to restore the earlier 'target' of one and a quarter million tons. There were even some hopes of exceeding it, and the hopes came true. Production in 1942 reached 1·3 million gross tons and the position in the shipyards and in industry in general appeared to be set fair for some time. There was still difficulty in recruiting special classes of skilled workers, such as riveters, riggers and fitters, but the total supply of labour which had grown in the preceding year continued to increase slightly owing to the introduction of women. What is more, some of the earlier additions to the labour force could now be employed to accelerate the construction of merchant ships, for the burden of ship repairs continued to lighten. By December 1942 the number of workers engaged on merchant ship construction was approaching 43,000, the highest figure of the war.[1]

The progress was bound to come to a halt in 1943 and 1944. By then the Battle of the Atlantic and the readjustment of priorities to fit the growing labour shortage began to have their effects on merchant shipbuilding. Faced with mounting losses of inadequately protected merchant shipping, the War Cabinet decided in October 1942 that the right policy would be to use shipbuilding resources for

[1] See *Statistical Digest of the War* in this series, Tables 113 and 21.

the production of escort vessels rather than for additions to the Merchant Navy. The hulls for corvettes under the new programme could perhaps be supplied by prefabrication without greatly encroaching upon merchant shipbuilding, but it was impossible to engine them without reducing the merchant shipbuilding programme by at least 100,000 tons. The latter was accordingly scaled down in January 1943 to 1,199,000 tons in 1943 and 1,129,000 tons in 1944.

In accepting this reduction in the merchant shipbuilding 'target', the War Cabinet hoped that increased supplies of labour would make up the loss incurred by the transfer of workers and berths to the making of escort vessels. But the growing difficulties of labour supply left this hope unrealised, and the loss to merchant shipbuilding remained uncompensated.[1] After September 1943 the number of workers in shipbuilding began to decline, partly through natural wastage and partly in response to the War Cabinet's requests for cuts.

The actual output nevertheless did not slacken off as fast as might have been feared. The total output in 1943 reached 1·2 million gross tons and, moreover, contained a number of vessels more difficult to produce than standard tramps. Even the ordinary tramps built in 1943 were more complex and costly vessels than those of 1940 and 1941. Their speeds were higher, their fittings, defensive equipment and crew accommodation were more elaborate.

The comparative buoyancy of the output figures in 1943 largely reflected the improvements in the physical equipment of the shipbuilding industry resulting from the Admiralty's campaign for re-equipment.[2] Of the £6·9 millions which was the estimated cost of the re-equipment scheme sponsored by the Shipyard Development Committee only about £2·4 millions was expended on yards devoted mainly to merchant shipbuilding. In some instances the development schemes may have done little more than arrest the accumulated deterioration of plant and equipment through the war years. Yet as long as the cuts in the labour force were relatively small the improvements were sufficient to keep production slightly above the planned level.

It was not until 1944 that the losses in the labour force, coupled with the changes of emphasis within the shipbuilding programme itself, brought about a drastic reduction in both output and programmes. The merchant programme was now deeply involved in the 'final' moves of the offensive strategy. Less attention was being paid to mere volume of output, and resources were being diverted in ever-

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[1] In view of this, and of the unsatisfactory results achieved in the first six months of 1943, the estimates of merchant shipping output were revised in July to a total of 1,145,000 tons for 1943 and 1,103,000 tons in 1944.

[2] See pp. 296–98.

growing measure not only to the construction of naval vessels and fleet auxiliaries but also to merchant ships capable of serving the needs of the offensive; and some of these required an increased productive effort per gross ton. Merchant vessels suitable for operational roles had been included in programmes since the summer of 1942—mainly tugs. In the course of late 1942 and 1943 there appeared in the programme numbers of vessels like the coastal tankers for cased petrol to be used in combined operations, tankers of 5,000 tons deadweight for service in smaller Mediterranean and Far Eastern harbours, crane ships, vessels of the 'Bel' type for transhipment of heavy cargoes, to say nothing of tugs and lighters.

Above all, the merchant programme as a whole had to be sacrificed to the building of tank landing craft. In November 1943 the War Cabinet decided that, in addition to tank landing craft produced by standard prefabrication methods, an additional number would have to be built in the normal shipyards, including merchant berths. Shortly afterwards similar accommodation had to be made for a new type of tank landing ship or transport ferry (L.S.T.3) for South-East Asia Command. The net estimated loss of merchant shipbuilding from all these causes in the course of the year was approximately 80,000 tons. The actual loss of output however was even greater than the cuts in the programme and the inroads into it. Total production in 1944 just exceeded a million tons (1,014,000 gross tons) and would have fallen still further had not the downward movement in the employment figures been temporarily arrested in the closing months of the year. By then preparations for war against Japan were in full swing.

(4)

Aircraft Production

(a) THE REALISTIC PROGRAMMES

Much more continuous and more general was the expansive urge in aircraft production. The strategic change-over to the offensive did nothing to impair the importance of aircraft and more especially that of the bomber. In January 1942, as in October 1941, the bomber was still the only means of getting to grips with the enemy at home and ranked first among the offensive instruments available to this country. In the strategic discussions between Britain and the United States an intensive bombing attack on Germany was apt to be considered both as a contribution to the joint enterprise with Russia and as a preparation for the coming landing on the Continent. Even higher estimates of what the bomber could and should do were

current in the R.A.F. The heads of Bomber Command assumed—and acted on the assumption—that, given all the aeroplanes and bombers they asked for, they could bring Germany to the very verge of defeat by bombing alone. This doctrine was never accepted quite so baldly by the high strategic command in this country or the United States, but enough of it entered into the official plans, as they were taking shape in the course of 1942, to keep the demand for bombers at a level at least as high as it had stood in 1941.

Aircraft production therefore continued to enjoy the prior claim on resources which it had acquired in the dramatic summer months of 1940. In the course of 1941 it had to share its claims with a number of other urgent war-stores, but its total demands, especially after the introduction of the bomber programme at the end of 1941, were so great as completely to outweigh the burden of other priority demands. It would not be an exaggeration to say that throughout 1942 aircraft production was by far the largest single claimant to additional factors of production, and more especially to labour. Its requirements under the bomber programmes for more than a million additional men and women[1] and for an intake for the first five months of 58,000 per month, were of course greatly exaggerated and could not possibly have been met. Yet even in October 1942, after the requirements had been pruned by the Lord President and the Minister of Production, they still amounted to 208,000 for the second half of the year, which was more than the comparable requirements of the other supply departments together.

In the late autumn of 1942 as a result of the developing battle in the Atlantic the bomber programme had for a time to concede the highest priority to anti-submarine vessels and weapons, and soon afterwards M.A.P. had to share in the December reductions of the manpower requirements of the war. The whole scale of national contribution to the war in the air had to be slightly reduced.[2] Yet the reductions which M.A.P. was expected to undergo were much less than those of other departments. In accordance with the Prime Minister's directive the combined effort of the R.A.F. and M.A.P. was to be raised by additions of aircraft rather than by increases in the R.A.F. personnel, and the original manpower demands of the R.A.F. and M.A.P., for 472,000 and 603,000 respectively, were reduced by 225,000 for the former but only by 100,000 for the latter. Allowing for the reductions, the combined allocation of M.A.P. and the R.A.F., at 750,000, was still as great as that of the Navy, the ship-

[1] i.e. for the programmes of September 1941 and the supplementary bomber programme (see pp. 125–26). This figure of labour requirements was reduced in consultation with the Lord President's office to 850,000 additional workers by the end of 1942 (see p. 220).

[2] See pp. 224–25.

building industry, the Army and the Ministry of Supply put together, while the allocation of M.A.P., at 503,000, was nearly 75 per cent. of the combined quotas of the Ministry of Supply and the Admiralty.[1]

The allocations were of course lowered again in mid-1943 when, it will be recalled, all programmes had to be drastically cut. On this occasion M.A.P.'s allocation for the eighteen months' period was nearly halved from 503,000 to 259,000.[2] But while deciding on these reductions the War Cabinet also reimposed the overriding priority of M.A.P.'s claims to the resources of the country. In the Prime Minister's opinion, the failure to increase the supply of bombers was then the greatest danger facing the war effort as a whole, and every possible endeavour had to be made to enable the aircraft firms to obtain the labour they were promised. They were to be allowed to retain the mechanics they had received on loan from the R.A.F. and all the men and women who under existing rules were liable to be called up for the Services. The newly-developed machinery of 'headquarter preferences'[3] was to be harnessed to fill the vacancies in the most important branches of aircraft production. So effective indeed was the cumulative action of the various priority measures that for the first time in the history of aircraft production the intake of labour into the aircraft industry exceeded allocation, and by the end of 1943 the industry had received 307,000 persons instead of the 259,000 allotted to it in July 1943. It was not until July 1944 that, with the general curtailment of war industry, M.A.P. at last lost the priority it had enjoyed with but one interruption since 1940.

The strategic importance of the bomber was not, of course, the sole motive behind the priorities. The privileges conferred on the aircraft industry reflected not only the urgency of its products but also the insufficiency of its output. The programmes of September and October 1941, already repeatedly mentioned and described, opened up a new phase in the history of expectations. From now on all efforts had to be concentrated, without digression or interruption, on the supply of bombers for the strategic bombing of Germany. But from the very outset the demands of the Prime Minister and of the Air Ministry, and the hopes of M.A.P. itself, proved too hard to fulfil, and in the end they had to be scaled down to conform more closely with economic and industrial possibilities.

This change in the method of 'programming' aircraft production at the turn of 1942 and 1943 was another turning-point. The aircraft industry and M.A.P. were approaching that point all through 1942. It will be recalled that as a result of the discussions in the autumn of

[1] The total allocation for these was 785,000.

[2] See Table 33, p. 225.

[3] See pp. 268–69.

1941 the bomber programmes which M.A.P. undertook to fulfil were considerably less than the 14,500 bombers by 1943 asked for by the Prime Minister. Yet even this objective was beyond the reach of the industry. Whereas the programme of December 1941 laid down that 12,159 aircraft would be produced in the first six months of 1942, only 11,583 were in fact produced.[1] In the course of the year output as a whole was only two per cent. below the programme of July 1941, but this relatively narrow difference concealed gaping deficiencies in more important types of aircraft, and it will be shown that worst of all was the position of the bombers and of naval aircraft. It is therefore not surprising that by the autumn of 1942 a sense of disappointment and disquiet entered into the discussion of future prospects.

The use of 'target' programmes as yardsticks to measure failures served to increase this perturbation. While most people were aware that the 'target' programmes were not wholly realisable, they did not know how great was the measure of 'unreality' taken for granted in their compilation. The final crisis in the use of unrealistic targets came to a head in the autumn of 1942. The Secretary of State for Air, Sir Archibald Sinclair, acting with the knowledge of the Prime Minister made what he called his 'Clarion Call' to the Minister of Aircraft Production to produce enough heavy and medium bombers to raise the operational strength of heavy and medium squadrons in Bomber Command to a total of fifty by the end of the year. The Minister of Aircraft Production, after consultations with the industry, promised by an all-out effort to produce 780 heavy bombers during September, October and November. But although this was 255 more than had been produced in the preceding three months, it was 170 short of the figure laid down in the programme of July 1942,[2] and the Minister of Aircraft Production had to admit that the July programme 'was too high for the firms to live up to'. Programmes had, he said, customarily been fixed 'rather higher than most firms can probably do . . . because such a policy keeps them pressing hard all the time'. On the other hand he emphasised that his promise to the Secretary of State for Air of 780 heavy bombers was a realistic one—'what I think can be produced'.

These words gave the clue to the new policy of lower expectations. The Minister, Sir Stafford Cripps, who had been appointed in November 1942, and the Chief Executive, Sir Wilfrid Freeman, now back at M.A.P., favoured a radical change of method. In their view the effect of the 'carrot' was short-lived: 'if dangled too long it loses its effect altogether'. At the same time it led firms to build up stocks of materials and components in excess of their needs, thus helping to

[1] See Table K, Appendix 3, and Appendix 4.
[2] See Table L, Appendix 3.

create shortages. What, then, was to take the place of the old type of programme? No single answer to this question was possible. Programmes had several purposes: first, to serve as the basis on which contracts were placed; secondly, to form a basis for provisioning materials and components and for calculating raw materials, machine tools and labour; and finally to serve as the standard by which the performance of the industry could be judged. Some of these objects could be satisfied by a 'minimum' programme, i.e. a programme which would provide the two Service departments with 'the best and most accurate programme possible' on which to base their strategic planning and give the War Cabinet a fair standard by which to judge industry's performance. On the other hand responsible people at M.A.P.—among them the Deputy Director General of Statistics and Programmes—considered that aims pitched above the minimum programmes might still be necessary. Much was to be said for planning production in a way which would allow the minimum programme to be exceeded, and also for retaining some degree of inflation as an incentive to firms whose management was as yet less efficient than the average.

Nevertheless the yearning after a more conservative standard by which the performance of M.A.P. and industry could be judged prevailed over other considerations and found its expression in the first 'realistic' programme of January 1943.[1] The programme showed a startling contrast to all its predecessors. It was a 'minimum' programme in that it promised the number of aircraft which M.A.P. was prepared to guarantee that industry could deliver. In the Minister's words, the programme was 'the most accurate forecast (possible) of what we shall in fact get produced'. All predictable contingencies, such as holidays, sickness, and absenteeism, were allowed for, and on this basis a minimum programme for each firm was fixed by reference to its past performance. At the same time the incentive inflation of the 'carrot' was not entirely eliminated. Each firm's programme carried an additional quantity roughly representing the 'extent to which we (the Ministry) believe the firm is likely to fall below any programme which is set it'. The object was, in the words of the new Minister, 'to put the programme for inefficient units beyond their present output but not beyond their reasonable capacity'. Special arrangements were also made for provisioning materials at a rate greater than the programme required so as not to prejudice the possibility of its being exceeded by the more efficient firms.

To the outside world this programme came as a severe shock. It dispelled illusions which had been nursed for years, and which successive disappointments seem never to have touched. Compared

[1] See Table M, Appendix 3.

with previous programmes, figures were indeed low, for the new programme implied a reduction by the end of 1943 of thirteen per cent., distributed as shown in Table 40.

The 'Realistic' programme for 1943 and the previous aircraft programme

TABLE 40 — Numbers

	Old programme[1]	New programme[2]	Changes
TOTAL . .	32,399	28,147	− 4,252
Heavy bombers . .	6,245	4,724	− 1,521
Medium bombers .	3,872	3,342	− 530
Light bombers . .	526	549	+ 23
Fighters . . .	12,718	11,220	− 1,498
General reconnaissance .	831	1,221	+ 390
Naval types . .	3,575	2,011	− 1,564
Trainers . . .	4,632	5,080	+ 448

Sacrifices of heavy bombers and Fleet Air Arm types were specially criticised; yet compared with the actual output in 1942 the programme promised a steady although not a spectacular improvement. Total output for 1943 was programmed to show, in operational types alone, an increase of thirty per cent. over the actual output for 1942, i.e. 23,067 aircraft against 17,730, an increase of 5,337. In the end, the programme was approved by the Defence Committee (Supply) although it was agreed that the estimate of naval types should be further discussed.

With minor adjustments in April this programme continued in force till September 1943 when the time came for further realistic adjustments.[3] For in spite of the minimum rates now adopted the firms were still falling down on their programme scales. The result of the revisions in September was to lower again the general level for the remaining months of the year, and to compensate for the immediate decreases by raising the forecasts for 1944. The experience of the next few months, however, showed that the September reductions, like those of the preceding April and January, were still insufficiently realistic, and further reductions would in any case have been necessary in 1944. In the end the reductions came as a result of the general scaling down of munitions programming at the end of 1943.

The reduced allocations of labour to munitions industries of

[1] i.e. 'Consolidated' Programme, dated July 1942. See Table L, Appendix 3.

[2] i.e. 'Realistic' Programme, dated January 1943. See Table M, Appendix 3; this programme also included ninety-two transport aircraft in 1943.

[3] See Tables N and O, Appendix 3.

December 1943[1] made it no longer possible to contemplate the old aircraft programmes, however realistic. Although the cut in the labour force employed at the end of the year was not great (some 105,000 in all), the expectations of the labour intake which M.A.P. considered necessary for the fulfilment of the existing programme were lowered by 155,000. The programme had to be reduced in proportion—by about eight per cent. in numbers and four per cent. in structure weight—and the monthly output was not planned to rise above 2,600 aircraft. The principle urged by the Prime Minister, that of preparing the heaviest possible impact on the enemy in 1944, was not thereby prejudiced. The cuts were mostly at the expense of trainers and of aircraft whose operational quality was unsatisfactory or uncertain, e.g. Stirlings and Warwicks, or whose possibilities of development had been exhausted, e.g. Wellingtons, Hurricanes, Beaufighters and Sunderlands, or whose usefulness was impaired by delays in development, e.g. the Buckingham. The more important types urgently required by the Royal Air Force, e.g. the Lancaster, Halifax, Spitfire, Tempest and the Mosquito, were not only kept in but were 'designated', i.e. the firms making these types were promised preferential treatment by means of the recently devised 'preference' machinery for labour vacancies.[2] Output of heavy bombers was to increase from 475 in March 1944 to a peak of 670 in October 1945, fighter output was to remain fairly even at about the 1,000 mark, whilst medium bombers and general reconnaissance, transports and trainers were substantially reduced. Naval types alone were to be considerably increased.[3]

The programme with further adjustments in March 1944[4] remained in force for some months and was not revised until the more general scaling down in the summer. The new programme which was then envisaged forecast a lower and a slowly falling output up to December 1946.[5] The peak monthly output figures for all types were reduced to a fairly stable level, which fluctuated between 1,900 and 2,300.

(*b*) PRODUCTION LOST AND REDEEMED

The programmes were thus continually scaled down, but—to repeat—their scaling down was due as much to the unduly optimistic projects of expansion as to the failure of aircraft production to

[1] See Table 34, p. 227.

[2] See pp. 268–69.

[3] The War Cabinet, which took note of the Minister of Production's conclusions that the efforts of the Service and supply departments to adjust requirements and production had avoided an injury to the vital war machine, approved the programme on 27th January 1944.

[4] See Table P, Appendix 3.

[5] This programme was approved by the War Cabinet and issued in August 1944. See Table Q, Appendix 3.

expand. For, viewed by itself production grew throughout the period. Output measured in numbers, in structure weight, and in structure weight corrected by man-hours, rose throughout the period, as shown in Table 41.

Output of aircraft 1942–44

TABLE 41 — Monthly averages

Period	Numbers	Structure weight	Structure weight corrected by man-hours
		(million lb.)	(Jan. 1942 = 1,000)
1942: First quarter	1,879	9·17	1,001
Second quarter	1,982	10·80	1,165
Third quarter	1,980	11·82	1,241
Fourth quarter	2,049	12·67	1,328
1943: First quarter	2,135	14·21	1,472
Second quarter	2,201	15·53	1,591
Third quarter	2,171	15·37	1,585
Fourth quarter	2,246	16·63	1,698
1944: First quarter	2,473	18·82	1,918
Second quarter	2,396	18·44	1,885
Third quarter	2,048	16·80	1,718
Fourth quarter	1,903	15·45	1,573

It will thus be seen that, however measured, production rose steadily in the first half of 1942, somewhat more slowly in the second half of 1942 and the first half of 1943, slumped in the third quarter of 1943 and then rose again towards the end of 1943, and more steeply in early 1944. A marked decline in output did not set in until several months after the cuts in the labour force of the previous December—indeed not until the third quarter of 1944. The labour force grew throughout the period to reach its peak of 1,821,500 at the beginning of 1944, and the man-hour equivalents of finished airframes grew from 42 million per month in the first quarter of 1942 to some 60 million in the last quarter of 1943.[1]

Yet measured against programmes output appeared consistently laggard. In the first half of 1942 the gap between programmes and output was considerably less than the conventional fifteen per cent. exaggeration implied in the 'pre-realistic' programmes. But in the second half of 1942 the scissors opened up very widely until by the end of the year production, especially that of bombers, lagged as badly as at any previous point except the winter of 1940–41.[2] Worst

[1] The growth continued well beyond that date. Unfortunately the basis of computing man-hour equivalents was changed at that date thus making accurate comparisons impossible.

[2] In the first half of 1942 production of all types of aircraft was ninety-seven per cent. of the programmed figure in the 'Bomber' programme of December 1941. In November 1942 it was eighty-one per cent. of the programmed figure and in December eighty-three per cent.

of all during 1942 was the output of heavy bombers. In the first six months of the year their output was some twenty-two per cent. below the current programme; in the second half of the year the gap widened to about twenty-eight per cent. of the revised programme of July 1942.[1] As has already been indicated the gap persisted even after the first 'realistic' programmes were introduced. In only one month of 1943 (March) did total output of all types of aircraft exceed the programmed figure, though in two months (February and May) it was within two per cent. of its target. In all other months, in spite of successive readjustments of programme, the gap persisted and was widest of all in July.

The lagging record of total production was somewhat redeemed by the good showing of the heavy bombers and fighters in 1943. From January to June the output of the 'heavies', especially of the Lancasters, at last caught up with the programme and thereafter the gap was relatively narrow. Fighter production also settled down to within a short distance of the programme targets. On the other hand medium bombers straggled behind schedules in spite of the drastic reductions in the autumn of the year. Worse still was the record of naval types. They were far behind programme and the distance between output and programme widened from July onwards. It was only towards the very end of 1943 and during the first six months of 1944 that aircraft production at last approached sufficiently closely the targets of the programmes to make further adjustments of the latter unnecessary.

In this story of output failing to expand until the end of 1943 but expanding more rapidly thereafter it is easy to discern the action of forces some of which were common to war industry as a whole, while others were peculiar to the aircraft industry. Shortages both new and inherited played their part. In the course of 1942 the wholly-renovated department of Materials Production in M.A.P. brought system into the provision of raw materials and greatly raised both estimates of the aircraft industry's needs and the productive capacity of the fabricating firms. But in the meantime shortages of fabricated raw materials could still be blamed for failure of production. M.A.P. used the argument more or less convincingly in a discussion about the naval Barracudas in the early months of 1943. Similarly, in the discussions on the April 1943 revisions of the 'realistic' programme M.A.P. issued a warning that the revised programme, though slightly smaller in total structure weight, might require a larger amount of raw materials than it was safe to assume would be available. Throughout the year raw materials, though

[1] In the same periods the output of light bombers was some thirty-six per cent. and thirteen per cent. respectively below the current programmes.

adequate on paper, were still too short for even minor additions to programmes; and this at a time when the programmes were not in fact being met in full. This naturally created the impression that the Director General of Materials Production was still planning under the influence of inflated programmes, i.e. was assuming that programmes would not be met in full and thus need not be fully provided for. The real explanation however was to be found in the more simple fact that the recent expansion of raw materials production was still too recent and that the Director General of Materials Production was finding it difficult to build up the month's lead of materials which was required by the January programme and was necessary for the smooth expansion of output. By the end of the year however the position righted itself, and the output of fabricated materials appeared more or less adequate even allowing for production of spares and contingencies of scrap. In November 1943 the Deputy Director General of Statistics and Programmes was able to report that supplies of raw materials were running more smoothly than at any time since the war had started; and although occasional difficulties still cropped up till the end of the war, the provision of raw materials in general ceased to count as a major limitation on M.A.P.'s efforts.

Much more important was the shortage of labour. It has already been shown that the net intake of men and women into the aircraft industry between July 1942 and December 1943 ran far behind the original requirements presented by the Ministry or even the much reduced scales laid down by the Lord President and by the Minister of Production in the early autumn of 1942 or by the War Cabinet in the allocations of December of that year.[1] It is therefore not surprising that the insufficiency of labour could provide the Ministry with an obvious explanation of insufficient production. The argument was not, of course, accepted by the Ministry of Labour. Its recurrent rejoinder to M.A.P. was that shortage of labour was not an impediment to greater output. On at least one occasion the Minister of Labour could cite instances of labour being taken on and then finding no real work to do, and on another occasion he was able to claim that it was a common experience for his department to be asked by firms to stop sending labour as soon as labour was sent to them in anything like the numbers they said they wanted. Had the Ministry of Labour been concerned with production it could also have pointed out that in 1942 very few failures to achieve the planned output could be attributed to the shortage of unskilled labour: a fact which was in February 1942 admitted by Sir Charles Craven, then Controller General at M.A.P. Against this M.A.P. argued that even

[1] i.e. 307,000 compared with an original requirement of 603,000 and an allocation in December 1942 of 503,000, adjusted to 259,000 in July 1943. See pp. 225 and 305.

if labour were sufficient for production at the level at which the latter stood at any point of time, the general shortage was retarding further expansion of plans and further increases of output.

In the final resort, however, supplies of labour were, as they were indeed bound to be, essential for further increases of output. And of this no better proof could be found than the rise in output in response to the improved labour supplies at the end of 1943. The response was not of course apparent at first sight. The curve of labour intake was at its flattest during the first six months of 1943, but during this period output was well up to programme. During the latter half of 1943 the labour intake curve was much steeper, but the output curve was flatter. The peak output of the aircraft industry came later: in the early part of 1944. These lags do not, however, belie the connection between labour intake and output. If it is assumed that the productive effect of any given labour intake is felt, say, six months later, this would directly connect the fall in output during the latter part of 1943 with the abnormally low labour intake early in the year. Similarly, the spectacular output of early 1944 could be connected with the high labour intakes of later 1943.

However, improved labour supplies were not alone responsible for the rising output curves of the end of 1943 and early 1944. Indeed until the curves began to rise an impression was gaining ground within M.A.P. itself that the aircraft industry as a whole appeared incapable of the growth expected of it and that neither additional raw materials nor additional labour would lead to commensurate increases in output. In spite of all the repeated increases in the aircraft programmes between the summer of 1940 and December 1942 output expanded at slow and very steady rates. The actual curve of production in 1941 and 1942, though rising, did not follow the hopeful curve of any of the later programmes. It rather conformed to the trend forecast in the 'Harrogate' programme of 1940,[1] even though the aircraft industry had in the meantime received further additions to its capacity and greater injections of labour and material than the programme of 1940 had envisaged. It was thus easy enough to jump to the fatalistic generalisation that a natural limit to aircraft production was inherent in the scale of British war economy and in the powers of the industry's managers.

The generalisation appeared to find some support in M.A.P. and even in its statistical and programming department. Commenting on the stubborn inability of the industry to expand more rapidly than it did, the Deputy Director General of Statistics and Programmes was moved to observe that the administrators had hitherto tended 'to over-simplify the numerous and complex forces which controlled

[1] See p. 69.

and limited the growth of an organism as complex as the aircraft industry.

> No one would assert that the size of a man is uniquely determined by the quantity of food given to him; we know that the size is intimately connected with the balancing and integration of the related parts and with the forces which are engendered by growth which finally constitute a limit to the growth itself. But we are too ready to assume that more labour or more machine tools etc. automatically will produce a bigger industry and more aircraft.

His analysis of the growth of the aircraft industry led him to believe that it was nearing its peak effort. To illustrate this point he showed that during the year 1940–41 the increase in monthly output was 428, during 1941–42 it was 343 and during the year 1942–43 it was only 127. He added that during the coming year 1943–44 the increase in output was programmed to be no less than 600 aircraft and 5½ million lb. of structure weight, or nearly four and a half times that achieved in the preceding year.[1] His conclusions from these facts were simple. The new programmes should take account of the unpredictable and intangible influences which held back output and should consequently not be increased beyond the peaks previously planned. This conclusion was soon to be reinforced by a pessimistic review of the prospects of individual firms presented at the end of the year by various production directorates and was willy nilly accepted by the Chief Executive.

Had the diagnosis been made a few months later and based on facts more directly drawn from the daily experience of the industry it might perhaps have been expressed in more concrete and familiar terms. The difficulties of aircraft production as distinct from the difficulties of other branches of production were inherent in both the peculiarities of aircraft and the peculiarities of aircraft firms; and by 1943 few people in M.A.P. did not know what those peculiarities were. From the production point of view aircraft were the most unsettled and unstable of all the instruments of war. Programmes as a whole changed very frequently. It will be shown presently[2] that there was a constant pressure for improvement of current types, for additional numbers of later types, and for the substitution of new types for old. The retarding effects of modifications on output had fully manifested themselves before 1942 and will be discussed again at greater length.[3]

So much for the peculiarities of the product. The peculiarities of

[1] The year was measured from October to October.

[2] See Section (5) of this chapter, the Quality of Aircraft.

[3] For delays in the development of new types, see pp. 55–56, 124–25, 173–74. The effects of modifications on aircraft production are discussed in sub-section (*d*) of Section (5) of this chapter.

the producer were, if anything, even more obvious. What most of them boiled down to was the strains which expanding industry put upon its human resources. It will be recalled that the experience of 1941 and 1942 had already demonstrated that an industry so new and so unused to large-scale production could not go on expanding indefinitely without outrunning the capacities of its leaders. Similar experiences continued to accumulate in the course of later years, but at the same time the evidence of individual factories revealed that the ceilings were not as low or as fixed in some firms as in others. In firms with previous experience in economic production on a large scale, e.g. Fords or English Electric, or in aircraft firms providentially blessed with production managers of unusual ability, e.g. A. V. Roe, output was not—or at least not yet—held back by any 'natural' limits. And that also meant that further improvements in efficiency of management and labour might enable the industry to break through the complex system of impediments which held it back.

This indeed was the sense in which towards the end of 1943 the Ministry of Aircraft Production appeared to interpret the record of the industry. The measures taken were mainly directed at the managerial efficiency of the industry as a whole. They took various forms. Certain firms with a consistently bad production record were compelled to change their entire directing personnel, even if this meant that ownership had to pass to the State. Firms which had proved their managerial efficiency, e.g. English Electric, were asked to take an ever greater share of total output, even if that meant their entering into fields from which they had in the past kept away, e.g. the development and production of the Sabre engines. In addition, the Ministry tried to stimulate the efficiency of the industry as a whole by constructive technical advice. The Production Efficiency Board, which M.A.P. set up in 1943 under the chairmanship of Sir Charles Bruce Gardner, a former head of the British Association of Aircraft Constructors and a *persona grata* with the industry, was a step in this direction. The record of this organisation is one of discreet achievement. Without attempting any major reforms or any acts of conspicuous interference, the Board offered technical advice on efficiency devices, on management, on utilisation of tools, on technical processes; and the advice was as a rule gratefully taken.

Above all, the general level of efficiency was rising by its own momentum. In addition to the measures consciously adopted in the Ministry and directed at the higher levels of the industry's personnel, the accumulating experience and 'know how' in the industry itself were having their effect; and the dexterity of the labour force also grew. Viewed separately the improvements were slow and small, but their combined action was sufficient to lift the productivity of the industry as the year 1943 was drawing to its end. Reports from firms

in the course of early 1944 all brought news of improving organisation and growing economy of operations. The man-hour equivalents of most standard types appeared to fall; even their money costs showed a downward tendency.

Thus by the second half of 1944, i.e. about the time when the War Cabinet was due to enforce its wholesale cuts in munitions programmes as a whole, the aircraft industry at last reached its long-awaited and long-delayed moment of fulfilment. Its supplies of labour and raw materials were at last adequate for its most essential needs; its managerial efficiency and the skill of its labour force were at their highest peak. The instability of design and of programmes alone continued to interfere with output almost as badly as heretofore. To this extent—and to this extent only—the earlier hopes of 'mass production' were proving unrealisable. Even here the 'Speer' experiment in Germany and certain experiences in this country in 1938 and 1939 indicated possible solutions (and more will be said about them elsewhere[1]), but they would have necessitated radical changes in the processes of design and development. With the war in Europe nearing its conclusion the time for radical remedies had passed.

(*c*) REPAIRS AND SPARES

In tracing the rise and fall of aircraft production it is important to bear in mind the effort which was being devoted to the repair of aircraft and the production of spares. For although some provision for spares had been made and some diversion of industrial effort to repairs had been allowed for in aircraft programmes since the earliest days of aircraft production, the effort devoted to spares after 1940 became much greater and imposed a correspondingly greater burden upon industry. The repair of aircraft made a vital contribution to the winning of the Battle of Britain. In August and September 1940—the two crucial months of the battle—nearly forty per cent. of the current supply of fighters to the squadrons was made up of repaired aircraft. The subsequent growth of the repair organisation and its activities is well illustrated in Table 42 below, though statistics of aircraft repairs are not entirely comprehensive. For example, during the Battle of Britain the so-called 'fly-in' repairs, that is the immediate first-aid repairs which were available to pilots at repairers' aerodromes, escaped formal registration. Out of a total of approximately 164,000 airframes which went to the Metropolitan Air Force between May 1940 and July 1945 more than 79,000 or forty-eight per cent. were the output of the repair organisation. In 1943 the proportion was as high as fifty-five per cent.; and although in 1944 the percentage declined the total number of airframes repaired continued to grow.

[1] See pp. 408 and 464-465.

Number of aircraft going to the Metropolitan Air Force January 1941–July 1945[1]

TABLE 42

Period	Total	From new production[2]	From repair output	Number from repair as percentage of total
				%
1941 . .	25,271	10,711	13,560	54
1942 . .	32,554	15,919	16,635	51
1943 . .	32,516	14,584	17,932	55
1944 . .	41,605	23,005	18,400	44
1945 (Jan./July)	17,322	9,485	7,837	45

The increase in actual effort was even greater than these figures reveal. Medium and heavy bombers absorbed an increasingly larger share of airframe repair output throughout the war. These types required a greater effort per airframe, and the number of airframes repaired was also rising. During the heavy bomber offensive of 1943 and 1944 the proportion of heavy bombers supplied to the Metropolitan Air Force from repair rose from 29·6 per cent. to 36·5 per cent. of the total (see Table 43). Any table based on numbers of airframes therefore underestimates the achievement of the later years.

Heavy bombers: number going to the Metropolitan Air Force, 1942–44

TABLE 43

Period	Total	From repair	Number from repair as percentage of total
			%
1942 (Mar./Dec.)	2,652	653	24·6
1943 . . .	6,648	1,971	29·6
1944 . . .	9,010	3,285	36·5

That the burden of repair should have been heavy and that it should have fallen mainly on general industry may appear obvious to an outside observer familiar only with the industrial processes in the later stages of the war. In actual fact the great effort devoted to repairs and the employment of 'civilian' industry for this purpose were relatively late developments. Until August 1938 the prevailing view at the Air Ministry was that, in time of war, repair of aircraft would be physically impossible and from an economic point of view

[1] Repairs contributed relatively little before May 1940 whereas new production was considerable. A figure of twenty-five per cent. for 1940 would appear reasonable.

[2] North American and British.

undesirable. This view was essentially the same as that which was to prevail throughout the war in the air force of the U.S.S.R. where the tendency was to replace worn-out and badly-damaged aircraft by new machines instead of devoting a great deal of effort to continuous and piecemeal maintenance and repairs.

The economics of the doctrine would not have survived a closer calculation or the test of experience had experience been available. The evidence of the later years of the war—1942 to 1945—showed very clearly that it was more economical to expend resources on repairs to the extent to which this was done in Britain than it would have been to devote them to production of new aircraft. Thus it was calculated that the amount of material which was used for Lancaster spares during that period and which made possible the repair and return to service of 3,816 aircraft would, if employed in the construction of new aircraft, have yielded only 622 airframes. Comparable figures for the Wellington were calculated at 1,428 new airframes against 5,865 repaired, and for the Spitfire, 3,915 complete airframes against 9,339 repaired. Similar comparisons are possible between the number of aero engines and propellers actually repaired and the number of new engines and propellers which could have been produced by the expenditure of the same quantity of material on new construction. In each case repair meant a great saving of materials. The comparative costs in labour between repair and new construction were even more eloquent. The peak of employment on airframe repairs was reached in November 1943 when the number of workers thus employed was 63,600. At the same time 664,200 persons were employed on new airframe production. Yet, as already mentioned,[1] fifty-five per cent. of the aircraft which went to the Metropolitan Air Force in 1943 was repaired aircraft.

The doctrine was in fact given up by August 1938 when the Air Ministry considered a plan for a war-time repair and maintenance organisation. A scheme of the repair organisation as it emerged in March 1939 assumed that repairs would play an important part in keeping the R.A.F. supplied with aircraft; but it did not yet envisage the employment of private industry. Repairs were to be entrusted to a service wholly controlled by the R.A.F. in which civilian labour would be employed and, as a short-term measure, civilian contractors would be engaged. The long-term plan envisaged the establishment of six large general repair depots, three to be staffed by R.A.F. personnel and three by civilians under R.A.F. control. It was eventually agreed that one of the latter should be managed by a civilian firm on an agency basis, and Lord Nuffield accepted the task of running it.

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[1] See p. 316.

No repair work had in fact been undertaken in the 'agency' depot by October 1939, and by then the whole plan of the repair organisation was challenged by Lord Nuffield and his immediate assistants. They questioned the underlying assumption that industry in time of war would have no capacity available for repair work and criticised the concept of a general repair depot. In their opinion repairs, like production, had to be divided according to the different types of work; and they advocated that repairs should be dealt with by firms specialising in different types of repairs. They also suggested that the management of the entire civilian repair scheme should be handed over to an industrial firm experienced in dealing with a large number of scattered undertakings. They offered for this purpose the services of the Morris Motors organisation, and the offer was accepted by the Secretary of State for Air.

To begin with, the repair organisation was mainly based on the 'fringe' firms, i.e. aircraft firms producing their own designs which were outside the inner circle of the main airframe contractors to the Air Ministry. At that time there were nineteen such firms with an aggregate floor space of approximately a million square feet. The estimated potential output from these 'fringe' firms and the five 'parent' firms which were undertaking aircraft repair was 250 airframes a month. In addition, a large number of small firms from outside the aircraft industry were introduced to supplement the work of the 'fringe' firms. A great proportion of the contractors came from the motor car sales and servicing units already connected with the Morris Motors organisation.

In the course of 1940 repair facilities were to be removed still further from R.A.F. control and to be distributed still more widely among industry. It was Lord Beaverbrook's settled policy to make M.A.P. responsible not only for the Civilian Repair Organisation, but also for repair work carried out at the Service Repair Depots controlled by the '43 Group' of the R.A.F. Lord Beaverbrook also subjected the industrial capacity available for repairs to the same measures of dispersal and expansion as the rest of the aircraft industry. As a result, the circle of repair contractors, many of whom were already engaged on production work of some kind, was considerably enlarged.

The intermingling of repair work and new production was also made necessary by the uncertainties and fluctuations of demand, and these led to the Ministry adopting a 'hospital bed' policy. Contractors engaged for repair work were expected to keep themselves in readiness to carry out repairs when the need arose. The apparent wastefulness of this system could be offset only by employing contractors who were engaged on other work into which repairs could be 'spliced'.

With the introduction of the heavy bombers, the expansion of the contractors' circle was to some extent arrested. The complexity of the machines demanded high skill in repairs and specialised knowledge of the types under repair. The policy in M.A.P. therefore was to place on the 'parent' firms—Short Brothers, Handley Page and A. V. Roe—responsibility for the repair of their own aircraft. New factories were to be built, one for each type, to be run either as a subsidiary or directly by the 'parent' firm. This plan did not, however, develop quite as expected. Although factories were in fact set up by the 'parent' firms, transport and take-off difficulties proved greater than at one time anticipated. In 1942 the emphasis shifted to 'on site' repairs, and in 1943 a large number of additional hangars for the repair of aircraft were laid down in airfields used by bombers. The 'on site' repairs yielded a higher return on investment and proved more economical in labour than the system of specialised repair factories, but they could not of course replace factory work altogether. Certain categories of work, e.g. the breakdown of written-off aircraft and the salvaging and repair of parts, were essentially factory jobs. So also was the production of spares.

Indeed, the main problem of repair was not so much the siting of the work and its management as the supply of spares. Throughout the war, and more especially between 1941 and 1943, the people responsible for the repair organisation constantly complained of an insufficient supply of spares. The Air Ministry, concerned as it was with the maintenance of aircraft in service, continually complained of the preference accorded in M.A.P. to new production.

There is no denying that production departments favoured new production. The critical war situation and, above all, the efforts that were put into fighter production in 1940 accentuated their preference. Some remedial measures, mostly of an administrative kind, were taken in September 1941, but the supply of spares continued to give cause for anxiety throughout 1942. The anxiety spread outside the Air Ministry and Service circles. In its tenth report the Select Committee on National Expenditure[1] argued very strongly against the common attitude that less credit was attached to the production of spares than of complete aircraft. By that time, however, the policy was also changing in the Ministry of Aircraft Production. A Spares Committee was set up to investigate the provision of capacity and materials for spares, the method of ordering and the best way to implement orders. In addition to detailed improvements the committee offered in July 1943 its final judgement that a reallocation of resources between new production and spares was the real solution of the spares problem.

[1] *Select Committee on National Expenditure*, Session 1942–43, Tenth Report, dated 4th August 1943, para. 23.

Fortunately, the general improvement in the supply of materials from mid-1943 onwards brought the necessary relief. More spares could be and were produced without conflicting with the requirements of new production. The growth of output was in fact greater than the needs of the repair organisation alone demanded, for growing quantities of spares were also required for the routine maintenance of aircraft; and large quantities of spares were frequently ordered by M.A.P. for direct delivery to the Services. These deliveries added an incalculable element to the problem of spares and may have added to the difficulty of planning their production.

In general, the difficulties of planning may in part have been responsible for the lingering feeling that not enough attention was paid to spares in M.A.P. The production departments maintained that any shortage of spares that existed was artificial and owed its existence to the unco-ordinated method of ordering and to the method of distribution, both controlled by the Air Ministry.[1] Whatever the real cause, the shortage itself was becoming less pronounced after 1943, as Table 44 shows:

Aircraft awaiting spares as percentages of all aircraft with the R.A.F. Home Commands

TABLE 44[2]

		Total for all Commands	Bomber Command	Fighter Command
		%	%	%
1941	June[3] .	8·7	4·8	7·5
	December	8·1	6·6	7·9
1942	June .	6·8	4·5	6·1
	December	7·1	5·4	6·9
1943	June .	5·2	3·8	5·2
	December	3·1	2·4	3·6
1944	June .	2·7	1·4	3·5
	December	2·5	1·4	3·6
1945	June .	2·5	1·4	2·7

In view of the much larger number of aircraft requiring repair and repaired in the later years, the much smaller proportion awaiting repairs denotes a very much better supply of spares. The fact that

[1] The Rolls-Royce spares problem was solved by the setting up in November 1940 of the Sawley Spares Depot, which was operated by the firm as the sole supply and distributing centre for Rolls-Royce spares. Distribution delays were thereby avoided, shortages were foreseen and immediate production action to meet them was taken by the firm.

[2] This table relates only to aircraft in squadrons and not to those dealt with by the Repair Organisation.

[3] No figures prior to June 1941 are available.

some aircraft were still kept waiting may suggest that some shortage of spares was still felt, but it is not necessarily evidence of insufficient allocation of resources in industry or in M.A.P. The ordinary hazards of war-time planning were quite capable of creating equally great temporary shortages of parts and components in the main lines of new production.

(5)
The Quality of Aircraft

(*a*) THE DOCTRINE OF QUALITY

The achievement of aircraft production cannot be fully measured by numbers of aircraft made and repaired. The quality of aircraft must be taken into account in assessing the past record of aircraft production, just as it was taken into account in forecasting future output. The quality of aircraft was subject to changes much more radical and more frequent than those of any other weapon, not excluding the tank. What, from the point of view of this study, is even more important is that, in their endeavours to maintain the quality of aircraft, the Air Ministry and M.A.P. frequently had to sacrifice its quantity. And here again, of no other weapon, not even of the tank, can it be said that its output was equally subjected and sacrificed to considerations of quality. Had aircraft design and development been frozen or even retarded at the beginning of the expansion, or even at the beginning of the war, and no modifications or replacements been allowed to interfere with the flow of production, the output would have far outstripped the actual figures. Whenever obsolete types were 'faded out' and new ones were brought in, the flow of production was inevitably interrupted at the very time when all the 'teething' troubles had been overcome and the smooth flow of production could develop. But, apart from new types, continuous modifications of existing types to fit them to the ever-changing conditions of war in the air continually disrupted work at the factories. The curves of output of all the well-established and, consequently, much-modified types, like the Spitfire, the Wellington and the Mosquito, were bent and broken by repeated depressions, each caused by some new modification or improvement.

The dilemma was well understood and, as a rule, taken for granted in the supply branches of the Air Ministry and in M.A.P. It was apparently accepted by Lord Swinton and his collaborators during the crucial years of the pre-war expansion. On the whole, it also continued to guide the policy of M.A.P. in the war; and nobody ex-

pressed the view more clearly than Sir Stafford Cripps in his speech to the aircraft workers in September 1943.

> We have throughout [he said] applied one cardinal principle—that quality is more important than mere quantity. Nothing but the best and most up to date is good enough for our magnificent airmen. Whatever the complications or drawbacks arising from the rapid introduction of improvements or changes, we must introduce these at the earliest practicable moment.[1]

The vigour with which the doctrine was invariably expressed must not, of course, be taken to mean that it could always be applied to the letter. The dilemma between quantity and quality was much easier to resolve in principle than in application. Occasions were bound to arise, both before and during the war, when in numbers alone the R.A.F. was so deficient that the sacrifice of quantity could not be faced. On these occasions the doctrine of quality had to be much diluted, if not dispensed with altogether. One such occasion occurred at the very beginning of the expansion in 1934, when there appeared to be no other way of inaugurating the process of rearmament in the air except by a temporary contravention of the quality doctrine. It will be remembered that at the time the more up-to-date types of aircraft on which the Air Staff built its hopes for the future were not ready for production, and that public demands and political pressure for a larger air force had to be satisfied by large orders for admittedly inferior types.[2] The next occasion when the need for mere numbers threatened to take precedence over considerations of quality was perhaps that of Programme L in the spring of 1938, when following Hitler's march into Vienna the Government sanctioned immediate orders for 12,000 aircraft to be ready by 31st March 1940.[3] But it says much for the advanced condition of aircraft development at that time that the programme, for all its emphasis on quantity, contained very few types which the Air Staff could consider as operationally unsatisfactory.[4]

Concessions to mere quantity were also made in all the extensions and additions to Programme L during the rest of 1938 and in 1939, as well as under the various plans for the deployment of the 'war potential'. Although, in commenting on some of the proposals, the Air Staff had to admit that the additional orders placed immediately after the Munich crisis meant 'equipping many squadrons with air-

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[1] Speech made by Sir Stafford Cripps on 21st September 1943 to delegates from the management and workers' sides of firms in the aircraft industry.

[2] See p. 16.

[3] See p. 18.

[4] Although larger numbers of Wellingtons, Hampdens and Blenheims were then ordered than the interests of an up-to-date bomber force justified, the orders for fighters consisted entirely of the most advanced types—the Hurricanes, Spitfires and Defiants.

craft of which the operational value is limited', immediate additions to the Air Force could not have been achieved in any other way. Yet even then little was done to interfere with the projects of the newer types scheduled to come in during 1940 and later. New and important specifications were being pushed forward in the hope of being introduced into the Air Force in the second year of the war.

Again, in the late spring and summer of 1940 the emphasis on quantity was so placed as to interfere, albeit for a short period, with the Air Ministry's plans for better aircraft. The concentration of production on the five types as agreed on 15th May between Lord Beaverbrook and the Air Staff has already been dealt with.[1] Its corollary in matters of quality was a pause in all development which could not be directly related to the immediate needs of the Battle of Britain. This meant that a great deal of development work continued, but it was subject to the overriding test of urgency. Theoretical research into basic aeronautical problems was not stopped, but all other research, design and development work was to be devoted to the modification and improvement of the five preferred types. Such additional effort as could not be absorbed in the aircraft of first priority could be diverted to the aircraft of second priority and to such other work as 'could be made effective within a year'.

This order of priority still allowed work to continue on the heavy bombers of the 1936 specifications (the Stirling, the Halifax and the Manchester) which were expected to come into operational use during 1941. It may also have stimulated improvements in existing types, some of which were doubtless of very great importance. The one for which Lord Beaverbrook would probably take personal credit was the speeding-up of the installation of the 20-mm. gun in the wings of the Hurricane and Spitfire in time for the later stages of the Battle of Britain.[2] But the period also saw some immensely important developments of radar and of certain other aids to air defence. Only slightly less important was the installation of the new engines, such as the Merlin XX in the Hurricane and the Merlin 45 in the Spitfire,[3] or the adaptation of the Blenheim, the Beaufighter, the Defiant and, above all, the Hurricane to new functions in land battles and in sea

[1] See pp. 123-24.

[2] Four-cannon wings were introduced in the Hurricane production line at Hawker's (Mark IIc) in February 1940. Thirty Spitfire I.s with wings fitted with two cannon only were delivered to the Service in August 1940. Thirty sets of damaged Hurricane wings were converted by semi-tooled and bench methods to carry four cannons. Owing to technical difficulties they were not delivered to the Service until about January 1941.

[3] The Hurricane II with Merlin XX engines had been projected since the early months of 1940. It was not at first expected to come in until December 1940, but the delivery was now brought forward to August 1940, several months earlier than originally expected. The installation of Merlin 45 engines into Spitfires was first suggested in December 1940. It became an urgent Air Staff requirement and was introduced into the production line at Supermarine's (Marks Va and Vb) in March 1941. Twenty-three Spitfire I.s were converted to Spitfire V.s by Rolls-Royce and were in service by February 1941.

convoys.[1] Moreover, by the autumn of the same year the first priority was widened sufficiently to include the principal Fleet Air Arm types as well as a certain amount of advanced work on high-altitude aircraft. On the other hand, the work on some advanced types had to be suspended for at least nine months.[2] But more important than the suspension of some current projects were the more general effects on experimental work and thought. The concentration on immediate operational requirements affected the practical facilities of research and development. Thus, for a while aircraft and pilots were withdrawn from experimental establishments for service in operational squadrons, with the result that the Director General of Research and Development was moved to complain that 'the establishments were no longer capable of the tremendous effort required . . . on projects of great urgency'.

This particular difficulty was soon remedied, and the entire emphasis on preferred types came to an end early in 1941. By the spring of that year some of the suspended projects, such as the Typhoon, were resumed again. In this period the prototype Mosquito was completed; the Beaufighter night fighter was developed; the Whittle jet engine was pushed forward and was given priority for further development and production; prototypes were ordered for a new medium bomber, the Buckingham, and came very near to being ordered for the Hawker high-speed bomber.

Broadly speaking, during the first half of 1941 the Air Staff and M.A.P. were able to restore something like the normal balance between quality and quantity; and once restored, this relation prevailed until the end of the war. Yet even then recurrent deviations from the general line were inevitable. A chronic cause of deviation was perhaps the tendency to bridge over the waiting periods for new types delayed in development by means of 'stop-gap' orders for older types. Three aircraft especially, the Battle, the Blenheim and the Whitley, were repeatedly ordered long after the replacement date originally set for them had arrived. Some deviation from the pure principle of quality might also be found in the multiplicity of types of aircraft

[1] The Hurricane Mark IIb with twelve-Browning wings was introduced in March 1941. Other variations included the important Sea Hurricane Marks Ia and Ib with catapult and arrester gear for the merchant ship fighter scheme which was rushed through in the early spring of 1941; the tropical version of the Hurricane Mark II was also completed in the spring of 1941. The Beaufighter was modified for long-range fighter duties with Coastal Command. The Beaufighter Mark II with Merlin XX engines fitted to be used for night fighting in conjunction with the newly developed A.I. interception equipment, was introduced into the production line in March 1941. The Defiant Mark I was modified for night fighting and later owing to Service requests the Defiant Mark II with Merlin XX engines was introduced.

[2] Among the projects jettisoned first were the prototypes for some of the aircraft with which it was planned to re-equip the Air Force in 1942, e.g. the new bomber designed to the 1939 specification (B.1/39) which was under development at the Bristol Aeroplane Company and at Handley Page and the cannon-turret under development at Boulton Paul Aircraft.

serving the same operational function. Thus, as a result of accidents, of delays in development, and of uncertainties in policy, M.A.P. found itself at the end of 1942 having to provide for the continued production of at least three four-engined bombers and of at least four aircraft of heavy bomber weight, with the prospects of a fifth in the offing.

The total effect of these deviations, however, was not such as to obscure, still less to nullify, the influence of the 'quality doctrine'. They were never allowed to become anything more than temporary and unfortunate departures from the ideal, and were always regarded in the Air Ministry and M.A.P. as merely a temporary evil. The government departments in charge of requirements and production never advocated 'output at all costs', and at no time did they allow the quality of output to be wholly submerged by mere numbers.

(*b*) EXPECTATIONS AND DELAYS

What in fact impaired the average quality of aircraft was not the departures from the policy of the Air Ministry and M.A.P., and not the conscious concessions to the interests of production, but the inevitable delays and postponements in the appearance of new and improved designs. This study, devoted as it is to problems of production, is not the right place in which to discuss the progress in the quality of British aircraft. It will therefore be sufficient to note that over the war years as a whole British aircraft was not inferior and was at some points superior to enemy aircraft. British and German bombers do not, of course, admit of relevant comparison. Whereas Britain did not try to compete with the Germans in the development of dive bombers for tactical use with the Army, the Germans did not seriously tackle the development of heavy bombers for strategic bombing. It was nevertheless generally accepted that the quality of British light and medium bombers, as exemplified by the Blenheim and the Wellington before 1940 and the Mosquito after 1940, and the quality of the heavy bombers, more especially the Lancaster and its successor, were equal to the operational demands. In fighters, where the competition was very close and comparison was easier, the race in quality was more or less neck and neck. At some points, as in 1938, early in 1940 and again in 1944, German design drew abreast, or even slightly ahead of the British; at other times the British fighters proved superior in performance and general quality.

The high average level of quality was a great achievement; but what from the point of view of production was more relevant was that the high quality was largely achieved not by frequent introduction of new designs, but by the constant modification and improvement of established types. Had the R.A.F. been entirely dependent for their technical progress on frequent replacement of old designs by new, an

uninterrupted improvement in the quality of their aircraft would have been difficult to attain.

Throughout the war the introduction of new designs was fraught with delays and disappointments. Broadly speaking, between 1935 and 1940 the design and development of fighters proceeded more or less according to plan. The detailed plans under the re-equipment programme of 1936 (Scheme F) were founded upon the expectation that by the spring of 1939 the British fighter squadrons would be equipped with fighters of the quality of the Hurricane and Spitfire.[1] These hopes were somewhat delayed, more especially in the case of the Spitfire, but the overall delays were not greater than about seven months. Under Scheme F it was expected that 600 Hurricanes and 300 Spitfires would be delivered to the R.A.F. by March 1939. In actual fact these totals were achieved in October and August 1939 respectively, even though the first aircraft of each type was in production little later than the date promised by the firms and expected by the R.A.F.[2] Viewed in detail, some of the other contemporary hopes failed to come true. The much-hoped-for cannon fighter—the Whirlwind—completed its preliminary stages eight months after the expected date, and was not very successful when it appeared.[3] Even greater difficulties were encountered during the development of the Tornado-Typhoon, with the result that this type came into general service with a delay of about twelve months.[4] Yet disappointing as these expectations were in detail, they did not widely destroy the general plan of providing the Air Force with a cannon-firing, two-seater fighter for night and long-distance duties and with a single-engined aircraft carrying cannon in its wings. The gaps in the programme were filled by the Beaufighter and the cannon-firing Hurricane. Both these innovations were available in sufficient numbers, and approximately at the time at which the appearance of suitable types of aircraft for these functions had originally been expected.

Somewhat longer were the early delays in the progress of new bombers. Already in 1936 and 1937 disappointment and delay in the re-equipment of the Air Force had resulted from the slow development of the Hampden and the Wellington. In the end, the Hampden and the Wellington appeared in production about a year later than

[1] See p. 16.

[2] The first Hurricane was delivered in December 1937 and the first Spitfire in June 1938.

[3] The firm had promised to bring the aircraft into production nine months after the production order. The order was given in January 1939 but according to statistical records the first Whirlwind was not delivered until June 1940, that is eight months later than the firm's promise.

[4] According to the July 1939 programme, the first Typhoon production aircraft was expected in July 1940, but according to the statistical records the first Typhoon was not delivered until July 1941, a delay of twelve months.

originally expected, and nearly six years after their tender design stage.[1] In the case of both aircraft, however, the harm done by the delays was more than compensated for by the improved quality. The Wellington and the Hampden, as they appeared in service in 1939, were not only much larger and better aircraft than those originally ordered from the firms, but were also capable of heavier loads, longer ranges and (in the case of the Wellington) greater development.

In a sense both the failures and the successes of the 1933–36 race of medium bombers left the general plans of the Air Staff unaffected. From the middle thirties onwards the Air Staff plans for bombers were anchored on the heavy bombers. Several developments converged on this point. On the one hand there was the growing belief in bombing as a strategic weapon. To this strategic idea there came to be added in the course of time a set of tactical and technical notions which led inevitably to the same conception of bomber design. For if bombers were to be used as an independent striking weapon they had to be given a greater range and carrying power than the medium and medium-heavy bombers then under development.[2] By February 1937 the Air Council had definitely made up their minds in favour of the super-bombers, and in the previous autumn there had appeared the two specifications with which the history of the heavy bombers begins, the B.12/36, from which sprang the Stirling, and the B.13/36, to which the Manchester and the original Halifax were both designed.[3]

Each of the heavy bombers then projected came to be delayed by failure of its engines, hazards of airframe design and by other accidents. The prototypes of the three heavy bombers—the four-engined Stirling (B.12/36), the Manchester and the Halifax (B.13/36)—were ordered in the spring months of 1937, and were expected to be in production during 1940. Under the expanded Programme L, as sanctioned in October 1938, some 3,500 heavy bombers of all three

[1] At the production conferences in 1936 it was estimated that the first production Wellington would be delivered in June 1937, and the first production Hampden in August 1937. According to statistical records the first Wellington was not delivered until October 1938 and the first Hampden not until September 1938, that is sixteen months and thirteen months late respectively. The tender design conference for the Wellington and Hampden was held on 29th May 1933, that is nearly six years before the delivery of the first production aircraft.

[2] The underlying technical ideas were part of the concept of the 'Ideal Bomber'. In a document prepared by Mr. B. N. Wallis of Vickers-Armstrongs (dated November 1938, entitled 'Bomber Aircraft—determination of the most economical size') and circulated by the company to the Air Staff, the optimum size was put at about 50,000 lb. all-up weight or some sixty-six per cent. more than the greatest weight to which the Wellington had then been developed. (The Wellington Ic weighed 30,000 lb. all-up.) In the official Air Ministry memorandum on the ideal bomber of March 1938, the optimum size was put up to 65,000–70,000 lb. At this size the aircraft was expected to attain the maximum carrying power and range compatible with the greatest possible capacity for defence. It was also thought to be more economical than smaller types in crews and ground maintenance. Both documents, however, did not do more than justify what by then had become the accepted trend of official requirements.

[3] Specification B.12/36 issued 15th July 1936; four-engined heavy bomber. Specification B.13/36 issued 8th September 1936; twin-engined medium bomber.

categories were to be delivered to the R.A.F. by April 1942.[1] But in the form in which the R.A.F. could safely use them the heavy bombers did not begin to appear in service until 1941, and the total of 3,500 delivered was not reached until the spring of 1943. The overall delay was thus about a year.

The delay was not of course a dead loss. In the case of only one bomber—the Stirling—nothing was gained from the postponement, since the bomber as eventually delivered was no better, and probably worse, than the aircraft the Air Ministry had hoped to get. But both the Handley-Page and the Avro bombers—the latter as the Lancaster—appeared in the end in a form superior to the twin-engined Halifax and the Manchester. To an historian the episode is therefore bound to appear as a blessing in disguise. Although the number available by the spring of 1942 was less than that forecast, the average bomb-load by that date (to say nothing of the qualities which could not be so easily added up) was higher than that which the twin-engined Halifaxes and Manchesters could have carried.

Thus, until 1940 and possibly even until 1941, plans and achievement did not diverge sufficiently to cause alarm. But the general impression is that after 1940 hopes began to outrun achievements by far wider margins. The expectations continued to be justifiably great, but the difficulties of introducing new types were even greater. One such detailed plan on which great expectations were based in 1940 and 1941 was that for the Spitfire/Hurricane replacement. Much was hoped of the Tornado-Typhoon, but the hopes were continually delayed by the shortcomings of the Sabre engine. The aircraft was planned to appear in service early in 1941; it did not get into service in small numbers till late in 1942; and what is more, the Typhoon, as it appeared in service, was not quite the aircraft originally expected. It was clearly a fast, sturdy aircraft, which proved especially suited for the installation of rocket armament and turned out to be most successful in low-level attacks. But it was not a replacement of the interceptor fighter class which was its designed role; and the gap in the development of single-engined pursuit fighters had to be filled by other means, mostly by further developments of the Spitfire itself.[2] Fulfilment and promise were somewhat more closely matched in the development of the Typhoon's offspring—the Tempest—though even there, as with the Typhoon, the Sabre engine proved the worst obstacle. The Tempest did not appear in January 1943 as expected; its first deliveries began in October 1943. Its final performance,

[1] 1,500 Manchesters, 1,500 Stirlings and 500 Halifaxes.

[2] The speed of the Typhoon in operation proved to be 30 m.p.h. below M.A.P. forecasts and about 60 m.p.h. below the figure which the designers had at one stage suggested —according to official performance figures issued by M.A.P. the actual speed was 400 m.p.h. Its climb and ceiling were inferior not only to the contemporary German aircraft, but also to the contemporary Spitfire, and the unreliability of its engine, the Sabre in its earlier versions, was a great handicap.

though very high indeed, was somewhat lower than originally expected, and was soon exceeded by the latest Spitfire and by the American Mustang III.[1] Indeed the Mustang, a marriage of an American airframe with a Rolls-Royce engine, was the only wholly new fighter to appear in service without much delay, and to fulfil every expectation in performance.[2]

Judged by domestic expectations the progress of new bombers in the same period was even slower. Of the types which reached the production stage, the Warwick was the most delayed and the least successful. It had been designed as a replacement for the Wellington as early as 1935 and then, owing to successive changes of official policy and the vitality of the Wellington itself, it was repeatedly redesigned. It was not until July 1942 that the Warwick bomber came into production, and by that time it was well behind the Air Staff requirements.[3] In January 1943 the final decision was made to convert the type into a transport and an air-sea rescue aircraft and it was for these unpremeditated uses that the Warwick began to be produced in numbers in the summer of 1943.

Another heavy bomber, the Windsor, grew out of two converging Vickers-Armstrongs' projects of high-speed bombers first conceived in 1941. The specification was not definitely formulated until 1942, and the difficulties of designs, more especially those of remotely-controlled armament, delayed the early prototype, and by the end of 1944 it was becoming obvious that the bomber would not mature in time to fulfil its original function of a high-speed heavy bomber.

In the same category should be included the only new medium bomber to be produced in that period—the Bristol Buckingham. The origin of the Buckingham goes back to the proposals which the firm made early in 1939 for a companion to the Beaufighter—the Beaubomber. The Air Staff showed no enthusiasm for the project until it was resuscitated at the end of 1940 in connection with the requirement for an Army close-support bomber. Discussions continued from May 1941 until July 1942, while the firm complained that it was losing interest in the project. It is therefore possible that had the Buckingham, instead of appearing in late 1943 or early 1944, appeared as first planned, late in 1942, the result might have justified the original

[1] The firm estimated a speed of 455 m.p.h. for the Tempest I. This was confirmed by M.A.P. but according to official performance figures issued by M.A.P. the actual speed was 427 m.p.h. The Spitfire XIV had a speed of 456 m.p.h. and the Mustang *III* a speed of 450 m.p.h.

[2] Other plans in the field of fighters concerned the high-altitude fighter, and there delay did not turn out to be of material importance.

[3] The first prototype redesigned with Vulture engines flew in August 1939 and the second with Centaurus engines in April 1940. The production order was finally placed in December 1940. Owing to a shortage of Centaurus engines considerable numbers of early Warwicks were modified to take American Pratt and Whitney Twin Wasp engines. Tests of the first aircraft revealed great weaknesses in the design; the aircraft was heavy, slow, under-powered and unable to maintain flight on one engine.

decision. The relative failure of the Buckingham was to some extent due to the shortcomings of the early Centaurus engine, which was about ten to twenty per cent. inferior in power-output to that originally planned. Another circumstance which prejudiced the future of the Buckingham was the somewhat unexpected excellence and versatility of the Mosquito. In the end the Mosquito was able to do more than the Buckingham ever aspired to, and much more than it in fact achieved—it could travel faster over ranges only slightly shorter and could carry a load equally heavy, if not heavier. The result was that at the beginning of 1944 the R.A.F. were about to receive a brand-new bomber to fulfil a largely obsolescent tactical function.[1]

The most outstandingly successful bomber of the period was without doubt the Mosquito. Like the Spitfire, it also succeeded in maintaining its superb quality in all its subsequent developments and modifications as a night fighter, as a high-altitude photographic reconnaissance, as a fighter-bomber, and as a special-purpose fighter mounting heavy armament. Thanks to the Mosquito, the British Air Force outstripped all its foreign rivals in the field of light bomber and twin-engined fighters throughout the later stages of the war.

The field in which failures occurred and hopes were deferred most frequently was that of naval types. These troubles over naval types were very nearly as old as the expansion itself and prejudiced the quality of naval aircraft even between 1934 and 1940. Naval requirements throughout this period were focused on two special types: the torpedo-spotter-reconnaissance and the fighter-dive-bomber or fighter-reconnaissance. The very hyphenation of the titles points to the unusual character of naval requirements. A Fleet Air Arm aircraft had to be capable of a multiplicity of functions since the limited accommodation in the floating aerodromes did not allow them to house a wide assortment of specialised aircraft. The need for storing aircraft in hangars below deck and operating them from floating platforms added to the difficulty of their design. Further difficulties resulted from certain tactical requirements of the Admiralty. Thus for a time it insisted on providing for a navigator in fighters, even though the general character and dimensions of the design happened to be best suited for single-seater aircraft. These limitations did not appear to matter much so long as the strategic assumption was that the Fleet Air Arm would not be required to operate within range of enemy land-based aircraft, but they became very serious when circumstances of war pitted the Fleet Air Arm against enemy land planes.

This combination of adverse circumstances affected almost every

[1] It may be worth noting that the American Douglas Invader, a medium bomber scheduled to appear in 1944, had a history which from some points of view was as disappointing as the Buckingham. In 1942 official estimates gave promise of a really high speed, 372 m.p.h., but, as was the case with the Buckingham, this speed, one of the chief attractions of the type, was not realised.

new project. The series of torpedo-spotter-reconnaissance aircraft produced during the expansion period began with the very excellent biplane—the Fairey Swordfish. But this aircraft, already in production in 1936, was for a number of years to remain the only fully satisfactory naval type in production. As a result the Fleet Air Arm entered the war in 1939 and fought on the seas until 1943 with the majority of its squadrons equipped with Swordfish, a type which was obsolescent in 1938. With these aircraft the battles of Taranto and Matapan were won, the *Bismarck* crippled, and—in participation with the R.A.F.—Malta maintained as an offensive base throughout her siege.

The story of the fleet fighter is even more melancholy. What eventually saved the naval fighter force was that in the end, contrary to the Admiralty's belief, converted single-seater land-fighters proved excellent fleet fighters. It was they and the American naval fighters, the Martlet, the Corsair, and the Hellcat, that formed the backbone of the Fleet Air Arm fighter force from 1941 until 1944.

By the third year of the war the insufficient progress of naval types became apparent outside Service circles and was brought home to the public by the loss of the *Prince of Wales* and the *Repulse*, and the escape of the *Scharnhorst* and *Gneisenau*. A debate in the House of Lords,[1] and a series of more fragmentary discussions in both Houses, followed in quick succession, and drew from the unofficial political spokesmen of the two Services a certain amount of explanation mixed with mutual recrimination. But although political discussion for a time succeeded in focusing public attention on the slow progress of naval types, it did little to reveal its causes. Had a proper inquest then been possible it would probably have shown that the difficulties over naval aircraft were partly due to special causes and partly sprang from causes common to all new designs of aircraft under war conditions.

(*c*) ABRIDGEMENT OF TIMETABLE

In so far as the delays were purely technical and sprang from inevitable hazards of scientific and engineering progress, they need not concern us here at all. But by no means all the disappointments could be regarded as legitimate technical risks. Viewed historically, the most damaging cause of disappointments over performance was not technical failure but the mere fact of accumulated delays. For, in the field of aircraft design, hopes deferred were hopes disappointed. Some designs which, on technical grounds, appeared most promising at the time of their inception turned out to be total or partial failures, merely because they had been delayed in development and were therefore too late to meet the strategic and tactical needs for which they had first been conceived.

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[1] H. of L. Debs., Vol. 125, Cols. 794–828, dated 27th January 1943.

The accumulated delays in the various stages were mainly to blame. The time which new types took on their way from their first inception as projects to their first operational use in squadrons was determined by two sets of causes: one was largely administrative and concerned the number and the length of the different phases in the progress of a design; the other was largely industrial and was concerned with the introduction of a new type into a production line.

The normal procedure, which was customarily followed before the early years of the expansion, involved six or seven separate phases. The first phase, that of inception, covered the period when the Air Staff compiled the operational requirements for a new type or when the aircraft firms gave birth to preliminary designs in anticipation of a coming operational requirement. The second phase covered the period when the Air Ministry, or later M.A.P., formulated the official technical specification embodying the operational requirements of the Air Staff, and possibly also the technical forecasts of industry. The third phase covered the competitive tender, and was largely devoted to a discussion, preceding the issue of the prototype orders, of the relative merits of the tender designs. The fourth phase was that of the construction of the prototype aircraft. This was followed by the fifth phase, that of tests and trials of prototype aircraft. The sixth, and in some cases the seventh, phase covered the development and production orders.

Considering the leisurely progress of new aircraft through the seven ages of design it is no wonder that new types took so long to mature. The length of the various stages of design and development of standard R.A.F. types in peace-time as seen in retrospect in the Directorate of Technical Development in M.A.P. was as follows:

Aircraft: stages of design and development

TABLE 45

Stages	Time allowed (months)		
	Small aircraft	Medium aircraft	Large aircraft[1]
1. Air Staff notify D.T.D.[2] of requirements for new type	zero	zero	zero
2. D.T.D. prepares specification	5	5	6
3. Competitive tender (tender invitation); tender analysis and placing of prototype orders)	8	9	10
4. Construction of prototype	12	16	24
5. Tests and trials	9	14	16
6. Development orders	13	13	17
Development trials	12	12	12
7. Production orders	6	8	10
Approx. total time	5½ years	6½ years	8 years

[1] Excluding large flying boats.
[2] Director of Technical Development.

The average was thus at least six years, and sometimes more. The interval was obviously too long, even for peace-time conditions, and was impossibly long in time of war. Strategic and tactical needs, which might have prompted a design at a certain stage, could not possibly have remained unchanged through the years of design and development. And to make all the necessary allowances and to forecast the tactical and strategic needs five or six years ahead was beyond the powers of the most prophetic of air strategists.

For all these reasons the six-year span could not be, and never was, taken for granted by the Air Ministry or by industry even in peace-time, and remedies began to be thought of from the early days of the expansion period. There were two ways of bridging the gap: one was to speed-up the procedure of some of the stages; the other was to cut out some stages altogether. The former—the general speed-up—was attempted all along the line, but the more drastic surgical methods were only possible at three stages: the competitive tender, the prototype and the development order.

The various abridgements of the prototype stage, sometimes incorrectly described as orders 'off the drawing-board', were introduced in a number of designs including the Halifax, the Manchester and the Stirling. In the end, however, the Air Ministry adopted the more drastic policy of cutting out the prototype stage altogether and ordering 'off the drawing-board' in the narrower sense of the term. Instead of delaying production orders until a prototype had been tested, the Air Ministry now placed orders for quantity production at the same time as the prototypes. If, as a result of the tests of the prototypes, modifications appeared necessary, they were incorporated into the production series. The best examples of orders 'off the drawing-board', pure and simple, were the Bristol Beaufighter, designed late in 1938 and ordered in quantity in April 1939, the de Havilland Mosquito, designed in December 1939 and ordered in quantity in January 1940 and several Fleet Air Arm types.

The other stage to be abridged and eventually to be cut out was the competitive tender. For many reasons competitive designs came to be regarded as a luxury which the country could not afford under the stringent conditions of rearmament and war. Competition could be cut out in two ways: either by allowing full play to private initiative in the initial stages (so-called 'private venture') or by the policy of special orders to earmarked firms. By accepting 'private ventures' the Air Ministry were able to save from six months to a year which would otherwise have gone on the preparations for competitive tender and the discussion of competitive designs. 'Private ventures' were frequently combined with the system of 'special orders'. Under this system the Air Ministry or M.A.P. entrusted the design and production of a new type to a firm which, in the Ministry's view, was at

the moment best able to create a new type of the necessary kind. What with the desire to save the time hitherto spent on organising competition, and with the imperative necessity to spare the efforts of the drawing offices, 'special orders' gradually became the prevailing system at M.A.P.

So much for the cuts and abridgements in procedure. What of their effects? Did they result in economies of time great enough to bring the new types out as fast as war strategy demanded? A study of the timetables of development of most of the more familiar types will reveal that the development period of 'special order' types and of the true 'private ventures' was shortened. Yet on the whole the savings were not great or universal enough to be wholly satisfactory in war-time. In spite of the abridgements, and long after they had been introduced into the development procedure, new types continued to be delayed on their way to quantity production. The gestation period of the early bombers was up to seven years, that of the heavy bombers developed during the war was at least four years; fighters took nearly as long.

Thus to all appearances the problem remained largely unsolved. While some savings in the timetable had been achieved by changes in procedure, the growing complexity of aircraft made for further delays in design and development. The estimates of the time required to design and develop an aircraft were therefore little better at the end of the war than they had been at the beginning. In the discussion about the heavy bomber for the Japanese war, which took place at the turn of 1943 and 1944, representatives of M.A.P. felt it necessary to warn the representatives of the other interested departments that a brand-new heavy bomber type could not be brought into operational service under five years from the date of the specification and preliminary design.

Yet even apart from delays caused by the complexity of later types, it is doubtful whether cuts in procedure could have done much to shorten at all appreciably the gestation period of new aircraft. And the main reason for this was that the new types were delayed partly because the timetable of design and development was too long, but partly also through causes which were largely industrial in character. One of the industrial factors was directly relevant to the business of design. Compared with the aircraft industry in the United States the British aircraft industry suffered from an insurmountable shortage of facilities, both material and human, required for rapid progress of new designs. A technical mission under Sir Roy Fedden, of the Bristol Aeroplane Company, which visited the United States during 1943 brought back remarkable information about American 'layout' for design and development. By comparison with the vast resources of the American design departments, those of British firms were diminu-

tive. Rolls-Royce was probably alone among the British airframe and aero-engine firms in possessing organisation for design and development of a size comparable to the American. Most of the others were far too small.

The insufficiency could in fact have been blamed, as it was, on the shortage of draughtsmen and section-leaders in the country, and that in its turn could be blamed on peculiarities of British technical education which concentrated on turning out engineers of high standing but offered fewer facilities for mass production of technicians of humble rank. But a study of the comparable data would probably have suggested that the shortage might to some extent have been due to the industrial policy of the Air Ministry and the economic organisation of the aircraft industry. It was possible to argue that by its policy of maintaining in being at least sixteen design firms the Air Ministry (and after it M.A.P.) brought about an excessive proliferation of design teams and a dissipation of scarce material resources and people. Even within single manufacturing combines like Hawker-Siddeley's it was possible to maintain several—at least four—independent design organisations, of which two as a rule designed fighters and two bombers.

The other industrial factor was not directly concerned with the organisation of design, but was probably more to blame for delays than any other cause so far discussed. This factor was the protracted character of the initial stages of production. That delays occurred at the production end of the timetable will be clear from the story of most aircraft scheduled for appearance under the expansion and wartime programmes. It was in the final phase, i.e. that of the production orders and first production deliveries, that the delays proved most stubborn and least amenable to cuts. Examples of types, the first deliveries of which were severely delayed for this reason, were the Wellington, the heavy bombers, and later the Typhoon, the Buckingham and the Tempest. In each of these cases delays occurred after the business of design and development proper had been completed.

Some blame for these delays may be attached to official agencies. Owing to the fluid tactical position and the changing strategic needs, the attitude of the Air Staff to aircraft while they were still under development changed so frequently that it was bound to delay the jigging and the tooling and all the other industrial measures necessary for their introduction into production. But even more important than the changes in the official requirements were the purely industrial problems of switching production to new types.

The problem was largely that of quantity versus quality. In theory the time a firm must take to introduce a new type into production is limited only by the speed at which the necessary buildings, plant and machinery can be provided; or, where the buildings are available,

only by the time necessary for the jigging and tooling-up. This in itself leads to delays. And in war-time, when the capacity for the manufacture of jigs and tools and for the making of production drawings was very limited, the delay was bound to be longer than in peace-time. But what retarded the introduction of new types most was that in factories fully employed on well-established types, new types could be introduced only at the expense of old ones. While new types were coming in, the losses in the old types were for a time bound to be greater than the output of new aircraft, with the result that total output declined.

This difficulty could never be wholly resolved, and could only be tackled by dovetailing new production with the old—a process which came to be known as the 'splicing-in' of production. The theoretical alternative to 'splicing-in' would presumably be a clean cut of the old production followed by a fresh start of the new production. The fact that this procedure did not even receive a nickname was sufficient evidence of its unpopularity. The Air Ministry and M.A.P. seldom contemplated replacing types in production in such a wholesale manner for the simple reason that at no point since the expansion were they able to allow as great a sacrifice of output as would result from a complete hiatus in production. Even at times when the quality doctrine reigned supreme a complete stoppage of output to enable a new type to come in was more than anybody in M.A.P., and still less in the aircraft firms, could recommend. For, apart from the monthly records of production, upon which great store was set, there was also the labour problem. Even in the earliest stages of expansion, and long before the general scarcity of both skilled and unskilled workers developed in industry, the firms and the Ministry took the view that a clean break in production would lead either to a dispersal of the labour force or to an excessive amount of idle time. Either course was distasteful to Government and industry alike. The general policy, therefore, was gradually to 'fade out' the old types and to introduce the new types in their stead equally gradually and with the least possible disturbance to total production and to the employment of labour. Thus, in the very nature of things, new types could not come into production, still less reach their maximum rates, for a very long time. The interval between the production order or the beginning of the tooling-up on the one hand and the maximum rates on the other was sometimes as long as two years.

Needless to say, the problem was well understood by the authorities and worried them not a little. The Air Ministry and M.A.P. did everything they could to press the firms to expedite the transition, and often succeeded in extracting from the firms optimistic promises. In a few, but very few, instances these promises were kept. In an overwhelming majority of cases the promised span was exceeded, as it had

to be, by a very wide margin. So before long it came to be realised in the government departments that mere promises were not enough; that the problem was one of policy and industrial organisation; and that as such it could only be solved by general measures and a general policy of production.

From time to time in 1938, 1939 and 1940 various people in the Air Ministry and M.A.P.—in the production departments as well as in the various planning agencies—made tentative studies of the problem and suggested tentative remedies. In the spring of 1942 Sir Ernest Lemon was asked to investigate the length of time necessary for the introduction of a new type.[1] In August of that year he submitted a report which covered the whole process from design to maximum production, and contained a number of recommendations. In so far as the delays were due to shortages of draughtsmen or insufficient planning, the remedies he proposed were fairly simple. They mostly consisted of various measures to economise labour in the drawing offices, or to put a time limit on the different stages preparatory to production. As for the main problem, that of 'splicing-in' new production with old, he had few radical measures to suggest. He admitted that in order to minimise the total losses in output, new aircraft would have to be introduced into production very gradually, and proposed an 'ideal' schedule under which the process could be telescoped into about fifteen months. Behind this schedule was the fundamental assumption that what made it impossible to jig-up new production without affecting the old was the shortage of floor space. One of his recommendations, therefore, was that additional floor space should be provided either by new building or by economies in the utilisation of existing floor space. His expectation was that new production would rise as the necessary floor space was cleared or added.

It is at this logical and historical point that the problem came nearest to that of general industrial policy and industrial organisation. The manufacturers needed no government advice to convince them that additional floor space would make the introduction of new types easier. Nor was that point at any time lost on the Air Ministry or M.A.P. Now and again in the expansion years, additions to floor space were sanctioned in order to facilitate the introduction of new types, and the policy was carried over into the war years. Judged by standards adopted in the pre-war schemes of 'war potential', floor capacity in assembly shops was well in excess of what industry needed to produce the aircraft which it was in fact producing in war-time. Under the 1938 and 1939 plans of 'war potential', output was planned

[1] The direct origin of this investigation appears to have been the anxiety of the Air Staff during the winter of 1941–42 for new types to be introduced (i.e. the Buckingham, the B.8/41, the B.11/41, etc.); M.A.P. was unable to introduce new types within its existing capacity on top of the recently agreed Bomber Programme of December 1941.

on the assumption of continuous shift-working in assembly shops as well as in machine shops.[1] But when war came, the average shifts worked were not more than one long shift in the assembly shops and not more than two incomplete shifts in the machine shops. Had the aircraft factories found it possible to introduce continuous shift-working, as the Royal Ordnance Factories did in 1941, not only would the surplus floor space which Sir Ernest Lemon demanded have been available in practically every aircraft factory, but great economies would also have been achieved in jigs and machine tools, both new and old. If so, the failure of the industry to create a fully-balanced capital equipment and to work it with multiple shifts must be held partly responsible for the insoluble difficulties and the insurmountable delays in 'splicing-in' of production.[2] On the other hand, to remedy the failure by a vast programme of new factory construction was a recipe too drastic to be adopted at the height of the war. Above all, it was open to the obvious objection that even if it succeeded in curing delays in the introduction of new types, it might well aggravate many other complaints from which aircraft production was suffering.

(*d*) MODIFICATIONS

The disappointments and delays over the introduction of new types may appear to pose a riddle. If new types were so difficult to bring into production in time, how was it that the Government and industry between them succeeded in maintaining the performance and the other qualities of British aircraft on a level so remarkably high compared with that of foreign aircraft, and with the tactical and strategical needs of the time? The answer to this riddle is that new types were not the only, and in the long run not the chief, means of raising the quality of British aircraft. In spite of all the thought and worry expended over them, the salvation came not only from new types, but also from piecemeal improvements of the old ones.

Piecemeal improvement of existing types fell into two broad classes. There were changes in aircraft which, in the first place, were sufficiently radical or comprised detailed changes sufficiently numerous to justify the allocation of a special 'mark' of an aircraft. In the second place there were changes which were not, taken separately, of very great importance in themselves, and therefore did not justify the allocation of a new mark number: these were 'modifications' in the narrow sense of the term. The line between 'marks' and modifications was thus not very hard or fast, for many mark numbers represented

[1] See p. 41.

[2] The same factors (the unbalanced character of the industrial equipment and its incomplete utilisation) also entered into the allied problem—that of transferring factories engaged on the production of one type to that of better types in production elsewhere.

little more than a collection of modifications centring round a special operational function.

It can of course be argued that there was no hard-and-fast line between 'marks' and brand-new designs. New mark numbers were mostly given to differentiate installation of a different engine or of a special equipment associated with certain operational functions (for instance, cameras, radio aids, deck-landing equipment, etc.). But sometimes whole structural members, such as wings and fuselages, were redesigned, with the result that, although the new mark would appear to the lay spectator almost identical in shape with the previous mark, the detailed drawings would in fact be largely different. The new marks which covered these radical redesigns were usually tried out first as prototypes, and in that case a new prototype specification and Air Staff Operational Requirements might be issued.[1] Some of the redesigns of existing types were so radical that even a new mark number was not thought to give sufficient recognition to the changes; in these cases a new name would be allocated and a separate set of master drawings would be assembled. Thus the Lancaster outgrew the bonds of the Manchester, the Tempest those of the Typhoon, the Lincoln those of the Lancaster, and the Spiteful those of the Spitfire.

Yet closely as some marks approximated to new designs, the principal distinction between the two (which is also the justification for new marks as against new designs) was that a new mark, however radical, required for its design, or for its jigging and tooling, or for both, much less time and effort than a brand-new design. The history of the Spitfire is the best illustration of this. Vickers' (Supermarine's) have tabulated the man-hours expended on the principal marks of the Spitfire and thereby revealed that no single mark required an expenditure of man-hours on design as great as that originally spent on the Spitfire Mark I. The highest number was that devoted to the Spitfire F.21 which was 165,000 man-hours, compared with 330,000 man-hours on the Mark I. The average man-hours spent on design of the fifteen marks tabulated was 41,000 per mark. The total design man-hours devoted to all fifteen Spitfire marks over a period of five years was 620,000, barely sufficient to design two new aircraft of the Spitfire Mark I type. This economy was even more marked in respect of jigging and tooling. The highest expenditure incurred was on the Mark VIII, and possibly the F.21; both were very much below the 800,000 man-hours reached in jigging and tooling-up the Spitfire I. The average man-hours for jigging and tooling marks was

[1] The new mark numbers covered by the simpler modification procedure on the other hand would merely require a trial installation of the special equipment with its fixed and removable fittings. The specifications to cover such a mark number would be a straightforward document for contract purposes merely listing the modifications that were to be incorporated.

69,000 and the total man-hours for the eleven marks for which figures are available was 760,000.

Indirect evidence suggests that the figures for the other much-modified types, such as the Wellington and the Lancaster, differed little from those of the Vickers' (Supermarine) Spitfire. Viewed as a whole the figures reveal the immense effort which British industry devoted to the modification of its successful types, and yet at the same time it proves the remarkable economy of the method compared with that of brand-new designs. By this means also the quality of aircraft was much more closely linked-up with the changing tactical needs and technical ideas than was possible under the existing timetable of brand-new designs. By a series of progressive changes, almost metabolic in their continuity and in their cumulative action, British aircraft kept well abreast of the lessons of air battles and of changing conditions in industry.

The five most successful aircraft of the war—the Spitfire, the Hurricane, the Mosquito, the Lancaster, and the Wellington—all provide the best examples of successful modifications. A similar story could be told about almost every other aircraft in service between 1938 and 1944. Some aircraft lent themselves better to piecemeal improvements than others. For example, the Air Ministry and M.A.P. did not subject either the Defiant or the Hampden to the same policy of continuous enlargement and redesign as the Spitfire or the Wellington, for the simple reason that neither aircraft was considered capable of much continuous improvement. In the same way the Whirlwind twin-engined fighter, unlike the later Mosquito, was not given a new lease of life by the installation of new engines, because its fuselage was too small and its entire layout was unpromising. Nor was the Stirling carried forward as a heavy bomber by successive emendations, while the modifications of the Halifax did not in every case produce the results expected from them and did not lift it to a position of operational parity with the Lancaster. But whenever an aircraft lent itself to progressive development its life was prolonged beyond the span originally allotted to it. Indeed, to be able to accommodate modifications and to lend itself to continued rejuvenation came to be regarded as a test and a hallmark of a basically good design.

At the same time, however, continuous modifications were much disliked by industry and by those people in M.A.P. whose chief concern was with output. For nothing interfered more with the flow of production than continuous modifications. A study of the production record of the Spitfire—one of the most frequently modified types—shows how incessantly the continuity of output was broken by sharp recessions. These recessions were sharpest of all between October 1941 and February 1942, when the Mark Vc and Mark VI were coming into production, and the Mark Vb was running out; between

June and August 1942 when the Seafire I and Mark IX were being introduced into the factory, which was already engaged on turning out three other different marks of Spitfire, and again in the late autumn of 1942 when the Marks XII, XI and VIII were being introduced. The output of each individual mark also suffered recessions which can in part be attributed to the introduction of modifications in the narrow sense of the term. In a somewhat smaller measure the production curve of every successful aircraft in the war showed the same tendency.

Indeed nothing militated more against the very introduction of quantity methods than the policy of piecemeal modification. It is true of several aircraft in quantity production by 1942 that, had the spate of modifications been anticipated when its production was planned and tooled-up, a much less elaborate capital equipment might have paid better than the one actually installed. As a general rule it can be said that most British operational aircraft were never allowed to be produced undisturbed in quantities large enough to reap the full advantage of their jigs and tools. In his memorandum already quoted, Sir Ernest Lemon, basing himself on the Spitfire data, computed that, whereas for the uninterrupted output of 1,500 components the jigging and tooling-up on quantity lines would have paid best, a series of 500 or less might more economically be produced with a far larger proportion of bench tools. Yet, very few unmodified batches of Spitfires were greater than 500, so that many components must have been produced under conditions which were better suited to bench methods than they were to the jigs and tools actually used.

It is therefore no wonder that modifications soon became a favourite subject of criticism in Parliament. But even without these criticisms the damage they did to production was well understood in the Air Ministry and M.A.P. Here, as in every other field of development, quantity and quality had to be delicately balanced, and on the whole the needs of quality were never seriously sacrificed.

In theory the American procedure could have been adopted. The treatment of modifications in the United States followed naturally from the partiality of Americans for undisturbed quantity production. Not only did they jig and tool-up their standard types more elaborately than was customary and possible in this country, but they also took special measures to prevent the flow of production from being disturbed by changes in design and modification. The measure they adopted to this end was to 'freeze' large batches of aircraft under order. By an arrangement with the Services the aircraft manufacturers were allowed to produce large quantities, varying from 500 to as many as 15,000 aircraft, without any modifications in the production line. The modifications would in that case all be grouped and timed to come in at the end of a batch thus 'frozen', and when intro-

duced they would be again followed by another 'frozen' batch. For modifications which might become inevitable in the intervening period special 'modification centres' were set up.

In this way most of the changes in American aircraft were what in this country would be described as 'retrospective'. In theory this procedure had much to commend it. It enabled quantity production to go on undisturbed for long periods at a time, and made it possible for American aircraft figures to make a brave showing in official returns. But where and when tactical experience was accumulating rapidly and continuously, as in 1942 and 1943 in the case of bombers in use in the European theatre of war, the United States Army Air Force demanded urgent improvement all the time, and the 'modification centres' were soon choked up with aircraft awaiting modification. When this happened, the flow of aircraft to squadrons was much more meagre than the impressive figures of production suggested. In the end it was difficult to escape the impression that the advantages of the system from the point of view of quantity were not as great as they at first promised to be. In addition, the sacrifices in quality were probably greater than they would have been under the more flexible and looser British system.

The method in this country was to introduce modifications as far as possible when and where required, but at the same time to control them in order to reduce their effect on current output. From the early expansion days, a special body in M.A.P., the Aircraft Modifications Committee, subjected all proposed modifications to a close scrutiny, classifying them in accordance with their urgency, and laying down a different treatment for each class of urgency. By the beginning of 1943 these rules composed themselves into something of a system, and were enshrined in one or two codifying documents.

The system, however, always remained rough and ready and less perfect in some respects than in others. It was more successful in classifying, sifting and reducing the so-called retrospective modifications, i.e. those recommended for aircraft in service. It was not equally effective in controlling modifications in the production line. At least some sixty to seventy per cent. of the modifications sifted by special committees were passed as not likely to interfere much with production or to result in great waste of parts and materials. Yet in actual fact the losses in time and scrap were greater than these figures would suggest. Some loss of time and resources followed from almost every modification, however small and innocent, and the aggregate effect of a 'year's ration' of modifications was to delay production even when little measurable delay could be attributed to any individual modification. In addition, there were a number of modifications which were urgent enough to be sanctioned in spite of the delays and the scrap they caused. In other words, production suffered

from modifications much more than in theory it should have done.

Yet in the light of the experience of the war years, it is difficult to say how the position could possibly have been remedied. The major difficulty in controlling modifications in production was that of measuring its two main variables, i.e. the importance of the modification and its cost in dislocation and scrap. In theory, no modification was allowed to interfere with production unless some urgency could be claimed for it. But urgency is a relative concept, merely a special instance of the general conflict between quality and quantity. Would the R.A.F. have preferred, say, 90 modified aircraft to 100 unmodified; and if not, what other ratios would have been acceptable? If the question were ever put to the Air Ministry, the answer would almost invariably be '100 modified aeroplanes'. In the words of the chairman of the Aircraft Modifications Committee, industry had in some measure 'to thank itself for this situation because on occasions, and by making a special effort, it achieved the alleged impossible'.

Without some sort of scale of conversion of this kind, measuring the importance of the modification against loss of time and material, control of modifications was difficult. The Air Staff did not arrange the modifications in order of urgency, but the fault did not lie wholly with the Air Staff. Often quality could not be balanced against quantity merely because, in the treatment of modifications even more than in the design of new types, difficulties were bound to arise from the separation, to quote the same official, 'between quality control and quantity control in the organisation of the industry and the ministries, plus the fact that practically all must be specialised in some limited field, and therefore unable to see the picture as a whole'.

The other difficulty was that of estimating the cost of modifications. It was clearly impossible to know and to judge in advance the extent to which production would be dislocated and scrap created by a modification. For such information as there was, the Aircraft Modifications Committee had to rely almost entirely on the forecasts of the firms, but hardly any firm could tell accurately beforehand what a modification would cost in delays of production. So, in the absence of such estimates, to quote the chairman of the Aircraft Modifications Committee again, 'how can one do better than impose a generalised resistance towards all modification proposals, tempered by "spot guesses" as to probable dislocation value?' In fact the effects were sometimes difficult to judge even in retrospect. Almost all estimates of the past effects of modifications needed careful sifting to separate the effects of modifications from those of other causes. Without such an analysis it was possible for M.A.P. officials to argue that some delays were due to inefficiencies in the firms' own organisation.

Rough-and-ready control was all that was in practice possible. Here, as elsewhere, approximate balance between quality and quan-

tity had to be struck, and the fact that in spite of continuous and repeated disappointments over new types, the quality of British aircraft was in fact maintained at its remarkably high level, may perhaps be taken as evidence that the rough-and-ready rule, like so many other rules of this kind, did not after all work out too badly.

(6)

Equipment for the Army

(*a*) THE INITIAL EXPANSION

The branches of the munitions industry to suffer the earliest and the heaviest reductions were those for which the Ministry of Supply was responsible, consisting mainly of army equipment. It is not that Army plans and with them the demands of the Ministry of Supply remained unaffected by the rising needs and ambitions of 1942. On the contrary, the first reaction of Pearl Harbour was to raise the establishment of the Army and its need for weapons even more steeply than those of any other arm. Some increases in Army establishment and supplies to the extent of five to ten per cent. followed from the Order of Battle presented to the Victory Conference of September 1941.[1] Very much greater were the additions resulting from the extension of the war to the Far East. In order to meet the Japanese attack the United Kingdom had to add to the strength of the field forces raised or wholly supplied from Britain, and there were also large increases in the Dominion, Colonial and Allied troops, which were in part supplied under the British armaments programmes. With the requirements for static troops in India, Australia, New Zealand and South Africa added, the total British Army plans at one time looked like exceeding 140 divisions or very nearly twice the level at which they stood in the spring of 1941.[2] Pruned of exaggerations and excrescences the plan as it took shape in May 1942 provided for some ninety-seven divisions[3] and was to remain at that level until the first reduction in the planned establishment of the Forces in December 1942.

There was of course no question of equipping and supplying the additional armies out of British production alone. Troops in the East, especially Indian and Dominion formations, were to an increasing extent to be supplied from local sources. Above all, America was to

[1] See p. 239.

[2] The Combined Order of Battle agreed during General Marshall's visit in March 1942 was interpreted to require 25 armoured divisions and 125 infantry divisions to be provided by April 1943 with British types of equipment.

[3] The equivalent of 73½ infantry divisions and 23 armoured divisions which Britain had the responsibility of equipping.

become the main provider for most of the post-Pearl Harbour increases. As new strategic commitments grew, the proportion of British requirements to be covered from American sources rose, thus greatly diluting the assumption of self-sufficiency on which British rearmament had previously rested.[1] Nevertheless, the War Office demands on the Ministry of Supply had to be greatly enlarged. By the middle of 1942, i.e. before the first cuts in the War Office programmes were made, the amended requirements for 1943 were at least fifty per cent. above the forecasts for that year made in May 1941.

Fortunately the bulk of the increased demands could be met out of the resources already available. Productive capacity created by the Ministry of Supply for its current programme was of necessity so great that it was able to tackle after 1942 great additions to current programmes without much apparent difficulty. Since the beginning of rearmament the underlying assumptions of the plans of the Ministry of Supply were that sooner or later the initial equipment of the Army would be complete and that the task of war industry would thereafter be reduced to covering replacements and wastage in the field of battle. Under the expansion schemes of 1940 and 1941 that point was expected to be reached by Z + 27, i.e. by the end of November 1941. Before long the final dates had to be postponed, and the culminating date commonly assumed during 1941 had to be put off to the closing months of 1942. Yet however much the culminating point was put off, it never ceased to be envisaged as a summit to be held for but a short time. As the year advanced it was becoming clear that the summit would be higher than originally planned, for industry was coping not only with the requirements of that year but also with the deficits carried over from 1941, and this meant lifting the rates of production above the levels previously planned. But this merely made it doubly certain that before long productive capacity would be in excess of current demands and could be made available for further additions to programmes.

This being the situation, the reactions in both the War Office and the Ministry of Supply to the new demands were by no means alarmist. Commenting on the first War Office intimation of the coming increases, the Under Secretary (Supply) pointed out that the programme as a whole was not as terrible as it looked. For, as he observed, the Ministry's plans had been made to complete the programme by December 1942, and then to continue those rates even if they happened to be in excess of requirements for 1943 as stated in May 1941. The Ministry of Supply had in fact considered and approved a production programme policy on that basis, and its implications had been formally discussed with the Treasury. What this

[1] See Chapter V, Section (4)(*b*).

implication meant in terms of programmes will be clear from the fact that the increases in the programmes, though fifty per cent. above the earlier forecasts for 1943, were only ten to twenty per cent. above the planned production for 1942.

The increases in the current plans for army weapons were thus modest. Yet increases they were. In order to maintain the rising rates of output the Ministry of Supply continued to add to its productive capacity, and above all to its labour force, and had every ground to expect some further additions, however small, until at least the end of 1943. In midsummer 1942, when the limits of manpower for the first time appeared within sight, the labour force under the ægis of the Ministry of Supply (including raw materials and industries not counted with the munitions group) totalled probably more than three millions. In the munitions branches alone it stood at 1,647,000. And in order to meet requirements still outstanding under the current production programmes the Ministry was still in need of at least another 119,000 operatives by the end of the year and another 58,000 during the first six months of 1943, or 177,000 for the twelve months June 1942 to June 1943.[1] The gross intake required was of course much greater, for by the middle of 1942 the weekly wastage of labour had reached 10,000 and was not likely to decline. Within the Ministry of Supply it had come to be assumed that even if the intake of labour were to run according to plan, it would by the end of 1943 do no more than balance wastage, and the labour force engaged on munitions would then reach its peak.

(*b*) THE CUTS

Small as was the net increase in the Ministry's plans for 1943 and modest as appeared to be its expectation of labour intake, neither was to be realised. Instead the Ministry was asked to submit to drastic cuts in its labour force and in its programmes. That the Ministry of Supply should have thus been singled out was more or less inevitable. It was nearer the peak of its output than were the other ministries; and it has already been shown that in approaching that peak it had built up a volume of capital capacity potentially redundant. In addition, the programmes contained a number of current items which were now beginning to appear excessive. Thus, although the filling factories were in June 1942 still some five per cent. short of their planned establishment (142,000 as against the planned employment of 150,000) and the gun ammunition they were making was still short of the approved requirements of the War Office, both stocks and current output were well above the current needs. Not only was gun ammunition being consumed or likely to be consumed in the near future at much lower rates than the original plans of the War Office foresaw,

[1] Later reduced to 132,000. For requirements to the end of 1943 see Table 32, p. 225.

but whole classes of ammunition now appeared redundant, more especially various types of gas-filled projectiles. There were also other items in the army programme which in the changed conditions of 1942 appeared capable of being sacrificed without much damage to the army equipment as a whole.

The causes, the purposes and the general trend of the reductions have been discussed elsewhere.[1] In the Ministry of Supply their coming had been foreshadowed for some time before they came up for interdepartmental discussion in October and November of 1942. There was some hope at first that the main weight of the reductions would fall not on the labour force of the Ministry of Supply but on the intake of the Army. For in the early stages of the discussions Lord Cherwell gave warning against the Services' requirements of manpower being satisfied at the expense of the munitions industries supplying them; and this warning appeared to reflect the Prime Minister's views at the time. Before long, however, it became clear that the Ministry would have to share in full the Army's reductions in manpower. In a written directive of 28th November 1942 the Prime Minister suggested cuts in the Army and the Home Guard, and also reductions in anti-aircraft ammunition and in supplies for chemical warfare sufficient to reduce the munitions labour force by 67,000. This meant that the 'target strength' at December 1943 would be 215,000 less than had originally been considered necessary. After much discussion the final decision as taken by the War Cabinet on 11th December 1942 imposed upon the Ministry a labour programme reduced as follows:

Strength of Ministry of Supply munitions labour force at June 1942	1,647,000
Increase estimated to be required by December 1943	+ 148,000
which would have given a total of . . .	1,795,000
Cut imposed	— 226,000
giving a target figure for December 1943 of .	1,569,000

At this level the labour strength of the Ministry would by the end of 1943 be 78,000 less than in June 1942. The actual cut was to be still higher. The figures in the War Cabinet plan related to the strength at June 1942, but by December 1942, when the plan was adopted, employment had risen to about 1,690,000. This meant that a net reduction of about 120,000 had to be achieved by December 1943.

The Ministry accepted the cuts, but was not in a position to carry them out at once. It had stipulated that the reductions should fall more heavily in the second half of 1943 and, to begin with, it continued to take on new labour.[2] But the reductions began to take effect

[1] See pp. 223–27.

[2] See Table 46.

in February and rapidly mounted in March and April. By then the economic stringency had grown to an extent which compelled the Government to accelerate the pace of reduction and to contemplate additional cuts. In April 1943 the Minister of Production advised the War Cabinet to approve certain restrictions in the allocations of steel for the remainder of the year. Consequent on this, the War Cabinet decided that the Ministry of Supply labour reduction, which under the decisions of early December 1942 was to have taken effect by the end of 1943, should be accelerated and be carried out, as far as possible, by the end of September 1943. Additional cuts followed the review of the manpower position in July 1943.[1] In accordance with the Prime Minister's proposal a further cut of 87,000 was imposed upon the Ministry of Supply to take effect if possible by the end of the year.

In submitting to the latest reduction the Minister of Supply thought it necessary to warn the War Cabinet that the machinery of his Ministry might not be in a position to cope with labour transfers at that rate. Nevertheless actual reductions in the course of the year exceeded the War Cabinet's instructions.[2]

Labour force in the munitions industries of the Ministry of Supply, January–December 1943

TABLE 46 Numbers

1943	Total	+ or — on previous month
January	1,702,000	+ 4,000
February	1,693,000	— 9,000
March	1,676,000	— 17,000
April	1,663,000	— 13,000
May	1,651,000	— 12,000
June	1,636,000	— 15,000
July	1,618,000	— 18,000
August	1,569,000	— 49,000
September	1,542,000	— 27,000
October	1,515,000	— 27,000
November	1,492,000	— 23,000
December	1,469,300	— 22,700
Total net reduction for the year		228,700

The further cuts which were going to be enforced in the Ministry of Supply's labour force in 1944 were to some extent nullified by the urgent demands of Mulberry and preparations for the invasion of Normandy, and more will be said about them later.[3] In December

[1] See p. 225.

[2] Actual transfers were far less than anticipated. The turn-over however was so great that the labour force was largely run down by not replacing all the labour lost.

[3] See p. 353.

1943, acting on the assumption that the war in Europe might be concluded during the following year, the War Cabinet decided on a wholesale cut in the labour force of munitions industries. The Ministry of Supply was instructed to shed 120,000 operatives in the first half of 1944 and a further 100,000 in the second half, thus reducing its total establishment by the end of the year to 1,249,000. As mentioned above, these cuts were later to be moderated in response to rising demands of the battles in Europe;[1] but before they could take effect the War Cabinet and the Ministry of Supply had to face the entire problem of re-forming war industry to suit the approaching end of the war in Europe and the active prosecution of the war against Japan.

It goes without saying that reductions of that magnitude in the labour force of the Ministry of Supply could not be carried out without amputating War Office requirements, and doing this more drastically than the cuts in ammunition proposed in the Prime Minister's directive of 28th November 1942. At first the Ministry of Supply hoped that if completion of the munitions programmes for 1943 were to be postponed until 1944 it might be possible to reduce the labour force without cutting too far into the War Office programmes. But when in the course of discussions it turned out that the process would not save as much labour as necessary, both the War Office and the Ministry of Supply had to agree on more or less wholesale reductions in the current programmes.

As a result of the discussions the War Office and the Ministry of Supply were able to make reductions in all the main types of gun ammunition and in most of the main types of artillery (25-pounder, 7·2-inch, 40-mm., 3·7-inch anti-aircraft and 6-pounder equipments), in 4·2-inch, 3-inch and 2-inch mortars, and also in predictors, binoculars, universal carriers, and, of course, in the gas projectiles and respirators in which a cut had been specially enjoined by the Prime Minister's directive.[2] Other stores were to be gradually reduced in the course of subsequent negotiations.

The negotiations were conducted with great dispatch and without any serious friction. Having settled in joint discussions with the War Office the main outlines of the cuts, the Ministry of Supply then proceeded to work out in detail the quantities and types of munitions to be reduced, and these estimates formed the basis of revised requirements of the War Office. In these preliminary stages, as well as in the detailed administration of the cuts, the Ministry was able to draw on a well-established departmental technique. During 1941 it had per-

[1] See p. 227.

[2] The Prime Minister's directive on the subject was dated 4th December 1942 and the Defence Committee (Supply) gave special authority for reduction in the output of respirators on 29th December 1942.

fected the machinery of the 'Production Programme Review Meetings', at which the Controller General of Munitions Production, assisted by the Second Secretary (Supply) and departmental representatives, examined the requirements of the Service departments and laid down 'authorised production rates' upon which the production directorates could work. The 'authorised production rates' so established carried authority throughout the Ministry, i.e. for the provision of buildings, machine tools, labour and materials; and were employed in the statistical returns to measure performance. This method of control could be and was adapted to deal with reductions as well as increases, and was used to establish the new 'reduction drill'. The procedure was the same as that by which new production rates were fixed at 'Production Programme Review' meetings, and the same consultative and co-ordinating machinery under the Second Secretary (Supply) was employed. So successful and so smooth turned out to be the procedure that it was later to be applied to the complicated business of industrial demobilisation and was in its essential features to be copied by other supply departments.

At the same time the administrative efficiency and ease with which the cuts were negotiated with the War Office and administered within the Ministry of Supply belie the difficulties and complications with which they were beset. Especially difficult were the War Cabinet's desiderata about the geographical location of the cuts. In decreeing the cuts the War Cabinet was anxious that they should be so carried out as to facilitate the transfer of labour to other uses. The Ministry of Labour accordingly insisted that the Ministry of Supply should release labour in areas where large unsatisfied demands of high priority were known to exist. It was also uneasy about the dismissals of labour in areas where alternative employment was difficult to find.[1] These desiderata were not always easy to reconcile with the relative order of redundancy which underlay the reductions in munitions programmes. A very large proportion of the munitions no longer needed or for other reasons capable of being cut was made outside the areas favoured by the Ministry of Labour. It was very largely in the production of ammunition that the cuts were taking place; and filling factories had as a rule been built in areas which before the war had been classified as depressed areas where alternative employment was scarce. If anything, the difficulties of complying with the wishes of the Ministry of Labour grew as the reductions proceeded. In the course of the earlier reductions, when the same war-stores were pro-

[1] These fears were to some extent based on a simplified notion about the local effects of cuts. In most of the major centres of the munitions industry a large number of firms were simultaneously engaged on contracts for several supply departments. In these cases cuts in the M.O.S. labour force often resulted in nothing more than a book-keeping transfer of labour from contracts for M.O.S. to those for M.A.P. and Admiralty. Marginal transfers of labour, however, were inevitable even in these cases.

duced in many factories and in several areas, it was often possible to reduce work where the Ministry of Labour needed relief, e.g. in Birmingham or London, and to keep it going in 'easy' labour areas such as South Wales, or in small isolated towns with little or no alternative work. But when the time came to cut further, the possibility of choice had gone.

Now and again the decision to cut had to be taken and forced through against psychological resistances within the Ministry and war industry. There was legitimate reluctance to dismantle an industrial capacity which had been built up with much difficulty and might have to be built up again at some future time. There was also every reason to suspect that as the war developed the Army might again demand further increases which the Ministry might not be able to meet. In practice these resistances were not strong enough to affect the course of the reductions, but they were typical of the more general problems created by the cuts. It was essential in administering the cuts not to create a mood of discouragement and disappointment. Hitherto the department had functioned with a single aim in view: the highest and speediest increase in production. All planning was aimed at further increases, all successes were measured by rising output and failures by 'shortfalls' of output. This attitude was transmitted from production branches to contractors and to their workmen, who were continually urged to expand output regardless of any other consideration. Now, with little warning, the officials, the contractors and the workmen had to be told to limit, or even to abandon, the efforts so recently demanded of them. The task was not made easier by the selective nature of the cuts. For, while called upon to cut down in some directions, industry was still expected to continue its forward urge with the old enthusiasm and impetus in other directions.

(*c*) THE RESILIENT OUTPUT

Fortunately, circumstances made it possible for the Ministry to maintain the total output at a level higher than that to which cuts in the labour force at first threatened to reduce it. While cutting its labour force, the Ministry pressed on with various measures of economy in the use of labour. The programmes of explosives and propellants were adjusted to the cuts in the filling of ammunition and some labour could be spared from them. In the engineering ordnance factories it was possible to reduce the amount of work sub-contracted to trade firms and thereby to economise in man-hours per unit of output, thus reducing production to a smaller extent than the labour force. Above all, efficiency in the filling factories continued to grow and total output did not fall in proportion to labour strength. The output of the Ministry to some extent also benefited from the delayed

timetable of the reductions, for both the labour force and the output continued to rise in the first two months following the War Cabinet decisions of December 1942.

By the beginning of 1944 there also came, as there were bound to come, certain important additions to the Ministry of Supply programmes. All the Services were being urgently prepared for the invasion of Europe, and it will be recalled that during the months of preparation the Ministry of Supply was called upon to undertake a number of projects of special urgency, and in the first place the piers and the concrete caissons for Mulberry. The downward trend in the Ministry of Supply manpower was thus checked.

In December 1943 when the Ministry was again confronted with War Cabinet instructions to bring its labour force down by at least another 120,000 in six months[1] the proposed cuts, unlike those of July 1943, were going against the trend of requirements. The Minister of Production invited the War Office to make reductions in many essential items such as spare barrels for artillery, small arms ammunition, signals and engineering equipment, anti-tank mines, infantry weapons, grenades and even tanks. But although most of these proposals had to be accepted, they were to a large extent counterbalanced by new operational demands from the field of battle. More especially the demand for artillery ammunition was mounting to an extent which made it necessary for the War Cabinet to revise its earlier labour plans. The cut of 120,000 in the first half of the year was halved, and the total reduction to the end of the year was not to exceed 170,000.[2]

In the meantime, what with the growing efficiency of production, the stringent economies of labour and the new trend of demands from the armies in the field, the index of production of the Ministry remained remarkably stable. For the whole of the period it moved as shown in Table 47.

The index is in many ways an approximate one since it was based on standard money values,[3] and money values do not normally give a true measure of industrial effort in terms of real expenditure of resources. The aggregate conceals some very significant movements in separate branches of the Ministry's activities. It tells nothing of the remarkable expansion of guns and ammunition in 1942 and early 1943, and of engineering stores in 1943 and 1944.[4] Above all, it hides the high level of tank production throughout the period. The numbers of tanks produced were 4,841 in 1941, 8,611 in 1942, and 7,476

[1] See p. 350.

[2] See Table 34, p. 227.

[3] See p. 175.

[4] Table 48 shows the Ministry of Supply index figures for certain individual warlike stores, 1942–44.

Index of Ministry of Supply total output of warlike stores, 1942–44

(Average of four months September to December 1939 = 100)

TABLE 47

1942	January	537
	February	623
	March	667
	April	676
	May	724
	June	742
	July	720
	August	689
	September	798
	October	802
	November	811
	December	780
1943	January	757
	February	821
	March	818
	April	765
	May	808
	June	718
	July	684
	August	631
	September	746
	October	721
	November	740
	December	652
1944	January	661
	February	737
	March	711
	April	686
	May	666
	June	608
	July	584
	August	554
	September	614
	October	631
	November	626
	December	545

in 1943. Measured by weight the progress was much more marked. During this period the tank shared with the aircraft the privilege of being maintained in full production to the very end, and of not suffering the reduction to which the bulk of other army weapons had to submit in 1943. The story of how during this period the design of tanks and tank guns—the 'sore spot' of 1941—was gradually improved, has been forecast in an earlier chapter.[1] But the course of improvement was chequered and uneven and resulted in a constant stream of modifications which added to the difficulties of production. The vehicles in production were also more complicated and heavier than the tanks made at the beginning of the war. That in spite of all the difficulties, old and new, tank production stood high and in general improved does credit to the administration of tank produc-

[1] See Chapter IV, Section (10).

Index of Ministry of Supply output of guns, small arms, ammunition, tanks, engineer and transportation stores, 1942–44

(Average September to December 1939 = 100)

TABLE 48

Month	Guns(*a*)	Small arms(*b*)	Shells and bombs		Small arms ammunition	Armoured fighting vehicles	Engineer and transportation stores
			Filled	Empty components			
1942 January	484	386	726	821	1,582	1,446	394
February	580	469	844	954	1,835	1,659	451
March	606	576	875	984	2,079	1,685	531
April	608	653	936	1,015	2,216	1,640	526
May	657	699	984	1,050	2,306	1,847	516
June	696	713	1,029	1,091	2,470	1,829	576
July	617	791	982	1,047	2,764	1,635	576
August	609	733	963	952	2,370	1,703	538
September	712	912	1,082	1,111	2,902	1,842	666
October	701	968	1,062	1,136	3,393	1,835	703
November	770	877	1,051	1,229	3,795	1,737	758
December	760	876	1,040	1,159	3,757	1,535	743
1943 January	778	975	963	988	3,519	1,726	689
February	793	1,030	1,023	1,033	4,022	1,851	816
March	763	1,072	971	962	4,488	1,784	884
April	704	1,069	818	823	4,325	1,861	860
May	767	1,114	802	807	4,879	1,984	915
June	653	993	701	678	4,823	1,577	924
July	597	829	599	567	4,943	1,579	913
August	532	868	525	469	4,581	1,445	995
September	639	903	598	521	5,475	1,765	1,182
October	563	884	581	500	5,547	1,509	1,262
November	530	940	561	486	5,914	1,505	1,350
December	421	833	490	476	4,819	1,468	1,215
1944 January	431	765	464	410	4,981	1,614	1,580
February	454	710	521	449	5,457	1,574	1,974
March	445	721	505	427	4,987	1,543	1,998
April	321	658	478	406	5,304	1,394	2,086
May	362	682	543	428	4,640	1,317	1,767
June	323	673	483	419	4,355	1,118	1,670
July	308	620	516	405	4,380	..	1,408
August	298	554	489	356	3,744	..	1,686
September	267	577	595	420	4,441	..	1,546
October	214	525	637	421	4,859	..	1,320
November	196	559	656	402	4,852	..	1,314
December	170	421	596	368	3,282	..	1,180

(.. not available)

(*a*) Includes field, medium, anti-aircraft, and tank and anti-tank guns.
(*b*) Includes small arms, machine guns and mortars.

tion in the Ministry of Supply,[1] and above all to the efforts of industry. The difficulties and peculiarities of tank production were a challenge to which many firms responded with great readiness and resource.

[1] The branch of the Ministry of Supply in charge of tank production was made in the summer of 1941 into an autonomous division, headed by Commander E R. Micklem, of Vickers-Armstrongs.

No index is available to reveal the expansion in certain fields in which the volume and value of output were small in comparison with those of the major weapons, but in which most remarkable progress was made. One such field was that of 'general stores' and, above all, that of medical supplies. The Ministry's responsibilities for 'general stores' and the part these stores played in its programmes were always great and on the whole tended to become greater in the later phases of the war. If army clothing no longer loomed as large as it had done at the beginning of the war, other miscellaneous articles accumulated in the Ministry's production programmes. A good example of these were 'packing cases, drums and other containers', especially jerricans.

The War Office decision early in 1942 to adopt the German type of petrol container, soon to become known as the 'jerrican', did not of course present a production problem of anything like the same magnitude as that of the major weapons. But its manufacture was not as easy and simple as its name suggests (it was no mere can). And, coming as it did, at the height of industrial mobilisation, it raised considerable difficulties. Its manufacture involved the extensive use of 'outside' firms;[1] plant and buildings to the value of over £1·5 million had to be provided. By the end of the war some 50 million special petrol cans had been produced, at a maximum rate in the second half of 1943 and again during the last quarter of 1944 of about half a million cans a week. By the end of 1942 the Ministry of Supply had also been given responsibility for the production of the conventional type of metal drums and kegs. Requirements of these for the War Office alone rose at the end of 1943 from under a quarter to three-quarters of a million per month, but in the same period output to meet these requirements was raised from one-third of a million to just over three-quarters of a million. Increased output was mainly obtained by rationalisation and more intensive use of existing capacity.

The most remarkable achievement outside the conventional range of weapons was undoubtedly the production of medical stores. From 1941 to the end of hostilities the major task of the Directorate of Medical Supplies[2] in the Ministry of Supply was to expand the output in the United Kingdom of a large variety of drugs and equipment, but it also had much responsibility for the control and economic allocation of inevitably scarce supplies. What with the accumulating casualties of war, the needs of Russia and of military and civilian relief in Europe and the Far East, requirements of drugs greatly increased and many vital demands proved exceedingly difficult to meet.

The problems were somewhat different from those of other war-stores. Without exception all the final processes in the manufacture of the drugs were of a specialised nature and could only be directed

[1] See p. 399.

[2] Established in July 1941.

by specialised technical management. New capacity was therefore developed within the existing specialist firms; much of it had to be added to existing plants, and, apart from the large schemes for the production of penicillin and a few small schemes covering a wide variety of drugs and instruments, it was financed by the firms themselves. But although the Ministry was not as a rule called upon to build new factories and extensions it had to initiate and sponsor a vast amount of activity, especially in the discovery and production of new drugs or the output of drugs previously imported.

The relative importance of special drugs varied at different times of the war, and the following are only two examples of the more important operational requirements which had to be met so very frequently. One such example is mepacrine, the new anti-malarial drug, and the second is the scrub typhus vaccine. In 1939 production of mepacrine in the United Kingdom was in the experimental stage, but large-scale production was achieved in time to meet the much increased demands from the Far East from 1943 onwards when supplies of the normal drug, quinine, were at a very low level. The submission by the War Office in 1944 of an urgent requirement for the scrub typhus vaccine to counteract serious conditions rapidly developing in the Far East necessitated the establishment of a special breeding and cultivation station for what was comparatively specialised and highly dangerous work. By the use of every resource and full priority, supplies were provided within six months.

Of the new general drugs brought into full-scale production during the war, the sulphonamides and penicillin were by far the most important. Between 1942 and 1945 the yearly rate of output of sulphanilamide, the original drug of the sulphonamides group, was raised from 153 tons to more than 500 tons. Production of other drugs in this group was on a somewhat smaller scale, ranging from 10 to 100 tons per year, but few of these drugs had been produced in any quantity previously, and the bulk of the supplies was made available in the later phases of the war.

Service requirements of penicillin, which was only in laboratory production in 1942, rose quickly, and large-scale planning became essential. To the end of the war home production of penicillin remained far short of the large War Office requirements[1], but between December 1943 and November 1944 approval was given for six new factories to be provided at Government expense at the cost of over £2 millions, with a planned total weekly output of over 35,000 mega units. Until 1944 however, production was entirely from pilot plants set up by manufacturing chemists. Other unassisted schemes were expected to increase output to about 9,000 mega units per week, but this increase was not achieved. The average monthly output in the

[1] 1¾ million mega units for 1944.

first nine months of 1944 was only 1,500 mega units, but output increased to 10,000 mega units in December 1944. By the spring of 1945 three of the government factories came into production, and by June output was over 34,000 mega units a month.[1] The total output to the end of the war was about 230,000 mega units, still below the War Office requirements; but, whereas during 1944 United States supplies of penicillin to the United Kingdom were ten times those of United Kingdom production,[2] during the first nine months of 1945 United Kingdom production exceeded supplies from the United States,[3] and made it possible to look forward to complete independence from imports.

(6)

Production of Radio

(*a*) THE 'INTER-SERVICE' WEAPON

The tasks imposed upon war industry cannot be fully judged without taking account of the instruments of war which did not occupy a permanent place in the separate programmes of the three Services, and could not be counted as special 'offensive' projects, but were nevertheless of great importance and raised major problems of design and production. One such inter-Service weapon, radio, assumed in the later stages of the war an importance both military and economic sufficient to justify a section to itself in this study.

From the administrative point of view, M.A.P. carried a large measure of interdepartmental responsibility for various aspects of radio production, and particularly for the production of valves and components. It acted during the first years of the war as an agent for the other departments directly, and from the autumn of 1942 onwards as an agent for the Radio Board. The latter came into being as a War Cabinet committee with controlling powers, but its organisation continued to be under the Minister of Aircraft Production as the ministerial authority on all radio matters, and Sir Stafford Cripps, in particular, took a large and ever-growing interest in its work. Yet in spite of all its close constitutional links with M.A.P. the supply of radio equipment was from every point of view an interdepartmental enterprise. The wireless equipment of the R.A.F. and the various devices which budded off from it were, of course, the most novel and

[1] It was only after the end of hostilities that the two factories established for the deep culture process came into production and output rapidly soared.

[2] 357,000 mega units compared with 36,000 mega units produced in United Kingdom.

[3] 196,000 mega units compared with 174,000 mega units imported from the United States.

most spectacular of the weapons in use in the later stages of the war, but they were by no means the only ones. 'The use of wireless in the Army', said the Assistant Chief of the Imperial General Staff in May 1944, 'has grown to a point where it now extends from the highest headquarters right down to the lowest component part of fighting units', and similar statements could have been made about its use by the Navy. By 1943 the shares of the Navy, Air Force and the Army in the total requirements of wireless, measured by their demand for valves, were thirty-three per cent., forty-one per cent., and twenty-one per cent. respectively.

The radio devices became more ubiquitous and more indispensable as the war advanced. How much they in fact expanded can easily be seen from the growing expenditure of the three supply services on radio and radar.

The expenditure of the Admiralty, Ministry of Supply and M.A.P. on radio and radar, 1939–44

TABLE 49

	£ millions
1939	5·5
1940	25·8
1941	53·3
1942	83·0
1943	116·1
1944	123·6
Total	407·3

Although the cost was mounting throughout the war years, the main increases came between the end of 1941 and the end of 1944. The total expenditure for these three years, at £322·7 millions, accounted for more than three-quarters of the total expenditure since 1939. Thus, as a supply problem, radio and radar is very largely a feature of the last three years of the war.

The 'peak' of the rising demands did not come into sight until 1944, and the output was still being expanded on the day the war in Europe came to an end. For this reason, if for no other, the industrial problems of radio production were in the closing years of the war still to some extent beset by problems of initial growth which the rest of war industry had left behind. Acute labour shortages came to radio manufacturers at about the same time as to the rest of war industry, but until the end of the war manufacture was held back more by a shortage of skilled labour than by that of manpower in general; and to the very end the main problem remained that of manufacturing capacity.

(*b*) CAPACITY TRANSCENDED

Before 1941 the demand, though growing, was well within the capacity of the radio industry and raised no awkward problems of

labour, materials or components. From the point of view of war-time demands, as they were to reveal themselves later, the radio industry of the thirties suffered from many limitations. Its staple product was the simple broadcast receiving set, and only a few of the large and well-known firms were experienced in the manufacture of equipment like transmitters, or had facilities for developing complex designs. Even the more experienced firms were unaccustomed to the special needs and exacting standards of military service; especially as Service specifications often displayed a certain indifference to ease of production. Nevertheless, productive capacity in general appeared fully equal to the foreseeable demands in war-time, for the radio industry was a large and growing one. The value of its final product (sets) rose from £5 millions in 1930 to nearly £13·75 millions in 1935, and its total employment from some 20,000 to 43,000 workers between the same dates. The progress was arrested in the years between 1935 and 1938, but not sufficiently to disturb the confidence of the men who were in 1938 engaged in planning industrial mobilisation in time of war. When in 1938 a committee was set up to investigate the supply of high-grade radio equipment for radar and interception purposes, it was able to report that there was 'no apparent shortage of suitable manufacturing capacity'.

The same verdict applied to other types of radio equipment, including most of the standard components. It applied above all to one component which was common to all radio equipment and which was later to become the main limiting factor of war-time expansion, i.e. valves. The production of valves before the war was almost entirely in the hands of the half-dozen or so valve-manufacturing firms which, together with the distributing organisation, made up the British Valve Manufacturers' Association. Of the total output of 12 million valves per annum, not more than half a million were produced for government uses before 1939. There was thus what appeared to be a vast reserve of capacity for war-time use, and the Air Ministry and other supply departments felt satisfied with the prospects. All they were concerned about were possible shortages of special types (then very limited in numbers) and the location of industry. In order to remedy the undue concentration of valve production in London, the Air Ministry established a 'shadow' factory to be operated by the General Electric Company (G.E.C.) in Lancashire. At the same time the Mullard Radio Valve Company began preparation for the manufacture of valves in the North, and the Admiralty took steps to safeguard the output of envelopes for silica valves by establishing a 'shadow' factory also in the North. With these additions the industry seemed to be capable of meeting a greatly increased military demand, and of doing so with reasonable security against enemy attack.

The experience of the early years of the war did not appear to disturb the confident picture of the pre-war planners. By 1939 a large number of firms had, often with the assistance of the Radio Department of the Royal Aircraft Establishment, learned to design and produce equipment of specialised character for the R.A.F. and the other Services. A vital part of the industrial effort was that which was devoted to the construction of the so-called 'home chain' of radar stations. The history of its conception and development will be told elsewhere,[1] and when told, it will show how by 1938 earlier scientific discoveries in the field of electronics enabled the Bawdsey Research Establishment of the Air Ministry to develop a technique for the detection of approaching aircraft. The home chain then designed required about twenty transmitting and receiving sets; and the equipment was well within the technical and economic resources of the two firms—A. C. Cossor and the Metropolitan-Vickers Electrical Company—from whom it was ordered.

The supply of components, and above all of valves, appeared almost equally satisfactory. The valve industry was proving equal to the calls made on it, although the expected figure of one million valves per month was not regularly reached. It was not until the needs for 1941 came to be assessed that existing capacity for the first time proved insufficient. Service demands for 1941 had risen to 17 millions, and a further six millions were still required for civilian use. Yet even then the increase was small enough to be met by a quick and sharp spurt. In the industry as a whole production was stimulated by suppressing unnecessary types, by working longer hours, and by introducing managerial expedients of various kinds. As a result of all these measures the annual rate of production reached the figure of 18 millions by the end of 1941. At the same time, to meet future needs, a few new factories were laid down, e.g. factories to be operated by the Cosmos Manufacturing Company and by A. C. Cossor.

The situation was to be radically changed in the course of 1941. The range of application of wireless techniques immensely expanded. Designs advanced by rapid steps, and the demand consequently grew both in quantity and complexity. No sooner had the main requirements of the home chain been fulfilled than various types of other wireless equipment, whose development had been delayed in the interests of the home chain, had to be ordered. The most important of these devices were a naval warning set, which as Type 279 and later 281 was to play a notable part in the early period of the war at sea; a radar device for laying anti-aircraft guns, known as G.L.; an air interception equipment to be carried in night fighters, called

[1] It is hoped that this subject will be dealt with in the forthcoming volume in this series on the Design and Development of Weapons. See also p. 195n.

A.I.; and a device for the identification of aircraft, called I.F.F. (Identification Friend or Foe). Yet even with these devices in being and other devices on the horizon in 1940, it was still impossible for anyone except a small number of scientists to foresee the effect of a technical revolution which had for some time been in progress.

The revolution followed the development of centimetric radar, which in its turn became possible when early in 1940 the 'cavity magnetron' valve was invented. It permitted the radar pulses to travel as it were along a narrow beam instead of 'floodlighting', as in the case of the home chain station, or of spreading along the comparatively broad beam of the early A.I. And this opened up new possibilities and enabled radar to play the great part which it did in various naval and military operations and in the bomber offensive of 1943 onwards.

The device for detecting submarines from the air, known as A.S.V.; the naval surface search equipment called the 271 set; the anti-aircraft gunlayer, G.L. Mark III, all depended upon centimetric technique. From the point of view of the bomber the new technique, in the form of the device called H_2S was a godsend.[1] The accuracy of bombing had come under suspicion by the end of 1940, and in the summer of 1941 an analysis of night photographs carried out at the instigation of Lord Cherwell confirmed the consistent failure of bombers to locate their targets.[2] What was wanted was a device which would give precision in bombing, and this need was supplied by Oboe and H_2S. Oboe was first used operationally in December 1942, and in the following spring it was used to control target-marking Mosquito aircraft in the great series of attacks upon the Ruhr. H_2S made use of radar's ability to discriminate between echoes reflected from built-up areas and those reflected from open country, and therefore was an aid to navigation as well as to precise bombing. H_2S was first used in the Pathfinder force in January 1943, and was later fitted in a large proportion of the heavy bomber force. In the later stages of the war at sea Admiralty scientists developed a series of combined gunnery and surface warning sets which greatly advanced the revolution in naval warfare which had begun with the early type 279.

From all these designs a greatly increased demand for equipment and components was bound to follow; and new demands in the radio industry were also coming from elsewhere. The experience of the B.E.F. in France had shown the need for a much more extensive use

[1] Non-centimetric devices, however, continued to play an important part.

[2] Radar scientists had not up to that date had much opportunity for studying a problem of this kind, but fortunately some attention had been given to radar as a navigational aid at an earlier period. As a result there emerged a device known as Gee, which enabled a navigator to determine his location. It went into service in March 1942.

of lightweight radio communications equipment for infantry use, and it was also realised that radio would play a part of ever-increasing importance in armoured warfare. As an example of the army demands which were to follow from these experiences may be taken the No. 38 set, a man-pack equipment of which some 200,000 were manufactured in the course of the war. Since War Office planning at this period assumed that the valve would be renewed seven times in the life of the equipment ('seven valves per socket'), a large industrial effort was required to supply the new need. During this period also the use of very-high-frequency communications equipment was greatly extended both in the Navy and the Air Force.

(c) THE VALVE PROGRAMMES

A new industrial situation was thus created. If earlier demands were well within the capacity of the peace-time industry, the new demands, especially those which came after 1941, outstripped it by a very wide margin. The output of main components as well as the capacity available for their assembly were all proving inadequate. More especially, the supply of valves, the main constituent of all wireless equipment, was beginning to hold back the expansion. From now on it was to be the main limiting factor in wireless production.

The problem of valves was not of course one of numbers alone. Radar required special valves; the centimetric devices in particular were built round the cavity magnetron, which was much more difficult to manufacture than a simple receiving valve. The appetite of radar devices for special valves appeared to be both insatiable and fickle; a valve which was urgently demanded one week would be obsolescent in the course of the next. During 1941 new types were being introduced at the rate of three a week, and the production of cathode ray tubes rose from 3,000 in January of that year to 14,500 in October. In January the total capacity of the British Valve Manufacturers' Association firms for all types of special valves was only about three per cent. of total valve capacity; by the end of the year the demand for special valves was approaching ten per cent. of the total demand and remained about ten per cent. for the remainder of the war. So even though the industrial effort can best be measured in terms of bulk programmes for simple valves, the problem of special valves must be borne in mind throughout the story.

At the end of 1941, i.e. at the time when the new phase of wireless design was beginning to affect production programmes, the requirements for valves in 1942 were forecast at 24·4 millions, i.e. nearly twice the rate of 1939. What is more, demands for 1943 threatened to reach the figure of 39·5 millions against the earlier estimate of 21·5 millions and a previous output of 12 millions. By cutting down provision for spares and by other economies the figure of 39·5 millions

was reduced to 32·4 millions, and eventually to 30 millions, for which, it was hoped, capacity could be made available. The remaining deficiency of general types, it was hoped, could be made up by American imports, upon which high hopes were already being placed. But even while the 30-million programme was being discussed, the need for further expansion was becoming clear. Late in 1942 the Parliamentary Secretary of M.A.P., who had been given a measure of interdepartmental responsibility, submitted a paper to the Aircraft Supply Council which foresaw the necessity of valve production at the rate of 50 millions per annum; and the forecast was to be fully borne out by the developments of 1943.

In that year the centimetric radar device for laying anti-aircraft guns was, after many design vicissitudes, due to come into full production. Naval equipments such as the latest surface search equipment had achieved great success and was being widely fitted in more advanced versions. In the Air Force H_2S and its sea variant were now on order on a large scale. Moreover, from now onwards every expansion of the armed forces—ships, armoured fighting vehicles, infantry battalions, training formations, air force commands—raised new demands for radio and radar, and miscellaneous requirements of various kinds were coming in large quantities from every quarter. Radio equipment was needed not only for home broadcasting but also for the B.B.C.'s activities overseas, for the resistance movements in enemy-occupied territories, for radio counter-measures such as jamming, for the police and for many other purposes.

It is therefore not surprising that requirements for valves in January 1943 leapt to 52·2 millions.[1] Nor is it surprising that the Radio Board found the demands well in excess of what could be supplied. The Services had to be asked, and agreed, to cut their requirements to the basic minimum, but further demands for 1944 were brewing while the current demands were being cut. By the autumn of 1943 the valve programme for 1944 stood at 60 millions. M.A.P. was prepared to accept a target of 45 millions in the hope that 15 millions would come from the United States, and proceeded at once to authorise additions to the manufacturing capacity. Yet these additions were soon to prove insufficient. In January the Aircraft Supply Council was informed that current output was at the rate of 42 millions, 'and the demand for 1944 now totals 90 millions'. For by now further types of equipment were coming into general use. Above all, on the defensive side the system of devices for the ground control of interception set up a large demand for components; and at about the same time centimetric ground radar sets to give warning of low-flying aircraft and of ships were introduced. Another large

[1] They rose at first to 61·4 millions, but acting at the request of the Radio Board the minimum demands were reduced to 52·2 millions.

requirement followed the adoption of radio beacons for aiding airborne forces; and, needless to say, the use of radio and radar equipment continued to spread in the routine operations of the three Services.

To deal with new increments M.A.P., acting as the executive agent of the supra-departmental Radio Board, launched a combination of new projects and in particular an industrial expedient known as the 'feeder' system, about which more will be said presently. But the new projects could not bear fruit at once, and to meet the immediate difficulty other expedients had to be tried. They were for the most part painfully familiar: a careful apportioning of supply and a more stringent sifting of calculated demands, culminating by April 1944 in further and more drastic cuts. The War Office, for instance, reduced its demand for valves from 47 to 35 millions; the other departments tried to reduce their requirements in the same way. On 4th May 1944, the Service representatives reluctantly agreed to accept an 'irreducible minimum' of 52 million valves.

A gap of some 15 to 20 million valves still remained, and was eventually filled with supplies from America. The importance of the American contribution to British supplies of wireless equipment in the last two years of the war has already been mentioned.[1] The imports of valves from the United States grew from 1·4 millions in 1942 to 2·3 millions in 1943, and then soared up to 17·4 millions in 1944. In addition, during that year large numbers of complete wireless equipments were supplied directly to British forces in various theatres with valves *in situ* and as spares.

(*d*) THE INDUSTRIAL PROBLEM

What made the remarkable rise in American supplies possible was that the American radio industry, like the rest of their war industry, had enough time and resources as its disposal to plan its operations as a long-term enterprise laid out and tooled up for standardised output on a mass scale; and by the end of 1943 this policy had begun to yield vast returns. But even more than in most branches of American war production, the high returns had to be paid for in time spent on preparation. This alone would have prevented the British radio industry from following the American method, even if ability to do so had been present. Production in this country had grown between 1940 and 1944 from 12 million valves to over 35 million—a very great increase indeed. But it was achieved by gradual improvements in the efficiency of plants, and above all, by piecemeal additions to capacity made to match each increase in demand as it occurred. It has already been shown that this was the method by which the 1940

[1] See p. 248.

increases in capacity from 12 million valves to 18 million and then to 24 million were obtained. When at the turn of 1941 and 1942 the 30-million programme for 1942 matured it was also met by additions largely piecemeal to existing capacity. The plant kept in reserve as an insurance against enemy action was brought in, and so was the capacity of one of the larger radio firms not previously drawn upon for the supply of valves for war purposes. The British share of the 52·2 million programme for 1944 was met in the same way, by making additions to the capacity at three of the largest manufacturers of valves and electric bulbs, who had already made themselves responsible for a large share of the total output.

The bulk of the new additions was organised and tooled up on lines not radically different from those which had prevailed in the industry on the eve of the war. More efficient machines had become available but, in general, the processes remained dependent on supplies of skilled labour. The only project involving radical change of method was that of the 'feeder' system, by means of which M.A.P. hoped to meet the 1944 programme. Valve manufacturers were to be split into two sections: one requiring specialised technical supervision and costly plant; and the other requiring light equipment and relatively little specialised technical supervision. Most of the latter were assembly factories equipped with little more than benches, spot welders and jigs, and employing mostly unskilled and semi-skilled female labour. Thus differentiated, the industry was arranged into groups each consisting of feeder plants associated with a main factory. It was hoped that by this means the industry might be able to expand its current rate of output by about fifty per cent. and reach the target of 63 million British-produced valves per year. Unfortunately the proposal came too late to make much difference to the 1944 output.

In the manufacture of equipments the introduction of radically new manufacturing processes was likewise a difficult task. Before the war the assembly of complete wireless equipments—mostly receiving sets—in this country was not a highly organised or elaborately equipped industry. While large establishments such as G.E.C. were able to supply their own valves and components and to maintain elaborate facilities for research, most of the manufacturers as a rule purchased their components and assembled them in simply-equipped establishments. So limited were their staffs and equipment that some of them bought designs of circuits from the valve manufacturers who supplied them with valves.

The rise in military demands was not accompanied by fundamental changes in the method of assembly. Now and again some of the larger firms were able to rationalise the flow of production: thus on the eve of the war E. K. Cole redesigned the general-purpose communication set for the bomber so as to make it amenable to

mass production. But this was not the common procedure. Even the firms anxious to reorganise their methods of production found themselves working in conditions inimical to economic planning of output. The industry expanded in response to immediate military needs and to rapid progress of scientific designs, and the 'regular' programmes were urgent and unstable enough. But, in addition, so essential was it to make newly-designed equipment available with the least possible delay that 'crash' orders had frequently to be fulfilled at the shortest notice regardless of cost. Notable early examples were the production of the first centimetric A.I. sets by G.E.C. and of the first fifty H_2S equipments by E.M.I. (Electric & Musical Industries) in 1942. 'Crash' programmes of this kind became standard practice as the war progressed, and most of the later mark numbers of existing equipments were regularly ordered in this manner.

The pressure for 'crash' programmes came mainly from scientists representing research establishments, but their value was clear to all impartial observers. Lord Justice du Parcq, reporting on 'crash' programmes in 1943, recorded his conviction that:

> where need is urgent (as it is with regard to many [radar] devices), facilities for quick small-scale production should be greatly increased. . . . There are many cases in which 200 sets now are of more value than 1,000 in nine months time.

No one believed more firmly in the value of 'crash' programmes than Sir Robert Renwick, the Controller of Communications Equipment in M.A.P., who justified resort to them in a paper prepared for the Aircraft Supply Council, and pointed out that they

> permit of initial deliveries of equipments to the Service in five to six months, instead of a minimum of twelve months which is required for tool production.

The idea of the 'crash' programme, once it was established, dominated the whole field of radio production. It is probably true to say that almost every manufacturer of equipment undertook at least one 'crash' programme of some importance. The more important firms undertook many. Certain firms and certain factories belonging to the large firms were devoted very largely to this type of work. Dynatron Radio, a small firm which devoted itself before the war to the making by hand of high-quality receivers, was an example of a firm which was used almost entirely for this purpose. Allen West & Company undertook a similar role for the Admiralty; and this department also placed 'crash' programmes, as did the others, with the big radio firms with which it was most closely associated, such as Metropolitan-Vickers, B.T.H. and Ferranti. As regards 'crash' programmes of Air

Force radar, a factory of E. K. Cole was also assigned to the manufacture of equipments in small numbers. Although it was sometimes diverted from this purpose, its main role was not entirely lost sight of.

How inimical 'crash' orders were to rationalised production can be shown by a few examples. Twenty-one Monica equipments produced by 'crash' programmes were priced by A. C. Cossor at £482 each; a normal production programme of 7,000 of the same equipment by the same firm was supplied for £180 each. A radar display unit cost £1,400 for each of thirty equipments by 'crash' programme and £800 for each of 600 under a normal production programme. Fifty receivers produced by E. K. Cole as a 'crash' programme cost £215 each; 600 produced as a normal programme cost £25 each.

Although the relatively high costs of items produced by 'crash' programmes were in themselves a tribute to the freedom with which the firms employed emergency methods, it nevertheless makes it easy to understand why, essential as they were, such programmes were so disliked in the industry and in many quarters within the ministries. They required an abnormal use of skilled labour on what were essentially hand-made, or at least semi-tooled, projects, and they disrupted rational planning of production and provisioning in factories. Added to the general fluidity and urgency of the programmes they helped to deter the manufacturers from embarking on a thoroughgoing reconstruction of production methods.

The need for expansion was thus met not by recasting the industry to suit the mass demand but by enlarging the floor space in factories. Two of the leading firms, A. C. Cossor and E. K. Cole, which may be taken together for a moment as an example, had expanded their combined floor space nearly four-fold between 1934 and 1941, and by 1942 the industry at its assembly end appears to have possessed sufficient floor space to cope with most of the additions to programmes.

In this process the limiting factor was labour, and in view of the industry's methods, the labour problem was mostly that of skilled and supervisory grades. Complaints of labour shortages recurred continually from May 1941 onwards. The 1942 crisis in radio production was ascribed primarily to shortage of skilled labour, and in April 1942 the Director of Radio Production revealed that owing to the labour shortage about eighty per cent. of the industry's plant was worked for only sixty hours a week, and the American plant which was being installed in the industry was thus operated for little more than half the number of hours which the Americans regarded as essential for its economic utilisation. What added to the difficulty of labour supply was the great need of the Services for young radio technicians and the continuous losses which the industry consequently suffered from labour call-ups.

Various attempts to deal with the problem were made, mostly the same as those which two or three years previously had been successfully adopted in war industry in general. Training schools were established, upgrading was carried to its farthest limit. Other measures followed the report of a committee which the Minister of Production set up early in 1943 to inquire into the utilisation of labour in the radio industry. The skilled labour employed by the industry—some 8,000 men and women—were 'frozen', i.e. retained in the industry irrespective of age and irrespective of alternative claims on their services.[1] The recruitment of the university-trained personnel, for which the demand of the radio industry and radio research establishments appeared insatiable, was taken in hand by a committee under Lord Hankey's chairmanship established in October 1939.

Compared with the shortage of skilled labour, that of unskilled and semi-skilled labour did not appear to cause great difficulty, or at least did not cause any difficulty which was not already besetting war industry as a whole. According to the report of the 1943 committee the total employment in the radio industry, though difficult to estimate, was about 100,000, and the Ministry of Production accepted the figure of 120,000 by January 1944. The total demands for additional labour were estimated in January 1943 at about 30,000, but the estimate was very rough and the subsequent movement of employment showed that it was exaggerated. The industry was advised to resort to areas where labour was easy—Aberdeen, Edinburgh, Plymouth, Llanelly and Wigan. At that late hour the advice was not and could not be adopted as a whole. Nevertheless, complaints of the difficulty of recruitment of labour in general were not as insistent as they were at the same time in other branches of war industry. The general impression is that the intake of unskilled labour continued to be limited by the shortage of skilled and supervisory grades—and fortunately the resulting gaps in supplies were easier to meet out of American production than in most other programmes of weapons.

Apart from the atomic bomb, no weapon of warfare devised in the second World War made so deep an impression on the imagination of the public as did radar. Devices such as H_2S, reproducing on a screen in an aircraft a map of the country over which the aircraft was flying, seemed uncanny. The effort of producing such revolutionary

[1] This was not a new expedient. In October 1942 Mr. Garro Jones (as he then was), the chairman of the Production, Planning and Personnel Committee, which had been formed that month, tried to secure a 'standstill' order from the Minister of Labour. Mr. Bevin was not prepared to issue a 'standstill' order, but he gave an assurance that he would give effect to Mr. Garro Jones' representations, provided the Labour Supply Officers of the departments would support the request. The departments, however, proved to be unwilling to do so.

devices under extreme pressure of time, and subject to an incessant flow of modifications from scientists was very severe. But it was only a part of the effort made by the British radio industry. The great build-up in the production of communications equipments, of valves and of components was an industrial undertaking of the first magnitude; and it was bound to make a great addition to the economic problems of Britain at the height of her industrial effort.

CHAPTER VII

THE DEMOBILISATION OF INDUSTRY

(I)

'The Run Down'

THE campaign in Germany came to an end in May 1945; the end of the European war was not, however, marked by a general demobilisation of war industry. The rapid, almost overnight, liquidation of the munitions industry which followed the end of the 1914–18 war was not to take place this time. The 'run-down' of war industry had begun a long time before victory in Europe was in sight and continued long after it had been achieved. It has already been shown[1] that cuts in the allocations of labour to the munitions industry had to be made in 1943 in order to maintain the strength of the fighting Services during 1944. Some further scaling down of employment and of industrial activity beyond that point was being forced on the country by the exhaustion of labour reserves and by the wastage of manpower in the field of battle or in industry. Both employment and production were already well below their peak by the time the prospects and the date of victory in Europe became sufficiently certain and sufficiently near to make it possible to plan further contraction as part of the general demobilisation. The peak rates of output of small arms ammunition had been passed in the last quarter of 1943; the peak rates for tanks slightly earlier, in the second quarter of that year; the peak output of guns of 2-pounder and over and of mortar bombs had been reached in the first quarter of 1943, that of filled shells and aircraft bombs in the fourth quarter of 1942.[2] Combatant types of aircraft alone were not being reduced in 1943, though even they were destined to pass their peak output in the first quarter of 1944. Employment in the munitions industry was receding accordingly: the peak figure of 5,233,000 was reached in mid-1943, by mid-1944 the labour force had been reduced by 222,000.[3]

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[1] See pp. 224–225.

[2] See Table 48, p. 355.

[3] See W. K. Hancock and M. M. Gowing, *British War Economy*, *op. cit.*, p. 351.

Having begun before VE-day the reductions were planned to be spread over a long period after that day. In general, the policy of the Government was to avoid the dislocation and unemployment which had accompanied the sudden demobilisation of industry in 1918; but events made it unnecessary to enforce the policy. The strategic situation would in any case have made it impossible to plan the demobilisation except as a long-spun-out process. The Battle of Europe lasted somewhat longer than had been hoped, and there was also the war in the Far East to follow. The sequence of strategic landmarks made it, therefore, necessary to think of the demobilisation as going through several stages. Stage I, i.e. the period separating the war effort at its peak from victory in Europe, was to see a gradual reduction in munitions production to the level required to sustain the war in Europe and to prepare for the campaign in the Far East. Stage II, between victory in Europe and victory against Japan, was to see a further reduction to the level required by the commitments in the Far East. Final demobilisation was to take place in Stage III following the victory in Japan. Yet even in this last stage the production of munitions might have to be sustained at a level at which the armed forces retained in service could still be supplied and the minimum 'war potential' be maintained.

(2)

Stage I

Preparations for such reductions in war industry as could be made in Stage I began on the morrow of the successful landing in Normandy. But while the fortunes of battle on the Continent fluctuated, the scales of war production, the estimates of industrial employment and the timing of future cuts for Stage I all remained uncertain. The departments had to plan on the assumption that the war in Europe would come to an end by a certain date, but for a long time the date could not be foretold with any finality. The assumption behind the Government plans through the greater part of the summer of 1944, i.e. from the middle of June to the beginning of September, was that the war with Germany would not continue beyond the 30th June 1945, and the provisional manpower allocations for 1944 which had been made in December 1943 were revised and scaled down on that basis.[1] But for a time it appeared possible that victory would be achieved much sooner. On the 4th September 1944 the War Cabinet came to the conclusion that events on the Continent were moving sufficiently quickly to allow current manpower calculations to be

[1] See Table 34, p. 227.

made on the assumption that the war with Germany would come to an end by the 31st December 1944. On the 29th September the Prime Minister suggested a somewhat later date. He thought that with enemy resistance stiffening, the war might continue until the end of February 1945. None of these more sanguine hopes were however allowed drastically to transform the earlier plans. Although it still appeared possible that the war with Germany might soon end, the War Cabinet decided on the 17th October that the reductions in munitions output should not go beyond the adjustments in manpower made on the assumption of the war ending by 30th June 1945. For, in addition to the growing uncertainty of the position on the Continent, the War Cabinet thought it important not to take any decisions that might create a misunderstanding with America about the scale or the cause of cuts in British production. An agreement had recently been reached at the 'Octagon' Conference in Quebec on the continuance of American supplies during Stage II, and an Anglo-American Committee under Mr. Morgenthau and Lord Keynes was at that time working out the amounts to be provided under the continued lend-lease. It would therefore have been very difficult to explain and to justify cuts in British production immediately after substantial assistance in Stage II had been promised by the United States and while requests for large allocations were under discussion.

Before long, however, even the assumptions based on the war ending by 30th June 1945 were beginning to appear too optimistic. On the 25th January 1945 the Prime Minister informed his colleagues that the advice of the Chiefs of Staff was that the 30th June was the earliest date on which the war with Germany could be expected to end, even though they thought that the 1st November 1945 was the date beyond which the war was unlikely to continue. He considered that the Minister of Production, in consultation with the Minister of Supply, should plan production in such a way as to fit in with these dates. This meant that for some products, e.g. ammunition, production would have to continue at a level which assumed that the war would go on until 1st November 1945.

These uncertainties did not end until March or even April 1945. By the 29th March the Prime Minister had come to the conclusion that events were moving sufficiently fast to allow the Manpower Committee to work on the assumption that the European war would end not later than the 31st May, unless an unexpected reverse were suffered. This date was confirmed by the Prime Minister on the 14th April, and preliminary action in anticipation of the end of hostilities with Germany could now begin in earnest.

The problem of making definite and final dispositions about future output and employment was further complicated by the uncertainties about the weight that had to be attached to the conflicting claims on

resources freed by the victory in Europe. In a directive of 26th February 1945 the Prime Minister set down the objects of forward planning in their new order of priority. First priority was still to be given to what was required to achieve the defeat of Germany at the earliest possible date; above all, to the maintenance of the first-line strength of the Army in Europe. A decline in British air strength in Europe at an early date, i.e. in the latter half of 1945, would however be possible. And in general it could now be laid down that manpower was not to be employed on the manufacture of aircraft or other munitions of war designed for use in the European theatre which could not be completed until after the end of 1945. Subject to these requirements every effort was to be made to facilitate a reasonable expansion of civil production. In order to meet this two-fold demand some delay in the build-up and equipment of Forces to be deployed against Japan had to be accepted.

One of the main results of this directive was to end the exclusive concentration on the needs of war production. The needs of the civilian population were now second in the order of priority, and the attention of the Ministry of Production and the Government in general was being rapidly focused on the problems of restarting civilian industry. But the change in prospects and in topics of official discussions was as yet more definite than the change in the munitions industry itself. The rearrangements and reductions during Stage I were not such as to make as yet an appreciable difference to the volume of production. That the supply to the Army would continue to run at a high level was something to be expected.[1] The land battles on the Continent made it necessary to maintain a high rate of production for a number of army stores. Some items on the Ministry's programme, especially ammunition for medium and field artillery, were now required in large and increasing quantities. The Ministry had to build up again its production rates for shells and other field ammunition on the assumption that full-scale activity against Germany might continue until the third quarter of 1945. This necessitated the restoration of maximum production rates of empty shells. At the end of November high priority had to be given to materials and labour needed to reach new targets for field ammunition, even though the Ministry of Supply expressed doubts whether the new targets could be reached owing to the impossibility of building up new capacity in the short period then available. Full rates of tank production also had to be reinstated as the United States War Department had decided that they must take the whole of the available

[1] In a document circulated in October 1944 the Minister of Production made it clear that owing to the quantity of stores accumulated and in transit, reductions in the army supplies proposed on the assumption that the war with Germany would end on 30th June would make no appreciable difference to the striking power of the Forces for five months, or until the end of March 1945.

American output for their own Forces. After a short interval the American authorities agreed to resume their assignment of tanks to Britain, but British tank production nevertheless had to be kept up to maximum rates until the end of the German war was actually within sight. This was done even though some of the firms mainly responsible for the production of the latest tanks were already busy converting a large part of their tank capacity to the production of heavy vehicles and agricultural tractors. Production of cruiser tanks was now being planned so as to achieve its maximum rate by September 1945, the production of Centurion tanks was planned to achieve its full rate in November. It was only after the Prime Minister's minute of 29th March 1945, followed soon by the adoption of the 31st May as a firm date for the end of the war with Germany, that the high production rates for ammunition and tanks could be substantially reduced.

In the meantime the Ministry of Supply had to be allowed to maintain a labour force larger than that previously laid down for it. Whereas in the provisional manpower allocation for 1944 made in December 1943 the Ministry of Supply was expected to reduce the number of its employees by 220,000, the reduction was altered in September 1944 to 170,000.[1] But for the Prime Minister's directive of 29th March with its clear forecast of 31st May 1945 as the terminal date of the war, the allocation of labour to the Ministry of Supply would have had to be made larger still.

If the high level of production and manpower for the Army could be accounted for by the battles on the Continent, the Navy's demands on manpower and production remained high chiefly because it had to turn its main attention to Stage II earlier than the other Services. Reductions in the Admiralty's labour force by 30th June 1945, as proposed in September 1944, were to the total of 68,000. But the requirements of the Navy were largely independent of events in Europe, for the Admiralty's attention was now very largely devoted to preparations for naval operations against Japan.

These preparations were going on during the last six months of 1944. As a very large new naval construction programme inherited from previous years was on hand at the beginning of 1945,[2] the new construction programme for 1945 was kept very small so as to enable the Admiralty to concentrate on the miscellaneous non-fighting ships needed to service the fleet in Far Eastern waters,[3] and mainly on ships for the Fleet Train. The need for a substantial Fleet Train had been recognised for a long time, but the decisions taken at the

[1] See Table 34 and p. 353.

[2] It included a battleship, thirteen light cruisers and a number of other ships.

[3] In December 1944 it was laid down that there should be a concentration on comparatively short-term work and that ships due for completion after December 1946 must proceed on a low priority.

'Octagon' Conference at Quebec in September 1944 had led to further additions to the requirements. At the conference it had been agreed that the British fleet should participate in the main preparations against Japan in the Pacific on the understanding that the British fleet would be balanced and self-supporting. This principle eventually involved considerable additions to the earlier plans for the Fleet Train. Twenty large ships and twenty-five small ships were asked for by the Admiralty, as well as some base accommodation ships, floating cranes and other vessels. Three main reasons were given for the increased requirements. In the first place, the earlier estimate that the voyage between the rear and the advanced base would average 2,000 miles had been revised to 4,000 miles. This automatically increased the number of auxiliary vessels needed. Secondly, expenditure of ammunition was expected to rise after July 1945, and a monthly expenditure figure of 10,000 tons was now substituted for the earlier estimate of 2,500 tons. This necessitated an increase in the number of armament store-carriers and of armament store-issuing ships. Thirdly, a higher margin was now allowed for losses and casualties among the auxiliaries.

The justification for maintaining a high rate of aircraft production was less obviously military. The original intention of the Government was to make up for the less easily reducible needs of the Army and the Navy by accelerating the reduction of aircraft production. Whereas under the provisional manpower allocations for 1944 M.A.P. was to lose 69,000 workers, the allocations as revised in September 1944 involved a reduction of 198,000.[1] But here again actual reductions lagged well behind the original plans. The Ministry was expecting to operate under the 'September' programme[2] which would have resulted in very substantial reductions in the output of aircraft during the first six months of 1945. M.A.P. did not feel, however, justified in introducing the reductions at once. It argued that the dangers of drastic reductions lay 'not so much in the risks of a premature curtailment of our military effort as in the fear that it might be construed in America as a premature conversion of our economy to civilian trade'. A compromise solution—the so-called 'modified September' programme—involving much smaller cuts was therefore introduced. This offered the prospects of a much larger curtailment of production after June 1945 at the expense of a somewhat more gradual decline before then.

[1] See Table 34.

[2] The 'September' programme was based on the assumption that the German war would end by 31st December 1944.

(3)
Stages II and III

Reallocation of manpower and materials and redistribution of production for Stage II turned out even more difficult to plan in advance than the cuts and allocations for Stage I. In theory it was possible to begin seriously to examine the necessary plans a few weeks before D-day; in fact little could be decided and the country entered into Stage II with its immediate economic prospects uncertain. To the difficulty of forecasting the duration of the war in the Far East was added the uncertainty about the supplies which would be available from America and about Britain's share in the coming military tasks. Britain's role in those eastern theatres in which she had in the past borne most of the fighting appeared more or less settled. At the Allied 'Octagon' conference in Quebec in September 1944, it had been agreed that British forces should concentrate on the recapture of Burma and Malaya. But as regards the campaign against Japan herself the only definite decision was that the British fleet should share with the American Navy in the major operations. The roles of the R.A.F. and of the Army in the final operations against Japan were left undecided. At the 'Terminal' conference at Babelsberg in July 1945 it was possible to take a decision about the use of a British bombing force (the eventual use of some twenty squadrons was agreed). But all that could be decided about the Army was that 'in principle' a Commonwealth land force and, if possible, a small tactical air force, should take part in the final phase of the war against Japan. The decision was made 'subject to the satisfactory resolution of operational and other problems' and these problems (including the size of the British land force) were still under discussion at the time of the Japanese surrender. General MacArthur's provisional proposals for a force of three divisions re-equipped with American equipment and receiving logistic support from the United States was not favoured by opinion in Britain, which questioned whether British participation on such a limited scale and under the restrictive conditions proposed would help to re-establish Britain's position in the eyes of the Far East peoples. Less than a week after this exchange of views the Japanese surrender took place.

The impossibility of forecasting the quantity of warlike stores that would be needed was all the more unsettling owing to the changes that the war with Japan made necessary in the quality of stores for tropical jungle conditions. The Navy, in addition to the increased requirements for the Fleet Train, needed ships specially built or adapted for action against the Japanese Navy and specially con-

ditioned for service in the Far East. Capital ships completed as recently as 1942 had to be extensively altered in accordance with the latest war experience. Different types of small boats were now required: boats of the sloop type with greater endurance and capable of mounting larger anti-aircraft armament than the corvettes and frigates. Gunnery equipment of the most up-to-date type was needed for ships both new and already completed, especially new mountings and directors to give the fleet the advantages of blind fire. Vessels also had to be 'tropicalised'; and requirements also included large quantities of equipment which had not previously been wanted, such as distilling plant, laundry plant, refrigerating and air-conditioning plant, etc., to enable a large number of ships to work for long periods in the tropics.

The demands on M.A.P. were equally loaded with modifications and with special equipment for operations in the Far East. Far greater provision than hitherto had to be made for refuelling in the air. Large numbers of aircraft had to be 'tropicalised' by the introduction of such items as sand excluders, water tanks, larger radiators, cooling apparatus and additional oxygen bottles.

Activities in the Ministry of Supply were also complicated by demands of the Far Eastern war, which were as complex and uncertain as similar demands on the Admiralty and M.A.P. The fluidity of the strategic notions about the role of the Army in the Far East has already been mentioned. In addition, the War Office was unable to formulate its requirements without a physical stock-taking in the overseas theatres, and in its opinion the results of the stock-taking would not be available until September. In general, while the Ministry reduced output in the more 'orthodox' branches of munitions production, it was called upon to enlarge it in others. It had to face the needs of the war in Japan and also a large 'amenities' programme. The physical conditions of war in the Far East, the psychological needs of an army faced with the sixth year of war service, the possibility that large numbers of British troops might be called upon to fight in close company with American troops—all these considerations led to a drastic revision of the Army's 'standard of life'. The Prime Minister's directive was that British troops should be provided with amenities as near as possible to those enjoyed by the American troops. As a result, heavy demands were made for a variety of stores which were in very limited production. The output of some objects —mobile refrigerators, domestic refrigerators (electric and kerosene), air-conditioning units and electric fans—was greatly increased, but in general the demands were too great to be met from available resources, even if these were to include limited aid from the United States. Much of the additional output had to come from new firms and was, therefore, slow in developing. Above all, the demand as a

whole came so late that it did not appear possible to meet it in any substantial measure during 1945. The capitulation of Japan, however, took place before any emergency measures had to be considered.

The Japanese offer of surrender came on 10th August and four days later came the declaration of VJ. Full demobilisation could now be decreed. The Government had decided that production of munitions should be cut with the highest possible speed, and the Service departments were accordingly instructed to agree on interim cuts ahead of a full assessment of Stage III requirements. These were not expected to be ready before mid-September.[1] Arrangements were to be made for raw materials earmarked for munitions production to be made available as rapidly as possible for civil production.

The rate at which reductions in munitions production could in fact be made during the first eight weeks following VJ was estimated by the supply departments in terms of manpower as shown in Table 50.[2]

Estimated reductions in manpower during the first eight weeks following VJ-Day

TABLE 50

Department	Assumed strength at VJ-day	Estimated reduction in following eight weeks	Percentage reduction
	Thousands		%
Admiralty (Supply) .	780	— 55	7
Ministry of Supply .	1,100	— 600	55
M.A.P. . . .	1,100	— 500	45
	2,980	—1,155	40

It was admitted that the supply departments' estimates of the labour forces at VJ were little more than intelligent guesses and revised figures were submitted later by the Ministry of Production (see Table 51), but a reduction of approximately 1·7 million workers was expected in the munitions labour force between VJ-day and the end of 1945.

By the end of the following year a further reduction of some three-quarters of a million workers was expected. The 'target' labour force

[1] It was reckoned that from four to six weeks would be needed by the Service departments for the calculation of their future requirements after the Chiefs of Staff had estimated the Forces to be deployed at 30th June 1946. This estimate was finally approved on 6th September 1945. The Chiefs of Staff undertook to provide a revised estimate by the end of 1945.

[2] It was emphasised that these estimates were framed without any guidance from the operational staffs of the Service Ministries on future Service requirements.

for production for all the Services, i.e. the Navy, Army and Air Force, was fixed by the Defence Committee in February 1946 at 500,000; a figure that was actually reached by the end of October 1946.[1]

Estimated size of munitions labour force in supply departments, August–December 1945

TABLE 51 Thousands

Estimated strength at:	Supply departments' figures	Ministry of Production figures
1945		
23rd June (actual) .	3,103	3,103
15th August . .	2,980	2,900
15th October .	1,825	c. 1,700
31st October .	1,320	1,250

A quicker and more complete winding-up of munitions production was impossible. It has already been mentioned[2] that the Government did not want to cut war production so quickly as to outrun the ability of civilian industry to absorb labour. But as it turned out the real difficulty in the way of a more drastic reduction was the continued needs of the supply departments.

Releases from the Admiralty's munitions labour force was slowest of all, for the Admiralty had a large programme of shipbuilding, reconversion and repairs. After VJ a switch-over in priority was made from naval to merchant work; the only naval work which remained in category I was the maintenance of minesweepers. In the two months after VJ the construction of naval vessels valued at more than £82 millions and including nearly 500 landing craft, twenty-four destroyers and twelve submarines was cancelled, but the bulk of the labour released from new construction was transferred to merchant shipbuilding and repairing. Meanwhile, until at least the end of 1946 the naval repair programme was expected to remain very high. Not only were large numbers of ships overdue for repair, but much additional work had to be carried out, such as the removal of defensive equipment from armed merchant ships and of guns and equipment from vessels requisitioned for naval purposes and now to be returned to trade.

Merchant shipbuilders were fully employed in the construction of new vessels for British shipowners to replace war losses or for foreign shipowners; and merchant repairers were fully occupied with the repair and reconversion of merchant vessels. As it was, little impres-

[1] See E. Devons, The Progress of Reconversion, *The Manchester School of Economic and Social Studies*, Vol. XV, No. 1, January 1947, p. 1.

[2] See p. 372.

sion was made in the months immediately following VJ on the accumulated repair work, and more tonnage was immobilised at the end of 1945 than at the beginning of the year.

Releases from aircraft production were considerable, and larger still were those from industries working for the Ministry of Supply. The cuts in the M.A.P. labour force were indeed greater than the Air Ministry wished to see. In its view, the end of hostilities with Japan should not have greatly affected the production of aircraft. A few types were about to become obsolescent and their production would cease in any case, but other types were needed for the equipment of the post-war Air Force. As the aircraft programme had necessarily to be based on R.A.F. requirements one year ahead, the Air Ministry considered that no estimate of these requirements could be made until the views of the Air Staff were known, and it was therefore strongly in favour of postponing decisions. Before the end of the year the Air Ministry had to accept a further cut of 100,000 in the M.A.P. labour force working for the R.A.F., but the acceptance was, to say the least, reluctant. The Air Ministry would still have preferred to wait for the Air Staff's estimates; and it also argued that a major cut in production would compel the R.A.F. to subsist for an indefinite time on increasingly obsolescent aircraft, and would also make it impossible to meet Dominion and foreign requests for surplus aircraft. Nevertheless, M.A.P. proceeded to reduce its commitments, and between August and September succeeded in cancelling a large number of contracts very rapidly.

In the Ministry of Supply the action taken after VJ followed on the measures which had been taken soon after VE. Production of a number of items on the Ministry's programme had been reduced immediately after the Prime Minister's directive of 14th April.[1] The monthly rate of production of tanks, both infantry and cruiser, could then be very substantially reduced; the peak production rate of some self-propelled guns was halved. In addition to the immediate cuts, the Ministry had been able to arrange for a number of further reductions to be carried into effect after 30th June. In agreement with the War Office the Ministry gave up most of its first preference claims for labour, and began to remove items from the 'designated lists'.[2] After VJ-day demobilisation continued 'the same as before, only more'. Items, the production of which could either cease or be reduced, were notified to the Ministry of Supply by the War Office.[3]

[1] See p. 373.

[2] See pp. 268–269.

[3] Similar notifications were also sent to the Ministry of Supply by the Admiralty and Air Ministry. The Admiralty decided that the production of by far the larger part of naval armaments could be stopped immediately. The Air Ministry decided that all orders for small arms ammunition for the R.A.F. could be cancelled and also those for high-explosive bombs, incendiary bombs and rocket projectiles, except in so far as it was necessary to build up a peace-time reserve.

Detailed discussions between the two departments commenced early on 14th August, and the first cancellations of contracts could be sent out by telegram the next day. By 21st August the War Office had notified reductions large enough to permit the Ministry of Supply to cancel the bulk of the outstanding requirements of the 'Vote 9 Stores'.[1]

The procedure of these 'end-of-war' cancellations was that of the 'reduction drill' employed in the later years of the war to release Ministry of Supply labour for other supply departments.[2] Actual transfer of labour was not involved for such items as clothing. Reductions in Service contracts for clothing could do nothing to release labour from clothing firms which were now busy working for the seriously depleted civilian market. Nor were reductions at all armament firms immediate. The production of a few new weapons was continued pending a definite restatement of Army requirements; for other munitions, such as tanks and certain classes of ammunition, a long-term programme was being planned and final decisions had for the time being to be held over.

The tempo of reductions was increased in December 1945, and became very fast in the following three months. The actual progress of reductions in the Ministry of Supply labour force on munitions production from VJ until the end of March 1946 is shown in Table 52.

Labour force on munitions production in the Ministry of Supply, August 1945–March 1946

TABLE 52 — Thousands

	Total (employers and employees)	Reduction on previous month
1945		
August	1,049	..[3]
September	875	174
October	732	143
November	657	75
December	551	106
1946		
January	474	77
February	418	56
March	280	138[4]

[1] i.e. warlike stores, including guns, ammunition, tanks and wheeled vehicles, and machine tools for their manufacture.

[2] See pp. 350–351.

[3] No figures were issued by the Ministry of Labour for July 1945. For employees only, the reduction compared with June was 186,900.

[4] Includes adjustments relating to earlier months when the labour on Ministry of Supply work was overstated.

After the first quarter of 1946 reductions in the production programmes for the three Services were determined by the long-term needs of the Forces. The size and establishment of the Forces in peace, the requirements of the Army of Occupation, and the needs of the 'war potential' were now the considerations which governed the size of the munitions industry to be retained. They all had to be taken into account in the forward planning of military requirements for the purposes of the first post-war Estimates: those of 1946–47. The 'permanent' level envisaged in the plan was all but reached in November 1946. Less than 500,000 men and women were by then employed in the manufacture of supplies for the Services compared with more than five million in mid-1943.[1]

(4)

The Reconversion

While programmes were being cut and global figures of employment were being reduced, the day-to-day adjustments of production from a war basis to a provisional post-war level, the clearance of factories and transfer of capacity to civilian uses went ahead steadily and somewhat uneventfully. Well before VE and VJ-day the supply departments had provided the Board of Trade with 'forecasts' for some hundreds of firms which appeared on lists drawn up by the Board of Trade for priority of release from war work. Such firms were identified as being of special importance either for export work or for urgent civilian requirements at home. These 'forecasts' gave the Board of Trade such advance information as was possible of the effects of the reduction process on industrial firms. This permitted the Board to concert with the various industries more realistic plans for the reconversion.

Wherever possible—it was found in practice to be largely possible—the Ministry of Supply withdrew the production of munitions from industry generally rather than from the Royal Ordnance Factories, the regular armament firms and firms which needed time to prepare themselves for resuming their normal peace-time production. Similarly, the policy of the Admiralty was to concentrate naval repair work in the dockyards so as to release capacity in private shipyards for work on merchantmen. Both in the cancelling of orders and in the clearing of factories of war-time plant, machine tools, raw materials or semi-finished stores, the wishes of the Board of Trade or other interested civil departments were met as far as possible. The Minis-

[1] *Ministry of Labour Gazette*. See also Table 1 in the article by Prof. E. Devons on The Progress of Reconversion, *op. cit.*, p. 18.

terial Storage Committee was invited to assist in the solution of such problems as the disposal of manufacturers' surpluses, the dumping of airframes, ammunition and other materials and the allocation of dumping areas. Requisitioned or government-owned factories for which the Board of Trade indicated useful alternative uses were also given priority of complete release. Although the supply departments were frequently urged to continue unwanted production so as to avoid unemployment during the reconversion period, authority to do this was never granted.

The return of industrial capacity to civilian employment was also connected with the problem of 'war potential'. The discussion of the issues involved in the retention of a 'war potential' are, however, out of place in a study published in 1952.

Thus ended the story of the industrial mobilisation for the production of munitions. The end of the story found British industry in a position very different from that in which it had begun making munitions in 1935 and 1936. Both its ability to produce for the civilian market under peace-time conditions and its capacity for continued or resumed output of munitions were much greater than they had been ten years previously. In both respects its powers of production had been transformed by the ten years of rearmament and war.

To begin with, the balance of individual industries was no longer the same as in 1935, or even 1939. The labour force of all the so-called 'investment' industries[1] which had expanded rapidly and substantially during the war was very much higher in November 1946 than it had been in June 1939, whereas the 'consumption' industries[2] had not regained their pre-war levels. A few examples of the most striking increases are listed in Table 53.

True enough, by 1946 the light industries, especially the textile industries and the distributive trades, had regained a little of the manpower they had lost to the various engineering and metal-making and metal-working trades, but the pre-war balance was not restored or even approached. Nor was it to be fully restored in the following three or four years of peace.

Even more important than the changed balance of employment were the changes in the equipment and methods of industry, and more especially in the equipment and methods of industries which had been most intimately involved in the production of munitions. The time for assessing or even listing the changes has not yet arrived, but it is impossible to leave the story of munitions without recording

[1] The metal, engineering, vehicle, shipbuilding and chemical group of industries.

[2] These include textiles, clothing, leather, wood and paper, food, drink and tobacco and building materials.

a warning against any tendency to regard the years of war production as a mere pause in the industrial development of Britain. Many an individual firm might look upon the war years as an interruption, or even as a setback in its progress. In everyday discussions the making of munitions is regarded as a dissipation of national resources. Yet not everything was a setback and a waste.

The numbers of insured persons in certain industries, June 1939 and November 1946[1]

TABLE 53

Industry	Numbers insured in: June 1939	Numbers insured in: November 1946	Percentage increase
	Thousands		%
Non-ferrous metals manufacture	55·9	87·8	57·1
Shipbuilding and ship-repairing	144·7	219·8	51·9
Constructional engineering	49·0	66·5	35·7
Electric cables, apparatus, etc.	195·9	265·5	35·5
Explosives, chemicals, etc.	174·3	235·5	35·1
Scientific instruments	48·3	65·0	34·6
Marine engineering	52·2	70·2	34·5
General engineering	704·7	944·3	34·0

In the first place, a large volume of new industrial capital was created. In the national accountancy of the war years Government expenditure on buildings, plant and machinery for the munitions industry was lumped together with other items of Government expenditure, as if it was as fully 'consumed' during the year as the other war-stores. There was thus nothing in the accounts to set off against the running-down of the capital assets of civilian industry, and the figure for 'disinvestment', i.e. the net losses in the productive capital of the country, was put very high. Yet investment in the munitions industry was bound to add to the country's capital resources. Most of the industrial buildings erected in war-time have since been occupied by post-war industries; a very large proportion of the machinery not worn-out physically at the end of the war (and assuming a ten-year life for machine tools most of the general tools installed during the later years of the war still had several years of life before them) found post-war employment. Public utilities are, of course, outside the scope of this study, but it should be noted here that some of them, and especially the electrical supply industry, had to grow to match the needs of the growing munitions industry.

In the balance, more important still have been certain other less tangible gains. The increase in the labour force of certain industries

[1] See Table III in the article by Prof. E. Devons, *op. cit.*

was accompanied by the spread of new skills among the working population. The number of workers in the engineering industry in general, and more especially the number in such key occupations as those of draughtsmen and tool-room operatives, was in 1946 much larger than that of 1939. The supply may still be inadequate in 1952, but the shortage is merely a sign of the continued expansion of the metal-working trades. In some of the heavier and dirtier branches of engineering, such as foundries, critical shortages of labour may have developed. But these were only to be expected in years of 'full employment', and have moreover led a number of firms to mechanise and clean up the work in their foundries to the lasting advantage of themselves and of industry in general.

Indeed the changes in methods and processes of industry and in attitudes of managers, though least tangible of all the developments, have perhaps been the most remarkable. The momentum of the rising efficiency of management which underlay the soaring output of munitions in the later years of the war was bound to continue into the years of peace. The historian of post-war industry will not fail to notice the evidence of new managerial attitudes and techniques. He may or may not be inclined to contrast them with the managerial sloth of the early twentieth century, but he will have to relate them and ascribe them to the experiences of the war years.

CHAPTER VIII

THE STRUCTURE OF MUNITIONS INDUSTRY

In retrospect British munitions production appears clearly marked by a number of features which students of British economy would at first sight recognise as typically British. A large proportion of what were munitions of war in the broad sense of the term—transport vehicles, electrical equipment, locomotives, mechanical appliances and 'general stores' of every kind—were manufactured by the appropriate sections of commercial industry from existing plant. In these branches of war production the industrial structure, i.e. the size, organisation and equipment of firms, was bound to remain in war the same as it had been in peace. But even in the munitions industry in the strict sense of the term, i.e. in the production of weapons and of specialised military equipment, the characteristic features of British industry could be observed. In the first place, production appeared to be—to use a somewhat exaggerated term—atomised, i.e. carried on in numerous industrial establishments of which a high percentage were medium-sized or small. In the second place, production was not greatly specialised. A very large proportion of the munitions produced came from the 'general' industry of the country equipped for 'general' industrial—mostly engineering—operations.

(1)

The Division of Production

Needless to say neither feature revealed itself in clear and wholly unbroken outline. To say that small and medium-sized firms predominated does not mean that war industry was utterly innocent of industrial units representing great conglomerations of capacity under single management. In almost every branch of production great or even immense enterprises were to be found. At least one, Vickers-Armstrongs, made a very large contribution to almost every department of war production—ships, tanks, aeroplanes, guns and small arms. The vast industrial organisation of I.C.I. continued to expand during the war, and much of it was wholly absorbed into the making of munitions. Naval construction at the shipyard level was bound to be in the hands of large firms. As a result of the continuous expansion

of orders received by the main aircraft firms, large units predominated in the final or 'assembly' stage of production. Two aircraft firms, Vickers-Armstrongs and the Hawker-Siddeley Aircraft Company, were between them responsible for nearly half the total output of military aircraft. A number of other great firms, having switched over from civilian production to munitions, continued to operate as large units and to apply the methods of modern large-scale enterprise. The great motor firms continued to manufacture motor vehicles for the Services, and in addition most of them (Austin, Nuffield Organisation, Daimler, Standard, Rootes, Ford) ran large aircraft and aero-engine factories; while another (Vauxhall) undertook the development of a heavy tank—the Churchill. The great firms in the electrical manufacturing industry—B.T.H., English Electric, General Electric, Metropolitan-Vickers—exceeded the vast scale of their pre-war activities. Some of them separately, and all of them in combination, were mainstays of war industry and principal sources of efficient and economical output. And then there were, of course, the Royal Ordnance Factories, most of which were conceived as very great undertakings indeed. R.O.F. Chorley, the first of the new filling factories, employed at one time 30,000 people, and a 'small' filling factory was defined in 1941 as a factory employing not more than 10,000 workers. Some of the new engineering Royal Ordnance Factories were comparatively small, but even the smallest employed more than 1,000 workers. Other R.O.F.s, like Woolwich, and some of the new small arms ammunition factories were immense in size and in scale of operation.

These examples suffice to dispel the simple-minded notion that British industry in war, any more than British industry in peace, was largely made up of small workshops. Such information as is available about American war industry will also dispel the notion that Britain, alone among the belligerents, found a place in her war industries for small contractors. It will be stressed again later[1] that in some American trades small and medium-sized firms were very numerous. Even if they were apt to be neglected in the early years of American rearmament, they were in the end drawn into war production all over the country.

The manner in which such firms were enlisted was not, of course, the same in the United States as in Great Britain. In the United States small firms were not mobilised as they were in Britain through sheer necessity, i.e. merely because often there was no other industrial capacity to draw on. Their employment in the United States became a matter of deliberate policy. The arguments behind the policy were many and various, and some of the reasons commonly adduced were

[1] See pp. 405–406.

the same as in Britain, i.e. the need for what American documents describe as the 'dispersion of the load' or the 'broadening of the base' of war production. But even more powerful was the political and social incentive: the desire to alleviate the effects of the distortions and dislocations—the 'defence migrations', the 'ghost towns', and the 'distressed areas'—created by the rearmament contracts of 1939, 1940 and early 1941. These contracts gave rise to conglomerations of labour and plant under the control of relatively few firms and in relatively new places. As a result, a number of established centres of civilian production and, above all, small firms within them, were plunged into unemployment and distress.

To deal with the situation, the American Government took several successive measures. An Army Contract Distribution Division, which was established in the office of the Under Secretary of War a few months before Pearl Harbour, tried to place as many contracts as possible in distressed areas and amongst small firms. Together with the Defence Contract Service at the Office of Production Management it endeavoured to ferret out would-be contractors and sub-contractors in remote places. A year later these activities were reinforced by legislative action. In June 1942 Congress created the Smaller War Plants Corporation with a capital of $150 million charged with mustering small firms into war production. It was given authority to undertake munitions contracts which it could proceed to sub-contract to smaller firms. Following the establishment of the Corporation and the passing of the Small Business Act, much was done to carry out the policy. Small War Plants Officers were appointed as 'go-betweens'; the 'procurement directives' (the American equivalent of the successive instalments of the British Service programmes) often discriminated in favour of small firms by earmarking for them fixed proportions of the procurements. Other inducements and help to small firms were made available, such as loans or price premiums up to fifteen per cent. of the competitive prices. In addition, the procuring departments sometimes gave preference to firms willing to sub-contract, and even inserted into contracts clauses which favoured sub-contracting. Very largely as a result of these favours and controls the share of small firms in American war industry steadily grew. The proportion of contracts held by firms employing 500 or fewer workers in 1943 was 12·6 per cent. of the total dollar value of all contracts, it rose to 20 per cent. in 1944 and to 28·5 per cent. in June 1945.[1]

By comparison, the manner in which small firms were drawn into British war production was almost wholly spontaneous. Small firms were sought out by firms and by government departments in search

[1] The figures are based on the United States War Department's classification of contractors.

of productive capacity. Some were enlisted on direct contracts even in the pre-war period, particularly by the War Office and the Admiralty; and the process was greatly increased under war conditions. As a rule, the smaller firms, i.e. those employing less than 200 workers, were mainly, though by no means entirely, enlisted as sub-contractors by other firms. The first organised enrolment of small firms *en masse* was carried out on the eve of the war by the Nuffield Organisation for the repair of aircraft,[1] but the enlistment could not be wholly left to private enterprise. What was needed was some means of establishing rapid contact between small firms and contractors requiring capacity, and for this, normal commercial contacts were insufficient. The information now wanted was not about the commercial products of small firms, but about the size and kind of capacity they possessed and about the processes they could undertake; and this information was not readily obtainable through regular commercial channels.

The production directorates in the three supply departments began to take steps in this direction at least a year before the war broke out;[2] but the first concerted attack on the problem came in 1941 when 'capacity clearing centres' were set up under the Regional Boards.[3] The service was greatly extended and improved from 1942 onwards. The records and other facilities of over seventy capacity offices covering the United Kingdom helped firms and supply departments seeking capacity to get into touch with firms available for employment. This arrangement ensured that all firms, however small and dispersed, could be called in to meet urgent or increased demands.

This capacity organisation proved of great value in the second half of the war when the demand for components greatly increased. It was neither as elaborate nor as far-reaching as the American; nor was it subsidised by special pricing arrangements. Yet, in spite of the greater effort in the United States on behalf of small firms, the average size of American munitions factories remained larger than the British.

The contributions of great firms and of large factory units to the munitions production of the two countries is, of course, difficult to measure. It is nevertheless easy to show that the average industrial unit in American aircraft production was much greater than in this country. By the end of the war, in the United States there were fewer aircraft firms than in Great Britain, but they produced a very much larger number of aircraft. This does not of course mean that the output of the two great British combines, Vickers-Armstrongs and

[1] See pp. 318–319.

[2] In the Air Ministry a Directorate of Sub-contracts was appointed in November 1938.

[3] See p. 264.

Hawker-Siddeley, lagged much behind that of an average American firm. In any case what mattered was not the size of firms but that of production units, i.e. individual factories controlled by them. No aircraft factory in this country could rival in size the Willow Run plant of the American Ford Motor Company, and in the American aircraft industry, taken as a whole, output came from much larger units than in Great Britain. The average size of American airframe factories of main contractors in the United States was about two million square feet, compared with 0·75 million square feet of the average aircraft factory operated by the main British aircraft firms. Employment in the American aircraft factories was commonly between 20,000 and 40,000 people: employment in corresponding British factories varied from 3,000 to 15,000. The average production per factory unit engaged in assembly in the United States was sixty aircraft per week, with a maximum of 120. In Britain the corresponding average was ten per week with a maximum of about sixty.[1]

The relative contributions of large and small firms in other branches of production are impossible to measure. A mere comparison of the total numbers of contractors in the two countries would be largely irrelevant even if it were possible. The total number of firms acting as main contractors and sub-contractors for the three British supply departments may have been well above 30,000.[2] The figure is, however, highly inexact. It has been arrived at by adding together the number of contractors to each of the three supply departments, and no allowance has been made for contractors working for more than one department and thus counted more than once. On the other hand, some of the sub-contracting firms may have been left out of the estimates of the numbers of contractors to departments. The figure is perhaps sufficient to bring home the large number of firms drawn into war production. But even a better proof of this will be found in the non-statistical fact that in the last year of the war nearly all the firms in the metalworking, engineering and allied industries known to the regional officers of the Ministry of Production, and a large number of firms in other industries, were engaged on munitions production.

This well-known fact may also suggest the reason why in Britain, without any special legislation or preferential treatment, so many firms, small and medium-sized, found employment in war contracts. The survival in the war years of the bulk of private firms and their active participation in war production meant that, in spite of all the measures to direct labour to new employment and to 'concentrate'

[1] See E. Mensforth, Airframe Production, *Proc.I.Mech.E.*, Vol. 156, No. 1, 1947, pp. 28 and 36.

[2] Some 14,000 engineering works (other than garages) were engaged on contracts for M A.P. at the peak of aircraft production.

civilian production in order to release resources, industrial mobilisation was much less of a reshuffle than the etymology of the word 'mobilisation' might imply. The main process of industrial mobilisation consisted not only in moving labour, management and other resources to places where munitions were to be made, but also in placing orders where resources were already to be found. Often new capacity had to be created to make use of labour where it was available. In the special parlance of the day this was often described as 'taking work to labour', although it might with equal justice have been described as 'taking work to buildings and management'. For the great majority of the industrial firms which had functioned before the war were able to participate in war production without fundamental changes in their location and organisation.

Viewed in perspective this method of mobilising industry may appear unexceptional to the point of being obvious. Was there, it may be asked, any other way of expanding war production except by enlisting private enterprises where they were to be found? Yet this was not quite the method of industrial organisation in war which had sometimes been forecast. The Committee of Industrialists under Lord Weir, appointed in December 1933 to advise the Supply Board on industrial matters,[1] took it for granted that armament firms alone would not carry the whole burden of munitions production and that Vickers-Armstrongs and the Royal Ordnance Factories would have to be supplemented by 'selected' engineering firms. The emphasis was, nevertheless, on selection. Only the larger firms in the engineering industry possessing suitable experience and plant and provided with facilities for design and development, would be suitable for war contracts, at any rate at the beginning. Some members of the committee also believed that if ever it were found necessary to spread the work on munitions more widely, the orders would best be canalised through the 'selected' firms.

The recommendations had been framed before the scale of the rearmament effort had become apparent, and they did not greatly influence the subsequent activities of the production branches of the Service ministries. From the outset the War Office and the Air Ministry ranged very widely over the entire field of engineering and allied firms in selecting firms for the early contracts, and more widely still in making up their list of firms for the 'war potential'. Moreover, the subsequent experience of rearmament and war compelled the supply departments to widen their limit of selection still further and to relax their principles of selection. By the time the war peak of industrial mobilisation was approached they were prepared to make use of any factory offering the essential minimum of services, and of any working

[1] The committee consisted of Lord Weir, Sir James Lithgow and Sir Arthur Balfour. Its report of February 1934 is referred to on p. 36.

industrial concern which appeared to possess the essential minimum of competence.

This apparently indiscriminate policy, generally applied by 1941, was partly to be accounted for by the urgent need for ready-made factory space. Taking work to existing buildings required less time and waiting than the shifting of resources to specially-erected war factories. Much was heard during the war about shortages of machine tools and great stress has been laid on them in this history. Yet much of the delay in starting new war factories came not from the absence of tools but from the slow progress of building operations. Machine tools (at least most machine tools) were often available before the buildings were ready; and now and again Royal Ordnance Factories and privately-owned munitions factories had to install tools and to begin operations in unfinished buildings—sometimes under tarpaulins.

To a number of observers in and out of the Government the length of time which Royal Ordnance Factories took to build appeared unconscionably long. Critics were able to recall that in the war of 1914–18 National Factories were often built in well under one year. Until the very outbreak of the war in September 1939 some private firms were able to have their new factories and extensions built very quickly. In 1938 Metropolitan-Vickers put up a factory for radar equipment in little more than thirteen weeks and built another munitions factory in the five months from April to August of the same year.[1] New aircraft factories erected between 1936 and 1938 took, as a rule, little longer than a year to build. On the other hand, few of the larger factories built during the 1939–45 war were completed in less than eighteen months, and some took longer than that. To this the obvious reply was that factories in this war were often more difficult to build than in the last. Most of them needed elaborate services —gas, electricity, steam, internal transport; some (especially the new aircraft factories) required much larger unobstructed spaces than the factories of 1914 vintage; others had, in conformity with the Government's policy, to be located in areas which, however convenient from the point of view of labour supply, could not offer 'easy' building sites. Now and again, and more often before 1940 than in the later years of the war, critics put the blame for procrastination on government departments. During the later years of the war there were also the obvious difficulties due to shortages of labour, materials and transport.

There were thus many good reasons for delays—at least some delays—in building. Yet even if building had been done as expeditiously as in 1914–18, the waiting period would still have been too long for many of the urgent war-time needs. When in the hurried

[1] See *Contribution to Victory:* An account of some of the special work of the Metropolitan-Vickers Electric Co. Ltd. in the Second World War, 1947, p. 191.

months of 1940 the Ministry of Aircraft Production decided to disperse the aircraft industry, there was and could be no question of building new factories. Existing buildings—sometimes odd buildings on odd sites—had to be taken over without much delay. In December 1940, when B.S.A. dispersed post-haste their production of the Browning gun, the buildings they took included a woodworking shop, a sugar store and reinforced concrete works;[1] and yet they had a better choice of buildings than firms which had to disperse their production a few months later. Similarly, in the closing years of the war when the supply departments had to cope with a vast collection of new and urgent demands, additional capacity had to be found where factories were already in existence. New building was therefore bound to play a much smaller part in the deployment of war industry than it apparently did in the United States.

The need for economising in building time does not however explain everything. It partly explains why many large firms carried out a great deal of their work in small factories. It will not by itself account for the wholesale employment of existing firms, middling, small and diminutive. What led to their employment was the conjunction of existing buildings with the other scarce factor—management.

As a result of their experience in the early years of rearmament and war, officials in the supply departments had come to attach an ever-greater importance to management. The better-managed firms were singled out and loaded with contracts to the point of overloading. The war-time story of a famous electrical firm and of its rapidly expanding responsibilities in war production is essentially one of a government department—in this case M.A.P.—imposing successive responsibilities on a group of managers who had proved themselves in the earlier stages of the war. Among the contractors of the Ministry of Supply there were quite a number of firms with managers whom the Ministry rated so high that they were invariably entrusted with difficult and urgent contracts. There was an engineering firm in the North which before the war produced a small car in rather small quantities, but which was now expected to tackle one difficult munitions job after another; or a well-established firm in the Eastern Counties which before the war specialised in making large-scale equipment for the food industry, but which was now expected to lead the way in a variety of engineering jobs, mostly in the making of gun components and carriages; or a great motor firm in the Home Counties, and yet another firm of electrical manufacturers in the Midlands, both of which turned into veritable arsenals, making everything from tanks to components of small-calibre guns.

[1] See D. M. Ward, *The Other Battle:* A history of the Birmingham Small Arms Co. Ltd., 1946, pp. 68–72.

Indeed, on more than one occasion the existence of a manager of proved quality was sufficient to attract munitions contracts, however remote might be the field of the manager's pre-war activities. A famous firm of chocolate manufacturers in the Midlands was asked to undertake the manufacture of aeroplane parts and components for rockets at its home factory and to manage a new factory for 'jerricans' in London; a Scottish transport corporation was asked to make parts of aircraft. But nothing illustrates better the crucial importance of management than the war-time career of certain well-known promoters of football pools. They became a large unit of war production manufacturing not only parachutes and balloons, but also machining parts of aircraft, ammunition and gun carriages. What to some extent commended the firm to the officials was its experience in employing large numbers of young women and its extensive premises. But what qualified it most was the reputation of its directors for efficiency and drive.

It was because managerial enterprise was so scarce that the supply departments in the later years of the war were so anxious to employ more or less all the competent entrepreneurs there were, and to do so in their own firms. Hence also the remarkable picture of British production with its countless small workshops operating as part of the munitions industry. Some of them were nothing more than local garages, but each garage proprietor brought with him his building and his enterprise. It was the building and the entrepreneur that were required in the later stages of the war when time for new building was denied and the supply of managers was very limited.

(2)

Production Specialised and Unspecialised

The atomised structure of British war industry is closely related to its second feature, its unspecialised character. British war industry was unspecialised in more senses than one. It was not, and could not be, concentrated in armament firms, i.e. in undertakings possessing previous experience of making arms with nuclei of skilled arms-makers among their employees and facilities for the development of weapons. There were, of course, the three old-established ordnance factories—the Royal Arsenal, Woolwich, the Royal Small Arms Factory, Enfield Lock, and the Royal Gunpowder Factory, Waltham. There was the great armament firm of Vickers-Armstrongs; there was also B.S.A. with its long and intimate experience in the making of small arms; Beardmores, where the aptitude for the manufacture of guns had not wholly died out; and there was capacity for the

manufacture of small arms ammunition at I.C.I. and at Greenwood & Batley. In addition, at least three newly-founded private enterprises were set up in the rearmament years with the sole purpose of making munitions: Nuffield Mechanizations, the British Manufacture and Research Company and New Crown Forgings (a subsidiary of Stewarts & Lloyds). Despite the serious deterioration in shipbuilding capacity many of the shipyards which had previously specialised in naval construction were still available. In aircraft production most of the larger aircraft firms had before the war catered mainly for the Air Ministry and had the necessary experience of tendering and designing to Air Ministry specifications.

Yet even with the aircraft and naval shipbuilding firms included, the size and scope of the armament industry was very small, and there is no need to explain at length why it was no greater. The specialised armament industry reached the highest point of its development during the great naval armament race before the first World War, and it was bound to slump in the inter-war period when naval construction all over the world greatly declined and the demand for munitions sank very low. The slump in the armament industry led to the winding-up of some firms and the drastic curtailment of others. At the same time the part which armament firms might be called upon to play in a future war had come to be questioned. The experience of the 1914–18 war appeared to prove that in time of war munitions could and should be made by the unspecialised industry of the country. Reporting in 1918 the McKinnon Committee drew the moral that 'the basis of armament supply is now so broad that specialising in the future on the part of a limited number of firms will probably not be necessary for the safety of the country'.[1] The lesson was well learned by the men in charge of the pre-war preparations. In planning future industrial mobilisation they assumed as a matter of course that the British armament industry would be insufficient to cope with the problem of war supply in its entirety and that the bulk of the orders would have to fall on 'general' industry and, more especially, on its engineering, electrical and chemical branches.

British war production was also 'unspecialised' in another sense of the term, that of equipment. At the peak of war production, and to some extent even in the earlier stages of expansion, the use of unspecialised plant and machinery was widespread—more so than it might have been had Britain possessed the time and the resources to build her munitions industry anew.

It is, of course, important to bear in mind that the lack of specialisation was only one of degree. Factories specialising in the production

[1] Second interim report, dated 22nd November 1918. See Cmd. 229, March 1919. *Report of the Committee of Enquiry into the Royal Ordnance Factories, Woolwich*, p. 8.

of munitions had to be set up. Without them the war industry would have been unable to produce the immense quantities of munitions it in fact turned out. To begin with, the armament industry proper greatly expanded during the years of pre-war preparation and continued to grow during the war. In the early stages of expansion between 1936 and the outbreak of war, and even during the early years of the war, the supply departments busied themselves with the building-up of a specialised arms-making industry. The measures which the Admiralty then took to expand capacity largely consisted of additions and improvements to naval dockyards and to the factories of the principal naval contractors. The 'shadow' factories which the Air Ministry attached to the main motor firms might perhaps be regarded as additions to the non-specialised capacity. But at the same time (more especially after mid-1938) the Air Ministry sponsored vast additions to the floor space and the machining capacity of the principal aircraft and aero-engine firms. Above all, the efforts of the War Office were concentrated on the build-up of a specialised armament capacity in private hands and of a network of Royal Ordnance Factories.

These preoccupations with specialised capacity were, of course, inevitable and were implied in the very notion of a general industrial mobilisation. For it was assumed that 'general' firms, even when mobilised and properly adapted to the needs of war production, would be unable to meet the demand for some of the most important and 'difficult' munitions. In the War Office and later in the Ministry of Supply the tendency was to grade munitions according to their suitability for production by ordinary firms. At one end of the scale there were stores, like uniforms or water-bottles, which could be made by the clothing and hardware firms in the country. At the other end of the scale there were munitions, like filled shells, which bore no relation to any commercially marketable commodity and which could not be made by the equipment or processes of civilian industry. Between these two extremes there were war-stores of greater or lesser affinity to either type; and it was generally assumed that some of them were unsuitable for production by an average firm. On these assumptions a fully-mobilised war industry required a large component of specialised munitions factories; and the building-up of this component was, therefore, bound to appear as an urgent prerequisite of the industrial mobilisation to come.

This was, broadly speaking, the procedure recommended to the Government by the Committee of Industrialists to which a reference has already been made.[1] In their view the first step in rearmament was to decide what expansion of capacity was possible at the Royal

[1] See p. 392.

Ordnance Factories and Vickers-Armstrongs. The next step was to decide what new production units could be set up and operated by Royal Ordnance Factories and Vickers. The final stage was to decide what additional capacity would have to be obtained by the introduction of industrial firms. In the event, the supply departments built new armament factories and approached a number of 'general' engineering firms more or less simultaneously, but until 1939 the main effort and most of the new orders (such as there were), apart from orders for shells and tanks, were absorbed by the Royal Ordnance Factories and the armament firms.

This preoccupation, inevitable in the early stages of rearmament, did not and could not survive the demands of war, especially after the crisis of 1940. The measures which the Admiralty had to take in order to enlarge the range of firms supplying it with instruments and equipment have already been described:[1] so also have the successive additions to the circle of the 'family' firms in the aircraft industry.[2] This circle was greatly extended by the coming into operation of the 'shadow' factories and by the enlistment of several large firms into the manufacture and assembly of aircraft. Thus, in the manufacture and assembly of the Halifax bomber a group of firms participated in addition to the 'parent' firm (Handley Page)—English Electric, Fairey Aviation, Rootes, and the 'London Aircraft Production Group' (a combination of the London Passenger Transport Board and a number of London motor firms). The making of bombers of the Manchester-Lancaster-Lincoln breed was entrusted to a number of firms, and many other aircraft in quantity production were also made by firms outside the 'family'. In the building of engines not only were the factories of Rolls-Royce, the Bristol Aeroplane Company, and Napier extended and duplicated, but several 'newcomers', including the Daimler, Austin, Standard and Ford motor companies, took a large and growing part.

Among sub-contractors, firms outside the aircraft industry always predominated. The labour force at sub-contractors serving the makers and assemblers of airframes increased well above the thirty-five per cent. target of 1938.[3] Sub-contracting in aircraft construction rose from ten per cent. in 1938 to thirty per cent. by the middle of 1939 and to over forty per cent. in the later years of the war.[4] In a few instances nearly ninety per cent. of the total value of the orders placed with aircraft firms was sub-contracted.[5]

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[1] See pp. 299 and 397.

[2] See pp. 21–22, 319–320; also pp. 435–436.

[3] See p. 22.

[4] See E. Mensforth, Airframe Production, *Proc.I.Mech.E., op. cit.*, p. 26.

[5] See E. Devons, Planning in Practice, *Essays in Aircraft Planning in War-time* (Camb. Univ. Press, 1950), p. 150.

The record of army weapons tells the same story of a gradual submerging of the specialised armament firms and of Royal Ordnance Factories in the general body of mobilised industry. The filling of shells and, to a very large extent, the making of explosives and propellants remained to the end of the war the prerogative of the Royal Ordnance Factories, I.C.I. and the agency factories. Guns, i.e. gun barrels and mechanisms, had also been regarded as 'armament work' *par excellence*, requiring special equipment and experience.[1] Indeed, the earliest batches of orders for guns in 1937, those for medium and heavy anti-aircraft guns placed in the opening years of rearmament, went to the new Royal Ordnance Factory which was specially equipped for the purpose. They continued to be largely made in Royal Ordnance Factories and by armament firms until the requirements of these guns were substantially met. In 1937 production of Bofors 40-mm. anti-aircraft guns was undertaken by the same Royal Ordnance Factory and by a new armament firm (Nuffield Mechanizations). The initial orders for 2-pounder tank and anti-tank guns went to the Royal Arsenal, Woolwich, to a recently-erected Royal Ordnance Factory and to Vickers-Armstrongs. With the outbreak of war further capacity for the manufacture of anti-aircraft guns and 2-pounders was to be provided in new Ordnance Factories. From the summer of 1939 the erection of new Royal Ordnance Factories for guns followed in rapid succession; by 1941 at least ten Royal Ordnance Factories were engaged in making guns. Yet, so rapid had been the introduction of 'outside' firms, i.e. firms normally engaged in civilian manufacture, that by the end of 1942 only half the total output of guns of 40 mm. and over came from Royal Ordnance Factories. A proportion of the remainder came from Vickers-Armstrongs and Beardmores, but the larger part came from the 'outside' firms.

Field guns were from the outset largely entrusted to 'outside', i.e. non-armament, firms. Such firms played an important part in the conversion of the 18-pounder guns; and between 1941 and 1943 they were called upon to play a part at least as important in the making of the 25-pounder. From 1940 onwards 'outside' firms were also engaged in ever-growing numbers in the final manufacture of 2-pounder, 6-pounder and 17-pounder tank and anti-tank guns, 3-inch tank howitzers and 95-mm. howitzers. Indeed, when in 1940 capacity

[1] Unlike guns the manufacture of gun carriages and mountings was considered better suited to 'outside' firms. From the very outset of rearmament there was a division of labour by which the various Royal Ordnance Factories and armament firms made the gun barrels and mechanisms while 'outside' firms made mountings and carriages. Among the new Royal Ordnance Factories Nottingham alone was planned to make complete equipments. The bulk of the gun output depended on carriages and mountings made 'outside': thus in the rearmament plans of 1937–38 the Royal Ordnance Factories were assigned approximately one-quarter of the total output of carriages.

for the 3-inch tank howitzer had to be found at short notice, the Ministry of Supply placed the production contracts almost entirely among 'outside' firms. The main contractors for the 6-pounder in 1942 included five Royal Ordnance Factories and nine private firms, of which seven were 'outsiders'. Among the contractors engaged in sub-assemblies for the 6-pounder gun, 'outside' firms greatly predominated. The position was even more striking for 6-pounder carriages. Altogether by 1942 some fifty-five firms had been drawn into the manufacture of 6-pounder carriages; and had production been allowed to continue on the scale originally planned, there would have been by the end of 1942 nearly 100 firms engaged on the making of the carriages—nineteen acting as 'parent' firms and about eighty as supporting contractors. In general, at the end of 1942 about eighteen groups of 'outside' firms were engaged on the making of guns and over forty on carriages. If the work of sub-contractors were counted, the total contribution of 'outside' firms to gun production, and most certainly to carriage production, must by that time have greatly exceeded that of the Royal Ordnance Factories and the private armament manufacturers put together.

The production of small arms illustrates even better the growing part of the non-specialised firms. Small arms in production at the beginning of the war, the Bren machine gun for the Army, the Browning machine gun for aircraft, the Beza large-calibre automatic gun for armoured vehicles, the Vickers' machine gun for the R.A.F. and the Boys' anti-tank rifle, were being made by the Royal Small Arms Factory at Enfield or by private armament factories, mainly B.S.A. and Vickers-Armstrongs. The same is largely true of the early instalments of the various 20-mm. guns. The Hispano-Suiza gun which came into production in 1938 was mainly manufactured by the British Manufacture and Research Company and by other specialist armament factories including Royal Ordnance Factories specialising in small arms. In 1943 the British Manufacture and Research Company was responsible for forty-six per cent. of deliveries, a Royal Ordnance Factory specialising in small arms for about twenty-five per cent., B.S.A. for twenty-six per cent. and the Royal Small Arms Factory, Enfield, for three per cent.

None of the small arms introduced in later years—rifles being the only exception—could be ordered from specialised makers in the same proportion as the Browning machine gun or the Hispano-Suiza gun. When in 1940 the Admiralty introduced into production the Oerlikon 20-mm. gun, B.S.A. undertook to make the gun in its entirety. But although this firm from the very outset relied upon a large number of sub-contractors they were unable to cope with all the expanding orders, and the Admiralty was compelled to go outside the armament industry and to appoint several 'general' firms to act as

main assembly firms. At the same time the Admiralty placed orders for components with a large number of other 'outside' firms. When the latest of all the 20-mm. guns—the Army's Polsten—came to be ordered, 'outside' firms were enlisted from the very beginning. By November 1941 when the requirements for the gun crystallised, the capacity of B.S.A. and the other specialised makers of small arms was fully loaded. The new gun was therefore specially designed to enable firms outside the range of specialised weapon-makers to undertake its manufacture. The early work on the gun was done by the Royal Small Arms Factory, Enfield, and by the Royal Ordnance Factory, Poole, but the main burden of production fell on 'outside' firms. Some of the latter undertook the main assembly, while a large number of other firms (some thirty-four by 1943) supplied components. It was only in January 1943 that the tailing off of earlier orders enabled some of the Royal Ordnance Factories to accept a large order for Polsten guns. By that time, however, the old line of demarcation between munitions suitable and unsuitable for production by 'outside' firms had almost completely broken down.

So much for the specialisation of firms. The specialisation of equipment was a different matter. A fairly general use of special equipment was essential. In so far as it was in their power, the production directorates of the Service ministries fostered throughout the years of rearmament the widest possible use of specialised machinery and plant. From as early as 1934 the War Office based its plans for industrial potential on the expectation that it would be both possible and necessary to 'mass produce' a number of munitions by means of specialised plant and machinery. Needless to say, much of what the War Office wished to do in order to provide civilian firms with specialised equipment was bound to remain on paper. Yet even then a great deal was done to design or to help in designing many new types of munitions-making machinery. Some of the special machines were designed by the firms themselves, others by Government agencies; but whatever their authorship, ingenious and highly-specialised machines made their appearance both before and during the war. Thus there were special presses in the aircraft firms, there were new machines for the economical rifling of gun barrels, for the making of cartridges and shells, for small arms ammunition, for the machining of rotor blades of gas turbines, for cutting large and difficult gears, for the manufacture of fuses.

Indeed, in the making of some arms the use of specialised machines and tools was indispensable if they were to be made in any quantity. There was first of all the question of the size of machining operations. The boring of gun barrels, though in principle no different from any other boring operation, required machines capable of making holes

much longer and truer than those normally specified in general engineering practice. One of the reasons why makers of machinery for oilfields were at first expected to participate in the making of gun barrels was that they were believed to possess the necessary equipment and experience in the 'long bores'. Yet, as it turned out, they too had to be provided with special equipment for the purpose. Similarly, the machining of the long spars of aircraft frames, the making of the larger gun forgings, the manipulation for the welding of medium and heavy tanks, all raised technical problems which were necessarily those of scale, i.e. of weight and size. For this reason alone munitions contracts necessitated the installation of special machine tools, hammers, presses and cradles.

The other peculiarity of weapon production which made it necessary to install special tools was higher precision. For as a rule, greater accuracy and precision were required in the manufacture of weapons than in the making of most peace-time products. In the making of gun mechanisms or shell components, of fire-control gear or predictors, a degree of precision was expected which ordinary engineering tools could seldom achieve. In general, it was necessary to install machines and to use tools capable of working to much smaller tolerances than was customary in the engineering industry.

Even where special plant and machinery were no different in either design or construction from those employed in civilian industry, they were sometimes required in much larger quantities than in ordinary well-balanced engineering factories before the war. Thus, welding as a method of joining metal parts in assembly had been used in Britain for years before the war, but it did not become a common practice until it had to be generally used in war industry and, above all, in shipbuilding[1] and in the making of gun carriages and tanks. With the extension of welding came also the need not only for welding equipment proper, but also for manipulating cradles and for plant for heat treatment. Simultaneously with the greater precision of machining operations came also a vast expansion in the use of high-speed tools and the consequent changes in the processes and equipment of tool-rooms.

Thus, a great deal of specialised equipment was bound to be installed, and it is not surprising that single-purpose tools and specialised plant of every kind should have been employed in greater numbers than before the war. Yet, in most firms, the general character of industrial equipment was not thereby radically changed. New and special machines were often grafted on to the more ordinary equipment of firms or, as the expression goes, the equipment of the firm was 'balanced' for arms production. A large proportion of the machine

[1] See p. 297.

tools supplied during the war years were general-purpose tools: lathes and drills, or other types of unspecialised plant and machine tools used in engineering and other metalworking industries.

What is true of individual machines and plant is truer still of entire workshop units. Much of the specialised equipment was supplied (sometimes had to be supplied) in combined 'units', i.e. complements of machines making up in combination specialised and self-contained workshops. In pre-war plans for rearmament and war potential, specialised 'units' figured very prominently. They were an obvious alternative to brand new factories since they made it possible to produce munitions *en masse* by means of special machines, while making use of the facilities of existing firms: their management, their technical experience and staffs, their tool-rooms.[1]

One of the most important instances of specialised equipment to be installed in the rearmament period was the shell-forging plant which produced shell bodies with finished cavities and thus obviated much internal machining. This plant was from the outset made up as a self-contained production 'unit', and was first erected at Stewarts & Lloyds—the firm which had developed the design in co-operation with the War Office. Almost all the subsequent expansion of shell-forging capacity, both at the 'parent' factory and elsewhere, was achieved by the installation of similar shell-forging units—some sixty-two were manufactured and forty-two installed in Great Britain by the end of the war.[2] Integrated combinations of machines were also designed for the manufacture of cartridge cases and the machining of gun ammunition, and were installed in a wide range of private firms. The output of small arms ammunition, mechanical time fuses and cartridge cases came entirely from combined 'units' of specialised machines. When the decision was made in 1941 not to replace current 2-pounder production with 6-pounders, but to prepare instead for production of 6-pounders in large quantities in the near future, several factories were equipped with elaborate and highly-specialised 'units' of machine tools and plant capable of turning out the gun on well-nigh mass production lines.[3] From some points of view, the installation required for the assembly of aircraft was made up in integrated 'units' of this kind. They consisted very largely of assembly jigs unsuited to any other type of aircraft (hence the difficulty and delays in changing over to new types of aircraft).

Nevertheless, in the entire field of munitions self-contained factory 'units' equipped with specialised plant were far from being universal.

[1] This was the policy of the Armament Supply Committee of the Supply Board from before 1934: then and as adopted later, it was mainly intended to apply completely to certain types of munitions, particularly to shell production.

[2] See p. 43, and *An Industrial War Record:* A Review of Activities of Stewarts & Lloyds Ltd., 1939–45, p. 29.

[3] See p. 194.

A large part of the output of munitions in this country came from factories which, whether large or small, were laid out as 'general' engineering shops, even though they may have been strengthened or adapted by the addition of special equipment. Changes from civilian production to that of making weapons, and changes from one weapon to another, were to a large extent achieved not by the complete re-equipment of factories, but by the re-tooling of existing machines and by the addition of relatively few special machines to existing plant.

(3)

Inheritance and Necessity

The peculiarities of munitions manufacture—its dispersion and its unspecialised structure and equipment—may appear to perpetuate what have often been regarded as the congenital characteristics of British economy: its multiplicity of small firms and its predilection for traditional methods. The inherited elements in the make-up of war industry must not, however, be exaggerated or misunderstood. Broadly speaking, the dispersal of ownership and control among private firms and the reliance on small factory units were less congenital than the lack of specialisation. But even the latter was due more to the circumstances of Britain's war than to the inherited constitution of her economy.

No doubt, taken as a whole, British industry on the eve of the war was less 'concentrated' than that of the United States, the U.S.S.R. or even Germany. Small firms, i.e. those employing fewer than 100 workers, were relatively more numerous in Great Britain. Diminutive firms, i.e. those employing less than ten wage-earners, were undoubtedly more numerous in Great Britain than in the United States and in the U.S.S.R., though, perhaps, not more so than in Germany. Large firms, i.e. those employing more than 1,000 workers and still more those employing more than 5,000 or 10,000 workers each, accounted for a smaller share of the national output in Great Britain than they did in the United States, the U.S.S.R. or Germany. Although some of the world's greatest combines were formed in Great Britain and operated from London, industrial combinations (as distinct from trade associations) did not play as important a part in the national economy as that played by the great American firms or German cartels. It is, therefore, only too easy to see a connection between the comparatively 'unconcentrated' structure of British industry in peace-

time and the greater dispersal of ownership and the smaller size of factory units in war-time industry.

Some connection there certainly was; yet it is not as obvious as it might at first sight appear. In the industries which bore the main brunt of war production, the metalworking, machine-building and electrical industries of every kind, international differences in structure were not as great as in other branches of production. These industries harboured large numbers of small firms in all countries. In them, side by side with relatively few vast manufacturing enterprises, such as the great motor manufacturing concerns or the main electrical manufacturers, smaller workshops continued to play an important part. Some of them found a natural function in the work of repair and maintenance which invariably develops around every industry producing complicated machines and implements. But large numbers of small firms were also to be found at the manufacturing end and were to some extent sustained by sub-contracts from their greater brethren. With one or two famous exceptions, American motor firms, like their opposite numbers in this country, manufactured a relatively small proportion of their components and devoted themselves mainly to the assembly of cars. To some extent this was also true of the large machine-making firms who obtained castings, forgings, tubes, bolts and nuts and even more complicated components from firms much smaller than themselves. The proportion of smaller firms 'tied' to larger firms, i.e. earmarking their entire output to a single large customer may have been much greater in the United States than in Great Britain. But whether 'captive' or 'free' small firms found it possible to survive in large numbers in metalworking industries in both countries. (See Tables 54 and 55.)

Average number of wage-earners per establishment[1]

TABLE 54 Numbers

	In the United Kingdom (1935)		*In the United States (1939)*	
	All establishments	Establishments employing more than ten wage-earners	All establishments	Establishments employing more than five wage-earners
Engineering, shipbuilding and vehicle trades . . .	38	153	98	146
Iron and steel trades excluding blast furnaces, iron and steel smelting and rolling	30	109	67	90
Non-ferrous metals trades .	30	86	40	72

[1] Details explaining the composition of Tables 54 and 55 are given in Appendix 6.

Percentage of total number of wage-earners in establishments employing[1]

TABLE 55

	Less than 101		101 to 500		501 to 1,000		Over 1,000	
	U.K. (11–99)	U.S.	U.K. (100–499)	U.S.	U.K. (500–999)	U.S.	U.K. (1,000 and over)	U.S.
	%	%	%	%	%	%	%	%
Engineering, shipbuilding and vehicle trades . .	24	15	23	24	14	14	39	47
Iron and steel trades, excluding blast furnaces, iron and steel smelting and rolling	30	29	42	50	15	16	13	5
Non-ferrous metals trades .	39	30	38	30	15	10	8	30

It is thus impossible to hold the British industrial structure before the war wholly responsible for the relatively greater dispersion of the British munitions industry in war, or for the employment of the many small factory units. Had the British munitions industry enjoyed the necessary breathing space and been able to deploy itself, so to speak, at leisure, it might have contained a much larger proportion of great newly-created plants *à l'americaine* and a much larger proportion of its output would have come off mass production lines. The leisure, however, was not given. To repeat again—in Britain the necessities of industrial mobilisation during the war did not allow sufficient time for building-up the munitions industry anew. Industrial capacity had to be taken where found, and as much of the existing equipment as possible had to be utilised for immediate purposes of production.

In addition, there was also the policy of dispersal to meet the bombing attack. It has already been shown that the dispersal units originally intended as reserves and as safe retreats for 'parent' firms bombed out of their main premises were eventually taken over and fully occupied even when the main premises still stood undamaged and intact.[2] A great deal of additional capacity was thus created in most branches of war industry, but mainly in those engaged in aircraft production. But although much additional floor space was thus made available it was often made up of small and even diminutive units. Thus in 1943, at the end of the German bombing, B.S.A. found themselves operating, in addition to their main factories, some thirty-five dispersal units.[3] The average size of the units was bound to be much smaller than that of the firm's main 'parent' factories.

[1] Details explaining the composition of Tables 54 and 55 are given in Appendix 6.

[2] See p. 165.

[3] See *The Other Battle, op. cit.*, p. 78.

The same exigencies of time and the effects of enemy attacks also prevented greater development and use of specialised equipment. Even if the conditions of war had been more suitable to specialised industry, the shortage of dollars would have made it difficult to build up a munitions industry as highly capitalised and specialised as that of the United States. But to some extent differences of industrial methods in this country and the United States were bound to assert themselves in this respect.

It is common knowledge that before the war American firms specialised more than their British counterparts and that the tendency to specialise reached down to the smallest manufacturer. It has already been mentioned that in the United States a great proportion of small firms were tied to large customers and were thus producing a limited number of components.[1] But even where firms were not thus 'tied' there was a general tendency among them to confine themselves to a narrow range of products. In a branch of metalworking industry least suited to specialisation, the 'jobbing' founders, which by definition are expected to work for the open market to customers' specifications, firms tried as far as possible to make large batches of uniform products. In the 'jobbing' branch of the drop-forging and stamping trades, most shops restricted their activities to no more than about half a dozen types of components. A recent report cites an example of a medium-sized factory employing about 600 people engaged all through the year almost exclusively on pressing backing plates for car brakes.[2] Other factories may not have reached the same degree of specialisation and standardisation, but even the smallest among them refused to set their presses for short-run batches. As a result, the whole organisation of the workshops, indeed the very composition of the labour force, was different.[3]

That in Great Britain the average contractor and sub-contractor managed their affairs differently is undeniable. British firms both large and small were much less specialised; their products were more diversified; and they were prepared to produce in a far wider range

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[1] See p. 405.

[2] See *Report of the Pressed Metal Productivity Team*, Anglo-American Council on Productivity, July 1950, p. 4.

[3] A British mission, reporting on American industrial methods, recorded that even in such a diversified trade as that of drop forgings the very meaning of the word 'skill' differed from the British. It meant deftness and agility in a repetitive and highly-specialised operation. At one forge a 'skilled' hammer-man was employed for two years in forging crankshafts of the same standard size and design. (See *Report of the Drop Forging Productivity Team*, Anglo-American Council on Productivity, April 1950, p. 46.) The insistence on specialisation was partly the result of ingrained habits of the manufacturing classes. The small American sub-contractor was able to standardise and to specialise because his client—a cost-conscious manufacturer—was prepared to take highly-standardised components in large quantities. A recent British report refers to numerous examples of pressing-shops in the United States in which a press-run lasting possibly three or four weeks produced pressings sufficient for a year's needs of a contractor. (See *Report of Pressed Metal Productivity Team, op. cit.*, p. 4.)

of measurements and designs. And for this the material conditions of British economy were largely responsible. In the United States a large internal market with a relatively uniform demand made it possible to standardise production and to reduce in every industry the number of variations in designers' specifications. In Britain the domestic demand was both smaller and less uniform. What is more, a number of industries and, above all, the metalworking industries produced to a large extent for export and had to cater for a great variety of needs in different parts of the world. The opportunities for standardised output and specialisation were correspondingly smaller.

This congenital lack of specialisation could not be done away with in the few years of rearmament and war. It has been shown that where specialised equipment was absolutely essential, as in the manufacture of ammunition, it was created and the necessary delays were accepted. For the rest, the urgent enlistment of a multitude of firms, particularly in the later stages of the war, meant that the equipment and the methods of pre-war industry were in the main carried over into war production.

So much for the inheritance. Whether inherited or imposed by the conditions of war, the structure of British war industry undoubtedly differed from that of the United States. It may have differed even more from that of the U.S.S.R. where both before and during the war, indeed even before the Revolution, the average size of industrial undertakings was very large by Western standards. Whether British war industry was more dispersed and less specialised than German war industry is difficult to say. It is, however, probable that after 1943, as a result of Speer's reorganisation and in response to Allied bombing, Germany's vast reserves of domestic and handicraft industries were more fully drawn upon.

Did British war production suffer from its dispersed structure and less specialised equipment? The disadvantages of small-scale enterprise and of unstandardised production are well known, and have of later years received great publicity. Small firms could not afford sufficient facilities for experiment, design and development; very few were adapted to quantity manufacture. Though some undertakings were as efficient as the best anywhere, a large number of firms in the engineering and allied industries fought shy of the methods of modern large-scale industry and did not fully master the more advanced arts of modern management, such as the scientific organisation of the 'production line', the economical 'break-up' of operations, or even efficient cost-accountancy and store-keeping. Before rearmament the arts of modern management were strange even to some of the aircraft firms. The early records of aircraft production abound with examples of stubbornly persisting small-workshop methods. It is therefore all

the more remarkable that by the end of the war the efficiency of some British aircraft factories, measured in labour costs per unit of production, should have risen to equal that of comparable American factories. In those few cases where a type happened to be in production for a long enough period in quantities sufficient to bring about the economies of large-scale production (i.e. where weekly output was twenty to thirty bombers or fifty to sixty fighters) costs per airframe in man-hours were probably about the same as in factories of the same size in the United States.[1]

If, nevertheless, the average cost of aircraft, taking the output as a whole, was in the later stages of the war much higher in Britain than in the United States, this was probably due to the differences in the scale of production and in the size of average factory units. Arguing from what is known of the average size of American and British factories and from what can be assumed and has been observed about the economies of quantity production of airframes, some authorities have concluded that the American output could be expected to be (and probably was) half as costly in man-hours per aircraft as the British.[2]

Unfortunately similar comparisons for war industry as a whole are difficult to draw. The artificial rate of exchange between the pound and the dollar make purely monetary comparisons between British and American costs meaningless. The differences in the design of weapons and in methods of manufacture make it equally difficult to compare costs in terms of man-hours. Conclusions about comparative costs of most American and British weapons can therefore be no more than impressions. Such impressions as can be formed suggest that in some branches of munitions industry real costs in the United States were considerably lower than in Britain. On the other hand, it is by no means certain that there was much difference in costs in the manufacture of gun ammunition or small arms ammunition —two fields in which specialised capacity predominated in both countries. And it is certain that British ships cost less per ton of weight than the American. The ingenious method of prefabrication and sub-assembly which Mr. Kaiser introduced into the manufacture of ships made it possible to produce large numbers of cargo vessels, but they turned out to be very costly.

The relevant comparison, however, is not between American and British costs, but between the cost in Britain of weapons produced by traditional methods and the cost of weapons turned out *en masse* from new and specialised plant. But here again exact measurements are

[1] See E. Mensforth, Airframe Production, *Proc.I.Mech.E.*, *op. cit.*, p. 36. The argument assumes that in aircraft, differences of design were not such as to prevent comparison.

[2] See E. Mensforth, *op. cit.*; T. P. Wright, Factors Affecting Costs of Airplanes, *Jl. Aeronautical Sciences*, Vol. 3, 1936, p. 122, and the Wilbur Wright lecture, T. P. Wright, Aviation's Place in Civilisation, *Jl. Roy. Aeronautical Soc.*, Vol. 49, 1945, p. 299.

impossible. Comparison in costs of different war-stores are beside the point; while in comparing costs of the same war-store it is difficult to find instances of the same store being made both in specialised mass-producing factories and in factories not thus equipped. In general, the economies of mass production, when they happened to be introduced, were only too obvious. Measured in man-hours and machine hours the cost of shell bodies manufactured by the new mechanised forging methods and machined on the specialised equipment was considerably below that of the shell bodies produced during the war of 1914–18 even though shells now had to be made to much finer tolerances; the 6-pounder production in highly-specialised and elaborately-equipped factories was much more economical than that of any other gun of comparable complexity; and the cheapness of the Sten gun, which was designed for mass production, became a byword. It has also been shown that at two British factories producing the same aircraft with very similar equipment and tools, the one producing about fifteen aircraft per week took about twice as many man-hours per airframe as the one producing fifty-five per week.[1]

Yet economy in production, even in terms of labour, is not the only, or even the chief, yardstick of industrial efficiency in time of war. Even if it could be shown that some of the British methods of war production brought with them the disadvantages of high real costs, these disadvantages might still have been worth accepting for the sake of countervailing advantages. And the main countervailing advantage of the British industrial layout was readiness.

In the early stages of industrial mobilisation, i.e. between 1938 and 1940, the speed of rearmament was all-important. What the situation demanded, and what the Government and the public expected from industry, were quick and immediate returns. Ability to get off the mark without much delay was often prized beyond all other industrial virtues. Readiness became even more important after 1940. Britain was in the front line of battle and in that position the ability of industry to respond to military demands with the least possible delay was more essential than ever. From this point of view, the smaller scale and the less elaborate equipment of the average British manufacturing unit was in itself a blessing in disguise. It may not have brought the peak rates of production to levels as high as those in the United States, but it often made it possible not only to achieve a quick start of deliveries, but also to complete the full requirements earlier than would have been possible with a more carefully planned layout.

In general, British industry, equipped as it was largely with general tools, staffed with men trained to tackle manufacturing tasks of great

[1] See E. Mensforth, *op. cit.*, p. 36.

variety, was well adapted to respond to the urgent and fluctuating demands of war. It was highly elastic, and elasticity meant ability to meet demands which fluctuated not only in quantity but also in kind. The war industry was constantly called upon to improve the quality of weapons, to introduce new weapons and, above all, to make modifications in the old. Throughout the war the designs of most standard weapons were being continually altered. There were forty-one 'marks' of the Merlin engine, twenty 'marks' of the Spitfire, eleven 'marks' of the Churchill tank; but these and most other weapons were also subjected to a host of modifications and variations too small and piecemeal to deserve the status of a 'mark'. When modifications were so frequent, methods of mass production in elaborate production lines, equipped with special-purpose tools, lost much of their value.[1] True enough, the Americans, with their great experience in mass production and their vast machine-making resources, were often able to equip large manufacturing units for the mass production of weapons in less time than it sometimes took to adapt or to 'balance' existing factories in this country. But again, the relevant comparison is between specialised and unspecialised factories in this country; and here it remains true that the less specialised factories with their simpler equipment found it easier to introduce modifications and to change over from one type or mark of weapon to another than factories elaborately equipped for mass production. Thus, the factory, which Ford's equipped for the production of Merlin engines on mass production lines and managed throughout the war, succeeded in producing the single-stage Merlin engines more cheaply and more rapidly than the factories of Rolls-Royce themselves. But, unlike the Rolls-Royce works at Derby, they were unable to change over to the two-stage marks of the Merlin without a complete re-equipment of the machining and assembly shops.

(4)

Sub-division of Production and 'Free Issues'

The corollary of an industrial structure as dispersed as the British was what, for want of a better term, might be called the division and sub-division of production. Production of war-stores could be shared in two ways, by dividing responsibility for the making of the final product and by 'farming out' the production of parts and components. Where a single firm was too small or too preoccupied to shoulder responsibility for the entire output of a weapon, the obvious remedy

[1] See p. 342.

lay in distributing the contracts among a number of firms.[1] This was also desirable as an insurance against bombing. Throughout the years of rearmament and war the division of orders among several manufacturers was a rule to which there were few exceptions.

The second method of dividing the manufacture of weapons was for some firms to act as 'main manufacturers' and be given contracts for the assembly of complete weapons, while other firms made parts or components. It is this form of sub-division that is commonly termed 'sub-contracting'. It was the normal habit of most firms to 'buy out', i.e. to sub-contract, parts, components and accessories, and facilities for sub-contracting were accordingly great. In the Midlands, the North-West and the Clyde the conglomeration of sub-contracting firms had before the war become one of Britain's most competitive advantages, or to use the jargon of text-books one of the 'external economies' of her industry. Although production in smaller engineering workshops was less standardised than in the United States, many of them owed their survival to their concentration on separate engineering processes. Thereby the makers of industrial goods were relieved of the necessity of providing themselves with facilities for all the ancillary stages of production. Moreover, in the regions in which the engineering industries conglomerated, sub-contractors were so numerous that ancillary operations were performed at highly competitive prices.

How considerable these economies were is illustrated by the example of a well-known electrical firm in the North-East which in the last stages of the war was considering a plan for establishing an up-to-date factory of electrical appliances capable of producing all the parts and components of the finished article. But even before its plans matured it discovered that, however efficient and up-to-date its plant, it could not compete with much smaller and more modestly equipped manufacturers in the Midlands who merely assembled parts manufactured for them by sub-contractors.

The economies of sub-contracting were sufficiently great to sustain the system throughout the booms and depressions of the inter-war years. How deeply ingrained it then became is illustrated by another example of sub-contracting. Some time before rearmament had begun the Engineer-in-Chief of the Fleet discovered that a firm in the Midlands was the sole maker of some very large forgings much needed in the manufacture of certain armament. The firm was very competent, though small, but it had become the only repository of the necessary technique and equipment. The Engineer-in-Chief therefore rightly concluded that safety demanded that similar facilities should be developed elsewhere. Orders for similar forgings,

[1] An important reason for the division of orders in the pre-war programmes was the need for educating several firms as 'war potential' capacity.

or orders embodying them, were placed with several large firms, including one or two famous makers of armaments. It is easy to imagine the Engineer-in-Chief's surprise and disappointment some months later when he discovered that the same Midlands firm, acting as sub-contractors, was busy making the very forgings which had been ordered from the larger firms for their education.

This being the habit of general industry, sub-contracting was bound to establish itself in the munitions industry from the very beginning of rearmament. The contracting departments of the three Services tried to secure the highest possible degree of sub-contracting, and in some cases contracts were negotiated with the understanding that a great deal of the work would be sub-contracted.[1] But, on the whole, the tendency to divide and sub-divide manufacture, and above all to separate the final assembly from the sub-assembly and from the manufacture of parts, became more pronounced as the war progressed and the circle of main contractors widened. The making of 3·7-inch anti-aircraft guns and of the early batches of Bofors guns could still be entrusted to factories manufacturing weapons in their entirety; but the manufacture of guns in later years, e.g. 6-pounder and 17-pounder tank and anti-tank guns, had to be split among a large number of contractors. In addition, the contractors themselves sub-contracted the essential components or relied upon the supply departments to provide them. The same is true of tanks. The facilities of Vickers-Armstrongs enabled them to make most, though by no means all, the components of the Valentine tank. But many of the firms subsequently employed on tank manufacture limited their work to final assembly only, though Leyland Motors, Nuffield and Vauxhall Motors were notable exceptions. The contracts for the cruiser tanks—the Crusader, the Covenanter and the Cromwell—were divided among several heavy engineering and locomotive firms, many of which were responsible only for the final assembly of the tank.

A still better instance of the growing importance of sub-division and of sub-contracting will perhaps be found in the story of small arms, summarised elsewhere in this chapter.[2] The story is essentially one of production shared by a large number of firms; but it also exhibits the ever-growing reliance on sub-contracting. The largest of the early contracts for small arms—those for the Browning machine gun placed by the Air Ministry in 1935—was to be carried out more or less wholly by B.S.A. and Vickers-Armstrongs; each a self-contained firm if ever there was one. But when in 1939 vast new orders for the Browning machine gun appeared imminent, B.S.A., the principal makers of

[1] A reference to the Directorate of Sub-contracts in the Air Ministry was made on p. 390.

[2] See pp. 400–401.

the weapon, had to adopt a different system. They built a new factory devoted mainly to the assembly of components: the latter were to be sub-contracted to a large number of 'outside' firms. Still more extensive had to be the sharing of contracts and sub-contracting in the manufacture of the Admiralty's 20-mm. gun—the Oerlikon—which began in 1940. B.S.A. were the principal contractors, but they had to enrol some forty-three firms all over Britain as sub-contractors.[1] A similar system was adopted in the making of the latest of the 20-mm. guns—the Army's Polsten.

Sub-division and sub-contracting became a habit and a necessity. Without it a large number of firms brought into war industry could not have been woven into the general system of armament orders. By the middle of the war sub-contracting had become not only extensive but also highly complicated. Firms which acted as main contractors for some finished weapons also manufactured parts and components for other contractors. How complicated and circular the system could occasionally be is shown by an instance of a Vauxhall sub-contract described in full in the firm's own history.[2] A firm undertook to supply Vauxhalls with a certain component of the Churchill tank. Being intended for a big and heavy armoured vehicle, the component required a very large and heavy casing which turned out to be beyond the unaided powers of the sub-contracting firm. The first firm therefore sub-contracted the casing to a second firm. This firm in its turn found it necessary to look for someone to help it in carrying out its undertaking, so it sub-contracted a part of the work to Vauxhalls.[3]

It has already been indicated[4] that sub-contracting components was not the only method of freeing manufacturers of finished munitions from the necessity of producing their own components or fabricated materials. The most important alternative method was that of 'free issue' or 'embodiment loan'. Supply departments often took it upon themselves to find the necessary productive capacity for parts and components, and ordered them on their own account. Components thus ordered were then issued to manufacturers for embodiment into the main weapon (hence the term 'embodiment loan').

In the early years of rearmament it would have been difficult to find a clear principle or policy behind the distinction between com-

[1] See *The Other Battle*, *op. cit.*, pp. 175–77. Later several other firms—engineering establishments of high repute but without previous experience of the manufacture of weapons—had to be invited to share with B.S.A. the responsibility for final assembly.

[2] W. J. Seymour, *An Account of our Stewardship*, 1947, p. 83.

[3] For a similar instance in the sub-contracting of the Lancaster bomber see E. Devons, *Planning in Practice*, *op. cit.*, p. 114, footnote 1.

[4] See p. 411.

ponents ordered directly by the Government and the components left to private arrangements between main contractors and their sub-contractors. Most of the components on 'free issue' in aircraft production and in naval construction were either large and complicated, or were in the nature of 'equipment', i.e. detachable and largely independent installations. Thus, naval guns, aircraft engines, propellers and turrets—all large and complicated equipment—were as a rule supplied as 'free issues' or 'embodiment loans'. So were also instruments of every kind. Yet this distinction was not observed at all consistently. Undercarriages—a highly complex and substantial part of an aircraft—were as a rule 'purchased' by the aircraft constructors; so also were pumping and lifting gear of every kind and a great deal of the electrical installation on naval vessels.

Quite different considerations in fact prompted government departments in later years to assume responsibility for the ordering of components. Standardised items of equipment lent themselves well to centralised ordering and to distribution by 'free issue'. In aircraft production 'free issues' helped to standardise components and were often used with that object in view. This, however, was not the sole explanation of the growing importance of 'free issues'. Where the components happened to be designed wholly or mainly in the supply departments or in their research establishments, e.g. radio equipment and most of the armament in aircraft and ships, the department as a rule ordered and supplied them as 'free issues'. Parts and components received from the United States could be most conveniently supplied in the same way. Similarly it was convenient to treat as 'free issues' components which were also being ordered for the Service departments—the Air Ministry or War Office—to be used in army units or air squadrons as spares and replacements. What frequently involved government departments in the ordering and distribution of components was shortages, more especially shortages which called into play the Government's powers of allocation and distribution. When supplies of materials and components used by more than one firm or even by more than one industry, such as ball-bearings, became 'difficult', i.e. actually in short supply or insufficient for projected expansion of programmes, government departments stepped in so as to ensure that priorities were observed, and that new provisions were sufficient. The need for allocating supplies led to decisions to 'plan' them, and the planning of supplies of difficult components often led to 'free issue'.

As shortages was one of the main causes of official involvement with the supply of components, the involvement was bound to grow with the increasing scarcity of capacity, labour and materials. Towards the end of the war the system also commended itself for

reasons of efficiency and economy.[1] It offered the obvious economies and conveniences of bulk buying and issue; it promised to rationalise the distribution of orders of components and to prevent the overloading of some firms and the under-employment of others. Above all, it offered a remedy against the evils of cross traffic. When B.S.A. found themselves employing, on the production of the Browning gun, sub-contractors as far apart as Dowlais in Wales, Crawley in Sussex and Glasgow in Scotland, this may well have appeared to them as something of an achievement. But to the supply departments the scattering of sub-contracts over the face of Great Britain inevitably spelt endless complications and delays, additional difficulties of inspection and unnecessary loads on the transport system.

The tendency on the part of the supply departments to introduce 'free issues' wherever possible was, therefore, more or less inevitable. Equally inevitable was the opposition from some firms. A great aero-engine firm or an old and famous armament firm could argue that it was linked with its sub-contractors by years of commercial collaboration; that it and its sub-contractors knew each other's methods and requirements and therefore spared each other a great deal of effort and time. To interfere with mutual relations so reliable would, it was argued, only add to the waste and confusion of war-time industry.

Opposition on this issue did not, however, flare up into real conflict. Neither side pushed the arguments to any length. No private firm objected to 'free issues' in principle. Some of the firms which were most anxious to protect their relationships with sub-contractors from Government interference were in fact receiving most fabricated materials and some components as 'free issues'. At one point the clearing banks suggested that a system of universal 'free issues' embracing the bulk of materials, parts and components might assuage industry's need of circulating capital.[2] But the supply departments were not greatly influenced by the purely financial advantages of 'free issues'. In general they never contemplated recasting industry by centralising the supply of components. In 1942 the Federation of British Industries expressed their objections to the threat of a greatly extended system of 'free issues', but the threat was unreal. Neither then nor at any later time was there any danger of a wholesale replacement of private sub-contractors by Government orders of parts and components. It was not the habit of the British Government in war-time to work to cut-and-dried principles in industrial organisation, still less to force them upon the resistant body of British industry.

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[1] See E. Devons, *Planning in Practice*, *op. cit.*, Chapter IV: Planning the supply of components.

[2] See *The Banker*, Vol. LIX, No. 188, September 1941.

(5)
Groups

With the division and sub-division of production among many firms, some form of integration was a necessity if the disadvantages of a dispersed industrial structure were to be avoided. The supply departments themselves could, of course, be relied upon to co-ordinate the activities of the many thousands of their contractors and to prevent too great a waste of effort as a result of the division and sub-division of orders. But an obvious corollary of sub-division was the grouping of firms to ensure that all firms sharing the manufacture of the same weapons obtained the necessary knowledge of techniques and supplies of drawings, tools and materials. This was as a rule necessary even when the firms happened to be large. An occasional exception was sometimes provided by Royal Ordnance Factories or armament firms engaged on the execution of very large-scale orders, but even they sometimes found it advantageous to join groups.

There were two main types of group organisations for munitions production corresponding to the two main methods of dividing production. Where the production of complete munitions was distributed among several main contractors, the group (let us call it a 'quantity group') consisted of the firms responsible for the final manufacture of a store. Where in addition the supply department also sub-divided the production, i.e. issued direct contracts for the manufacture of sub-assemblies as well as for the final assembly, the group (let us call it a 'process group') consisted of both the final assemblers and the sub-assembly firms. Here separate groups might sometimes be formed by each final assembler and his sub-assemblers, or one group might combine all the final assemblers and sub-assemblers. It should, however, be noted that the group system was necessary only where production was divided between separate firms. A large part of aircraft production came from factories or subsidiaries controlled by the same commercial firm, e.g. Vickers-Armstrongs or Hawker-Siddeley, and in these cases co-ordination between individual factories could be left to the headquarters of the combines.

In the first type of group a special position was occupied by the 'parent' firm. In an aircraft or tank group the 'parent' firm was usually the firm which had produced the design, but where it happened that the designing firm did not share in the production, another firm could be nominated as 'production parent'. Usually, the 'parent' firm was called upon to provide other firms in the group

with drawings and, in some instances, with jigs and tools. In addition, it often assumed responsibilities for the distribution of materials and components. As the group system became more widely adopted there occurred frequent instances in which 'parental' functions were divided among several firms. Thus the responsibility for jigs and tools might be undertaken by one of the members, or by several members each working out a particular technique. Possible variations in the distribution of responsibility within a group were considerable.

Both types of group organisations were established in the rearmament period, but their numbers and activities were considerably increased under war conditions. The earliest group was set up to bring together the five firms which shared in the manufacture of Bristol engines—the first engine 'shadow' scheme started in 1936 under the leadership of the Austin Motor Company. This group was of the second type, i.e. a 'process group', since only two of the firms thus grouped undertook final assembly; the other three were engaged on major sub-assembly. The earliest grouping for the War Office programme was for the 18/25-pounder gun conversion scheme, which by 1937 had led to the formation of two groups. The beginnings of the group system in tanks may be traced back to 1937 when four firms undertook the production of light tanks under the 'parentage' of Vickers-Armstrongs.

Apart from the tank group, these early combinations were 'process groups', and as a rule came into existence without a formal constitution. Thus the two groups formed in 1937 for the 18/25-pounder gun conversion had no formal organisation, even though they were to have a long life. Tank groups were not formally organised as such until 1939. On the other hand, 'quantity groups' combining major manufacturers of the same weapons were usually the outcome of deliberate policy and often appeared on the initiative of the supply departments.

The first, and indeed the major, examples of 'quantity groups' thus formed were the aircraft production groups established in January 1939. The idea appears to have germinated at the Air Ministry and it emerged officially at the end of 1938 when production planning of a new programme had to be considered. This meant introducing a limited number of new types of aircraft and dividing the total production of each type between several firms. For this a group system was considered essential. It offered the best means whereby the designing firm could establish satisfactory relations with the other firms and could help in securing efficient standards of technique and equipment. In January 1939 three groups were formed for new bomber types and three for new fighter types. The Stirling and Halifax groups were headed by the designing firm, with the addition of the Rootes and Austin 'shadows' in the first, and English Electric

in the second.[1] The Manchester group was more complex; it had A. V. Roe as the designing firm and Armstrong-Whitworth and Metropolitan-Vickers as the other producers. Some opposition to the idea was at first expected because some designing firms were to be asked to undertake production of aircraft designed by other firms. But, in the event, the firms accepted the new situation and loyally contributed to the resources of the groups.

The official initiative in the formation of these aircraft groups showed itself in their organisation. In the early stages each group was administered by a committee of the firms presided over by the Director General of Production at the Air Ministry, and was served by a secretary and finance member from that Ministry. Sub-committees, with officials sitting on them, looked after management problems, jigs and tools and sub-contracting. It appears however that the Ministry did not intend to take a prominent part beyond the early stages. Very few meetings of the committees were in fact held, and by the outbreak of war each group came to be centred on 'parent' firms and to be administered from their works. Officials still attended the meetings of the groups, but no longer directed them.

In the initial stages of production, groups mainly concerned themselves with design problems. The 'parent' firm undertook to supply drawings to the other members of the group. Usually the designing firm had a Ministry contract which gave it the authority and imposed on it the obligation to give technical assistance to the other firms. At this stage firms also shared information and ideas about jigs and tools. As production passed out of its early stages, the group organisation mainly occupied itself with the purchase and allocation of materials. In addition, there were the problems of modifications and of the production of spares.

The organisation of groups for tank production was on very similar lines to that for aircraft. Tank production groups were in some ways more important as they included all the firms engaged on tank assembly. In consequence, the entire industry engaged on the final manufacture of tanks was honeycombed with groups. The head of the group was the 'production parent', but the 'parent' was not always the firm that designed the tank, and its functions might vary from group to group. The general tendency was to entrust the 'parent' firm with as much as possible of the ordering and progressing of components and materials even though the Ministry to an increasing extent took upon itself the responsibility for these supplies.

As mentioned above the earliest group was formed by the four firms which with Vickers-Armstrongs undertook production of light tanks in 1937, but the real formation of tank groups came in 1939 and

[1] For the later expansion in the membership of the Halifax group see p. 398.

1940 with the great increase in the number of firms engaged on tank assembly. The largest groups were for the Churchill with eleven firms headed by Vauxhall Motors, and for the Crusader with nine firms headed by Nuffield Mechanizations. Many firms were, of course, in more than one group. In 1943 some twenty-seven firms 'made up' eight groups with a membership of forty-two. Within each group firms of every type were to be found. In the 'Churchill' group there were three motor vehicle firms, four railway carriage and wagon builders, a locomotive builder, a shipbuilding firm and two engineering firms.

The group system also pervaded the production of guns and carriages during the war. Some form of group organisation was set up for all gun and carriage production except where it happened to be entirely in the hands of R.O.F.s and the armament firms. In general, the more elaborate was the division and sub-division of production, the more necessary was it to combine firms into groups. As already noted, the conversion of 18 to 25-pounder guns was from 1937 in the hands of two groups of firms,[1] but as a formal organisation was lacking it was left to the Ministry to co-ordinate the supply of materials and 'free issues'. The first formal group for gun production was that formed in July 1940 for the 2-pounder. 'Outside' firms had been employed on the gun since April 1939, and with the introduction of bulk purchase of materials and with the growing need for greater output, production committees and group organisations had to be formed. For the 6-pounder a group committee, introduced in February 1941 at an early stage in production, undertook the rationalisation of production by adopting that highly elaborate sub-division of processes which became the feature of 6-pounder gun production. For 17-pounder production, a similar committee was formed early in 1942.[2]

The production of these three types of guns was sub-divided into major stages, or sub-assemblies, for which direct contracts were issued. The groups were therefore of a 'process' type, and the members of the committees were the contractors for the main sections of production—barrels, breech rings and mechanisms and the final assembly.

In carriage production 'outside' firms had a much greater share than in gun production.[3] In consequence, production committees and group organisations were established for almost every type of carriage and mounting. Two groups were formed in 1940 (25-

[1] See p. 418.

[2] An unusual feature of the group committee for 17-pounder gun production was the grouping together of Royal Ordnance Factories and 'outside' firms. The chairman was from the Royal Ordnance Factories and the co-ordination of raw material supplies was undertaken by the ordnance factory organisation.

[3] See p. 399n.

pounder carriage and 40-mm. platform), two in 1941 (40-mm. mounting and 6-pounder carriage), and two in 1942 (2-pounder and 17-pounder carriages). The carriage production committee members were confined to the final assemblers of the carriages; the firms engaged on major sub-assemblies were not included. Such 'process grouping' as there had to be was informal and was run separately by final assembly firms.[1] The supply of maintenance spares became a serious problem in carriage production and for several types of carriage the capacity for the production of spares had to be organised by a special sub-committee of the production group.

The administration of each production committee was a considerable task and, apart from one committee administered by an R.O.F., the work was undertaken by one of the 'outside' firms in the group. This method of administration relieved the production directorates in the Ministry of much detailed co-ordination and introduced a form of decentralisation and self-government welcomed by the firms. But the main contribution of the firms went much further than mere improvement in administration. The 'process groups' succeeded in co-ordinating production to a degree which could otherwise have been reached only in single factory units. Similarly, by co-operating in 'quantity groups' main contractors were able to secure at least some of the efficiency and economy which otherwise could have been achieved only in large-scale production with highly-specialised technical services.

Groups were extensively used for airframe, tank, gun and carriage production and, by the Admiralty, in the production of landing craft and small naval vessels. But groups also occurred in other fields. Whenever production methods had to be co-ordinated, or a complex division of resources had to be introduced, a committee of firms was established. Some of these co-ordinating committees were concerned with semi-finished materials, and at least two of them—the gun-forging committee and the drop-forging committee—gave outstanding service. In general, various forms of industrial collaboration became a marked characteristic of British war production.

The group system as such did not concern itself with the enlistment of small firms. In the aircraft and tank groups the members were mainly large firms. This does not, however, mean that small firms always remained unorganised or unaided except as sub-contractors to a main contractor. In some instances small firms formed themselves into commercial groupings and collectively undertook direct contracts from production departments. This, however, was not the only method of bringing such firms together. Two examples of other

[1] As with guns the R.O.F.s were included in some of the carriage production groups.

methods were provided by the Civilian Repair Organisation by which the activities of hundreds of small firms engaged on aircraft repair were co-ordinated by a motor vehicle manufacturing organisation,[1] and by the administration by football pool promoters of the supply and distribution of spare components for shell fuses manufactured by small firms. There was also some machinery for co-operation among small firms which was mainly concerned with plant and machine tools. Thus much help was given in securing an even supply of small tools by the 'Mutual Aid' scheme. Under that scheme meetings and contacts were organised in each region for users of small tools who were willing to exchange stocks of small tools to meet current demands.

In general, mutual assistance was often made available to firms which were not necessarily members of an organised group or employed in making the same munitions. It was a marked feature of British war production that co-operation and mutual assistance developed to a high degree, not only between friendly firms or firms in the same trade association, but also between firms which had not hitherto worked together or had even competed against each other.

[1] See p. 319.

CHAPTER IX

GOVERNMENT AND INDUSTRY

(I)

Public Ownership and Management

THE persistence in war industry of most of the congenital features of British economy may conceal from view the fundamental difference between the management of munitions industry in time of war and the normal conduct of trade and industry in time of peace. Nowhere was the contrast more fundamental than in the relations of Government and industry. The Government was now the sole customer of war industry as well as its chief supplier of raw materials and components. It will presently be shown that, as the war developed, the Government also became the chief source of new industrial capital. In some fields Government agencies designed the articles which industry made. Now and again they took a hand in planning factories, workshops and the layout of the machinery within them. The manner in which all these functions were exercised and the relations between Government and industry which resulted from them were bound to determine the whole 'climate' of war production: its methods, its internal relations, its incentives.

Public ownership and management greatly increased, but the share of total production allotted to State factories was not the same in the three supply departments. The method adopted in the Ministry of Supply and, to a smaller extent, in the Admiralty was to allocate to State factories and to private firms distinct and separate roles in production. The Air Ministry and the Ministry of Aircraft Production relied mainly on a closely supervised body of private contractors. In addition, all the departments made use of a hybrid form of enterprise—the agency factory—wherein public ownership of factories, plant and machinery was combined with private management.

Industrial establishments owned and managed by the State formed a large part of the total industrial capacity engaged on munitions, but their relative importance varied from department to department. In naval work public ownership was largely confined to naval dockyards and to a few Admiralty factories. Naval dockyards, however, specialised in repair and altogether represented a relatively small proportion of the industrial effort devoted to naval

work. The Admiralty factories were also few and, measured by the numbers employed, did not account for a large share of the work done under the ægis of the Admiralty. In June 1945 some 35,700 workers were employed in naval dockyards and some 70,000 on engineering, explosives and chemical work in other Admiralty establishments, compared with a total of 667,700 workers employed on Admiralty orders.[1] In the industrial effort administered by the War Office, and later the Ministry of Supply, public ownership and management played a very important part indeed. At the peak of the industrial effort there were forty-three[2] Royal Ordnance Factories employing over 300,000 people, very nearly twenty per cent. of the total number which at that time it was estimated were employed on Ministry of Supply contracts. And it will be shown presently that in certain respects the contribution of the Royal Ordnance Factories to the war effort as a whole transcended the limits defined by their direct share in the total employment and output.

Long before 1914 the Royal Ordnance Factories had become a part of the War Office tradition. In the inter-war period the growth of political opinion opposed to the private manufacture of arms may have induced the War Office to assign to Royal Ordnance Factories a greater part in future plans than they might otherwise have occupied. In this way, tradition and the political climate favoured the full expansion of the Royal Ordnance Factory system. But, in addition, this trend coincided with what the War Office considered were the technical and economic requirements of weapon production.

A technical requirement which favoured the employment of Royal Ordnance Factories was the need for large new factories to produce highly-specialised munitions. The older Royal Ordnance Factories had the technical knowledge essential to the planning and management of factories for the manufacture of explosives, small arms and small arms ammunition. Armament firms also had specialised technical knowledge and were in many respects complementary to the Royal Ordnance Factories. But in some fields the technical resources of the Royal Ordnance Factories were greater than those of the private armament firms. Royal Ordnance Factories alone had the experience and personnel required for the planning and management of new filling factories; and this was a further reason why until 1940 all the new factories for the filling of shell ammunition were Royal Ordnance Factories. In 1940 it became difficult to draw

[1] Of this total, 252,300 were employed in shipbuilding and ship-repairing—148,400 on naval vessels (35,700 in naval dockyards and 112,700 in private yards of whom approximately 40,000 were engaged on repairs, etc.) and 103,900 on merchant vessels. See *Statistical Digest of the War* in this series, Tables 19 and 21.

[2] This figure excludes one former Royal Ordnance Factory which at this stage of the war was being operated as an agency factory.

further managerial resources from the Royal Ordnance Factory organisation, and certain selected industrial firms were invited to manage some of the smaller of the new filling factories. This break with tradition and policy was reluctantly accepted by the War Cabinet.

Underlying the War Office policy of developing a large network of Royal Ordnance Factories was also a general principle of industrial policy. It has already been noted that in deciding the distribution of orders between Royal Ordnance Factories and private industry, the War Office and the Ministry of Supply were at times guided by a classification of munitions according to their affinity to civilian goods.[1] Munitions which, either in design or method of production, bore no recognisable relation to marketable civilian commodities were as a rule considered to be unsuitable for private industry and were earmarked for 'specialist' factories, i.e. for the factories of the surviving armament firms and, above all, for the Royal Ordnance Factories. The filling of ammunition was thus thought to be a 'Royal Ordnance Factory job' *par excellence*; the making of most weapons, i.e. the final manufacture of gun barrels and mechanisms and of small arms of traditional types, was also thought to be best suited to the Royal Ordnance Factories and armament factories specially equipped for this work.

As we have seen earlier,[2] 'outside' firms were gradually, but in the end extensively, introduced into the manufacture of guns and carriages, shells and fuses. Nevertheless, new Royal Ordnance Factories were constructed for all these stores: for guns and carriages no less than ten new factories were provided. The 'outside' firms introduced to this work took the place of the extensions which otherwise might have been added to private armament firms; they did not replace the Royal Ordnance Factories. The latter played an essential role in this field in spite of the introduction of 'outside' firms and the role was greater in the second half of the war than at any previous period.

This line of division between private industry and Royal Ordnance Factories did not remain sharply drawn throughout the war. It has already been shown[3] how necessity compelled government departments to engage 'outside' firms to make weapons which had previously been assigned mainly to the Royal Ordnance Factories and to the armament firms. On the other hand, the production of at least one highly-important weapon had to be shifted across the line of demarcation in the opposite direction. Throughout the years of rearmament and for the greater part of the war, officials at the War Office and the Ministry of Supply assumed that the special features

[1] See p. 397.
[2] See pp. 399–400.
[3] *Ibid.*

of the tank made it suitable for production either by motor firms or by firms with experience in the construction of locomotives and railway carriages. The former, it was thought, would bring to the design and construction of tanks their experience of internal combustion engines and their understanding of gear-boxes and transmission systems; the latter would have the necessary equipment and experience in the assembly of large vehicles made of very heavy metal components. In consequence, the capacity for tank production was from 1936 until 1944 expanded almost entirely by the introduction of 'outside' firms. Vickers-Armstrongs, with its unbroken tradition in the construction of tanks, continued to play an important part in both design and production up to 1940, but after Dunkirk its activities were almost entirely confined to the production of the Valentine. The Royal Arsenal, Woolwich, which had some part in the development of the pre-war tanks, had ceased producing tracked vehicles in the rearmament period. No Royal Ordnance Factory was given any part in the output of tanks ordered during the first few years of war.

This distribution of responsibilities had to be revised in the last two years of the war. It was not that the 'outside' firms failed in the making of tanks. Considering how new they were to the job and how hastily the preparatory work of design and development had to be done, Vauxhall's experience with the Churchill tank proved more creditable to the firm, and the tank itself proved more of a 'success', than critics in 1942 appeared to think possible. Similarly by 1943 two further offspring of the cruiser tank design, the Cromwell and the Comet, emerged from their teething troubles with some credit to their manufacturers. Nevertheless, the protracted and painful difficulties of tank design and tank production throughout the first three or four years of the war demonstrated that both the motor industry and the heavy locomotive firms had everything to learn about tank production. This proved to be a highly-specialised industrial art without parallel in peace-time industry and without any special affinity with any branch of civilian engineering. On the other hand, Royal Ordnance Factories, especially some of the well-equipped heavy engineering shops in the Royal Ordnance Gun Factories, had carried out engineering assignments so varied and so difficult that there seemed to be no reason why they should not be entrusted with the making of tanks. In 1943 they were, in fact, asked to convert the American Sherman tanks to the requirements of the British Army. This necessitated the replacement of the American gun by the British 17-pounder and a thorough reconstruction and re-equipment of the turret. At about the same time a minister—troubled as he must have been at the delays in the production of tanks—was heard to express his surprise that the Royal Ordnance Factories had not been given the job of making tanks. This they were to be given before

long. In 1944 a Royal Ordnance Factory which had been employed on gun production was converted for the manufacture of the Centurion, the latest version of the infantry-cruiser tank to take the field in the war.

The remark attributed to the minister bore witness to the blurring of the demarcation between the functions of Royal Ordnance Factories and private industry. It also reflected his knowledge that the Royal Ordnance Factories were expected to play a role not evident in the original demarcation. This was essentially the role of a pioneering and emergency service. The pioneering part was inherent in the peace-time organisation of the three old-established ordnance factories: the Royal Arsenal, Woolwich, the Royal Small Arms Factory, Enfield Lock, and the Royal Gunpowder Factory, Waltham. They were so organised and staffed as to be able to act as 'parents' to the newer Royal Ordnance Factories. The Chief Mechanical Engineer at Woolwich was in charge of the design of buildings and of the layout of the new Filling and Engineering Ordnance Factories. The managers of the new Royal Ordnance Factories were frequently recruited from the personnel of Woolwich and of the other two old-established Royal Ordnance Factories; and it was from these factories that there came the nucleus of skilled labour which was to form the backbone of almost every Royal Ordnance Factory in war-time. The manufacturing processes in the new Royal Ordnance Factories were, to begin with, based on the practices at the Royal Arsenal, Woolwich, and the Royal Small Arms Factory, Enfield. The part which the Royal Gunpowder Factory, Waltham, played in setting up the new explosives factories has already been indicated.[1] The three old-established Royal Ordnance Factories also acted as research and development workshops in collaboration with the various research and design organisations of the War Office and the Ministry of Supply. It was in the Royal Ordnance Factories that the prototypes of most of the field and anti-tank guns were first manufactured and developed. The Royal Small Arms Factory, Enfield, did the necessary development work and adaptation of the Bren, the Sten and the Polsten guns. Technicians from Waltham, together with their opposite numbers at government research departments, were responsible for a very large part of the development of explosives and propellants throughout the years of rearmament and war and also for the development of the manufacturing processes.[2] At Woolwich several new special machines for the making of munitions were designed. It was Woolwich engineers who travelled to Switzerland to investigate the equipment required for the making of automatic fuses; and it was engineers from Woolwich who developed and

[1] See p. 177.

[2] For the part played in this by I.C.I. see p. 399.

perfected many of the methods for mass-production of small arms ammunition and evolved the blue-prints for much of the highly mechanised and largely automatic plant which was to operate so successfully during the war.

Some of this pioneering function was later taken over from the three oldest factories by their younger offspring. Throughout the war the Royal Ordnance Engineering Factories were looked to for leadership, assistance and advice. They frequently assumed the duty of making the first batches of new weapons and of carrying the main responsibility for production until most of its initial problems were solved. Needless to say, the specialised armament firms in private ownership performed similar functions in the production of a number of weapons. Elsewhere mention has been made of the part which Vickers-Armstrongs played in the design, development and production of the 'Valentine' tank and of the Vickers' machine gun.[1] They were also responsible for the design and development of the 3·7-inch and 4·5-inch anti-aircraft guns. Emphasis has also been laid on the part which B.S.A. played in the initial production of several types of small arms, and on the part which even such a new armament firm as the British Manufacture and Research Company played in the introduction of the Hispano Suiza gun.[2] It nevertheless remains true that in most war-like stores, with the notable exception of the tank, the role assigned to the Royal Ordnance Factories was that of first starter. And as the war developed, the Royal Ordnance Factories were called upon to provide what to all intents and purposes was an emergency service. The production directorates in the Ministry of Supply turned to them on the very frequent occasions when a critical component was urgently needed and could not be made in time anywhere else. Several private firms could similarly be called to the rescue, but more often it was the Royal Ordnance Factories that shouldered the main burden of industrial first-aid.

It is difficult to say whether or not special demands were made on the Royal Ordnance Factories merely because they happened to be owned by the nation and were subject to the authority of the Ministry of Supply. These factories were not given over wholly to production for War Office requirements; production for all the Services was an essential part of their tradition and policy. They undertook the filling of ammunition and the supply of explosives to meet Air Ministry and Admiralty requirements; they supplied all the Services with small arms ammunition and to some degree with small arms; an important part of the Admiralty's supply of guns came from Woolwich and other Royal Ordnance Gun Factories. On the other hand, the administration of the factories was entirely under the Ministry of Supply as

[1] See pp. 188, 400 and 426.

[2] See p. 400.

previously under the War Office; and their administrative links with the Ministry were very close. The Director General of Ordnance Factories and the largely autonomous organisation of the Royal Filling Factories were housed at the Ministry's headquarters in Adelphi. They formed part of the department of the Controller General of Munitions Production[1] and their daily contact with the secretariat and the production directors of the Ministry was bound to be more constant and more intimate than that between the Ministry and private firms. They were also directly served by certain branches of the Ministry secretariat, more especially its labour branch. In general, their dealings with the Ministry were influenced by an assumption, seldom put into words, that the Royal Ordnance Factory organisation was the Ministry's 'own show' and could therefore be required to respond more quickly and more spontaneously to its urgent demands.

This assumption was, of course, at variance with the official doctrine about the position and organisation of Royal Ordnance Factories. According to that doctrine they were contractors to the Ministry in most respects similar to other contractors. They received orders for munitions on conditions similar to the contracts with private firms. They obtained their raw materials and labour on the same terms as the rest of the munitions industry and were subjected to the same system of allocations and controls. They were also expected to manage their enterprises in the same manner as ordinary industrial undertakings and, above all, to pay their way. When the production of certain munitions happened to be shared and run by a group of manufacturers including the Royal Ordnance Factories, the Royal Ordnance Factories were, in the eyes of the Ministry, in the same position as the other members of the group, even if they happened to play the part of mentors and pioneers.

The doctrine of Royal Ordnance Factories being firms like other firms applied also to the internal organisation and administration of individual Royal Ordnance Factories. Indeed, it is difficult to see how it would have been possible to run the Royal Ordnance Factories as efficient industrial establishments without adhering to the ordinary principles of factory management. There was, and could be, little difference in the nature of the production problems which confronted the managers of the Royal Ordnance Factories and those of private factories. Labour intake, assessment of wage rates, relations with trade unions and shop stewards, were labour problems common to war industry as a whole; just as the break-up of machining tasks into operations, the progressing of production, the management of stores and stocks, the supply of tools and the relations with sub-contractors, were 'shop-floor' problems common to all the factories in the country.

[1] See p. 140.

They had to be tackled and solved by more or less the same methods in both ordnance factories and private firms.

Yet some slight differences between publicly-owned Royal Ordnance Factories and privately-owned industrial concerns were to be noted even here. The superintendents of Royal Ordnance Factories were, compared with the managers of private firms, lowly-paid civil servants. The size of the salaries and economic considerations in general may have influenced the behaviour of the British managerial class during the war far less than in peace-time. Yet the fact remains that the smaller earnings of the superintendents did not pass wholly unheeded. Complaints were few, but comments were frequent.

Moreover, in some other respects as well the position of the superintendents compared unfavourably with that of managers in private firms. The division of functions between the factories and headquarters was a matter of considerable difficulty, and there appeared to be some justification for the conclusion that the functions of the superintendents were unduly restricted.[1] Some important functions, including financial administration and labour management, were not under the direct control of the superintendents. In addition, there was an increasing number of ancillary services, e.g. hostels and canteens, which were directly subject to specialist directors at headquarters. If, in practice, these arrangements did little to impinge on the administrative authority of the superintendents or to impair the efficiency of the factories, that was due more to the good sense of individuals than to the efficiency and logic of the system.

In general, Royal Ordnance Factories had by the second or third year of the war become surprisingly efficient—surprisingly, because they were new enterprises employing mainly 'green' labour. In peace-time the older Royal Ordnance Factories, and more especially Woolwich, had the reputation of producing high quality goods at very high cost. When on a certain occasion after the first World War the Royal Ordnance Factory, Woolwich, made a batch of locomotives, it was soon discovered that while the standards of precision and finish of the Woolwich products were somewhat superior to those accepted by commercial makers,[2] the costs were also very much higher. But then Woolwich was to a large extent an establishment for development and experiment, and carried an unusually high proportion of skilled cadres. Its system was not intended for normal quantity production; hence both the quality and the cost of the locomotives it produced in peace-time. The newer Ordnance Factories, on the other hand, were from the start intended for quantity production and

[1] See *Select Committee on National Expenditure*, Session 1941–42, Eleventh Report, dated 16th July 1942, para. 60.

[2] In fact the precision appears to have been too great for the locomotives to be serviceable in normal conditions of commercial operation.

were nearer than Woolwich, both in equipment and in the composition of their labour force, to the new extensions and factories set up and run by private firms. It is, therefore, not surprising that the efficiency of individual Royal Ordnance Factories, like that of individual private firms, depended much more on a combination of local circumstances than on the more general advantages or disadvantages of the Royal Ordnance Factory system as a whole.

Local circumstances were mostly in favour of the Royal Ordnance Factories. Their buildings were as a rule new and good; those planned in the early years of rearmament, particularly the Royal Ordnance Filling Factory at Chorley, were built and equipped in a manner which critics sometimes described as 'palatial'. The bulk of their equipment was, as a rule, highly specialised and integrated, and this in itself was a great advantage in comparison with many private firms. One or two Royal Ordnance Engineering Factories were equipped as 'general' workshops, but the quality of their equipment compared very favourably with that for industry as a whole. Superintendents were for the most part competent and energetic. There is therefore little cause for surprise that most Royal Ordnance Factories should have proved at least as efficient as the private firms producing comparable types of munitions. The Royal Ordnance Factories whose superintendents happened to be men of ingenuity and resource or young men of the highest technical competence stood out from among the rest of the industrial undertakings in war industry as models of economic and progressive management. When, on the other hand, a superintendent failed to 'hit it off' with his subordinates and workers, and was, in spite of his devotion, old-fashioned in his methods, the general efficiency of the factory was no higher than that of similarly managed private firms. Now and again a whole group of Royal Ordnance Factories was able to make striking advances in the efficiency of production. Something has already been said about the great progress made by the Royal Ordnance Filling Factories in the later part of 1941 and 1942.[1] That their output rose by at least forty per cent. above their initial rates of production may, of course, be explained by the low rates of initial output. Nevertheless, the fact remains that the Filling Factories were among the relatively few industrial undertakings in the country to introduce three-shift working and the various modern devices of scientific management, such as statistical quality controls and 'time and motion' studies.

Paradoxically enough this success may in large part have been greatly helped by the 'green' character of their labour and the novel character of their work. Trade-union rules and customs of the trade had little time to solidify into a rigid system. But it is also possible that public ownership was of some assistance. Labour relations do not

[1] See pp. 178–181.

form part of this study and will be dealt with in a separate volume,[1] but it is impossible to leave the subject of the Royal Ordnance Factories without putting on record the conviction of some superintendents that they were helped in their negotiations by being able to claim that private profit would not accrue from greater exertions of their workpeople. It may well be that the argument itself had little substance; that opportunities for profit in private industry were very limited; that workers in both Ordnance Factories and private firms were mainly concerned with the size of their pay packets and conditions of work. Yet if the claim helped, however slightly, to ease the relations between managers and workers, public ownership gave Royal Ordnance Factories an advantage over private industry.

By no means all the features of the Royal Ordnance Factories were to be found in the Royal Dockyards. Their problems of labour intake and labour relations were no different from those of the Royal Ordnance Engineering Factories and their managers were also moderately paid civil servants, subject to civil service rules and procedures. The Royal Dockyards, like the R.O.F.s, served as nurseries of technical personnel. They supplied staffs to the Admiralty design departments, and, above all, the various 'overseeing' services, including the Emergency Repair Overseers organisation, were recruited almost entirely from the Royal Dockyards. But here the similarity probably ended. The Royal Dockyards were old establishments and not, like most of the Royal Ordnance Factories, new creations managed and staffed by new people; nor were they, like the old Royal Ordnance Factories, compelled to 'bud off' into numerous filial establishments into which the bulk of their skilled cadres had to be transferred. In general, it is also difficult to draw parallels between the Royal Dockyards and private shipbuilders. The former seldom engaged in the building of new vessels and did not very often compete with privately-owned yards in comparable tasks.[2]

Equally unlike the Royal Ordnance Factories were the hybrid concerns already mentioned, i.e. the agency factories. The principle on which they operated was roughly similar to that of the National Factories of the first World War. Their buildings, plant and machinery were supplied by the Government, but private firms were invited to manage them for a fee. This was an obvious expedient for utilising the management and other resources of private firms, and it had been adopted at the height of the industrial effort of the first World War. Some such arrangement was therefore bound to be tried

[1] The forthcoming volume in this series on Labour in Munitions Industries. (See also p. 217n.)

[2] In peace-time the Royal Dockyards frequently had a vessel building in order to maintain the technique of naval constructors and to check costs.

during the years of rearmament. The additional reasons which prompted its adoption then were, to a large extent, connected with the financing of extensions to private firms. The difficulties and complications of government subventions to privately-owned factories were very considerable. In the summer of 1936 a sub-committee of the Treasury on contract procedure came to the conclusion that when completely new factories were being set up the balance of advantage lay in the Government paying the entire cost and acquiring ownership. Departments were accordingly instructed to do so whenever practicable and to make arrangements with private firms to operate the factories for a fee whenever direct management by the State was impossible or inadvisable.

This method appeared to commend itself from the very outset to the Air Ministry, though their reasons were not quite those of the Treasury. As part of the 'shadow' scheme of 1936 the Air Ministry tried to enlist a number of 'outside' firms, mostly those in the motor industry; and safeguards against the risks of redundant capital were thought to offer additional inducement. Hence the agency agreements which the Air Ministry made in 1936 for the construction of several new airframe and aero-engine 'shadow' factories to be operated by the motor industry. Similar arrangements were also adopted by the War Office from 1937, mainly for new explosives and chemical factories built at government expense but managed by I.C.I.

From 1938 the principle of agency factories was adopted for a wide range of munitions, and by early 1940 a large number of such factories had been approved. At the outbreak of war a number of agency factories were already making a vital contribution to war supplies, but they were as yet apt to be regarded as a not altogether satisfactory compromise. In 1940 the Air Ministry, which by then had established agency factories for a wide range of products, reported strongly against them to the Interdepartmental Committee on Economic Policy. The system, it argued, failed on the ground of efficiency mainly because the remuneration which it offered to firms did not provide a sufficient reward for economical and energetic management. Above all, it removed the fear of loss as a penalty for inefficient management. The Committee accordingly recommended that agency operation should be resorted to only where unavoidable.

The attitude of the Air Ministry and the consequent recommendation of the Interdepartmental Committee proved somewhat theoretical. Reporting as they did early in the war the officials of the Ministry could not perhaps foresee how little purely financial inducements and fear of loss would operate in war industry. They also underestimated the extent to which in time of war managerial exertions would be prompted by a sense of duty and national service.

Indeed, while making their recommendation the Economic Policy Committee themselves admitted that in some agency factories production costs had been lower than in a number of commercial undertakings engaged in comparable work; they were unable to cite any evidence of an agency factory with higher costs or lower efficiency than the average commercial undertaking. The Committee's recommendation was not in fact followed. As the war progressed the number of firms which had to be asked to undertake work in which they had little or no commercial interest grew rather than diminished, and the new work thrust upon them sometimes required the building of wholly new factories or self-contained extensions. Agency arrangements were an obvious solution of the problem and their numbers steadily grew. At 31st March 1945 the Ministry of Supply had 159 agency factories in operation, the Ministry of Aircraft Production eighty-seven, and the Admiralty nineteen.

(2)

Private Ownership and Control

It goes without saying that industrial establishments owned and managed by the State did not represent the bulk of industrial capacity engaged on the manufacture of munitions. Measured by their employment at peak, State enterprises and agency factories, including Royal Dockyards and Admiralty factories but excluding the various research establishments and their workshops, accounted for rather less than a quarter of war industry as a whole. The remainder represented undertakings managed and owned (or partly owned) by private firms or individuals.

The private 'sector' was thus very large, but the extent to which it was wholly private must not be exaggerated. Under the conditions of war, when firms did not compete for orders and were all but safeguarded from loss, private enterprise could not be expected to function in the competitive and adventurous manner of the 'representative firm' under the ideal conditions of *laissez faire*. Decisions of individual managements could no longer be as independent and autonomous as in peace. At the same time the responsibilities of the State for the affairs of private firms grew to the same extent to which the independence of private firms declined.

The extent of Government authority and supervision varied according to circumstances, and in general it was not the same in the three supply departments. Government authority was perhaps felt

most in the aircraft industry, even though the Air Ministry and M.A.P. did not found or manage any State factories. Suggestions for the founding of a State aircraft factory came to the Secretary of State for Air on a number of occasions during the rearmament period, and were carefully considered. But the settled opinion in the Ministry was that the disadvantages of State factories would outweigh their advantages. The argument against State factories was that they would take a long time to get going; that once they were in operation they would be difficult to close down. The National Aircraft Factories of the first World War,[1] even though they were managed by private firms, were mentioned in this connection, though it is doubtful whether the Air Ministry was much moved by arguments from historical evidence.

State ownership of aircraft factories had, of course, its political and psychological attractions. In November 1938 they were formulated in the House of Commons[2] by a Conservative member—Col. Moore-Brabazon, who was later to be Minister of Aircraft Production —and were often in the minds of the Public Accounts Committee. To this the Air Ministry's answer was that its control of prices and profits was a sufficient remedy against political and economic drawbacks of private enterprise.

Whatever the Air Ministry argument, its chief motive was the desire to keep alive in peace-time a large aircraft industry, and more especially to maintain in being the industry's facilities for design and development. The Air Ministry and the Air Staff were convinced that, however large the State-owned aircraft industry, the design and output of aircraft in war would still largely depend on the resources of private firms. It therefore seemed to them very necessary to sustain in peace a large and viable aircraft industry capable of shouldering the main tasks of aircraft design and production in war.

Hence, not only the Air Ministry's insistence on the need for giving contracts to private industry, but also the special relations which it established with firms it fostered and protected. Enough has already been said about 'family firms' in other parts of this book to make reiteration here unnecessary. What is important to note here is that the relations of the firms to the Ministry were so close as to make ordinary distinctions between private and public enterprise out of place.

Throughout the pre-war years the sixteen aircraft firms and four engine firms composing the 'family' enjoyed preferential treatment. The diet of regular orders, lean as it was, had to be reserved for them; their design offices were sustained by projects, some of which had no

[1] For an account of these, see H. A. Jones, *The War in the Air* (Clarendon Press, 1937), Vol. VI, Chapter II.

[2] H. of C. Deb., Vol. 341, Col. 1161, 17th November, 1938.

other purpose than to keep the designing staffs busy or to attract the attention of designers to certain problems in which the Ministry was interested. At the same time 'outsiders' were kept out of the circle of designing firms even though throughout the rearmament period they were welcomed as sub-contractors and were recruited for the 'shadow' schemes. In spite of the limited scope of aircraft business before 1936 attempts to enter it were made. In the early stages of expansion, pressure from 'outside' firms led to a certain amount of agitation, and once, in December 1936, it formed the subject of a debate in the House of Lords.[1] On that occasion a firm, Airspeed, succeeded in penetrating the Ministry's defences and established itself on the 'fringe' of the family group. It was even seriously considered for a design for the Fleet Air Arm. Other 'fringe' firms, such as General Aircraft, Folland Aircraft and Cunliffe Owen Aircraft, which repeatedly tried to have their designs considered, were for a long time kept out, however strongly their claims were pressed.

It was only in the later stages of the war that M.A.P. began to contemplate admitting to the 'family' of designing firms such newcomers as English Electric, but even then the proposals were not to break the circle, but merely to enlarge it. By that time, however, the 'family' had lost some of its exclusiveness, for M.A.P. had established links almost equally intimate with a number of firms outside the original 'family'. Yet even then the circle remained much narrower than the miscellaneous body of contractors and sub-contractors working for the Ministry.

Within the circle continuous attention was given to ensuring intimate relations with the Ministry by administrative contacts. The practice of installing Resident Technical Officers in the designing firms had been initiated long before the opening of the rearmament period. When, in the war, the system was extended to aero-engine and armament firms, their number rose to over fifty. Their main concern was with design and development, but their functions in the field were very wide. In the words of an M.A.P. report, the Resident Technical Officers were expected

> to give general guidance to the firm in the application of technical policy arising out of current research and development work, to take an active interest in maintaining the standards and improving the quality of the firm's business and to see that the 'daughter' firms, sub-contractors and repair firms receive the technical assistance they need from the 'parent' firm.

The Resident Technical Officer was by no means the only representative of the Ministry at contractors' works. A considerable number of the larger firms housed both an Overseer and an Aircraft

[1] H. of L. Deb., Vol. 103, Cols. 974–1004, 17th December 1936.

Production Officer. The Overseer was generally a senior R.A.F. officer, and while he had a special responsibility for maintaining close contact, through the Commands, with Service units, and for acting as the representative of the user, he was also the principal representative of M.A.P. headquarters, to whom the firm was entitled to refer all questions requiring immediate decision and to look for advice and assistance in every way possible. In general, the Ministry gave him plenipotentiary powers for use in an emergency. The Aircraft Production Officer did not possess the same senior status, but he was in a position to observe the course of manufacture at close quarters and often possessed an intimate knowledge of the problems, achievements and prospects of output in the factory to which he was attached. He was to prove an effective medium for transmitting to the firms the constant pressure for better production which M.A.P. tried to exercise throughout the war.

So much for the Ministry's representatives with the firms. Important as their role was it supplied only one of the many links between Government and the aircraft industry. In the field of design and development the M.A.P. establishments, and particularly the Royal Aircraft Establishment and the Aeroplane and Armament Experimental Establishment, played important roles in assisting the designers in the firms. In general it was their policy to 'wait to be asked'; but they seldom waited for long. In their special fields they were unique repositories of technical knowledge; they seldom dealt with issues in which headquarters might attempt to exercise pressure or authority; their relations with firms were therefore pervaded by an agreeable atmosphere of collaboration between experts.

On the production side individual directorates of M.A.P. were so organised that the affairs of each main aircraft factory were looked after by a special branch in a directorate under an Assistant Director. These Assistant Directors were in daily contact with 'their' firms, regularly visited them and were regularly 'posted' about their activities and problems. They were expected to watch the flow of production, to learn in advance of growing difficulties and threatening 'bottlenecks'. This often enabled them to act as the firm's unofficial progressing officers engaged in chasing scarce components and supplies. These services were, as a rule, readily received. Even firms which were officially distrustful of government interference were receptive enough of suggestions from personally acceptable officials. Many a small firm was saved from chaos by the devoted nursing of individual officials; many new officials learned their jobs from the practical experience of the first firms they dealt with.

On their part, the representatives of the firms kept in close touch with the Ministry of Aircraft Production. Members of their design staffs were in constant attendance at the technical branches of

M.A.P., bringing suggestions about future modifications and designs, receiving indications of future trends of official requirements and specifications. So intimate were these contacts that an historian of aircraft will find it impossible to allocate with certainty the initiative for most of the successful designs of aircraft which matured during the war.

This does not, however, mean that M.A.P. consistently tried to insinuate itself into the managerial functions of aircraft firms. When firms appeared to the Ministry to be so inefficient as to endanger the war effort the Minister, under his war-time powers, could appoint 'administrators' and even take over the ownership of the firm. The only occasion when these powers were exercised to set aside a board of directors was in March 1943 when M.A.P. took over the ownership and official responsibility for the conduct of a firm. In several other instances the administrators appointed by the Ministry conducted the affairs of the firms without changing their ownership or permanent control. A somewhat different act of intervention occurred at the end of 1942, when the Ministry, in its anxiety for the future of the Sabre engine, encouraged the transfer of the aero-engine business of D. Napier & Son to the English Electric Company. These, however, were exceptional instances, neither preceded nor followed by a fundamental change of policy.

Official suggestions when they were made to the firms were made tactfully, even if firmly. The Director of Materials Production might convey to the firms the desirability of replacing scarce types of materials by those more readily available; the suggestion from a production directorate that manufacturers might use rubber dies which had been successful elsewhere was the kind of advice which they could much more easily refuse to accept. The attempt to standardise components was carried forward with some deference to current beliefs and even prejudices; the reduction and systematisation of modifications, being more clearly the Ministry's business, was more firmly handled. And in addition to the advice which production directorates offered to firms in the course of their day-to-day work, the Production Efficiency Board[1] of the Ministry was from 1943 onwards ready to help wherever it could.

In all these activities the Ministry kept clear of anything that might be construed as direct intervention into the managerial independence of firms. In general, it did little to supervise or to direct the methods of production in the factories of its contractors. Had it tried to do so it would probably have been rebuffed by its contractors, and for the greater part of the war it seldom tried. True enough, at an earlier stage in the history of aircraft production, i.e. during the rapid expansion in 1938, attempts had been made to prepare for

[1] See p. 315.

a reorganisation of the aircraft industry on more rational lines.[1] The attempts, however, had been given up in the course of 1939 and were not resumed again.

The relations between the Ministry of Supply and its private contractors may have been somewhat less intimate than those between the aircraft firms and the Air Ministry or M.A.P. The War Office, and later the Ministry of Supply, developed furthest the use of State-managed factories and could, at least in theory, afford to concern themselves less with the affairs of their private contractors. In theory, the principle by which the R.O.F.s were entrusted with munitions, which civilian firms could not be expected to manufacture, made it less necessary to watch over the behaviour of civilian firms.

For this, the choice of the Ministry's contractors was partly responsible. Among them a prominent part was played by a small number of professional makers of armaments, mainly Vickers-Armstrongs and B.S.A. These were highly experienced specialists who did not require much close guidance from government departments. For the rest, the main body of contractors largely consisted of firms which, unlike the aircraft firms and the makers of the main aircraft components, combined their work for the Ministry of Supply with other contracts. Most of them had not in the past done much work for government departments and continued to produce for the civilian market long after they had received their first contracts under the rearmament schemes. Many of them still worked for more than one supply department even after they had been wholly absorbed into war production. It would have been very difficult and even impossible for the production directorates of the Ministry of Supply to keep a close check upon the way in which these contractors employed their resources or to try to influence the conduct of their business. When a firm in accepting a contract had to ask for additional machine tools, its need would be scrutinised in the production branch and in the machine-tool department of the Ministry of Supply before the request was passed on to the Machine-Tool Control; when the firm required additional capital this would also be subjected to a careful scrutiny by the production directorates, the finance branches of the Ministry and eventually by the Treasury; and some firms were also given advice and instruction in the initial stages of production. But once they had obtained their additional capital and had passed the initial stages of production, occasions for checks and supervision seldom presented themselves.

This difference between the private contractors of the Ministry of Supply and those of M.A.P. was, however, one of degree and must

[1] See pp. 21–22.

not be exaggerated. Above all, it must not be allowed to obscure the real authority which the War Office and, later, the Ministry of Supply enjoyed in their relations with private firms. The authority was largely rooted in the technical assistance which their officers had to give the private contractors. In the pre-war period the War Office organisation contained technical branches which functioned as repositories of specialised thought and information about the design and production of weapons. They played a very important part in the initial planning of munitions production and exercised great technical authority in the later contacts with industry.

The technical authority of the War Office and later of the Ministry of Supply in their dealings with private firms expressed itself in many ways. The War Office production manuals were no less important than their more widely-known military manuals in the armed Service. Throughout the rearmament period and the early war years, methods of production and special machines were developed for many types of specialised munitions.[1] With the introduction of 'outside' firms important contributions to technical development came from a wide range of firms, but as a rule, the technical staff in the departments could be relied upon to assist, and sometimes to guide, private firms in the solution of their technical problems.

Guidance of a more general character often came from the main seats of industrial administration in the War Office and the Ministry of Supply, i.e. their various production directorates. The purely administrative connections between the Ministry and its contractors were not perhaps as elaborate as in M.A.P. but they were not altogether lacking. In all branches of production for which the Ministry of Supply was responsible, a production officer representing the production directorate was within reach of every contractor. A system of resident production and design officers similar to that of M.A.P. was not adopted except for tanks, and even there the officers were usually resident only at the 'parent' firms. But manufacturers of tanks, like the manufacturers of most other stores, were served by area production officers, who were in direct and frequent contact with the firms and attended group meetings in their areas. On their part production directorates kept in touch with production at major contractors. Without attempting to prescribe any master plan of production, they played a very important part in working out the methods used for the making of specialised munitions. In many instances, their blueprints of production resulted in marked standardisation of methods; particularly where specialised plant had to be provided.

All these facilities for supervision did not, of course, add up to what is often meant by the term 'industrial control'. In the Ministry

[1] See pp. 401–03.

of Supply the words 'control of industry' were hardly ever uttered, and the substance of 'industrial control' was never consciously pursued. The firms needed technical assistance and guidance and received it; but the process was not that of prescription and injunction, but one of informal consultation. As a result of this co-operation private firms may have found themselves more dependent on the guidance of the department than is customary in relations of seller and buyer. But the dependence was accepted as part of the war and of industrial mobilisation; and on the whole it did not openly impinge on the autonomy of private management and on its sense of freedom.

The Admiralty's relations with its contractors were also very intimate. From some points of view they resembled M.A.P.'s relations with the aircraft industry, but they were of more ancient standing and were less concerned with private organisation for design and development. The costly nature of ships and their main equipment was reflected in the large size and small numbers of the Admiralty's main contractors. In ship construction itself, the Admiralty's interest, in 1935, was limited to about fourteen yards, known as 'naval yards'. But even the firms—and there were many—which supplied ancillary equipment had in many cases a long experience of naval work and of collaboration with the Admiralty. In general the chief feature of the Admiralty's relations both with the shipbuilding industry proper and with the 'inland' armament industry was their long historical continuity. Intimate contact with naval shipbuilders and the main armament firms was traditional, and naval requirements had in fact determined the very nature and shape of the industry which provided them. Thus, in the early twenties, there was much discussion in the Admiralty on the extent to which existing gun-mounting capacity should be kept in being, and it was well understood that it must rest with the Admiralty to find means, such as subsidies, of maintaining the capacity. In the event, Vickers was left alone in the field, and the part played by the firm in this field of design and production was such that in the inter-war years the phrase 'relations with industry' might be taken as meaning 'relations with Vickers'. In other branches of naval construction the field was wider, but not so wide as to destroy the intimate links between the Admiralty and its contractors.

The Admiralty's organisation for posting representatives in or near the works of its contractors had taken shape by the end of the first World War. Each of the Controller's departments, as a rule, maintained its own 'outport organisation', as it was called, and each 'outport organisation' followed the geographical layout of the industry with which it was concerned. The distribution of these industries differed widely, and the differences helped to bring out the

autonomous nature of the departmental organisations. In the inter-war period their duties were concerned with inspection rather than production, but as new production problems appeared with rearmament and war, their role underwent some change. By the outbreak of war there were about a dozen different kinds of officers, naval and civilian, representing the Admiralty locally at the works of its contractors. They ranged from Warship Production Superintendents and Principal Ship Overseers, who represented the Director of Naval Construction, to engineer officers, electrical engineers, gun-mounting overseers, and so on. The Admiralty did not maintain—as M.A.P. did—officers who were its plenipotentiaries at the works of particular contractors, but contacts with the most important firms were strengthened by other appointments. Thus, a Warship Production Superintendent was resident in each region and Engineer Overseers were resident with Vickers-Armstrongs and other firms engaged on large contracts for machinery.

Apart from placing this variety of overseers, organisers and advisers in local contact with its contractors, the Admiralty's guidance and assistance in production took the form of investigating production methods in its own establishments and passing on the results in one way or another to its contractors. Thus the work done in, for example, the Central Metallurgical Laboratory or other Admiralty development agencies proved useful in easing production problems. In 1943 there was set up at Rosyth an establishment which later came to be known as the Naval Construction Research Establishment, which devoted separate and specific attention to research in methods of construction.

In the field of naval design and development the picture was very different. The Admiralty, while keeping in closest touch with design and development in private firms, kept in its own hands general responsibility for the outlines and characteristics of naval vessels. A whole range of establishments worked to provide the shipyards and industry generally with the designs which they were to undertake: from the Admiralty Research Laboratory with its highly practical experience in the designing of ancillary equipment, such as electrical equipment, to the Admiralty Experiment Works, where the hull lines of new designs were determined on the model scale. In this respect the Admiralty system of liaison with its firms was, as has already been indicated, in many ways very different from that of M.A.P., whose main contractors were responsible not only for producing, but also for designing, both aircraft and engines.

In addition to all these contacts and controls, the supply departments possessed the technical and industrial links with private firms provided by the various services of inspection. In the Ministry of Supply, following the War Office practice, inspection of specialised

munitions was usually done at the manufacturers' works and frequently at several stages of manufacture. In consequence, all contractors, with the exception of the smallest, had at least one resident inspector, and at many firms there was a team of inspectors. It was an acknowledged fact that the inspectorates were well informed about the production methods of the firms. The contribution of senior members of the inspectorate to the efficiency of these methods was diverse and incalculable. It was only to be expected—and was also sanctioned by tradition—that inspection staffs at the War Office and the Admiralty should exercise considerable control over the contractor's technical standards; and from authority in technical standards it was but a short step to the consideration of methods of production.

At first sight the inspection of aircraft did not result in equally intimate contacts with private industry. The Ministry of Aircraft Production took over from the Air Ministry the Aeronautical Inspection Department, which had made its initial letters known throughout the whole aeronautical world. The A.I.D., which had severely strained itself by attempts at comprehensive inspection during the first World War, had, quite soon after its close, evolved a scheme of 'approved firms'. An 'approved firm'—whether manufacturing airframes, engines, materials, equipment or armament—was required itself to possess an efficient inspection organisation, and the aim of the A.I.D. became, so far as possible, one of inspecting the inspectors. The larger 'approved firms' had resident A.I.D. inspectors; smaller firms were 'visited' regularly. The principle of inspecting the inspectors, however, did not mean that the A.I.D. representatives were remote from the day-to-day affairs of the firms. Even though their influence on methods of production was indirect and somewhat remote, their authority on technical standards was great.

(3)

Prices, Profits and Assisted Investments

The differences here drawn between the private contractors to M.A.P., the Ministry of Supply and the Admiralty are, of course, true only as broad generalisations. It has already been pointed out that even among the contractors to M.A.P. the great majority were not members of the 'family'. Some of them, like the two main makers of undercarriages, might stand in as intimate a relationship

to M.A.P. as the main aircraft firms, but in general the miscellaneous contractors to the various supply departments were treated more or less alike. Many of them were in fact working for more than one supply department, and all of them were subject to more or less the same commercial regimen.

The fundamental fact in that regimen was the State's position as war industry's sole customer. Thereby the restraints and incentives of competitive marketing were removed. At the same time the State did not, and could not, exploit its monopolistic advantages as commercial buyers enjoying a similar position might have done. Prices were settled by contractual agreement, and had to be 'fair', i.e. sufficient to secure from loss the contractor who employed his resources with reasonable efficiency, while preventing inordinate profits.

This does not, of course, mean that prices lost all economic function. The most elementary incentives of private enterprise—the fear of loss and the hope of high profits—may have been removed. So must also have been the power of prices to guide the distribution of resources between alternative uses, since this was now to an increasing extent done by direct allocation of labour and materials. Yet carefully negotiated prices were still able to play a useful economic role in checking the wasteful use of resources. The preoccupation of the contract branches with prices and profits was to some extent political in inspiration and purpose. At a time when everybody was called upon to serve without regard to personal interest and convenience, and when sacrifices and discipline were urged on working people, the political pressure against conspicuous gain was very strong and had to be respected. But for all its political implications, the limitation of profits also served an economic purpose. It was not altogether true to say that the 100 per cent. Excess Profits Tax, added to income and super tax, was sufficient to deal with the economic evils of excessive profits. Wasteful use of resources could not be prevented by high taxation; it was if anything encouraged by taxation of profits, especially where munitions happened to be produced on the 'cost-plus' terms.[1] The economic evils of the 'cost-plus' terms were of course less when the profits allowed to the contractor were fixed and not calculated as a percentage of costs. Yet even in that form they contained no encouragement to economic production.

The undesirable features of 'cost-plus' prices were well understood in the contracts divisions of the supply departments, and it was the settled Government policy to invite competitive tenders wherever practicable, but in war conditions real competition and competitive

[1] The different types of contracts, methods of price-fixing, etc., will be dealt with more fully in the forthcoming volume in this series on Munitions Contracts and Finance, by W. Ashworth.

prices could not be easily secured. Other expedients had therefore to be adopted. One of them was that of 'maximum' prices, i.e. prices which must not be exceeded but could be reduced on price investigation; another was 'target' prices, i.e. prices prescribed in advance of production which were subject to adjustment on price investigation. Yet much as the departments disliked the 'cost-plus' terms they were sometimes inescapable. They often had to be allowed when production of a weapon was in its initial stages and the firms had no experience on which to base their quotations; or, again, when new or inexperienced firms had to be engaged. 'Cost-plus' charges even crept into contracts ostensibly drawn up on other terms.

The methods by which prices were settled and profits limited differed in detail from department to department, and the contracts divisions of the three supply departments also differed in the extent to which they tried to exorcise or succeeded in exorcising the evil of 'cost-plus'. But from the point of view of this study the inter-departmental differences in methods of settling prices are perhaps less significant than the relations between the Government and private firms which the fixing of prices helped to establish. For however much the departmental practices differed, they were all bound to make inroads into the autonomy and privacy of private enterprise. In most forms of price-fixing (whether 'maximum' prices, 'target' prices or 'cost-plus' prices) the firm's actual costs had to be 'ascertained'. This sometimes meant that the agents of the State had to be given access to the firm's books and accounts. Frequently it meant that costing officers could, stop-watch in hand, inspect, analyse and estimate a firm's methods of production and its use of labour and resources. Needless to say, the firms, or at least some of them, tried to preserve the privacy of their records from the eyes of the official investigators. Above all, there was a great reluctance to allow the data about costs to be used as evidence of the firm's technical efficiency or inefficiency. Firms were even more reluctant to see the technical information, disclosed for other purposes, used against them in costing their contracts. These fears as a rule proved unfounded, and the precautions unnecessary, but they all bring out how insecure and unprotected the privacy of business had become.

The settlement of prices and the limitation of profits were greatly complicated by yet another tie which had grown up between the Government and private firms, i.e. by the various schemes of capital assistance. The problem of financing the additions to the fixed capital of industry arose at the very beginning of rearmament. It was not that the additions required by industry were as yet so large as to be beyond the power of the capital market to supply through the ordinary machinery of capital issues. The main difficulty was not so

much the magnitude of the demand for new capital as the risks of eventual redundancy of investments. In general, during the greater part of the rearmament period firms were willing and able to provide additional fixed capital so long as they were reasonably sure of finding an economic use for it for a long enough period. When the Government announced in 1935 that it was its policy to treble the size of the R.A.F., some aircraft firms felt certain of being able to employ much additional capital equipment throughout its normal physical life, and raised in the subsequent four years from the capital market and from their suppliers a large volume of new capital.[1] Not all the firms in other sections of the munitions industry, not even the aircraft firms when faced with further expansions in 1936, could feel equally sure that the investments necessary for the fulfilment of the munitions contracts would not soon become redundant. They were therefore reluctant to accept contracts requiring much additional investment; and in order to overcome their reluctance the Government had to underwrite its potential losses.

The procedure by which the Government accepted the risks of redundancy was that of the 'capital clause' in aircraft contracts as standardised in the First McLintock Agreement of August 1936.[2] The capital clause of the agreement laid down that should the contractor find in the two years immediately after the 31st March 1939 that the capacity of his works extended to deal with Air Ministry's orders was in excess of what he required for the execution of his current orders it would be

> open to the contractor within the following twelve months to prefer a claim for compensation in respect of any loss which the contractor may sustain in the difference between the cost of the above mentioned capital assets written down by depreciation . . . and the market value of such assets at 31st March 1941.

Much use was made of the 'capital clause' in the Air Ministry even though it left the amount of compensation uncertain. By the end of 1939 the Air Ministry underwrote in this manner the risks of an investment slightly more than £8 millions. By that time, however, the 'capital clause' had already lost much of its effectiveness. In so far as the amount of compensation was reduced by the accumulated depreciation allowances, the purposes of the clause were largely nullified when the Inland Revenue authorities began to allow relief for exceptional depreciation wholly or mainly attributable to war conditions. Above all, the bulk of the investment which was now required

[1] Thirteen main firms in the industry chosen as a sample increased their assets during the expansion period by over £31 millions of which about £7 millions were represented by additional fixed assets and investment in subsidiary and associated companies.

[2] The occasion for this was the application of three aircraft firms for cover against risks of redundancy.

carried with it risks of a redundancy too great to be dealt with by any scheme which left open the exact amount and the date of compensation.[1] The sole remedy now was for the Government to provide the greater part or the whole of the capital.

The first occasion on which Government subvention to provide investment was asked for occurred as early as 1936. In May of that year two large associated firms asked the Admiralty and the War Office for a contribution to their capital expenditure. The firms were anxious not to be left at the end of the rearmament in the same situation which one of them had experienced at the end of the first World War, when it was brought to the verge of ruin by the weight of redundant plant on its hands. After prolonged negotiations a settlement was finally reached with one of the firms under which the Admiralty paid sixty per cent. of the cost of approved extensions; the firm retained ownership, but the Government was free from any obligation to compensate it for the eventual redundancy of the additional capacity. This was to be the prototype of one variant of capital assistance, the so-called 'contributory schemes', by which the Government contributed a proportion of the new investment, and the firms contributed their share and retained the ownership of the assets.

While the Admiralty was developing the contributory arrangements, the War Office and the Air Ministry concluded a number of agreements under which the Government shouldered the entire cost of extensions and retained ownership. It has been repeatedly stressed that the expansion of orders in the Admiralty both before the war and during the war was not as drastic as in other departments; most of its contracts were concluded with firms which had worked for the Admiralty in the past and already possessed considerable productive capacity suited for Admiralty orders. Additional plant was therefore likely to be so mingled with the firm's own plant as to make it very difficult for the Government to exercise over it an effective ownership. On the other hand, production of munitions for the Army entailed an ever-growing employment of firms which had no previous experience of munitions or special equipment for their manufacture and did not intend to stay in munitions production after the war. The additional equipment provided under these conditions could more easily be owned by a government department.

In fact where these conditions were absent the supply departments made use of 'contributory schemes'. This was the common way of financing additional investment of firms engaged in the manufacture of vehicles and in the provision of raw materials; both branches of war industry in which firms were doing the same kind of work as they

[1] In most cases the 'capital clause' valuation date was, by agreement, moved forward year by year and eventually into the post-war period, but the element of uncertainty was not thereby removed.

had done before the war and could be expected to resume after the war. The Ministry of Supply also found it expedient to make wide use of 'contributory schemes' to finance building construction, for buildings could more usefully be employed after the war than the specialised munition-making machines.

Summary of the Government's actual annual expenditure on fixed capital for war production, 1st April 1936–31st March 1945

TABLE 56 — £ millions

	Total	Admiralty	Air Ministry and M.A.P.[1]	War Office and Ministry of Supply
TOTAL *1936–45*	*1,029*	*89*	*384*	*556*
Private operation[2]	767	43	384	340
Government operation	262	46	—	216
1936–37				
Private operation	2	1	1	*
Government operation	2	1	—	1
1937–38				
Private operation	11	2	5	4
Government operation	8	2	—	6
1938–39				
Private operation	13	3	6	4
Government operation	15	3	—	12
1939–40				
Private operation	30	1	21	8
Government operation	23	3	—	20
1940–41				
Private operation	170	4	98	68
Government operation	78	8	—	70
1941–42				
Private operation	185	9	73	103
Government operation	70	9	—	61
1942–43				
Private operation	185	8	84	93
Government operation	38	6	—	32
1943–44				
Private operation	113	9	62	42
Government operation	16	7	—	9
1944–45				
Private operation	58	6	34	18
Government operation	12	7	—	5

[1] Expenditure on government operation was not separated in the accounts. It was small in amount, the total authorised up to 31st March 1944 being only £4 millions.

[2] Includes cost of construction and equipment of agency factories as well as cost of extensions and other building work and the supply of manufacturing equipment at commercial factories.

* Less than £500,000.

These distinctions were not, however, in any way permanent or fixed. By 1943 many contractors began to show a preference for 'contributory schemes'. The war appeared to be approaching its end and from the point of view of post-war prospects it often was good business to acquire capital assets by paying only a part of the cost even if rent was also to be paid for a year or two. But, for the same reasons, the departments showed themselves increasingly reluctant to enter into new agreements on these terms. The non-contributory schemes, i.e. those under which the Government paid the total cost of new capacity and retained ownership, remained the main source of the new long-term investment for war industry. They accounted for more than ninety per cent. of the total Government expenditure on plant and buildings for war production.

Altogether between 1st April 1936 and 31st March 1945 the three production departments invested over £1,029 millions on fixed capital for munitions industry. Of this total £767 millions was for production under private management, including about £250 millions for the construction and equipment of agency factories. The expenditure for the provision of fixed capital at the commercial establishments of private firms was thus at least £500 millions.

The movement of the Ministry of Supply's investments is interesting not only for its rise in volume but also for some other trends it exhibits. It will be noticed from the table that, whereas during the rearmament period and in the first year of the war, investment in the R.O.F.s represented the bulk of the Ministry's capital expenditure, investment in privately operated factories almost equalled that in Ordnance Factories in 1940–41 and exceeded it for each of the later years of the war. This is mainly a reflection on financial activity of the general trend discussed elsewhere,[1] i.e. of the greater preoccupation with the building-up of a specialised capacity in the early years and of the growing importance during the war of 'outside' firms which had not been available for armament work in the pre-war period.

The Government was also called upon to provide industry with its working capital. Participation in the financing of current expenses of industry was gradual and on the whole reluctant. In the years of rearmament and in the early years of the war the Treasury held that it was not the business of the Government to act as industry's banker. Firms were enjoined to find their own working capital by the various means open to them, i.e. either by raising funds from the capital market, or (the more usual manner) by bank credits. Circumstances were, however, making it increasingly difficult for industry to adhere

[1] See pp. 397–404.

to these orthodox methods of industrial finance. Government orders had to be placed with firms selected for their ability to make munitions and not necessarily for their standing with their banks. Some of the contractors playing an important part in munitions production were not 'credit-worthy' with their banks to the full extent of their commitments under their munitions contracts. Even firms of the highest commercial standing found themselves operating on a scale far in excess of their pre-war business.

An obvious remedy was sought and found in 'progress payments'. There was nothing unusual or exceptional in the principle that contractors should be paid some instalments of their final price while the work was still proceeding and long before the official deliveries took place. This had been the normal Admiralty practice for shipbuilding and machinery contracts. Some such arrangements were common in private contracts with builders and civil engineering firms; and they had been adopted in the munitions industry of 1914–18. In the early years of rearmament, the supply departments were prepared to make 'stage payments' provided they synchronised with the progress of the work and did not cover the entire cost of each stage. Thus the Air Ministry paid eighty per cent. of the value of each completed stage after inspection. What was exceptional and novel in 'progress payments' under munitions contracts was that the proportion of the total costs thus advanced was very high and that the payments began very early, sometimes in the initial stages of the work. Thus in order to relieve firms of the heavy initial outlay the Air Ministry agreed in November 1935 to make monthly payments of eighty per cent. of the money spent on the purchase of materials.[1] At the same time it increased the maximum amount of 'stage payments' to ninety per cent. In 1936 the Air Ministry allowed 'progress payments' up to ninety per cent. on some 'cost-plus' contracts covering not only materials but also labour and overheads. A year later jigs and tools were brought under the scope of the ninety per cent. 'stage payments'. By September 1938 the practice of 'stage payments' up to eighty per cent. was also firmly established in the War Office contracts for tanks.

Before long, however, it became clear that many firms would require assistance in the form of straightforward loans and advances if they were to be saved from serious financial embarrassment.[2] Until the middle of 1940 requests for large payments in advance of deliveries were as a rule referred to the banks on the understanding that the latter would be willing to enlarge their credits to firms possessing Government contracts. The departments were also able to

[1] Subject to a maximum to be determined by the Air Ministry.

[2] In August 1939 the Treasury reluctantly allowed the Ministry of Supply to make a loan to a firm for payment of wages though it refused to make this a general practice.

make somewhat more liberal and earlier 'progress payments' than hitherto. These measures were proving insufficient for the greater industrial speed-up in the second half of 1940. More especially the Ministry of Aircraft Production which, unlike the Ministry of Supply, did not as a rule use 'progress payments' to reimburse its contractors for wages and overheads, found itself under strong pressure to do so now. A seven-day week was being worked in most aircraft factories and multiple shifts in some; and the wage bill of the industry rose much above the pre-Dunkirk level. The Ministry therefore took the initiative in suggesting that the banks might be induced to change their policy so as to provide the industry with the working capital it needed.

The outcome was the so-called Scheme C, arranged after discussions with the Bank of England, representatives of the Treasury, the three war production departments and the clearing banks. The object was to ensure that the banks would readily meet the requirements of Government contractors and sub-contractors for working capital and that the difficulties of finance would cause no impediment to the flow of production. Among other steps taken for this purpose was the appointment by each supply department of a liaison officer specially assigned to deal with these problems. As a corollary to these arrangements with the banks the departments undertook to do all in their power to liberalise 'progress payments'.

Greatly liberalised they in fact were. The system frequently adopted was that developed in the Ministry of Supply. It authorised 'progress payments' to be made monthly up to ninety per cent. of the total expenditure incurred by the contractor at the time of payment. In actual practice the system was applied with a still greater liberality. M.A.P. frequently raised the 'progress payments' on account of materials, jigs and tools up to 100 per cent. of the contractors' outlay; other 'stage payments' were also raised with the result that contractors could receive as much as 97½ per cent. of the price.[1] The Ministry of Supply received in August 1940 authority to raise 'progress payments' to 100 per cent. of contractors' expenditure, provided that ten per cent. of the total value of the contract was kept in hand until the final settlement.

At this point the system of advances on 'progress payments' reached the peak of its development beyond which it could not go without gross overpayment and Government losses. Indeed, in 1941 various attempts had to be made to tighten the system somewhat. Yet in spite of the safeguards some £10 millions were owing to the Ministry of Supply in 1943 by its contractors for excess of 'progress payments' over the full price of the product. Over £4 millions was still owing for excess advances in 1946.

[1] This was where the price was fixed, or where a provisional price had been agreed.

In M.A.P. and the Admiralty, where the system was not applied in quite so liberal a spirit, the overpayments were very much less. It can, however, be argued that even at the level they reached in the Ministry of Supply overpayments did not form a very high proportion of the total value of the contractors' work, and were not too high a price to pay for the solution of financial difficulties of great delicacy and complexity.

(4)

Programmes and Plans

Thus, in various ways, the Government found itself drawn into intimate partnership with industry. Yet its powers and responsibilities were not assumed with the deliberate intention of sharing in the conduct of industry; nor were they manifestations of an industrial 'plan'. Some such plans took shape during the war, but on the whole they added little to the Government's powers over the conduct of industry. They as a rule stopped short at the factory gate.

'Central' planning in the War Cabinet Committees and later in the Ministry of Production mainly resolved itself into endeavours to relate the scale of industrial effort and its timing to the total supply of manpower, machines and materials on the one hand, and to strategic necessity on the other. Some such 'plan' underlay the Government's decisions on the allocations of raw materials and labour, though it was not until the end of 1942 that the fundamental assumptions of the decisions, both economic and strategic, could be stated with all the necessary definition and consistency and a 'plan' took shape. All the subsequent Government decisions varying the volume of industrial activity as a whole were but successive modifications of the central plan. At their best these plans were of necessity a better guide to the immediate problems of supply and allocation than those of the more distant future.[1]

Planning activities did not, however, begin or end at the centre. Both in logic and in time, the planning decisions of central bodies—the War Cabinet Committees before 1942, the Ministry of Production after that date—had to be preceded by corresponding planning decisions of individual supply departments. The latter had to decide how much labour, capacity and materials they would require in order to meet the demands of their respective Services. From this point of view the planning acts of the central authority were often little more than decisions to reconcile the claims to resources

[1] See the essay by Prof. E. A. G. Robinson on The Overall Allocation of Resources, *Lessons of the British War Economy*, edited by D. N. Chester (Camb. Univ. Press, 1951).

advanced by individual departments on behalf of the industries and of the munitions for which they were responsible. Having negotiated their allocations, departments had to implement their parts of the 'plan'. They had to see that the resources allotted to them in fact reached the industry; and they had to reconcile the sum total of orders at any given point of time with the timetable of military needs.

This description of planning is, of course, a rationalised and much idealised version of what the war-time Government was able to do. The story of how the various techniques of allocation and control were invented and perfected has been sketched out elsewhere[1] and will be told again in greater detail in specialised studies. In general, the instruments of central planning were ready long before their objectives could be combined into a coherent whole. An Order of Battle adjusted to the supply of weapons, the latter adjusted to economic resources, and productive resources in their turn apportioned according to strategic priorities: all these elements of a master-plan were not satisfactorily brought together until the third, or even the fourth year of the war. It will, of course, be remembered that before 1942 there were several inquiries into the country's economic powers in relation to its military needs. In the course of the pre-war discussions on the scale of rearmament and the 'role' of the armed forces, certain assumptions about economic potentialities were made, and rearmament programmes were fixed accordingly. The assumptions, however, were as a rule very simple and vague and were imperfectly supported by statistical measurement or economic argument. As a rule they were not even put into words. When a Chancellor of the Exchequer argued that the country could not afford a large Army as well as a powerful Navy and Air Force,[2] he did not, and could not, employ his operative verbs and adjectives in a quantitative sense. 'Could not afford' was not a statement carrying with it an estimate of changes in national income or standards of life; the words 'large' and 'powerful' did not stand for a definite number of squadrons and divisions and the munitions they might require.[3]

The Wolfe inquiry at the end of 1939 was perhaps the first attempt at a comprehensive as well as a quantitative approach to the economic problem of rearmament. For all its inaccuracies and over-estimates, it was the forerunner of future 'plans'. The next occasion for a similar attempt was the inquiry which Lord Stamp conducted in May 1940. Lord Stamp's brief and the character of strategic

[1] See Chapter III, Section (7), and Chapter IV, Section (7).

[2] See, for example, pp. 29 and 81.

[3] The absence of statistical data and the insufficiency of relevant statistical knowledge might in any case have made more definite quantitative forecasts at this stage very difficult. This is fully brought out in Prof. E. A. G. Robinson's essay, *op. cit.*, pp. 40–42.

planning at the time made it impossible for him to propose a perfectly co-ordinated scheme of strategic and economic objectives, but he tried to adjust the military liabilities to his estimates of the country's economic resources, and he offered a forecast of the scale and time-table of industrial mobilisation. Subsequent approaches to the same problem—above all the Beveridge inquiry of the last quarter of 1940 or the estimates embodied in Mr. Churchill's directive of March 1941 on the size of the Army—were made mostly from the point of view of supplies of manpower. It was not, however, until the late autumn of 1942 that the 'labour budget' took final shape.[1] At about the same time the Chiefs of Staff were able to provide the 'planners' with an Order of Battle worked out for transmission to the American authorities. By 'marrying' the new Order of Battle with their anticipations of the labour prospect in 1943 the Lord President in his report of November 1942 and the Joint War Production staff at the Ministry of Production were able to put down on paper first sketches of a true central plan.[2] From now on variants of some such plan invariably figured in all discussions of the allocation and re-allocation of resources between the Services and the supply departments, or between the separate supply departments. It also provided an invaluable frame of reference for the discussion of American supplies and allocations to this country.

Planning activities at departmental level may have grown somewhat faster, but it is doubtful whether the evolution was completed by the end of the war. To the very end planning authorities in supply departments remained somewhat diffused and the plans themselves differed not only in perfection but also in emphasis and purpose. It has already been pointed out that planning in the supply departments was a more complicated and a more, so to speak, 'composite' activity than the decisions which constituted planning at the centre. Much departmental planning was largely statistical, but much was inextricably bound up with executive action. Whether it happened to be an integral part of executive activity or was conceived as a largely statistical occupation it as a rule fell into two distinct types of activity: 'programming' on the one hand and 'production planning' in the narrow sense of the term on the other.

No single definition will fit correctly the variety of objects which the makers of programmes pursued, but, broadly speaking, 'programming' was primarily concerned with munitions and parts of munitions. The requirements of the fighting Services had to be 'broken up' and 'spaced out'. The total had to be 'broken up' to lay

[1] See p. 223.

[2] See pp. 223–224.

bare the balance of programmes, i.e. to establish separate quantities for each weapon, to estimate their equivalents in components, spares and fabricated materials. But before the programme could be brought into inner balance it also had to be 'spaced out', i.e. the future flow of individual weapons and of parts and components had to be so calculated as to prevent shortages and 'bottlenecks'.

As distinguished from 'programming', 'production planning' was primarily concerned with the flow and utilisation of industrial resources. Whereas planners at the centre, in the War Cabinet Committees or the Ministry of Production, thought of resources in general and in bulk, the industrial planners in the departments had to treat them in their concrete and specific forms. As a rule they thought in terms of factory units capable of a certain volume of output; but for some major schemes expansion of capacity had to be computed in terms of machines, labour and factory space.

By the end of the war the work of 'programming' had been extended and greatly improved. In the Ministry of Aircraft Production effective 'programming' began later than in other departments; nevertheless by VE-day it had grown into a very comprehensive and elaborate activity. In the Air Ministry during the years of rearmament, and in the Ministry of Aircraft Production during the first years of its existence, the planners were mainly interested in problems other than programming in the narrow sense of the term, and the practice of programme-making remained somewhat rudimentary. Future output of aircraft may have been forecast with some accuracy. It has already been mentioned that in the so-called 'Harrogate' programme of 1940 the output of aircraft was anticipated more accurately than in the programmes of later years.[1] In the two or three programmes which followed it, real expectations gave place to 'target' figures displayed in order to stimulate the industry to higher endeavours. When Lord Beaverbrook became Minister formal programming stopped though only for a short time. It was resumed in the autumn of 1940 but the programmes were still conceived as a series of 'target' figures for complete aircraft somewhat imperfectly sub-divided into main components.[2]

If the use of 'targets' for complete aircraft could still be justified by considerations of policy, the rough and ready manner in which parts, components, and materials were calculated could only be accounted for by lack of system and statistical skill. Both system and skill came in the second half of 1941 when a new department of Statistics and Programmes was set up in the Ministry of Aircraft Production. In new hands the aircraft programme grew in scope and relevance, and in

[1] See pp. 69 and 313.

[2] See p. 124.

the end came to cover the major part of the Ministry's activities. The forecasts of deliveries of complete aircraft were not, and perhaps could not be, greatly improved. They continued to be based on the promises of industry, tempered by the hunches which the planners may have had about the performances of individual firms. The forecasts were therefore bound to be very approximate and, on the whole, rather optimistic. On the other hand, the break-up of the figures of aircraft into engines, major components, spares and materials, could now be done with an accuracy impossible in earlier years. Much closer attention could be paid to stocks, to deliveries from the United States, to the different rates at which engines and other aircraft parts were replaced, to anticipated changes in aircraft requirements and design.

Needless to say, even these figures contained high margins of error and were sometimes no more than makeshift guesses. For programmes could not be more perfect than the highly uncertain data of aircraft production allowed them to be; and the limitations of programme-making were well understood in the Department of Statistics and Programmes. The economists in charge of programmes in the Ministry of Aircraft Production were very far from being planners by choice or persuasion, and set little store by the power of a government department to forecast and to control economic events. In fact, no one has publicised the imperfections of Ministry of Aircraft Production programmes more than the statistician responsible for them in the closing stages of the war.[1] Yet viewed in historical perspective and judged by the relative standards of all industrial and social forecasts, Ministry of Aircraft Production programmes at that time passed the pragmatic test of 'good' programmes. They provided the data for reasonable anticipations and a basis for the placing of advance orders.

In the Ministry of Supply, programmes took shape much earlier than in the Ministry of Aircraft Production. But although there the history of the programmes was more continuous than in the Ministry of Aircraft Production the exact functions of programmes and of programming departments underwent a number of fundamental changes. Generally speaking, the disputable issues of programme-making in the Ministry of Supply related not so much to the scope and validity of programmes as to the administrative links between the making of programmes and the other activities of the Ministry. The concept of the programme and the methods employed were the same as in the Ministry of Aircraft Production. From the very beginning of organised statistics in the Ministry of Supply (and they were as old as the Ministry itself) statisticians not only recorded past

[1] See E. Devons, *Planning in Practice*, *op. cit.*

orders and current deliveries, but also, in doing so, tried to match the quantities and the time-schedules of orders. The deliveries of gun-barrels and mechanisms had to be 'married' with those for carriages, the supplies of ammunition had to be brought into agreement with the supplies of guns and, at one stage of the war, even with the storage facilities in the country.

This work of reconciliation may at first sight appear not so complex as that of aircraft components, for, with the exception of the tank, no weapon ordered by the Ministry of Supply embodied as many components and instruments as those of an aircraft. In general, the flow of production controlled by the Ministry of Supply was not canalised towards a single series of composite weapons. There was, therefore, little danger of a miscalculation at one point of the programme upsetting the entire balance of the Ministry's production. But if the administrators and the statisticians at the Ministry of Supply were spared the intellectual conundrums of composite assemblies, another problem of balance equally complex and difficult invariably claimed their attention. In analysing requirements and in making forecasts they had to keep in sight the needs of the military formations for which the munitions were intended. And a badly-balanced flow of production—excessive production of some munitions, insufficient production of others—could delay or upset the equipping of a military formation as effectively as a shortage of a component could upset the assembly of an aircraft.

In theory, the balancing of equipment of military formations was the concern of the War Office; but, in practice, the Ministry of Supply could not afford to neglect it. For not only was it the Ministry's business to synchronise the carrying-out of the different parts of the programme, but it was also impossible for the War Office to detect and to judge the lack of balance in the flow of munitions without full knowledge of the industrial conditions and prospects. The sequence of orders and the fluctuations in the output of munitions had therefore to be watched from this point of view, and the balance of approved army requirements had to be scrutinised accordingly. As a result, the statisticians in the Ministry of Supply found themselves drawn into discussion of the War Office requirements at a very early stage. Before their official submission to the Ministry the army programmes as a rule underwent a course of prolonged preparation, jointly conducted by the technicians of the War Office and the statisticians of the Ministry of Supply.

The part which this statistical activity played in the preparation and analysis of War Office requirements raised the problem of its exact *locus* in the constitution of the Ministry. In the days when the department of the Director General of Munitions Production was part of the War Office machine, the munitions programmes were

settled by the Director General and were worked out in detail by the branch of the secretariat attached to him. This continued to be the procedure in the first eight or nine months of the Ministry of Supply. The small statistical service which the Ministry at that time possessed formed part of the Director General of Munitions Production's secretariat. In the summer of 1940 the reconstruction of the Ministry of Supply brought to the department Sir Walter Layton, as he then was, as Director General of Programmes.[1] In that capacity, and later (in July 1941) as chief of the Executive Committee of the Supply Council, Sir Walter Layton assumed general control of programme-making, and the statistical branch became his principal tool. It will be shown presently that Sir Walter Layton conceived the function of planning very widely, and raised issues which went beyond the scope of programmes narrowly defined. On the other hand, the new branch did not, and could not, appropriate every activity which went into the making of programmes. Detailed negotiations leading up to the settlement of the individual items of the programmes were often conducted by separate production directorates and co-ordinated by the secretariat of the Director General (after August 1941 the Controller General) of Munitions Production, who also kept in his hands current discussions with the War Office about the design and quality of the munitions the Army required.

The dualism was finally resolved in 1942 with Sir Walter Layton's translation to the Ministry of Production.[2] With his departure the entire task of programme-making was reabsorbed by the Controller General of Munitions Production. The statistical department again became the main tool of the secretariat in its negotiations with the War Office and in the detailed formulation of programmes. By that time the process of 'programming', with its periodical revision meetings, with its circulars and its notes, had crystallised into something of a routine (the secretariat, true to its War Office ancestry, preferred to call it a 'drill'), which enabled it in the later stages of the war to tackle the problems of reduction and demobilisation with an 'expertise' acquired in the years of expansion.[3]

The 'programming' of naval construction presented a problem similar to that of the making of programmes in M.A.P. and the Ministry of Supply, but it was a less complex problem. In naval construction, as in aircraft construction, the entire output culminated in the assembly of large composite units. But vessels were as a rule larger than individual aircraft, fewer in number, and therefore more, so to speak, individualised. When it came to major vessels, 'programming'

[1] See p. 139.
[2] See p. 256.
[3] See p. 351.

and forecasting in the Admiralty consisted not in tracing trends of large series of standard units, but in keeping a continuous and a highly individual record of the progress of separate ships through the various stages of construction and fitting-out. This could in the main be done by production officers looking after the construction of the individual vessels; the more purely statistical services could be smaller and less elaborate than those of M.A.P. and the Ministry of Supply. The problem of components was also one of ordinary progressing, i.e. settling for each vessel separately the times at which the various components would be required and ordering them accordingly. This was as a rule done either by the firms themselves, or by the corresponding production branch in the Admiralty. It was in the production of small escort vessels and landing craft that the problems of quantity production were for the first time encountered. But even there the numbers were much smaller and, in the case of landing craft, the assembly was much simpler than in aircraft production. The statistical problems were therefore comparatively simple. The real problems of forecasting arose only in relation to raw materials and labour, but these were outside the scope of 'programming' in the narrow sense of the term.

The story of 'programming' is thus one of uneven progress, but of progress none the less. Whether the technique of 'production planning', in so far as it can be distinguished from the making up of programmes, advanced equally far, or indeed advanced at all, is more difficult to say. In theory the purpose of 'production planning' was to ensure the efficient distribution and use of resources. The efficient distribution of labour, materials and machine tools was served by allocation, and by the end of 1942 the various techniques of allocation were fully worked out. The manner in which the distribution was done at the centre, i.e. by the Materials Committee and by other bodies under the War Cabinet and the Minister of Production, has already been described. Within the departments the work was part of the executive functions of the directorates and the secretariats and was thought to be inseparable from their current administrative preoccupations. Yet in performing it the departments carried out an essential function of forward planning. Continuous estimates of current requirements and consumption had to be kept, forecasts of future demands had to be made, and applications to central authorities for allocations had to be formulated. In order to cope with the necessary statistical work the directorates concerned with 'resources' maintained statistical services of their own. The statistical branch of the Directorate of Materials Production at M.A.P. was a well-staffed and well-conducted organisation; the branch of the secretariat concerned with labour did its planning work in a section headed by an economist.

There was no lack of specialised expertise in the branch of the Admiralty concerned with the requisition and distribution of raw materials. In the Ministry of Supply some of this work was canalised through the department of statistics.

'Production planning' did not, however, end with the distribution of resources. The critics of official action and the officials who insisted on the need for 'proper planning' had in mind a service which went beyond the allocation of resources to their use in industry. In the first place distribution of industrial effort, i.e. the balance between different classes of munitions, could be subjected to an economic test as well as to the purely military test of tactical and strategic necessity. It was an economic as well as a tactical or strategic question whether the quantity of shells in the army programmes compared with that of other infantry weapons was such as to employ national resources in the most economic fashion. Similar questions could be asked about rockets compared with other anti-aircraft defences, bombers compared with other aircraft, some bombers compared with other bombers, radar aids compared with other items in M.A.P. programmes; and from the early twenties the same questions were being regularly asked about battleships compared with other types of naval vessels. Some critics, and even some officials, also felt that greater economies of production could be achieved by better utilisation of resources in private firms, and that it was the function of planning to ensure that the most economic production methods were employed in industry and that orders went to firms capable of efficient production.

Planning in this sense never became the policy of the British Government. In taking decisions about separate items of Service programmes or about individual factories, the supply departments and the Treasury could not, and did not, ignore the need for the most economic use of resources. But the composition of munitions programmes and the flow of industrial production taken as a whole were not organised in accordance with an objective plan for the most economic utilisation of natural resources. For, of necessity, the Service programmes and war industry had taken their shape long before the need or the possibility of such planning became apparent. The War Office and the Ministry of Supply had begun to place large orders and to build up a large industrial capacity long before they were compelled to function within the allocations of labour and raw materials. Finance was at first the limiting factor, and the orders then placed were spaced out in accordance with approved rates of expenditure. In the later years of rearmament, in 1938 and 1939, the flow of munitions for the Army and the Air Force, though not yet for the Navy, was held back by the pace at which new capacity, more especially Ordnance Factories, could be brought into operation. Planning of resources at that time could have meant little more than

taking care that new factories and extensions were being laid down in the numbers and in the order which would make it possible to meet the approved requirements of the Army by the allotted dates. The size of the problem greatly increased in 1939, and with the outbreak of war a large number of new factories and extensions were approved.[1] But even then it was not yet the planners' business to make sure that the economic resources available—labour, materials, tools—were sufficient to meet all the new demands.

The emphasis changed in the second half of 1940. In general, the problems of this period were suited to—indeed called for—'overall' planning of production. The military requirements, especially those of explosives and ammunition, were at their maximum, and the nation's ability to meet them had to be constantly assessed and re-assessed. Some such assessment underlay the decision to make large 'capital' provision for new explosives capacity overseas. But the revisions of the Army scales for ammunition which took place at the turn of 1940 and 1941 were perhaps the most prominent examples of the planning decisions thus considered and made.[2] These decisions had been preceded by a great deal of 'planning' deliberation in the Ministry of Supply. The new Director General of Programmes made it his business to bring the factory programme and future output into a demonstrable relationship with the military position on the one hand and with national resources on the other, and for a time this aspect of planning figured very prominently in the deliberations at high levels, in the Minister's Executive and elsewhere.

Later, the emphasis shifted again, and 'planning of resources' was merged into more purely executive activities. But, though no longer segregated into a department of its own, 'planning of resources' could not be dispensed with. The Ministry of Supply was reaching the end of its expansion and was soon due to carry out a reduction in its programmes and output. The problem before it now was not how to create new capacity in the most economic fashion possible, but how to cut its labour force and output with the least harm to army supplies. And while cuts were being discussed and negotiated, problems of the economical use of resources had to be kept in the forefront even though overt references to a 'plan', or the very mention of the word, was very rare.

In the Air Ministry, and later at M.A.P., this type of planning played a less conspicuous part than it did in the Ministry of Supply. In the history of aircraft production during the war occasions for a drastic revision of production to ensure a more economic use of resources seldom presented themselves. This does not mean that the problems of the economic utilisation of resources did not arise at all.

[1] See p. 112.

[2] See pp. 134-135.

They appeared on several occasions, mostly in connection with the programmes for bombers, but their appearances were somewhat sporadic. They were not as a rule raised by the planners and statisticians, and did not necessarily form part of the general planning activity in the Ministry. Nor did they threaten the fundamental assumption of the aircraft programmes.

Thus the decision to devote a very large proportion of resources to the production of the bomber dates from the early years of rearmament. It was based on a chain of strategic and tactical reasoning which cannot be discussed here. The purely economic argument, i.e. whether concentration on the manufacture of bombers represented the most effective use of the nation's productive resources, did not figure very prominently in the pre-war discussions. Nor was it much discussed at the time when the general trend of specifications was modified in favour of large four-engined bombers. Most of the arguments then employed were also tactical and technical. The economic issue first obtruded itself at all conspicuously in the middle of 1943, when it occurred to a few persons connected with the PrimeMinister's statistical branch[1] and the Ministry of Production to inquire whether the strategic and tactical results expected from the planned bomber force of four-engined aircraft might not be achieved with much less expenditure of national resources by making the Mosquito bomber the standard equipment of the bomber force.

Nothing, of course, came of the inquiry, partly because its findings were inconclusive, partly because it had little backing either in the Air Ministry or in M.A.P. Much more serious turned out to be the series of inquiries into the distribution of industrial effort between the different types of four-engined bombers. By the middle of 1943 it became apparent that on purely military grounds the Lancaster bomber was the most efficient and the Stirling the least efficient of the heavy bombers in service. But, to begin with, the opinion was not backed by any agreed measurement of the efficiency of bombers. During 1942 some sort of measurement of fighting efficiency—weight of bombs dropped per aircraft lost—had been worked out. It was only necessary to relate this measurement to the comparative production costs of each type of bomber in terms of man-hours (this was done by early in 1944 on the simultaneous initiative of people in the Ministry of Production, M.A.P., the Air Ministry and elsewhere) to arrive at a clear and a fairly exact conclusion that the efficient use of national resources required the substitution of the Lancaster bomber for the others in service. This in fact became the official view of M.A.P., even though little could be done to carry the policy into effect. The loss in production during the period when the factories making the Halifax and the Stirling would be retooling for the

[1] See p. 144.

Lancaster would be greater than M.A.P. and the Air Ministry could accept. All that could be done then was to replace a proportion of the Stirling output, leaving that of the Halifax comparatively untouched.

A different aspect of the bomber programme was raised by the progress of radar. It will be recalled that by the end of 1942 the scientists at the Telecommunications Research Establishment had developed in H_2S a very valuable equipment for guiding bomber aircraft to enemy targets during the night. But, to begin with, Bomber Command hesitated to adopt and to install the new device. It was apparently reluctant to agree to anything that might slow down the output of bombers, and feared a delay in their delivery through retrospective modification to take H_2S. The representatives of the Telecommunication Research Establishment and their advocates could argue that without H_2S and other devices the efficiency of the bomber force—the weight of bombs dropped at the right places—would suffer to an extent far greater than it would by sacrificing some bombers in favour of H_2S. Here again the 'planning' argument, however conclusive, prevailed only in part. H_2S equipment was made and installed, but not in such numbers as to have a noticeable effect on the supply of bombers.

Similar issues, mostly those of detail, occurred on several other occasions in the later years of the war. But, like those of the bomber and H_2S, they were raised separately, sometimes almost accidentally, by individuals and sections in M.A.P., the Air Ministry or the Ministry of Production. The fact that they had to be raised at all bears witness to the reality of the economic issues underlying the strategic balance of programmes. But if, nevertheless, the balance of programmes was not periodically 'replanned', this was not due to the lack of awareness of the economic issues among the economists or civil servants. The main reason for the apparent neglect was that the pattern of M.A.P.'s activities and the general distribution of effort among the various parts of the aircraft programmes had taken shape long before the possibility and necessity of planning by resources became apparent. The inertia of the pattern throughout the war was such as to make it impossible to introduce major changes at short notice without unsettling the entire flow of aircraft production. At no stage was it ever possible to compile an aircraft programme which was theoretically desirable at that juncture. Changes in the programmes could only be marginal.

On the other hand, aircraft production was the only branch of munitions industry in which, at least for a while, officials at the Ministry attempted to 'plan' the organisation of production by industry. Detailed decisions about the 'layout' of production, about improve-

ments in machines and industrial methods were of course regularly made in the production directorates, especially on occasions when new weapons had to be ordered, or new capacity had to be found. These decisions were, however, taken piecemeal and were never related to the economic problem of war production as a whole. They were certainly not conceived as steps towards a general reform of industrial methods. The only occasion on which plans to 'rationalise' production began to be made occurred in the second half of 1938 in the Air Ministry. When in June 1938 Sir Ernest Lemon and his assistants took charge of 'planning', or of what stood for planning, in the Air Ministry, they approached the problem from the point of view of production engineering, which was natural to them.[1] What made the approach more natural still was that the aircraft industry at that time offered an obvious subject for examination by industrial consultants. In the course of the preceding two years it had grown out of its handicraft scale and methods, but, on the whole, had not yet fully mastered the methods of quantity output. The fundamental problems of aircraft production *en masse* still appeared to be awaiting examination, and the planners in the Ministry took it upon themselves to examine them.

Thus nothing appeared to be known about the economics of serial production, i.e. the extent to which, and the points at which, real costs per aircraft could be expected to fall when large quantities of aircraft were in production. The planners, therefore, tried to assemble the man-hour costs of aircraft at different phases of mounting production, and to draw curves of falling real costs comparable with those which a well-known aircraft engineer in the United States had compiled on grounds largely theoretical.

Another problem to be examined was that of production capacity. Continuous demands for new floor space and machining capacity were being made on the Ministry and vast sums were being invested in new factories and extensions. Yet there was very little knowledge of what output could be expected from a given unit of investment. So the planners set about computing 'densities' of workers per unit of floor space and the loadings of machine tools.

Yet another cost problem was that of variation in design. Designs of aircraft were being made and aircraft were being ordered without clear ideas about the comparative costs of different shapes and different methods of production of aircraft parts, which were made necessary by differences of design. So Sir Ernest Lemon's principal adviser in this field set about comparing the costs of producing wings of different types with a view to establishing standard wing costs, or even designing a standard wing.

The investigations were as yet very fragmentary and inconclusive.

[1] See pp. 21–22.

To begin with, relevant information was scarce and difficult to collect. Now and again it was willingly provided by the aircraft factories, but the bulk of it came from investigations carried out on behalf of the planning department by the Technical Costs Officers. The latter were a body of accountants with engineering qualifications and experience, who had previously been attached to the Admiralty and whose function it was to assist the contracts department in assessing the contractors' costs of production. The service was now made available to the contracts branches of the Air Ministry, but its employment by the planning department could be no more than a temporary device. The Technical Costs Officers had undoubtedly acquired a minute and intimate knowledge of the industrial processes in the factories they visited and could produce highly reliable and, from the engineering point of view, highly expert evidence. But the service was under-staffed, and its main business lay elsewhere.

The fragmentary character of the evidence made the researches somewhat inconclusive. It is possible that had this service been allowed to develop the Ministry might in the end have possessed itself of a blueprint of an 'ideal' aircraft industry, in which a few types of the most economical aircraft were made in industrial units where buildings, plant and machinery were utilised in the most economical fashion. A planners' blueprint of this kind might have been used as a standard by which to judge the performances of industry. That some such plan was possible, that it was also capable of being imposed upon some branches of the munitions industry, was later to be proved by a number of examples. At home, the Royal Ordnance Factories, and more especially the Filling Factories, were good examples of large munitions industries made up of more or less standardised factory 'units' all employing the same or largely the same equipment and methods of production. Abroad, the organisation for the production of fighters which Alfred Speer built up in Germany during 1944 was something of an 'ideal' engineering scheme worked out by methods not very different from those employed by Sir Ernest Lemon's assistants. So was much of the war-time planning of industrial production by great industrial enterprises in the United States; Mr. Kaiser's handling of the shipbuilding orders was a case in point.

There is, however, very little doubt that nothing short of a catastrophic collapse of aircraft production would ever have enabled the industrial planners at M.A.P. to enforce from above uniform methods of aircraft production. As it turned out the experiment of industrial planning did not develop sufficiently far to justify any 'blueprint', however modest. By the spring of 1940 Sir Ernest Lemon and his principal collaborators had left the Air Ministry. One or two production engineers on the headquarters staff continued to collect and to analyse production data for a few months, but the men in charge of

statistics and planning confined themselves mostly to other activities.

When in the late summer of 1941 the new department of Statistics and Programmes came into existence it did not include 'on its agenda' industrial planning as the term was understood in the days of Sir Ernest Lemon. The economists and economic statisticians who staffed it concentrated on 'programming' in the proper sense of the term, with the results which have already been described.[1] Inquiry into industrial processes and into the use of resources within aircraft factories appeared to them both impossible and unnecessary. The main yardstick of the production engineers—standard man-hours—appeared to them too crude and too unreal a measurement to apply to aircraft production. In general, the margin of error in the industrial measurements hitherto made appeared to them too great. But even if the measurements had been more accurate and sensitive, the industrial inquiries of 1938 could not have commended themselves to the statisticians now in charge. In their view the inquiries could have served only one purpose, i.e. that of showing which firms were, and which were not, efficient, and this they believed could be discovered in an easier and more direct manner.

Some of these arguments undoubtedly were relevant and true. It is, nevertheless, impossible to escape the impression that the reason which led the statisticians of later years to neglect the production data of the engineers who preceded them was the same as that which had prevented the engineers from working out a satisfactory system of programmes. These were two groups of specialists, each expert in the use of certain techniques and methods of analysis peculiar to its occupation. The same occupational specialisation which nowadays accounts for the economic *naïveté* of 'technocratic' literature and also makes the writings of some economists about industry appear to engineers and industrialists to be unreal and irrelevant, also prevented a simultaneous development in M.A.P. of both 'programming' and 'industrial planning'. In the end 'programming' developed almost as fully as could be wished. The failure of 'planning' to develop equally far may or may not have left some of the shortcomings of the munitions industry unobserved and uncorrected. But it has at least prevented Government planning from penetrating at all deeply into the managerial autonomy of private business.

[1] See pp. 445–456. For the difficulties which the department encountered in its endeavours to get nearer to the production programmes in the aircraft industry and to plan the supply of components with the help of the industrial information available in the production directorates, see the essay by Prof. E. Devons on The Problem of Co-ordination in Aircraft Production, *Lessons of the British War Economy*, edited by D. N. Chester, *op. cit.*

Appendices

Ref. p. 25

APPENDIX I

Naval Programmes of New Construction

'Deficiency' Programme, approved November 1935

TABLE A

This was a general plan for raising the strength of the fleet to the 'D.R.C.' standard by 1942. New construction was to be spread over the seven annual programmes 1936–42 as follows:

Seven capital ships to be laid down in the period 1937–39.

Four aircraft carriers to be laid down in the period 1936–42.

Five cruisers a year to be laid down between 1936 and 1939.

One destroyer flotilla (nine destroyers) in 1936–37; and thereafter one flotilla in alternate years up to 1942.

Submarines, sloops, other small craft and auxiliaries at the same rate as in the past, i.e. about three submarines and five or six sloops a year.

Estimated cost of the proposals:

TOTAL . .	£225,125,000[1]
1936 . .	£19,325,000
1937 . .	£31,042,500
1938 . .	£32,872,500
1939–42 .	£141,885,000

[1] Includes £25,095,000 carry-over to 1943 and subsequent years to complete the programmes, up to and including 1942, by 1946.

Ref. p. 26

Naval Programmes of New Construction, 1936–39[1]

TABLE B

Number

	'Accelerated' programme		'Rationed' programme	
	1936	1937	1938	1939[2]
Capital ships . .	2	3	2	2
Aircraft carriers .	2	2	1	1
Cruisers . . .	7	7	7	4
Destroyers . .	17	16	—	16
Submarines . .	7	7	3	4
Fast minelayers .	1	—	3	1
Escort vessels . .	2	3	—	2
Fast escort vessels .	—	—	—	20
Patrol vessels . .	1	3	—	56
Trawlers . .	2	2	—	26
Minesweepers . .	3	4	—	20
Motor torpedo boats	7	10	13	12
River gun boats .	1	2	2	1
Boom defence vessels.	5	16	5	8
Loop minelayers .	1	2	—	1
Motor landing craft .	—	6	—	—

[1] Various small craft, e.g. lighters, depot and repair ships, are not shown on the table.

[2] Up to outbreak of the war.

Ref. p. 60

Estimated Requirements of Small Vessels, 1940 and 1941

TABLE C

Class	Summer 1940	Autumn 1941
	Number	
Escort vessels . . .	436	720
Fast minesweepers . .	245	184
Trawlers	1,900	1,100
Magnetic minesweepers .	500	706
Motor torpedo boats . .	102	134
Motor launches . . .	390	600
Anti E-boats . . .	50	157
Boom defence vessels . .	70	80

With the programme of small vessels it is also necessary to reckon the requirements of fleet units employed on convoy and anti-submarine duties, and more especially the requirements of destroyers. The demands for destroyers for convoy escort and fleet duties were heavy in 1940 and were to become heavier; a high rate of losses—fifty-seven in the first year of the war—had to be provided for. Fifty 'old age' escort destroyers were acquired from the United States in September 1940, but they were not sufficient to meet the need and by the end of 1941 the annual programme had come to include forty destroyers compared with the sixteen in the original war 'emergency' programme. The programmes of 1940 and 1941 also included the early batches of landing craft to assist in the harassing operations on the Continent and to prepare for the coming offensive. Small as were these landing vessel programmes they made a sizeable addition to the emergency programmes of the post-Dunkirk era.

Refs. pp. 56, 107, 109

APPENDIX 2

Development of German Air Power 1933–44

First-line Strength[1]

TABLE D — Number

Date	Excluding transport aircraft	Including transport aircraft
1st August 1938	2,847	2,928
2nd September 1939	3,609	4,161
30th September 1939	3,763	3,990
29th June 1940	4,119	4,476
28th September 1940	4,028	4,393
29th March 1941	4,649	5,362
27th December 1941	4,176	5,167
30th June 1942	4,950	5,907
30th December 1942	4,207	5,090
30th June 1943	6,107	6,957
31st December 1943	5,536	6,439
30th June 1944	5,414	6,358
31st December 1944	6,297	6,797

[1] The figures are derived from the records of the German Air Ministry (Quartermaster-General's Department).

Aircraft Production[2]

TABLE E — Number

Year	Combat types	All other types	Total	Monthly average (all types)
1933	0	368	368	31
1934	840	1,128	1,968	164
1935	1,823	1,360	3,183	265
1936	2,530	2,582	5,112	426
1937	2,651	2,955	5,606	467
1938	3,350	1,885	5,235	436
1939	4,733	3,562	8,295	691
1940	—	—	10,826	902
1941	—	—	11,424	952
1942	—	—	15,288	1,274
1943	—	—	25,094	2,091
1944	—	—	39,275	3,273

[2] The figures for 1933–40 are those given in the United States Bombing Survey Report, those for the years 1941–44 have been taken from a reliable German document. Only the totals for all types are given for these later years, but the output of non-combat types remained fairly constant from 1939, except in 1943 when it rose by approximately 2,000.

APPENDIX 3

Tables of Principal United Kingdom Aircraft Programmes 1938–44

For the purpose of these tables bombers have been classified as follows:
Heavy: Manchester, Stirling, Halifax, Lancaster and Warwick.
Medium: Wellington, Hampden, Hereford, Whitley, Albemarle.
Light: Blenheim, Battle (under Scheme L only; thereafter under 'Trainers'), Mosquito (bomber and photographic reconnaissance unit).

Ref. p. 18

Scheme L (as revised in September 1938)

TABLE F — Number

	Total	Heavy bombers	Medium bombers	Light bombers	Fighters	General recon-naissance	Fleet Air Arm	Trainers and miscel-laneous
TOTAL	9,483	63	1,130	1,968	1,952	1,155	675	2,540
1939								
Jan.	425	—	48	108	75	31	14	149
Feb.	452	—	52	117	78	31	16	158
Mar.	504	—	55	129	85	33	23	179
April	543	—	65	127	96	41	30	184
May	594	—	72	144	110	47	30	191
June	637	—	78	155	122	53	37	192
July	681	1	84	155	140	65	43	193
Aug.	615	1	89	141	126	57	54	147
Sept.	713	3	93	133	155	87	62	180
Oct.	749	4	95	131	157	110	66	186
Nov.	754	5	98	110	164	119	67	191
Dec.	732	7	99	108	153	125	70	170
1940								
Jan.	757	10	77	125	173	141	67	164
Feb.	697	15	75	137	166	110	58	136
Mar.	630	17	50	148	152	105	38	120

Ref. p. 67

'War Potential' Programme of July 1938 based on the hypothesis of a war commencing 1st October 1939

TABLE G — Number

	Total	Heavy bombers	Medium bombers	Light bombers	Fighters	General reconnaissance	Fleet Air Arm	Trainers and miscellaneous
Total during 18 months	28,944	2,663	2,826	2,521	9,947	2,401	1,909	6,677
Total during 12 months	16,940	774	1,882	2,513	4,610	1,744	1,171	4,246
1939								
Dec.	1,178	9	137	265	211	185	71	300
1940								
March	1,413	27	168	250	300	199	97	372
June	1,482	87	186	140	484	93	113	379
Sept.	1,793	209	143	104	750	118	102	367
Dec.	2,006	310	164	—	899	112	122	399
1941								
March	2,170	368	155	—	983	105	127	432

Ref. p. 69

'Harrogate' Programme dated 19th January 1940

TABLE H

Number

	Total planned monthly output	Heavy bombers	Medium bombers	Light bombers	Fighters	General recon-naissance	Fleet Air Arm	Trainers and miscel-laneous
1940								
Jan.	977	—	107	175	160	172	41	322
Feb.	1,001	2	111	155	171	167	44	351
March	1,137	3	116	150	203	205	56	404
April	1,256	5	125	150	231	190	62	493
May	1,244	6	121	145	261	179	63	469
June	1,320	10	118	145	292	184	47	524
July	1,481	16	117	145	329	188	54	632
Aug.	1,310	20	94	108	282	178	46	582
Sept.	1,675	31	129	145	392	202	67	709
Oct.	1,711	42	149	145	427	204	73	671
1941:								
Jan.	1,717	80	185	164	490	176	93	529
April	1,819	126	190	128	516	187	115	557
July	1,971	167	221	120	540	179	128	616
Oct.	2,023	211	238	120	540	149	131	634
1942:								
Jan.	2,179	247	288	120	621	106	138	659
April	2,287	263	354	120	650	110	101	689
July	2,425	295	402	120	723	105	91	689

Ref. p. 124

Mr. Hennessy's 'Target' Programme dated 2nd October 1940

TABLE I

Number

	Total	Heavy bombers	Medium bombers	Light bombers	Fighters	General reconnaissance	Fleet Air Arm	Trainers and miscellaneous
TOTAL	37,973	1,572	5,510	3,026	14,835	1,154	1,665	10,211
1940:								
Sept.	1,620	9	185	186	547	97	63	533
Oct.	1,748	20	222	186	631	88	63	538
Nov.	1,955	31	263	187	697	88	70	619
Dec.	2,111	48	278	235	727	73	81	669
1941:								
Jan.	2,177	56	292	186	805	73	91	674
Feb.	2,253	65	311	186	847	68	100	676
March	2,375	78	318	186	912	69	109	703
April	2,489	95	337	186	962	69	117	723
May	2,468	102	357	186	1,010	70	126	617
June	2,565	109	380	186	1,050	67	133	630
July	2,601	113	397	186	1,067	63	135	640
Aug.	2,635	124	410	186	1,090	64	131	630
Sept.	2,705	150	435	186	1,105	65	122	642
Oct.	2,737	173	450	186	1,110	66	113	639
Nov.	2,762	194	445	186	1,125	67	106	639
Dec.	2,782	205	430	186	1,150	67	105	639

Ref. p. 124

Revised Draft 'Target' Programme dated 3rd July 1941

TABLE J

Number

	Total	Heavy bombers	Medium bombers	Light bombers	Fighters	General reconnaissance	Fleet Air Arm	Trainers and miscellaneous
TOTAL	50,766	6,971	4,464	1,649	19,263	1,005	4,240	13,174
1941:								
July	2,019	70	262	145	772	25	135	610
Aug.	2,116	81	264	140	824	24	136	647
Sept.	2,150	85	275	125	836	27	142	660
Oct.	2,146	84	281	95	837	35	137	677
Nov.	2,164	102	287	86	838	41	138	672
Dec.	2,187	125	284	82	846	44	134	672
1942:								
Jan.	2,157	152	283	80	827	44	136	635
Feb.	2,195	188	277	80	854	45	141	610
March	2,158	225	270	85	856	45	127	550
April	2,135	253	260	85	866	45	95	531
May	2,110	271	257	83	847	45	92	515
June	2,078	285	226	80	817	45	110	515
July	2,011	306	192	70	769	45	114	515
Aug.	2,026	332	169	55	771	45	139	515
Sept.	2,042	357	146	43	770	45	166	515
Oct.	2,071	382	130	35	771	45	193	515
Nov.	2,092	404	105	35	772	45	216	515
Dec.	2,123	418	100	35	770	45	240	515
1943:								
Jan.	2,105	439	95	35	770	45	256	465
Feb.	2,113	451	80	35	770	45	267	465
March	2,133	472	71	35	770	45	275	465
April	2,131	485	50	35	770	45	281	465
May	2,147	497	50	35	770	45	285	465
June	2,157	507	50	35	770	45	285	465

Ref. p. 306

The 'Bomber' Programme dated December 1941

TABLE K — Number

	Total	Heavy bombers	Medium bombers	Light bombers	Fighters	General recon-naissance	Fleet Air Arm	Trainers and miscel-laneous
TOTAL	56,205	9,748	6,841	2,188	21,801	1,061	4,655	9,911
1941:								
Dec.	1,992	79	280	64	777	35	122	635
1942:								
Jan.	1,975	91	280	82	793	32	118	579
Feb.	1,980	105	283	88	787	41	117	559
March	2,001	132	287	101	806	36	105	534
April	2,031	161	274	105	816	36	97	542
May	2,070	193	282	105	838	39	80	533
June	2,102	226	285	105	865	37	79	505
July	2,098	267	282	115	864	36	80	454
Aug.	2,107	304	268	120	867	42	97	409
Sept.	2,097	335	266	103	865	42	127	359
Oct.	2,131	368	253	80	879	42	159	350
Nov.	2,167	387	234	80	897	42	182	345
Dec.	2,210	418	230	80	898	42	207	335
1943:								
Jan.	2,269	450	230	80	906	42	233	328
Feb.	2,305	476	235	80	913	47	250	304
March	2,330	511	245	80	882	47	260	305
April	2,381	523	260	80	888	47	268	315
May	2,343	538	285	80	800	47	278	315
June	2,490	559	305	80	905	47	279	315
July	2,484	573	287	80	916	47	266	315
Aug.	2,483	590	290	80	916	47	245	315
Sept.	2,518	603	300	80	925	47	248	315
Oct.	2,531	611	300	80	928	47	250	315
Nov.	2,545	623	300	80	927	47	253	315
Dec.	2,565	625	300	80	943	47	255	315

Ref. p. 306

The 'Consolidated' Programme dated July 1942

TABLE L

Number

	Total	Heavy bombers	Medium bombers	Light bombers	Fighters	General reconnaissance	Fleet Air Arm	Trainers and miscellaneous
TOTAL	80,993	15,534	10,196	1,504	31,965	1,877	7,861	12,056
1942:								
July	2,168	229	306	73	915	54	80	511
Aug.	2,207	247	312	78	926	56	108	480
Sept.	2,306	286	313	84	941	66	142	474
Oct.	2,352	320	323	90	947	72	154	446
Nov.	2,405	344	320	88	960	72	179	442
Dec.	2,429	370	320	85	943	72	204	435
1943:								
Jan.	2,465	403	310	75	957	72	233	415
Feb.	2,503	434	300	70	972	72	261	394
March	2,538	458	282	65	995	72	285	381
April	2,580	473	292	30	1,030	72	305	378
May	2,656	492	313	31	1,058	72	317	373
June	2,721	517	330	30	1,071	69	326	378
July	2,735	536	335	30	1,063	67	326	378
Aug.	2,803	557	336	35	1,102	67	323	383
Sept.	2,828	574	344	40	1,117	67	298	388
Oct.	2,845	586	343	40	1,121	67	300	388
Nov.	2,853	603	342	40	1,113	67	300	388
Dec.	2,872	612	345	40	1,119	67	301	388
1944:								
Jan.	2,853	620	350	40	1,086	67	302	388
Feb.	2,868	623	355	40	1,093	67	302	388
March	2,887	625	365	40	1,097	67	305	388
April	2,896	625	365	40	1,106	67	305	388
May	2,901	625	370	40	1,116	57	305	388
June	2,912	625	375	40	1,132	47	305	388
July	2,899	625	375	40	1,144	47	280	388
Aug.	2,897	625	375	40	1,147	47	275	388
Sept.	2,901	625	375	40	1,166	47	260	388
Oct.	2,911	625	375	40	1,176	47	260	388
Nov.	2,901	625	375	40	1,176	47	260	378
Dec.	2,901	625	375	40	1,176	47	260	378

Ref. p. 307

The 'Realistic' Programme[1] *dated January 1943*

TABLE M — Number

	Total	Heavy bombers	Medium bombers	Light bombers	Fighters	General recon-naissance	Trans-ports	Naval	Trainers
1943:									
Jan.	2,141	284	283	69	877	78	—	113	437
Feb.	2,105	290	265	55	876	88	—	117	414
March	2,234	337	288	55	905	103	—	127	419
April	2,235	342	273	50	909	102	1	143	415
May	2,358	389	282	50	969	106	3	141	418
June	2,256	388	222	52	939	105	5	129	416
July	2,319	387	269	33	949	96	8	156	421
Aug.	2,280	401	261	32	874	110	6	172	424
Sept.	2,534	466	294	37	983	111	14	204	425
Oct.	2,625	487	309	40	1,012	112	17	221	427
Nov.	2,659	497	309	40	1,011	109	20	242	431
Dec.	2,493	456	287	36	916	101	18	246	433
1944:									
Jan.	2,564	491	304	37	918	100	19	265	430
Feb.	2,507	476	291	37	900	98	18	263	424
March	2,700	531	327	40	956	102	20	310	414
April	2,625	511	307	37	938	97	19	307	409
May	2,650	521	311	37	941	96	19	321	404
June	2,662	566	289	38	966	75	9	320	399
July	2,631	525	324	38	980	41	4	339	380
Aug.	2,527	525	315	38	919	43	—	318	369
Sept.	2,753	588	345	38	1,034	42	—	357	349
Oct.	2,765	602	340	40	1,037	42	—	360	344
Nov.	2,779	600	334	40	1,051	45	—	360	349
Dec.	2,573	544	288	36	977	43	—	331	354

[1] Excluding Gliders.

Ref. p. 308

The 'Realistic' Programme as revised in April 1943

TABLE N

Number

	Total	Heavy bombers	Medium bombers	Light bombers	Fighters	General recon-naissance	Trans-ports	Naval	Trainers
1943:									
April	2,211	360	254	51	908	92	—	139	407
May	2,327	414	255	48	955	96	1	140	418
June	2,297	420	252	45	943	99	2	129	407
July	2,256	424	230	10	914	96	2	159	421
Aug.	2,278	409	235	10	925	109	4	171	415
Sept.	2,521	486	260	10	1,014	111	8	198	425
Oct.	2,588	508	272	10	1,033	111	11	216	427
Nov.	2,648	530	281	10	1,042	109	13	232	431
Dec.	2,484	484	272	10	939	104	15	236	424
1944:									
Jan.	2,551	514	283	10	941	99	16	258	430
Feb.	2,511	504	276	10	924	97	18	258	424
Mar.	2,673	552	297	10	973	102	20	305	414
April	2,607	527	288	10	957	96	20	305	404
May	2,620	531	290	10	956	96	20	318	399
June	2,689	570	300	10	973	94	20	323	399
July	2,582	524	285	10	930	83	20	380	380
Aug.	2,493	515	275	10	952	43	20	309	369
Sept.	2,721	591	300	10	1,052	42	20	357	349
Oct.	2,747	607	295	10	1,067	44	20	360	344
Nov.	2,766	613	281	10	1,086	47	20	360	349
Dec.	2,564	565	234	10	1,007	43	20	331	354
1945:									
Jan.	2,612	600	213	10	1,047	17	20	344	361
Feb.	2,531	586	186	10	1,015	16	20	331	367
March	2,714	645	190	10	1,096	20	20	360	373
April	2,585	619	160	10	1,044	18	20	340	374
May	2,580	632	140	10	1,046	18	20	340	374
June	2,684	682	140	10	1,083	17	20	353	379

Ref. p. 308

The 'Realistic' Programme as revised in September 1943

TABLE O

Number

	Total	Heavy bombers	Medium bombers	Light bombers	Fighters	General reconnaissance	Transports and A.S.R[1]	Naval	Trainers
1943:									
Sept.	2,481	460	261	10	1,007	111	40	177	415
Oct.	2,241	480	260	10	1,007	111	47	204	422
Nov.	2,568	485	255	10	1,000	112	51	225	430
Dec.	2,430	446	255	10	930	102	51	233	403
1944:									
Jan.	2,572	486	272	10	973	96	57	248	430
Feb.	2,578	486	265	10	971	95	60	254	437
March	2,770	529	297	11	1,043	97	61	295	437
April	2,684	499	285	12	1,021	94	50	301	422
May	2,685	521	289	14	1,021	97	40	312	391
June	2,816	581	305	17	1,074	95	36	331	377
July	2,488	535	261	19	903	54	20	327	369
Aug.	2,592	521	273	22	1,106	20	20	306	324
Sept.	2,849	618	290	23	1,169	19	20	359	351
Oct.	2,865	629	285	26	1,183	17	20	371	334
Nov.	2,766	613	267	27	1,155	13	—	362	329
Dec.	2,601	587	231	28	1,084	11	—	356	304
1945:									
Jan.	2,752	621	223	29	1,168	12	—	375	324
Feb.	2,672	614	196	28	1,124	11	—	370	329
March	2,861	674	191	30	1,214	14	—	404	334
April	2,698	638	160	29	1,149	15	—	381	326
May	2,691	645	150	29	1,133	18	—	384	332
June	2,846	698	150	30	1,196	21	—	398	353
July	2,512	642	130	25	954	19	—	383	359
Aug.	2,638	636	115	30	1,176	23	—	349	309
Sept.	2,909	748	140	30	1,198	23	—	411	359
Oct.	2,911	745	140	30	1,201	25	—	411	359
Nov.	2,795	705	133	29	1,152	24	—	395	357
Dec.	2,666	673	126	28	1,097	23	—	380	339

[1] Air Sea Rescue aircraft.

Ref. p. 309

The First 'Manpower Allocation' Programme dated March 1944

TABLE P

Number

	Total	Heavy bombers	Medium bombers	Light bombers	Fighters	General reconnaissance	Transports and A.S.R[1]	Naval	Trainers
1944:									
March	2,588	475	223	11	1,012	122	105	267	373
April	2,463	461	198	17	970	112	99	269	337
May	2,513	477	213	24	973	113	106	283	324
June	2,554	494	225	32	979	110	104	301	309
July	2,378	468	194	19	900	107	91	302	297
Aug.	2,330	442	200	22	997	111	84	245	229
Sept.	2,522	512	226	23	1,026	88	101	286	260
Oct.	2,563	529	220	26	1,058	93	90	299	248
Nov.	2,507	513	206	27	1,047	85	84	298	247
Dec.	2,375	499	187	28	999	80	71	288	223
1945:									
Jan.	2,476	517	181	29	1,060	83	73	294	239
Feb.	2,389	514	162	28	1,034	66	62	282	241
March	2,557	570	172	30	1,119	57	62	306	241
April	2,408	540	156	29	1,055	53	47	302	226
May	2,422	557	148	29	1,052	48	53	308	227
June	2,566	618	149	30	1,087	49	52	333	248
July	2,359	586	137	25	947	46	41	323	254
Aug.	2,248	544	97	30	1,017	44	44	273	199
Sept.	2,627	662	130	30	1,101	52	46	352	254
Oct.	2,658	670	130	30	1,115	48	41	370	254
Nov.	2,536	636	124	29	1,067	39	37	357	252
Dec.	2,386	608	117	28	1,014	27	24	334	234

[1] Air Sea Rescue aircraft.

Ref. p. 309

The Second 'Manpower Allocation' Programme dated August 1944

TABLE Q

Number

	Total	Heavy bombers	Medium bombers	Light bombers and fighters	General recon-naissance	Trans-ports and A.S.R.[1]	Naval	Trainers
1944:								
Aug.	2,068	461	216	863	87	68	213	160
Sept.	2,218	489	210	953	92	79	256	139
Oct.	2,204	500	198	944	96	75	262	129
Nov.	2,131	481	184	920	90	80	259	117
Dec.	2,021	457	162	879	95	71	243	114
1945:								
Jan.	2,076	468	151	925	104	74	245	109
Feb.	1,969	458	131	874	97	75	230	104
March	2,106	512	132	953	82	84	243	100
April	2,001	480	117	931	63	69	243	98
May	2,033	491	107	958	63	65	243	106
June	2,156	549	103	1,025	68	56	257	98
July	1,871	471	68	925	59	35	222	91
Aug.	2,017	530	88	968	75	44	226	86
Sept.	2,232	585	88	1,085	75	42	266	91
Oct.	2,251	594	88	1,083	71	40	284	91
Nov.	2,164	569	84	1,031	68	37	285	90
Dec.	2,063	550	79	973	63	34	276	88
1946:								
Jan.	2,182	588	84	1,022	64	33	301	90
Feb.	2,075	563	79	972	54	25	294	88
March	2,251	636	88	1,030	50	20	336	91
April	2,134	601	82	974	46	19	323	89
May	2,290	657	88	1,031	43	20	360	91
June	2,162	622	82	964	37	19	349	89
July	1,966	536	66	883	34	15	341	91
Aug.	2,097	647	88	853	38	20	366	85
Sept.	2,300	679	88	956	38	20	428	91
Oct.	2,298	681	88	935	38	20	445	91
Nov.	2,194	644	84	878	38	19	441	90
Dec.	2,086	609	79	831	36	18	425	88

[1] Air Sea Rescue aircraft.

APPENDIX 4

Deliveries of New Aircraft in the United Kingdom by Main Groups, 1938–44

Monthly Deliveries

Number

	Total	Heavy bombers	Medium bombers	Light bombers	Fighters	General reconnaissance	Transports and A.S.R.	Naval	Trainers and miscellaneous
1938:									
Jan.	161	—	10	38	29	2	—	27	55
Feb.	140	—	9	43	15	2	—	27	44
March	210	—	10	48	36	2	—	32	82
April	158	—	7	41	3	2	—	24	81
May	213	—	7	41	24	5	—	31	105
June	163	—	3	37	11	3	—	20	89
July	210	—	—	42	24	5	—	26	113
Aug.	202	—	2	36	47	3	—	21	93
Sept.	326	—	18	51	40	5	—	24	188
Oct.	348	—	26	51	43	4	—	23	211
Nov.	364	—	30	61	49	3	—	14	207
Dec.	332	—	38	49	50	2	—	17	176
	2,827	—	160	538	371	38	—	286	1,434
1939:									
Jan.	445	—	54	59	78	2	—	12	240
Feb.	579	—	54	74	107	4	—	41	299
March	712	—	55	107	117	3	—	56	374
April	634	—	41	81	111	2	—	40	359
May	702	—	55	101	140	3	—	50	353
June	681	—	72	74	127	4	—	51	351
July	695	—	43	108	114	5	—	49	376
Aug.	568	—	51	81	83	2	—	45	306
Sept.	781	—	74	112	93	4	—	49	449
Oct.	748	—	91	100	106	3	—	56	392
Nov.	795	—	89	102	126	10	—	38	430
Dec.	600	—	79	80	122	19	—	22	278
	7,940	—	758	1,079	1,324	61	—	509	4,209
1940:									
Jan.	802	—	96	86	157	24	—	19	420
Feb.	719	—	66	65	143	29	—	20	296
March	860	—	91	75	177	31	—	25	461
April	1,081	—	130	91	256	37	—	32	535
May	1,279	1	183	124	325	52	—	33	561
June	1,591	1	239	167	446	64	—	43	631
July	1,665	4	242	173	496	34	—	47	669
Aug.	1,601	1	214	177	476	41	—	56	636
Sept.	1,341	3	163	112	467	22	—	43	531
Oct.	1,419	4	167	154	469	18	—	54	553
Nov.	1,461	14	169	163	458	18	—	60	579
Dec.	1,230	13	166	134	413	17	—	44	443
	15,049	41	1,926	1,521	4,283	387	—	476	6,415
1941:									
Jan.	1,198	17	150	117	313	15	—	69	517
Feb.	1,587	21	220	196	535	16	—	74	525
March	1,730	37	231	163	609	19	—	81	590

	Total	Heavy bombers	Medium bombers	Light bombers	Fighters	General reconnaissance	Transports and A.S.R.	Naval	Trainers and miscellaneous
1941: *ctd.*									
April	1,529	27	212	163	534	13	—	88	492
May	1,708	38	232	147	580	23	—	109	579
June	1,628	39	231	136	556	17	—	114	535
July	1,668	38	232	130	572	12	—	110	574
Aug.	1,793	50	237	99	645	3	—	121	638
Sept.	1,915	60	253	85	747	14	—	122	634
Oct.	1,847	57	275	70	676	13	—	122	634
Nov.	1,806	59	268	48	653	27	—	116	635
Dec.	1,685	55	236	39	644	24	—	106	581
	20,094	498	2,777	1,393	7,064	196	—	1,232	6,934
1942:									
Jan.	1,929	81	287	43	772	35	—	102	609
Feb.	1,802	81	259	54	754	28	—	84	542
March	1,908	104	281	56	781	31	—	104	551
April	1,981	127	284	69	850	39	—	80	532
May	2,025	141	311	76	876	41	—	61	519
June	1,939	164	284	80	814	42	—	61	494
July	2,005	179	320	71	842	42	—	52	499
Aug.	1,827	182	264	64	772	51	—	57	437
Sept.	2,108	215	314	80	877	58	—	117	447
Oct.	2,190	249	319	83	889	69	—	109	472
Nov.	1,948	220	284	75	799	56	—	108	406
Dec.	2,010	233	256	63	823	54	—	147	434
	23,672	1,976	3,463	814	9,849	546	—	1,082	5,942
1943:									
Jan.	2,076	282	260	51	852	62	—	121	448
Feb.	2,067	330	245	80	832	68	—	106	406
March	2,264	372	261	55	961	94	—	119	402
April	2,118	364	242	48	829	104	—	133	398
May	2,350	434	244	50	956	109	—	138	419
June	2,136	400	218	40	878	98	3	114	385
July	2,072	368	223	12	793	91	18	150	417
Aug.	2,108	355	200	7	950	89	15	142	350
Sept.	2,335	428	220	15	973	105	29	150	415
Oct.	2,317	439	217	7	926	91	40	178	419
Nov.	2,300	423	215	5	929	86	55	188	399
Dec.	2,120	420	192	6	848	57	49	181	367
	26,263	4,615	2,737	376	10,727	1,054	209	1,720	4,825
1944:									
Jan.	2,305	478	210	852		61	78	222	404
Feb.	2,399	449	217	959		111	64	225	374
March	2,715	520	226	1,098		130	85	265	391
April	2,361	469	206	933		102	64	266	321
May	2,417	486	213	944		97	87	279	311
June	2,410	487	218	970		94	98	276	267
July	2,026	428	162	861		63	77	239	196
Aug.	2,041	468	212	841		101	63	230	126
Sept.	2,078	486	212	864		95	75	253	93
Oct.	2,116	461	189	888		96	81	252	149
Nov.	2,012	431	182	840		91	81	248	139
Dec.	1,581	344	149	680		82	36	184	106
	26,461	5,507	2,396	10,730		1,123	889	2,939	2,877

Ref. p. 205

APPENDIX 5

Estimated Total Requirements[1] of Machine Tools, 1942–45

Number

For year:	1942	1943	1944	1945
TOTAL . .	111,148	97,731	84,955	48,170
Ministry of Supply .	29,620[2]	25,560	24,180	7,000
Ministry of Aircraft Production . . .	32,928	24,650	16,363	4,016
Admiralty . . .	2,400	6,000	7,000	5,500
Machine and small-tool production . .	11,000	4,000	1,300	200
Private purchases .	30,000	20,000	25,000	25,000
Export . . .	5,200	17,521	10,912	6,454

[1] As compiled not later than the second month of each year.

[2] This figure does *not* include the additional War Office requirements referred to in footnote (5) to Table 28, p. 205.

Refs. pp. 2 *and* p. 405-406

APPENDIX 6

Notes on the composition of: Table 1, Tables 54 and 55

TABLE 1

The following are the principles on which the figures in Table 1, which shows the expenditure on armaments and warlike stores between 1924 and 1933, have been compiled:

Navy: The main figures in column 2 represent all expenditure on shipbuilding new construction, re-equipment and repairs, and maintenance stores. The figures in brackets show the shipbuilding programmes of new construction only. The figures have been taken from the Statement of Programmes at the end of the Naval Estimates for the appropriate year.

R.A.F.: The figures in column 3 are those of Vote 3 of the Estimates (technical and warlike stores) less the costs of inspection, research and miscellaneous items.

Army: The figures in column 4 for the years 1924 and 1925 were obtained from War Office Stock Accounts Head VA, 11 and 12, and are only roughly comparable with the figures for 1926 and later years which are the figures in Vote 9 of the Estimates (warlike stores) less expenditure on research, inspection and miscellaneous items. Neither set of figures includes mechanical transport for the R.A.S.C.

TABLES 54 AND 55

(*a*) Tables 54 and 55 are based, for the United Kingdom, on the Final Report of the Fifth United Kingdom Census of Production which shows the position in 1935, and, for the United States, on the Sixteenth Census of the United States relating to the position in 1939. Owing to this difference in date and also to diversities in the grouping of various establishments in the United Kingdom and United States Census Reports, only rough comparisons between the size of establishments in the two countries are possible.

(*b*) The following main United States industrial groups have been included:

Engineering, shipbuilding and vehicle trades

Group 16 Electrical machinery.
Group 17 Machinery except electrical.
Group 18 Automobiles and automobile equipment.
Group 19 Transportation equipment except automobiles.

Iron and steel trades, excluding blast furnaces, iron and steel smelting and rolling

Group 14 Iron and steel and their products, except machinery—also excluded are blast furnace products (Industry No. 1141) and steel works and rolling mills (Industry No. 1412).

Non-ferrous metals trades

Group 15 Non-ferrous metals and their products.

(*c*) The total number of establishments in the United Kingdom has been obtained by adding the total number of firms employing not more than ten persons on the average to the number of establishments employing more than ten wage-earners, as shown below:

	Firms employing not more than ten persons on the average		Establishments employing more than ten wage-earners		Total establishments	
	Number of firms	Estimated number of persons employed	Number of establishments	Number of persons employed	Number of establishments	Estimated number of persons employed
Engineering, shipbuilding and vehicle trades . .	24,074	105,606	7,231	1,104,363	31,305	1,209,969
Iron and steel trades, excluding blast furnaces, and smelting and rolling .	10,347	31,722	3,567	388,181	13,914	419,903
Non-ferrous metals trades	2,989	12,370	1,414	122,097	4,403	134,467

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(The suffix letter 'n' denotes a footnote)

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