254 Due to a false appraisal of the significance of the air power mission of protecting the German armament industries, as the indispensable factor for any further conduct of the war, in addition to its normal tactical and strategic missions, Air Force armaments had been given only fifth priority within the overall framework of armament activities. Since building and manufacturing projects in the first priority category were treated preferentially in the allocation of materials and man power, immediate implementation of the plans to move all Air Force manufacturing activities undergrouns was impossible. It was only the massed Allied air attacks of 1943-1944 which convinced the Supreme Command of the dire importance of these projects, and the outcome was that at least fighter production was placed in the first priority category on 1 March 1944. Then it was possible for the Fighter Production Staff to commence planning for the movement of fighter producing factories underground. However, the necessities of war had increased man power and materials requirements extraordinarily in all fields, so that the speedy execution of urgent projects was subject to narrow limitations. For these reasons it was no longer possible to move all industries engaging in fighter production to properly protected premises. The majority of the Air Force supporting industrial firms still found themselves

255 compelled to endeavor to continue their operations by means of an above-surface dispersion of their factory installations with all the accompanying operational disadvantages. One firm, for example, had 250 separate installations, some of them at a distance of between 480 and 600 miles.

One example of what was done is that of the high-speed project for production of the He-162 fighter, known as the Volks Fighter, the various parts, sub-assemblies and assemblies for which were manufactured in the tiniest workshops imaginable distributed in each case over an whole rural district, all under the control of one leading firm and an engineer from the Technical Office.

Both the measures for movement to underground premises and those taken for the construction of concrete protected bomb-proof facteries were instituted too late. There can be no doubt that better fighter defenses could have been established to repel mass attacks if the necessary measures had been taken to protect the manufacturing industry immediately after realization of the effects of area bombing attacks in 1942.

Owing to the partial movement of factories to under-

256 ground premises and the wide dispersion of factory installations a direct collapse of manufacturing activities as a result of the Allied air attacks was averted. It was only near the end of the war that the destruction of transportation systems, which were

256 an indispensable necessity for the integrated functioning of the large number of contributing small factories involved, seriously reduced the output of aircraft.

There is no possibility to compile reliable figures showing the direct r sults of bombing attacks, since the relocation operations usually caused greater losses in output than the air attacks themselves.

CHAPTER 2

MANUFACTURING PREPARATIONS

Prior to 1933, the firm Fertigungs G.m.b.H. (Manufacturing Company, Ltd.) had the mission of preparing uniform measures which would insure speedy commencement and rational implementation of all plans for serial production. It was necessary to have an organization of this kind because none of the aircraftmanufacturing firms still in existence in 1932 had any prepared organization for or any experience in this field. Furthermore, their factory installations, their development systems, and above all their methods of drafting the necessary construction data differed widely one from another. In addition the manufacturing data prepared by the individual firms was totally inadequate for serial production methods.

In its preparatory work the Fertigungs G.m.b.H. compiled directives on construction operations in order to insure proper consideration of manufacturing requirements through a uniform subdivision and numbering system for the manufacturing data, through specification of the tools and other installations, etc., needed, as well as the manufacturing and other materials required.

Note by Translator: The name of the Manufacturing Co., Ltd. which could also be translated as the Production Co.,Ltd., will be retained in the original in the translation, since the is no real English equivalent.

257 By the end of 1932 the directives for aircraft were ready and had been tested in the manufacture of the Albatros L-78 under licence. These directives had been fully applied in the pre-1933 preparation of construction data for the aircraft types developed for assignment to the units which were to be activated under the first phase of the Rearmament Plan.

258 After rearmement commenced in 1933, the Fertigungs G.m.b.H., now within the Technical Office as the Production Branch, therefore had the mission of preparing similar directives for the manufacture of all other items of equipment.

In quick succession the new branch compiled the construction data directives for engines, items of aircraft and ground equipment, operating requirements., etc., and furnished them to the industrial firms.

Experts from the branch visited the firms involved frequently to insure application of the planned measures. The increasing scope of this work resulted in 1936 in the appointment of permanent personnel for the purpose at the more important factories.

Preparation of the construction data in accordance with the directives commenced immediately a new model was included in the Procurement Program, which was frequently the case before development and proving wer completed. The prupose here was to reduce the time spent between commencement of

258 the development of a new item of equipment and the time at which it could be placed in service with troops, so that the units could receive it as soon as possible. This requirement was seriously disadvantageous for the preparation of the data, since the designing firms in many cases had to prepare the data for serial production at a time when it was to be expected that numerous alterations might still be introduced. However, the extra work was accepted as unavoidable in order to achieve the stated target of speedy delivery to the troops, although this extra work could assume vast proportions when it is considered that as many as 10 000 drawings and additional lists were needed in the construction of a medium aircraft.

This method actually resulted in many cases in the equipment of units with aircraft and other items within a space of time which gave them a lead over foreign countries. In other cases, the outcome was setbacks during the war which produced serious disadvantages for the German side in the conduct of air warfare.

To insure smooth operations in serial production, the various assemblies and sub-assemblies needed were treated as separate items, each completed in a separate factory, also by serial production methods. Where a factory was subdivided into a number of separate workshops located in different

259 places special importance was attached to fulfillment of this requirement. The various construction units, or assemblies, had to be complete with all parts. For example the wing unit had to include the necessary steering devices, the undercarriage had to be complete with all appliances, and the fuselage had to be complete with all built-in items of equipment, wiring, tubing, etc., to insure proper final assembly and easy exchangeability. The disconnecting-point drawings clearly showedthe proper joinings and all connecting parts, and link-ups.

260 The instructions which the Production Branch gave to its representatives at the factories on the technical subjects of manufacturing, combined with the activities of these representatives at the various firms and the constant close contact thus maintained, made the transmission of valuable experience within the aircraft industry possible, a circumstance which produced valuable results in the development of items and their manufacture by other firms under licence.

A constant state of high operability in the field units depended largely on an easy and reliable exchange of expendable items and other spares when needed, so that very special attention had to be given to the subject of tolerances and proper fits. The manufacture of properly fitting spare parts not exceeding the prescibed tolerances could, however,

result in a lot of extra work in some cases, so that very careful attention had to be given to the subject of proper fits. The application of very narrow margins of tolerance could only be accepted in cases where it was absolutely essential for reasons of assembly operations and exchangeability.

In the construction of aircraft engines and equipment items the requirement of exchangeability was more easy to meet, since the processes here involved more precise work, so that the assembly could take place without any necessity for retooling.

Conditions were more difficult in fuselage construction. Here it was necessary to first develop manufacturing methods and installations, plus a tolerance margin system, to insure parts exchangeability without retooling.

A mutual exchange of experience gathered resulted in the compilation of manufacturing plans, particularly in cooperation with firms manufacturing items of equipment.

Using information gathered through close and detailed study, the time and machinery requirements per item were worked out, and directives were compiled governing the arrangement of conveyor belt lines. To accelerate measures to place newly established manufacturing plant in operation, all experience available was applied to establish the sequence and subdivision of the working time and machinery required. This

261 method had excellent results in starting operations at a development and a manufacturing firm handling production of the developed item under licence, since it was possible to furnish not only the construction data, but also such items as the time and tooling machinery requirements, and the tools needed, as well as the necessary gadgets, gages, etc.

Construction data were also prepared for the installations and so forth the manufacturing firm would require, in order to insure economical processes in both the developing and the manufacturing firm. The data for these purposes were numbered by the same system used in the numbering of data for the various assembly units.

When items of equipment were manufactured under licence by a number of separate firms, a careful coordination of the production data with the drawing and other data for the manufacturing facilities was required; otherwise there would have been no guarantee that the identical parts and assembly units produced by different firms would be easily exchangeable. The necessity that parts manufactured by various firms should be interchangeable necessitated the existence of master gages, with which the machinery and tools etc. used in the separate factories could be precisely coordinated. Constant checks were carried out by the official gage testing agency.

The experience gathered in the serial production of the individual items of equipment was applied currently to bring about improvements in the use of available machinery by means of appropriate modifications in the whole installation, in order to increase economy and output without increasing the labor employed.

The uniform coordination of all manufacturing processes and the consistently conducted exchange of experience in many cases resulted in extraordinarily large savings in the manufacturing activities. The outcome was a large saving in manufacturing time, installations, machinery, and materials.

In cooperation with the industry, constant efforts were made to improve manufacturing methods. Examples here are the improvement of the drawing processes, the [illegible] drop-forging system, and the rubber forming processes.

What has been said above applies also to the development of large and easily movable assembling equipment for fuselage construction; the sub-floor aircraft construction methods making it possible to mount individual parts, such as the wings, without the use of cranes by moving them into proper level with wagons.

The construction equipment, or scaffoldings, were tube structures furnished in kits, which could be easily set up and greatly reduced the installation costs for new factories.

263 In the case of the scaffolding kits for the construction of fuselages, wings, and tail assemblies, 60-80 percent of the individual parts making up the kit could be reused.

For the manufacture of an item of equipment or of a part of such item, the designer could select from a relatively large number of various manufacturing materials, which were similar in their characteristicsbut of differing composition. In the case of the various manufacturing materials required for aircraft construction by serial production methods, a wide diversion in the manufacture of the required materials was to be expected. The various methods of materials treatment and of preparing the various alloys remained a serious complication here.

The Production Branch therefore at an early stage set about making a standard selection among the various manufacturing materials and semi-processed materials available for manufacturing activities supporting the Air Force.

In view of the possibility that Germany might be cut off from foreign supplies of alloys not procurable within Germany, such as Nickel, Chromium, Wolfram, Cobalt, and tin, the first need here was to reduce the use of these to a minimum or to replace them entirely by substitute materials. The materials thus selected were compiled in what were called Aviation Manufacturing Materials Lists (Fliegerwerkstoffe).

264 The approved materials included 33 types of steel, 12 non-ferrous metals, and 36 light metal alloys, making a total of 81 types of metal , representing only 40 percent of the number formerly used. The lists contained all nedessary details on the mechano-chemical and technological characteristics. These were on special "performance sheets (Leistungsblaetter) bound in an Aviation Manufacturing Materials Manual (Flugerwerkstoff-Handbuch) and published by the Reich Air Ministry in 1935. The manual was revised from time to time, particularly during the war, in the light of new experience gained.

The outcome of the restricted selection of manufacturing materials was a more rational production of semi-finished products, particularly during the war. Furthermore, the smaller number of materials approved for use considerably simplified procurement and praparatory procedures and the processing of manufacturing activities. The system therefore represented an important measure to secure rationalization and a control of raw materials.

In addition to the above, the system reduced the variations of materials, forms, cross-sections and the consequently varying methods of roller, drawing, or pressing-stamping used in the production of semi-finished metal items. Constant pressure on designers by 1941 reduced the number of semi-

264 processed items used per ton of aircraft deadweight from 1000 to 200.

265 This consolidation of materials to be used in the manufacture of aviation items was not a process establishing standards, but the result of a selection among already existing alloys.

The necessary classification of the various materials thus selected was done by a system of four digit numbers, iron alloys commencing with the digit 1, non-ferrous metals with the digit 2, and light metals with the digit 3. The classification number was followed by a period and a digit in the range of zero to 9 denoting the processing stage of the material involved, which depended on the type of material itself.

The materials classification number plus the processing stage digit and the identification marking of the maker of the semi-finished product were stamped on the surface of the semi-finished product in a frequency which insured that it could be precisely identified from even only very small parts.

In the mass production of aircraft and aviation equipment, the establishment of standards can contribute largely to work rationalization and to simplification in the manufacture of individual parts as well as the manufacturing installations. At an early stage the Production Branch

265 commenced the preparatory work for this purpose. The target was to to establish what were known as "Aviation Standards" and Aviation Equipment Standards" (Luftfahrt-Normen und Luftfahrt-Geraete-Normen) for application in addition to the German Industrial Standards (Deutsche Industrie-Normen) already established, and in a manner similar to the also already existing Army ~~XXXXXXXX~~ Equipment Standards (Heeresgeraete-Normen). To improve the operating safety of aircraft a course differnt from the usual was adopted in the establishment of the new Aviation Standards and in approving other standards in the construction of aviation equipment. Contrary to the customary method of ignoring the materials used when classifying an article under the German Industrial Standards system and considering the contents of the standards specification sheet merely as a guide, every item approved as a standard aviation item of equipment was classified as being of a specific material, the purpose being to insure that approved standard parts would not be inferior in quality to non-standard parts. This important arrangement differentiated the individual construction parts for aviation purposes from the normal German Industrial Standards in point of quality.

Whenever possible due consideration was given to already existing international standards in compiling both the German Industrial Standards and the Aviation Equipment Standards.

266 The mission of parts standardization was not completed with the establishment of approved standards; the necessity remained to insure adherence to the standards in practice. For this purpose, a sele tion was made of the Standards Parts Sizes. Thus, of the officially approved standard bolts and screws only 2 1/2 percent of the defined types and sizes were selected and approved for aircraft construction.

One example of the resultant simplification was the fact that out of the existing 8 000 various types of roller bearings only 832 were mentioned. Besides the known and usual standard parts it also proved urgently necessary in aircraft construction to standardize power units, seats, control rods, throttle lever casings, and undercarriages and their types

267 of structure. These items were dealt with by special study groups, and the purpose aimed at and largely achieved was to simplify assembly operations, reduce the number of individual parts and the expenditure of materials and manufacturing times, and to improve repair possibilities and manufacturing equipment.

Another reationalizing measure was the increased use of repeat parts. Here the figure of 2000 parts was achieved in the case of some aircraft models.

In 1945 the Standards Records of the Reich Air Ministry had reached the size of four volumes. Including the German

267 Industrial Standards and Army Equipment Standards items approved for aircraft construction, these four volumes contained 660 sheets giving details on 25 000 standard parts of different shapes and sizes. By 1943 the Technical Standards Committee for Aviation had issued 400 sheets.

Of the standards established by individual firms 4 200 were approved by the Standards Section of the Reich Air Ministry and were in general use.

Of the various parts used in fuselage construction in 1943 between 35 and 45 percent were approved standard items, excluding rivets. Fifty percent of them were individual factory standard parts.

To achieve uniformity in the installations and facilities used in the manufacturing processes, and to establish standards for such items, the Production Branch set about developing models to be used throughout Germany. This work was done in collaboration with the appropriate firms, the appropriate authorities of the Army and Navy, and the technical organizations involved. The purpose of the directives thus compiled was to establish general conditions which would so influence the development of manufacturing equipment that its practicability would be insured and to avert any necessity for adaptation to existing standards only after constructional differences became apparent.

268 The system pursued in these efforts to establish standard manufacturing equipment throughout Germany differed from the system used in establishing the general German Industrial Standards, namely that of standardizing various existing constructions. Instead, only completely developed constructions were approved under the new system, which did much to accelerate the establishment of standards for manufacturing equipment and was therefore accepted without demur by manufacturing and using agencies. Quick results were achieved not only in the standardization of small items, such as drill templates inspection and master gages, and drilling and bevelling units, but even more so in the case of large complete manufacturing and assembling installations. The results were compiled in a Manual of National Standards for Manufacturing Equipment (Handbuch der reichseinheitlichen Fertigungsmittel).

Another mission of the Production Branch was to participate in the development of new and improvement of existing manufacturing processes and the installations required for such processes. The subjects dealt with here were such as the constructional use of suitable manufacturing materials or construction units, simplified structure of the parts to be made (for example, the use of die-casting instead of cutting porcesses and of welded sheet-metal parts instead of ~~xxxxx~~ cast or forged parts), and the development of new

269 working processes, such as welding instead of drilling or the use of rivets or screws; bevelling instead of turning; and machine instead of hand work.

The exchange of experience gathered was handled on the one hand by the engineers appointed by the Production Branch to supervise adherence to the manufacturing principles established, on the other hand by means of factory inspections, drawings, lectures and exhibitions, measures which produced fruitful results in the field of manufacturing activities. The exchange of experience covered primarily the fields of manufacturing time requirements, the results obtained with various methods of construction, comparisons of the various constructions and the influence of systems on weights and expenditure of labor.

In summarizing it can be stated that the preparatory work done by the Production Branch created the necessary conditions for the introduction of serial production. The measures involved included the establishment of uniformity in designing and drawing activities; clarification of the tolerance limits permitted in the fittings for Air Force equipment; the establishment of production plans, of construction data for manufacturing equipment; the compilation of approved materials for use in aviation construction; support in the compilation and introduction of Aviation

269 Standards and Aviation Equipment and Parts Standards.

The restrictions which at times had to be placed on the various firms appears fully justifiable in view of the conditions existing in the field of aircraft manufacturing in 1933. These included a complete lack of experience in the subject of serial production; the need for an easy exchange of parts to insure ready operability of field units; the necessity for optimum use of the manufacturing materials available; and the need for uniform construction in the case of aircraft and items of equipment manufactured by various firms operating independently one from the other.

CHAPTER 3

PROCUREMENT PLANNING AND PROCESSES[1]

271 The decisive data for the development of aircraft was provided in the technical specifications compiled by the Technical Office of the Air Force on the basis of the tactical requirements stated by the General Staff. The specifications were furnished to the industry.

In contrast with serial production processes, development work depended less on space requirements than on intellectual capabilities and was thus less subject to the restrictions of labor. It was therefore possible to assign such missions to a number of firms simultaneously, who worked in competition one with the other. This was an eminently important factor because of the necessity to gain a performance lead over foreign countries. The essential condition here was to prevent the exercise of official influences exceeding the requirements on which the problem was stated, the minimum technical performances required, and the purpose for which the item involved was intended. The sole mission of the technical personnel attached to the firms concerned from the very beginning of the designing processes was to insure very close contact between the Technical Office and the

1. Use has been made of a report by Stabs-Ingenieur Belter and personal experience of the present writer in the compilation of this chapter.

271 designing firms, to clarify open questions, and to maintain current observation.

The decision whether or not to introduce the item concerned for use in the field depended on the results of tests carried out later by the Proving Branch to determine its technical and tactical usability, on checks to determine whether the construction data adhered to the specifications of the manufacturing principles, on whether the construction would be easy to manufacture from the technical point of view, on the labor requirements if the model should be placed in serial production, and the possibility for firms other than the original designers to manufacture the model under licence.

Fundamentally different principles had to be followed in the case of serial production by industrial firms. Here, the ruling factors were the quantitative or numerical requirements stated by Branch 6 of the General Staff on the basis of the tactical plans of Branch 1 of the General Staff for complete equipment of the units to be activated, for training purposes at the service schools, for retraining of personnel to man the new model, and for reserve stocks--including replacements for precalculated losses; in addition, the needs of schools giving basic and advanced training had to be taken into account, since operability of the field units depended on the influx of newly trained personnel.

272 Numerical requirements in aircraft and equipment were based on the following authorized unit strengths

Unit	Aircraft
Wing or Group Headquarters	3
Squadron	9
" reserve	3

making a total of 39 aircraft per group. For fighter units computations were based on a strength of 12 aircraft plus 4 in reserve from 1940 on. The loss quota included in computations was 3 percent during peace and 25 percent during war, allowing for aircraft totally lost or so badly damaged that they remained unservicable and withdrawn from their unit for a considerable time.

During peace and during the campaigns in Poland, France, and Norway losses were smaller than the loss quotas allowed in comptitations. During the Air Battle for Britain losses equalled the quotas allowed, but later in the war they exceed the established quotas.

Since the Air Force supporting industries had to be built up from scratch in 1933 it was not possible to procure within the specified time the aircraft, engines, equipment, weapons, bombs, and ammunition required for the units to be activated nor the required ground equipment. The unit activation plans of the General Staff therefore had to be coordinated from time to time with the available industrial potential.

273 Usually a number of conferences between Branch 6 of the General Staff and the C Office (later the Planning Office) were necessary to establish production programs from case to case.

The results arrived at in the conferences provided the basis for the Procurement program which the C Office then had to work out, which in turn furnished the basis for decisions on all air and ground equipment, including the necessary supplies of ammunition, bombs, and personal equipment both in respect to the numerical quantities and the types involved.

The Aircraft Production Program stated the basic models and their variants decided upon in conference with the General Staff in accordance with the purposes for which they were intended, together with all the necessary items of equipment. The selection of models and/or their variants, ~~exclusively~~ and their inclusion in the Procurement Program, depended entirely on the stage reached in their development and proving and their approval by the Chief of the Technical Office for procurement.

The program worked out by the C Office furnished the basis on which the technical subdivisions of the Office could act, a procedure which was adopted unchanged by the Fighter Production Staff and by the Main and Special Committees at

274 a later date.

From a distribution of this program among the individual aircraft manufacturing firms the Industrial Delivery Plan resulted, which corresponded to the capacities of the various firms in personnel and space.

To make consideration of special operational circumstances of an possible of an internal nature the firms had the possibility of requesting modifications within the planned Industrial Program.

The final allocation to the firms of their share of the program represented the awarding of a contract and obligated them to immediately make all preparations for commencement of a new series or to continue on series already in production.

Simultaneously with the Industrial Delivery Plan the firms also received the Mobilization Program, which depended on the delivery plan and served as a planning basis for expansion, requests for raw materials, tooling machines, and fuels as well as all other essential requirements.

The distribution of the program among the firms was motivated by the desire to limit the volume of equipment items to be procured directly by the Technical Office, and transfer as much of the volume as possible to the responsibility of the industry. During the first phase of the industrial expansion, however, free trade procurement of the necessary items of equipment by the aircraft manufacturing firms would have

275 resulted in excess burdens on the firms producing the various items of equipment and in an unprofitable exploitation of their capacities. Therefore, the C-Office initially had to handle/ much of the procuring directly and later had to exercise a systematic control and distribution of the current contracts.

The actual objective aimed at was to gradually transfer full responsibility to the aircraft manufacturing firms for the delivery of the completely outfitted and equipped aircraft ready for operations. However, continuous changes and increases in the requirements and the limited capacities available made it impossible to achieve this objective. The C-Office did succeed in transferring responsibility for the procurement of instruments, general equipment, and other categories to the aircraft manufacturing firms, but the necessity remained for a systematic control by the Technical Office.

For the above reasons the Technical Office had to retain responsibility for the direct procurement of engines, radio and radar instruments, gun mounts, and bombs .

In spite of this partial direct procurement by the Technical Office, responsibility for the proper functioning of the completely outfitted and equipped aircraft had been transferred to the aircraft manufacturing firms, so that the necessity arose to maintain Government-owned stocks of these directly procured items at the factories. Administration of these

276 stocks was a responsibility of the Construction Supervisors.

Immediately after commencement of the rearmament program in 1933steps had been taken to commence registration of all available factory spaces on the basis of situation and property diagrams submitted for the purpose. This and the continuous supervision of expansions on the basis of mobilization plans made possible a clear insight into the space and operating capacities of the entire armament industries at any given time.

The chart showing the man-hour requirements for the aircraft models going into serial production, intended originally for the firms but later revised, plus the establishment of the man-hour requirements for the more important assemblies and part assemblies
part assemblies, and the breakdown of the majufacturing expenditures according to time spent on cutting, sheet metal, and assembling operations, and so forth, enabled the subdivisions of the Procurement Office to work out speedily manufacturing plans for the individual factories.

277 Without loss of time through inquiries at the firms, the Procurement Planning Branch was thus able, particularly in the case of immediate requirements by the General Staff, to work out within a few hours accurate recommendations and make them available as a basis for discussions. This proved an exceptionally sound procedure, particularly during times of crisis and during the war, and enabled the General Staff to make quick

277 decisions.

The subdivision of aviation industry firms into development and licensed manufacturing firms necessitated special measures to insure the proper processing of spare parts and their exchangeability when coming from various firms. In spite of the conditions of a planned economy, the principle of competition was still very much alive, particularly between the development firms and the firms manufacturing developed models under licence; the danger therefore existed that individual parts and assemblies might be made differently. To avert any such complicationsit became necessary to arrange licensing conferences between the participating firms under chairmanship by the Technical Office. These were designed to develop a clear understanding of the processes of manufacture under licence and bring about an enforced clarification of controversial issues. Later, it was frequently required that individual models while in serial production were to be adapted for other than the originally intended purposes. This and the increasingly frequent modifications caused the Technical Office to assign liaison engineers from the developing firms to the firms manufacturing under licence, and later to the

278 establishment of a Licensed Manufacturing Office, who were responsible for timely delivery of the manufacturing data and of all experience data .

278 The gradually increasing numbers of aircraft models and their variants to be manufactured by serial production methods led finally, in 1938, ~~led the~~ to the consolidation of the participating firms in organizations called rings (cartels), one cartel in each case containing all firms manufacturing a specific model plus the developing firm. From then on responsibility for proper execution of the whole series according to schedule and technical specifications rested within the cartel with the developing firm.

The special committees formed later by the Ministry for Armaments and Wartime Economy developed from this organizational setup.

The fact that the lead firm in each cartel now assumed responsibility for all planning for manufacturing materials, man power, items of general equipment, tooling machines, etc., considerably relieved the burden on the Technical Office.[1]

Maximum use was made of all available capacities in 1933 and 1934 for the serial production primarily of the already completely developed aircraft models plus aircraft for initial and advanced training at the schools. The systematic

279 expansion of the industry during this period could not yet have any appreciable effect, so that execution of the first

1. Both the Industrial Council and Saur claim to have been the originators of the idea of cartels or special committees. This claim is disproved, however, by the fact that neither the Industrial Council nor the Ministry for Armaments and Wartime Economy existed in 1938.

279 two procurement programs had to depend on the already existing capacities. The planned increase in the output primarily of front line aircraft took effect from 1935 on in accordance with the progress made in industrial expansion.

In addition to the introduction of newly developed models and th promotion of licensed manufacturing operations, the procurement period up to the beginning of the war served primarily to eliminate bottlenecks in the xxxxxfxxxtxxx of aircraft and aircraft engines manufacturing firms and, what was more important, in the industries producing semi-finished items and accessories. In addition to execution of the peacetime production programs, the mission remained of preparing the main factories and their sub-contractors to meet the requirements of mobilization plans.

The only possible way to meet the requirement for a speedy activation of units and their equipment with the most up to date aircraft models and equipment possible, in order to achieve a lead over foreign powers, was to reduce the time span between commencement of designing and delivery of the completed planes to the troops; this, in turn, could only be done by the development stage overlapping with the testing stage, which in turn overlapped with commencement of the serial production stage. However, it was necessary to include these models in the procurement program at a time

230 when theyhad not yet completed their tests. Although allowances had been made for possible difficulties, interruptions in the serial production activities therefore had to be expected, which meant that deadlines would have to be extended beyond the provisions of the planned program.

Since the General Staff based its dispositions on the planned programs, these dispositions were naturally also affected by extended deadlines. To avoid this disadvantage, the General Staff prepared special programs which, in point of deadlines, provided a greater measure of security than the industrial programs. What also made this arrangement necessary was the fact that, besides the requirements for troops, and schools in aircraft and equipment, the industrial program also had to include aircraft required for the Government, for the Leaders of the National Socialist Party, and for other purposes, which were not available to the General Staff. This preparation of separate General Staff and industrial programs continued until shortly before the war.

As the special purposes for which individual aircraft models were needed increased it also became necessary to increase the zero series (Nullserien) in the interests of a speedier completion of testing. For this reason the zero series were taken out of the general industrial program and placed in a special program for [illegible] test models and

zero-series aircraft.

Besides assigning basic research missions to research agencies, the mission of the Technical Office was also to formulate the technical ~~requirements~~ specifications on the basis of the tactical requirements stated by the General Staff, to furnish these specifications to the industry for the development of the necessary airborne and ground equipment, to support development work carried on by industrial firms, to conduct the necessary military and technical tests, to gather and apply all experience gained, to translate the technical requirements of the General Staff into industrial procurement programs, and to plan industrial expansion for serial production operations and repair services, to include the supply of spare parts for resupply purposes.

All of the above applied to all airborne equipment, namely, fuselages, engines, items of general equipment, such as flight and engine control instruments, navigational instruments, parachutes, oxygen equipment, automatic steering devices; mounts for aircarried guns; ground equipment; and nautical equipment.

Over and above this, that branch of the military was assigned responsibility for the development and procurement of those items of which it was the biggest user. The purpose

281 here was to insure the most rational production possible and the optimum use of the manpower and of materials in short sup-

282 ply. This arrangement applied in particular to weapons, bombs, radio and radar equipment, air torpedoes, gunpowder and other explosives, fuels, motor vehicles, AAA equipment, and fire control equipment.

Although this subdivision of responsibilities produced certain advantages so far as manufacturing was concerned, serious obstacles became evident in the continued development of some items of equipment. Special features required in airborne weapons resulted in newly developed models differing widely from the models ~~XXIXXXX~~ initially in use as aircraft weapons, and the development of these adapted models did not receive the proper support from the Army Ordnance Office. For this reason the Technical Office already at an early stage took over from the Army Ordnance Office responsibility for the development and procurement of airborne weapons. What facilitated this measure was the fact that new factories had to be established since those already in existence could not meet growing requirements.

The Army Ordnance Office was also responsible for the procurement of bombs, since ~~xixiixx~~ manufacturing processes were involved in their manufacture which were similar to those used in the manufacture of artillery shells. Man power

282 shortages and inadequate manufacturing capacities, particularly during the war, led to discordance between the Army Ordnance Office and the Air Force Technical Office, so that the latter found itself compelled to create its own manufacturing facilities, although only a part of the required quantities could be obtained by this means.

Circumstances were similar in the matter of air torpedoes, initially a responsibility of the Naval Ordnance Office. However air torpedoes required features differing basically from those of ship-carried torpedoes. Against strong opposition from the Navy, the Technical Office therefore, but not until 1942, took over development and procurement responsibilities in this field. Unfortunately, this late transfer of responsibilities caused extraordinarily serious delays in the specific development and use of air torpedoses.

The development and procurement of airborne radio equipment was another responsibility of the Army Ordnance Office. However, the necessity for further development in this field made it imperative that the user, namely, the Air Force, should devote more detailed attention to the matter, for which reason this responsibility was also transferred to the Technical Office.

Circumstances were more complicated in the case of radar equipment. Since the Navy had made considerable

283 progress in research and development here, and since the Technical Office was able to procure the instruments thus developed, it had to depend on the Navy Armaments Office for supplies of these instruments. One part for radar instruments was developed directly by the Technical Office, which also then handled its procurement. The development and procurement of AAA and fire control equipment was a responsibility of the Army Ordnance Office, since these items came in the artillery category. However, the close cooperation required between

284 the Antiaircraft Artillery and air units resulted in withdrawal of the Department for AAA Development from the Army Ordnance Office and its assignment under the Chief of Air Force Special Supply and Procurement Service. Procurement, however, remained a responsibility of the Army Ordnance Office.

The Joint Military High Command (OKW) handled the allocation of raw materials, [illegible] and of electricity and fuel supplies.

With the division of responsibility for the various fields of activities among the three branches of the military as described above, discordance had developed already during peace concerning the allocation of available potentials. The resultant difficulties increased particularly during the war, due very largely to the fact that the subdivision of responsibilities called for a complicated system of allocations.

284 The procedure adopted by the Joint Military High Command was to allocate all material needed for a specific complex to the appropriate requisitioning branch (the Army, Navy, or Air Force), with due regard for the priorities assigned the various items involved. This meant that the receiving military branch had to transfer a proportionate share to that branch which was responsible for the manufacture an item required. Since the quantities allocated by the Joint Military High Command were rarely adequate to meet full requirements, no possibility existed to check whether the responsible branch actually used its share of the allocation for the proper purposes for which that share was intended. Apart from difficulties within the individual Ordnance Offices, the system resulted in an exorbitant expenditure in administrative work and personnel. In this field the lack of uniform control by a central athority directing all armament activities had extraordinarily disadvantageous results.

Closer study would be necessary to determine to what extent a uniform control might have accelerated the tactical usability or improvement of the weapons and equipment previously mentioned, for example, of air torpedoes, and to what extent it would have secured allocations of man power and materials more in keeping with the requirements of the war.

285 The can be no doubt, however, that a centralized and uniform control would have made a more rational use of available potentialities and thereby increased supplies of equipment possible.

286

CHAPTER 4

PROCUREMENT OPERATIONS

With the aid of figures found in the records made available to the writer, the almost complete procurement reports covering the years 1936-38 and 1940, and supported by the results obtained in further research, it has been possible to reconstruct the sequence of events in aircraft manufacturing activities and avoid the possibility of serious discrepancies.

The completely available Programs Nos. 3, 4, 5, 6, 7, 8, 21-ue, 21-ue-2, and 222 and 223, plus the incomplete Programs Nos. 9, 10, 11, 15, 16, 17, 18/1, 18/2, 18/3, 19/1, 19/2, 20, and 20/1, which contain numerical details on the more important front line models, have been used in reconstruction of the Procurement Programs.

Between XXXXX early 1933 and the end of the war, the Technical Office, the Fighter Production Staff, and the Armaments Staff compiled a total of 40 procurement programs plus one emergency procurement program, numbered consecutively from 1 through 22 and from 222 through 228, including revised versions. Out of this total 35 were issued to the aircraft manufacturing industries as Industrial Plans.

The first three programs up to 1 October 1934 were based exclusively on the capacities found already in existence

286 The other programs were adapted progressively to the progress made in the program of industrial expansion.

287 In view of the relatively long time aircraft models remained in serial production, and therefore in order to enable manufacturing firms to do the necessary advance planning and thereby achieve economical production, each plan was envisaged for a duration of at least two years. In actual fact this arget was not achieved in a single case.

On an average three new procurement programs were established each year throughout the 1933-1939 period. This does not include rograms 12, 13, and 14, which were compiled but not issued because of fluctuating political conditions shortly prior to the war.

These continuous changes to the programs were due to various causes. It appears justifiable to assume that prior to 1937 the ruling factor was the effort to introduce newly developed types as speedily as possible in place of the models developed prior to 1933.

In order to avoid any possibility of errors, the Office up to 1941 issued completely new programs even when only small changes were involved. Field Marshal Milch changed this system, establishing that in the event of any changes to an existing program those concerned should be notified by means of what were called Alteration Sheets.

287 Other contributing factors which probably played an important role were the basic changes introduced by the General

288 staff in the operational and tactical conduct of warfare, the changing objective of the war--particularly during the war itself--and the consequent necessity to be able to adapt aircraft and equipment to various uses in such widely separated areas as Africa and northern Norway, Russia and Germany, and the Balkans.

Usually, the technical subdivisions only received information after a campaign or an operation had started of the radically different requirements which had developed. This meant that improvizations had to be introduced at very short notice and sometimes on a large scale by the industrial firms. This, in turn had a disrupting influence on serial production and caused smaller outputs.

For practical purposes one can say that these conditions of special action ruled continuously from the occupation of the Rhineland by German troops [German troops entered the Rhineland zone demilitarized in terms of the Treaty of Versailles and took occupation on 7 March 1936--Note by Translator] to the end of the war.

Other contributing causes were budget cuts, and, particularly just prior to and during the war, inadequate allocations of raw materials and the induction of important

288 industrial personnel with specialized skills for military service. Furthermore, in many cases the essential conditions which would have ben necessary for the industry to fulfill the programs had not been established.

For the above and other reasons, parts of the programs which firms had been unable to execute had to be cancelled, and this in trun made a revision of the programs and the issue of entirely new procurement programs necessary.

A detailed study would be necessary to analyze all the causes contributing towards the necessity for changes in the

289 various programs.

From 1933 to the end of the war the number of aircraft delivered by the industries totalled 140 586.

From the beginning up to 1937 output increased proportionately with the progressive expansion of the industries and the improvement and increase of factory equipment. The industrial output in aircraft in 1934 was 1817, and from then on the annual increase was as follows:

1934-1935	1 490	
1935-1936	1 941	
1936-1937	501	
1937-1938		output dropped by 501 433
1938-1939	2 266	
1939-1940	2 523	
1941-1942	2 318	
1942-1943	3025	

289 1943 9524

1944 15725.[1]

290 In 1934 aircraft output increased steadily up to a monthly output of 346 in May, but then decreased again until the figure of 149 was reached in December. The increase was due primarily to the delivery of training aircraft and in a smaller degree to provisionally equipped and reconnaissance planes. This was in line with the requirements stated by the General Staff in order to provide a possibility for large-scale training.

The drop in the second half of the years was due to changes in the fighter aircraft under manufacture, through cessation of production of the Ar-64 and a reduced output for the Ar-65 models.

The increase of 1490 aircraft in 1935 included particularly fighters, dive-bombers, and medium bombers, to a lesser degree naval aircraft, and in particular training models for beginners and advanced trainees. Among the reconnaissance types, He-45 was dropped from production on the assumption that a new model would be developed in time to take its place. In the fighter class the Ar-65 model was withdrawn totally from production and replaced by the He-51, deliveries of which had commenced in February 1935. In the medium-bomber class first deliveries of the Do-23 model commenced, reaching a figure of approximately eighty per month.

290 The increase of 1941 aircraft in 1936 was due to the mounting production of fighters, dive-bombers and again models for basic and advanced training. In the reconnaissance plane class, the He-45 was again placed in production. The same applied in the case of the He-46, the program for which had been closed at the end of 1935 but the plane had to be kept in production because development of its successor, the He-126 had been delayed. In the fighter class the Ar-68 took the place of the He-51, and the first zero series of the Bf-109 model were delivered. In the dive-bomber class, deliveries of the He-123 commenced in August and reached the monthly figure of 26 in December. No important changes in output figures occurred in the case of any of the other front line aircraft types.

The smaller increase of 501 aircraft in 1937 is accounted for by the fact that the He-45 program for a second time came to an end and to a reduced output of all other types in the last quarter.

The decreased output noticeable in the last quarter of 1937 continued in 1938, so that this year showed an aircraft output smaller by 433 than 1936.

The decrease was on a small scale in the classes of planes for advanced training, dive-bombers and naval planes, whereas the output in reconnaissance, fighter, and medium-bomber planes increased, the reconnaissance class because

292 first deliveries of the Hs-126 began to arrive. The output in training planes for beginners remained practically unchanged.

The overall output in training aircraft shows a drop of 1200, that of twin-engine dive-bomber and other types a drop of 120, compared with an increase of normal bombers xnd by approximately 300 and of fighters by about 420. Taking into consideration the wide margin of difference in the man-hour requirements for the various types, which were quite considerable, industrial performances in actual fact showed neither a decline nor an increase.

The increased number of fighters was due exclusively to the mounting output in Bf-109 planes, which by now had gone into regular serial production, the increased number of bombers was due to the larger number of He-111 produced. So far as manufacturing operations were concerned the only changes were the following:

the He-114 took the place of the He-60

the He-59 was again placed in production because of delays in the development of the He-115

the Hs-126 went into production, as previously mentioned

the Hs-123 was dropped from production

the Me-110 went into production as a new model.

Footnote 1, p. 389: To place these figures in proper perspective wartime production must be compared with the aircraft strength of units and the overall loss figures. See Appendix s 24-26.

292 1939 again for the first time brought an appreciable increase by 2266 aircraft over the previous year's output. In

293 May the output equalled the figure for March 1937. The decreased output in the second quarter of 1937 and the fact that production only started increasing again in the last quarter of 1938 can be ascribed only in a small degree to difficulties encountered when putting new models into production. The decisive factor was the unexpected reduction in the program the General Staff had stipulated for 1937. Whereas in the past the necessary funds had been available without any reductions to meet the needs of the procurement programs under execution, the 3 700 000 000 Marks required in 1937 for the procurement of the 6 226 aircraft needed for the plans established by the General Staff had to be reduced by 1 000 000 000 Marks.

Since the plans of the General Staff and the industrial program approved by Goering were to remain in force as the industrial target, the only possibility to clarify the difficult situation was to postpone the deadline by which the program was to be completed. This measure was devised to effect a saving of 550 000 000 Marks in the current financial year. In the 1938-39 financial year a reduction in the stated requirements of the General Staff was again intended, which would result in a saving of approximately the same sum.

This meant not only a reduction in current output but

294 also that preparation of the industry to meet the requirements of a mobilization had to be restricted to the most essential measures.[1]

This cut in funds was a measure which had an incisive impact on armaments for the Air Force.

Expansion of the industry to meet mobilization requirements and measures to increase current production, on which steady progress had been made since the initial difficulties had been overcome, now suddenly had to be halted. Since it was May 1939 before the figure for March 1937 was again reached two years of steady progress were lost in the armament program. If work had continued uninterrupted, the output of roughly 1200 aircraft achieved in March 1941 could have been reached two years earlier, by March 1939, provided the General Staff had stated appropriate requirements.

The reduction of General Staff requirements intended for 1938-39 was not effectuated because the international situation had again deteriorated considerably. It can be assumed that the reason for this was the fact that trade policy measures taken by the USA and Britain in international trade to impede German purchases of strategically important

1. See "Aktenvermerk ueber Besprechung zwischen Goering und Udet vom 5.6.1937;" also from personal experience of present author.
Footnote 1, p. 392: According to p. 390 the decreased output only occurred in the last quarter of 1937--Translator.

295 raw materials from foreign suppliers were beginning to make themselves seriously felt. The decision taken in the previously mentioned conference between Goering and Udet to release 2 800 workers from the aircraft industry was therefore not put into effect.

The increasing output in the first quarter of 1939 was made up chiefly of front line types, namely, reconnaissance, fighter, dive-bomber, twin-engine fighter, and liaison aircraft, with only a small increase in naval aircraft and still further reductions in the production of planes for training purposes. The largest increase was in the production of bombers, followed by fighters.

In the case of fighters, reconnaissance planes, and dive-bombers, the models currently in use remained in production without any changes, so that the increase was chiefly in the Hs-126, Bf-109, Ju-87, and Me-110 models.

In the case of bombers, the Ju-88 took the place of the Ju-86, and was coming from industry in increasing numbers since August. In addition the Do-17 and the He-111 remained in production, with He-111 accounting for the by far largest share of the increased output in bomber types.

With the Ju-88 now in production, three bomber types were being manufactured at one and the same time. A point

295 which still needs clarification is whether this was necessary, and whether and what measures were taken to insure uniform equipment of the individual units, to facilitate resupply of spares, and whether it was not possible to restrict production to two types in order to rationalize production.

The Ju-52 remained in production as a transport plane.

In the naval plane class, the He-114 and He-59 were taken out of production and replaced by the He-115 as a multipurpose plane and the Ar-196 as a ship-based plane.

The upward trend in output continued in 1940, namely an increase of 2623 against the increase of 2 266 in 1939. This increase was hardly appreciable, however, in the state of war, because the preparatory measures against the eventuality of mobilization had provided for a considerably increased output already in the first year of warfare.

It is to be assumed that the reason here was that the systematic mobilization perparations which had been planned could not be put into effect in the aircraft industry. The plans were based on the assumed declaration of economic mobilization, inwhich case certain production would have ceased, so that the factories involved could be used for war purposes and the man power released from them could be employed in war industries. Furthermore, the change of

297 machinery which would have been necessary did not take place.

Mobilization of the armament industry was dependent on the general economy, but general economic mobilization was not automatically bound up with mobilization of the armament industry. When military mobilization (K-F-II) was proclaimed on 25 August 1939, civilian fields remained on the whole unaffected. A state of economic mobilization was admittedly declared on 3 September, but with important restrictions. Mobilization regulations applied only to the most necessary changes required in the national economy.

All measures of economic mobilization were determined largely by the currently ruling views on the situation. The production plan for war, which the Air Force had submitted to the Joint Military High Command (OKW) was not put into effect by the Joint Military High Command with the outbreak of war. Only certain measures were ordered in instruction to the various Economy Inspectorates designed to accelerate the speed-up of production in a number of armaments factories.

The general view that the war would be of only short duration also resulted in serious opposition to any restriction of the normal peacetime economy. Furthermore, later efforts by the Joint Military High Command to have the entire economy mobilized encountered resistance by the Plenipotentiary General for National Economy, who opposed use of

297 industries for military purposes which were engaged in supplying civilian needs.

Under such circumstances the conditions did not exist

298 which would have been necessary to set the general mobilization of the aircraft industries in motion.

Special studies would be necessary to clarify whether and to what extent the General Staff, under the impression of the then ruling favorable military situation, addressed increased requirements to the Chief of Air Force Special Supply and Procurement Service. This is so particularly in view of the fact that after conclusion of the campaign in France in 1940 main emphasis during preparations for Operation Seeloewe against Britain was shifted to the Air Force and the Navy in all armament activities, which provided possibilities to implement measures to expand Air Force armaments.

With commencement of preparations for the campaign against Russia and the expansion of the Army to 180 divisions, the mission of providing armaments for the Army again took precedence.

This might explain in part why the increase in production was smaller by 2 318 aircraft than in 1940, particularly since the ruling view in the highest levels of military command was that the Russian campaign of 1941 could practically be concluded by the winter of that year. Since work on the

29[illegible] the Public Buildings Program also continued into 1941, at least to a great extent, inductions of personnel in preparation for the campaign against Russia had an extraordinarily hampering effe t. To all these complications must be added the manpower difficulties caused by the fact that personnel allocations had been 20 000 below the required figure and the loss of 20 000 workers recalled for military service who had been released on furlough for employment in the Air Force supporting industries. Furthermore, it was anticipated that the industries involved would have to release personnel to factories engaged in the manufacture of AAA equipment and bombs. For these reasons no considerable increase in output could be expected.[1] Very similar conditions existed in respect to the allocation of raw materials.

After Field Marshal Milch took over the responsibility for aircraft production as the new Chief of Air Force Special Supply and Procurement Service in November 1941, output mounted by 3 025 ~~mxmx~~ in 1942 over the year before and again by 9 524 in 1943.

The 1942 increase was made up primarily of fighter, medium-bomber, reconnaissance, dive-bomber, twin-engine fighter, naval, and liaison planes, with also a small increase in training aircraft. The output in transport and advanced

1. See "Vortragsnotiz Udet's vom 5.3.1941."

299 training planes decreased.

In addition to the Bf-109, the FW-190 model, which had gone into serial production in 1941, accounted for the fighter increase. In technical performances there was little difference between the Bf-109 and the FW-190. The reason for its being included in the program was the desire, for planning purposes, to have not only water-cooled but also air-cooled

300 engines as an alternative. What role prestige problems of Construction Chief Tank, of the firm of Focke-Wulf, may have played in the decision requires further study.

In the twin-engine dive-bomber and fighter classes the increase was due to commencement of the Hs-129 series as an armor-protected twin-engine fighter and reintroduction of the Me-110 because of the failure of the M-210.

In the medium bomber class He-111 output increased while Ju-88 output remained unchanged . The He-177 was also newly placed in production, but serious complaints for a time prevented its being placed in service.

The continued increase in 1943, by 9 524 aircraft over the 1942 figure was made up primarily of fighters, dive-bombers, and twin-engine fighters, with only small increases in bomber, transport, and naval aircraft production. The output of the models initially intended for reconnaissance purposes decreased. Owing to the inadequate performances

300 of the Fw-189, part of the output of Bf-109 planes were used for reconnaissance.

In the twin-engine fighter class the Me-410, developed from the Me-210 came into service. This model and the Me-110 accounted for the increased twin-engine fighter output.

301 The bomber models in production remained unchanged in 1943.

Field Marshal Milch's desire to increase fighter production in order to provide better protection for industries against air attack found expression in a changed production program calling for a larger number of fighter aircraft.

Even before Field Marshal Milch assumed responsibilities as Chief of Air Force Special Supply and Procurement Service, Goering in June 1941 had given him special authority to take measures designed to increase fourfold the current output. The authority empowered him to close down non-essential factories, confiscate building materials and erect non-permanent type buildings, confiscate machinery and allocate it to armament works, confiscate manufacturing materials for the Air Force programs, and to intervene in industrial personnel matters, all in deviation from the existing regulations governing war budgets. Undoubtedly this authority did much to bring about an increased output, although the measures

301 involved could only be effectuated in coordination with the Minister for Armaments and the Wartime Economy in 1942 and 1943.

In addition to the above, Milch introduced a firmer control of the Air Force supporting industries, more exhaustive use of the reserve stocks of materials held by the various firms, and the employment of prisoners-of-war after a course of industrial training.

As the war drew on, however, even the increased output

302 achieved proved inadequate, and the unfavorable position of the Air Force in respect to allocation priorities made further increases in industrial output for the Air Force impossible.

It was only after the Fighter Production Staff assumed responsibility for fighter production and, in August 1944, the Armaments Staff took over all procurement responsibilities for the Air Force, that possibilities existed to place at least fighter production in the first priority category for a start. This brought about an increase by 15 725 aircraft more produced in 1944 than in 1943, but it must be borne in mind that this increase applied only to fighter types, while the production of all other types was seriously curtailed. The actual increase in manufacturing performances is thus far smaller than would appear to be the case, because of

302 the smaller expenditures required for fighter than for bomber or other type aircraft. For a just appraisal, a precise comparison on the basis of man-power unit requirements would be necessary.

Once the program was awarded the highest priority, the Fighter Production Staff had all means available to step up production, which the Chief of Air Force Special Supply and Procurement Service had been unable to obtain in the past in spite of constant efforts.

Here it is necessary to point out that both Udet and Milch at an early stage already had stressed the necessity for the preferential manufacture of fighter aircraft. As early as in 1943 a Fighter Production Program was compiled under instructions from Field Marshal Milch, but was rejected by Goering and Hitler. This program provided for the production of 6 000 fighters per month. To have put this program into effect would have involved complete cessation of bomber production. Although it is unlikely that this essential condition could have prevailed, the implementation of a fighter production program even on a smaller scale would have had an extraordinary impact on air warfare and probably would have provided adequate protection for German industries.

Up to 1937 the industries were able to carry out in accordance with plans the production programs compiled by the

303 Technical Office, and it had even been possible to make deliveries over and above those required by the programs. Later, and particularly durin the war, as previously mentioned, various factors prevented the fulfillment of requirements in accordance with plans. The factors included the man-power difficulties caused by the induction of skilled personnel for military service, inadequate allocations of materials in short supply, the implementation of special projects, and changes in the programs. The changes mentioned were in part due to the fact that models were placed in serial production before their tests had been completed.

The moethod of placing models in serial production before they were properly ready might have resulted in delayed deliveries before the war, but would not have created insuperable complications. Under war conditions, however, the faulty development of two models, the Me-210 and the He-177, combined with faulty decisions concerning the use of the Me-262 which withheld this model from important missions of air warfare, naturally produced dire consequences.

Development of the He-177 as a long-range bomber-reconnaissance plane was based on the tactical requirements stated by the General Staff for the 1938-39 program. Specifications provided for the plane to have twice two engines, each pair with one propellor, giving it a flight capability of 3 600 miles

304 (6 000 kilometers) with a crew of five. The records available at writing contain no details on the other flight performance requirements. The specification of two twin-motors may have been designed to improve general performances or to make the plane suitable as a dive-bomber.

One outcome of the ruling views, prior to the war, on the tactical use of bombers was that general opinion called for dive-bomber tactics as the best method of attack. To obtain the necessary sturdiness, however, and if four separately installed engines had been used, the required performances were only possible with a considerable increase in deadweight. It therefore seems safe to assume that the development of the He-177 was due from the outset to the specification that it was to be capable of dive-bombing action.[1]

During development, however, and also during serial production prior to completion of the development and proving stages, basic difficulties became evident in the form of fire hazards, a tendency to side slip, and inadequate stability of the wings.

Particularly among the planes of this type delivered to the troops from serial production numerous cases of fire and of inadequate flight properties were reported. This made it necessary to withdraw the model and carry out extensive

1. This view is confirmed by statements from Generalingenieur Heidenbach, at the time Chief of Aircraft Development. Final clarification will probably be possible--Continued

305 modifications and redesigning work.

Even before the weakness described above had become apparent, the Chief of Air Force Special Supply and Procurement Service while on a visit at Aechhin had studied the practicability of installing two twin-engines or four separately mounted engines, and had recommended four separately installed engines. In view of the fact, however, that the competing model, the Fw-191, achieved only half the operating range with its separately mounted four en ines, Goering decided against further development of planes with four separately installed engines.

The modifications referred to above resulted in an extraordinarily long delay in serial production of the He-177, on the availability of which the General Staff had based its planning.

First deliveries of this plane would have been due under Delivery Plan 9 in January 1941, under Plan 10 in March 1941, under Plan 11 in July 1941, under Plan 222 in October 1942, and ubder Plan 323 in April 1943, the latter two plans calling for production of 2 000 of these aircraft in each case.

Development of the aircraft was only projected in 1938, so that the deliveries provided for under Plan 9 were too optimistic in view of the size of the plane. However, given

Footnote 1, p. 404--continued: with source material still expected by the present writer.

306 more thorough and careful designing, it should have been possible to commence deliveries by the end of 1941 or the beginning of 1942. In actual fact the first serviceable aircraft of this type reached the troops only in August 1943, involving a delay of at least eighteen months. In operations the gap thus caused could not be filled by the use of other types of aircraft. As early as at the end of December 1942, the lack of He-177 aircraft resulted in a shortage of 2000 He-111 aircraft at the front, a shortage which it was no longer possible to remedy.[1]

It was only due to the supply requirements for Stalingrad in January 1943, for which purpose all available aircraft were pressed into service, that the first squadrons of He-177 went into action. Here again, fires caused losses, but the cause of these fires was ascribed to the extemporized nature of the operations involved, the inadequate ground organization and the inadequate servicing provided.[2]

The first group of these aircraft, using equipment for the Hs-293, went into service as the 1st Group, 40th Bomber Wing, on 15 October 1943.[3] It was early 1944, however, before the model went into service as a long-range bomber after the

1. See "GL-Besprechung, 9. 12. 1942."
2. See "Besprechung Goering-Vorwald, 4. 2. 1943."
3. See "Besprechung Goering-Peltz, 22. 9. 1943."

307 required quantities of bombing equipment had been delivered. Again, however, delays occurred because no timely preparations had been made in the field of ground organization, and personnel and technical requirements.[1]

From the end of June 1944 on it was at last possible to equip the 3d Wing with these aircraft, at a time when Hitler had already declared that the model in its existing form was no longer of any interest[2] and Saur had already cancelled it from the production program.[3]

Parallel with the above work, the Technical Office had continued on the development of a 4-engine aircraft, the He-277. In 1943 the Chief of Air Force Special Supply and Procurement Service pressed for a change-over to this model.[4] However, the change-over did not take place and development of the He-277 had to cease under instructions from Saur.

The delayed delivery of this model to the troops produced exceptionally disadvantageous results, particularly in the field of submarine warfare. The evident lack of suitable aircraft in this field influenced Oeschonnek, acting on requests from the Naval Operations Staff, to request release of a limited number of He-277 aircraft in February 1944, the condition being that they should be very easily serviceable, for naval long-range reconnaissance and submarine support

1. See "Bericht Major Schubert, 25. 4. 1944."
2. See "Besprechung Hitler-Speer, 12. 6. 1944."
3. See "Haegerstabbesprechung, 27. 6. 1944." --Continued.

307 operations. However, the side-slip tendencies of this model had not yet been remedied, so that they could not be delivered to the troops.

308 A more detailed study would be necessary to determine what impact this plane could have had on the conduct of submarine warfare if it had been ready for service as planned at the end of 1941 or in early 1942.

The flaws which became apparent in the He-177 were undoubtedly due to faulty designing and to Heinkels efforts to achieve maximum flight performances even at the cost of other disadvantages.

Deficiencies so far as the engine installation was concerned resulted from the placing of the exhaust pipes, the inaccessibility of the engine for servicing purposes, and inadequate engine performances.

From the very beginning the Technical Office had insisted on easy serviceability[1]. However, this demand had not been met because it would have have necessitated a longer fuselage because of the need to move the engines 20 centimeters farther forward. Other flaws were an inadequate lubricating oil circulationwhich resulted in gear troubles, the development of oil scum, and the faulty placement of the oil cooler, which was a source of trouble through freezing.

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1. Information from Generalingenieur Eisenlohr.

308 It was March 1943 before Heinkel was able to report to Goering that the deficiencies had been remedied and that serial production could begin in the summer of 1943, after having reported months before that the model was in perfect order.

The firm of Daimler-Benz refused to acknowledge the pattern by which the two pairs of engines were mounted as a construction of its own designing.

The Me-210, intended to take the place of the Me-110 from which it had been developed, went into serial production and was included in the procurement program before its tests were completed, as was the case with most models. It had already been included in Program 10, which required delivery of 884 of these planes in January 1941. The same figure was retained in the next few programs, but in Delivery Plan 21 delivery dates were postponed to October 1941. The number planned for delivery from the A series of this plane remained unchanged, and the same program called thus for 1677 planes of the C/D series with deliveries due to commence in March 1942.

Actually, production, including the zero series, commenced in July 1941 on a small scale.

During test flights and also afte the first unit had been equipped with this model, difficulties occurred in flight operation due to flat spin, slide slip, and difficult control at take off. A study by the Industrial Council produced a

309 verdict coinciding with the opinions given by the Chief of Section I T of the General Staff and by the Chief of the Proving Station that the model could be rendered usable after the modifications required by the Technical Office had been made. The changes were to be incorporated in the series from the 401st aircraft on, while those manufactured prior to the change up to the 300th plane, were to be adapted in a workshop for front purposes, and the other 100 were to be adapted for use at schools. While work was in progress, however, the number of changes needed mounted from four to forty, so that serial production could not be resumed before 1 October 1941.

The delays which occurred in completion of the test models and the discovery that other important changes were needed finally led to a decision by Goering to cancel this model from the program and cease its production. Instructions were to complete six aircraft of the model 210 and ten of the S variant for testing purposes. The roughly 300 planes which were almost completed and the material already cut to measure for another 300 were stored at the Gablingen air base.

Simultaneously with commencement of Me-210 production, measures to halt the current series of Me-110 were set in motion. Although precautionary measures had been taken to increase the production of the Me-110 model, it

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310 proved impossible to provide a carryover to commencement of the new series. Production of the series continued on a decreasing scale until December 1941 and was resumed again in February 1942 on a small scale. It was May 1943 before the specified monthly output of 125 planes of this type was again reached.

The consequent lack of aircraft for the equipment of units could only be offset to a small extent by the use of Me-109 planes.

311 After favorable results obtained in tests with a redesigned version of the Me-410 for use as a night fighter, and also as a fast bomber, plans again provided for inclusion of this plane in the plans for serial production, primarily for use as a daytime bomber in operations against Britain.

Finally deliveries commenced with 1 013 planes in June 1943 and continued until September 1944.

A number of factors contributed towards the faulty development of the Me-210.

In his efforts to secure performance advantages, Messerschmitt in all designs exposed materials used in the construction to the utmost strains permissible. Consequently, almost every model developed by him required considerable reinforcing after the results of test flights became known. Furthermore, it was found that work stated by him to be complete was by no means completed. Contrary to the findings by the

311 Development and Proving Branches of the Chief of Air Force Special Supply and Procurement Service, he reported in writing to General Udet that the Me-210 was ready for inclusion in the Procurement Program, whereupon its inclusion in the program was ordered.[1] Furthermore, untried changes were introduced by Messerschmitt while the plane was in serial production. These changes deviated from the pilot model and, among other things, resulted in very frequent undercarriage breakages.[2] Already during inspection of the mock-up model the Development Branch of the Chief of Air Force Special Supply and Procurement Service stated the requirement that the tail part must be lengthened, an instruction which was not carried out.

Messerschmitt's tendency to play off one department of the Air Force against the other was particularly evident during development of the Me-210. The General Staff and the Chief of Air Force Special Supply and Procurement Service had required the model as a twin-engine fighter and fast bomber. Without their knowledge the designe were influenced by three commanders of front line units, again along three different lines: as a long-range fighter, as a dive-bomber, and as a replacement for the outdated Ju-87. Actually then, the first designs submitted were for a long-range fighter which

1. Statements by Generalingenieur Heidenbach and the responsible supervisor Bobet.
2. Statement by Bobet.

312 failed to meet the requirements stated by the General Staff and the Chief of Air Force Special Supply and Procurement Service for a twin-engine fighter and/or fast bomber.

The faulty development was thus largely due to failure to observe the requirements of the Technical Office and to the influences brought to bear from various quarters.

One important factor here was the tendency of some firms to accept suggestions and recommended changes only too eagerly when these were put forward by front line officers during visits and to apply the changes without approval from the Technical Office. Since these suggestions and recommendations

313 almost always emanated exclusively from personal views, they diverged widely one from another and produced influences in the industries which usually had an unfavorable impact on items required for specific purposes.

Development of the Me-262 was started by the firm of Messerschmitt in 1938 as Project P01065 in close contact with the Technical Office. Propulsion by means of two jet engines and without propellors represented an entirely new departure and required as an essential condition the clarification of fundamental technological problems. In order to avert serious reverses, the flight properties of the plane were therefore tested with an additionally installed Jumo-210 liquid-cooled engine. The first flight took place in 1941.

313 The firm of Heinkel had constructed the He-178 as early as in 1939 after its own designs, and had flown it as a jet propelled plane. However, this plane was merely a test vehicle for power units and was not taken into consideration later for military purposes. This non-use of the plane was fully justified, since continued development of a suitable fuselage hinged upon completed development of the jet engines.

An inspection of the jet power unit after the first flight by the He-178 revealed very serious damage, the repair

314 of which required engineering facilities not available at the Heinkel Works as a fuselage constructing firm. For this reason the engine developing group transferred to an engine manufacturing firm, probably the Bayerische Motorenwerke, the main mission of the firm of Heinkel under existing programs being to develop and manufacture bomber aircraft.

The fact that the firm of Heinkel was overburdened with development contracts, plus the personal tendencies of Professor Heinkel whenever possible to seize on any project that seemed promising had resulted in complications during serial production of practically all models developed by him, particularly when these models were manufactured under contract by other firms, and particularly because of inadequate construction data.

For all of the above reasons the development of a

314 jet fighter was assigned to the firm of Messerschmitt.

The Me-262 was to be powered by the jet engine developed by the Baye ische Motorenwerke, with which the first test flights were carried out. Owing to delays in the development of this engine, however, a jet engine developed by the firm of Junkers with smaller performances was used.

On the occasion of a visit by Field Marshal Milch and General Udet in Augsburg in 1941, Professor Messerschmitt reported on the stage reached in developing the two models, Me-162 and Me-262, intended for jet propulsion.

Under the impression of the favorable military situation, however, Hitler had ordered in 1940 that all development work

315 on projects which would not be ready for the field within a year was to be halted. The firm of Messerschmitt therefore received instructions during the visit mentioned above to cease tests with the two models since it was not to be espected that they would be ready for the field in the foreseeable future.

Contrary to these instructions work on the fuselages and on the engines continued with support from engineer personnel of the Technical Office, although not much progress was made owing to the impossibility to secure the allocations of personnel which would have been necessary to accelerate the work. Work on the project therefore continued only on a restricted scale.

315 Although it soon became evident that the war would last longer than antidipatedso that the necessity existed to continue work on developments requiring a lengthy period of time, work on develppment of the two models received little support.

Because the firm of Messerschmitt was so heavily overburdened with designing and construction missions, Field Marshal Milch in 1943 even planned a division of current missions in such a menner that the firm was to continue work on the Me-209 and Me-410 medels, while the Me-163 and Me-262 were to be handled in a special factory by the firm of Lippisch and Gartenl.[1]

This would have hampered and seriously delayed work on the two latter models, since it would only have been possible to start work on them in a new factory at the cost of a serious loss of time.

The obvious purpose of this intended measure was to expedite production of the Me-410 as much as possible in order to make up shortages in unit equipment due to the faulty development of the Me-210.

This division of missions was not carried out because of personal differences between Lippische and Messerschmitt.

In October 1942 tests with the aircraft powered by the Junkers jet engine were completed,[2] but Field Marshal Milch

1. See "GL-Besprechung vom II. 2. 1943."
2. See Ibid 18. 5. 1943.

316 withheld orders to include it in the procurement program until after General Galland had carried out further test flights in May 1943.

The reasons for this repeat test by General Galland as long as six months after completion of the normal tests needs closer examination. It must be assumed that the order for a renewed test was due to a negative appraisal by front line air pilots who, although generally experienced, were not familiar with this basically new development and the changed tactical circumstances in air operations.

The tests carried out in October 1942 and later showed the necessity for more detailed work on the construction data, but this work received little support because of the negative appraisal of the aircraft. In fact, these data were not even ready by May 1943 in a form which would have permitted manufacturing of the aircraft in another factory under licence.[1]

Although the order to place the new model on the Aircraft Procurement Program concurrently with the order to cancel Model Me-209 and tranfer the priority hitherto awarded to this model to the Me-262 model represented an acknowledgement of the importance of the Me-262 for the conduct of air warfare, the basically unfavorable position of the aircraft industries in respect to priorities with the entire complex of armaments

1. See "GL Besprechung vom 18. 5. 1943."

317 production remained a serious obstacle.

Field Marshal Milch's demand for completion of the construction data and the manufacture of 100 aircraft of the new model before the end of 1943 was therefore frustrated by the necessity to repeatedly delay deadlines. One hampering factor here was also that of organizational and personnel difficulties within the firm of Messerschmitt.

Completion of the data in a condition which would permit manufacture in another factory under licence , with complete conversion of the installations originally intended for the Me-209 to now handle the Me-262 was planned for May 1944,[1] but had to be postponed to 15 June and the [illegible] provision of the necessities for operation of 100 of the new aircraft had to be postponed to 15 August.

Instead of the 100 aircraft to be produced before the end of 1943, possibilities to commence manufacturing were only

318 created by the beginning of 1944. Even then production was very slow to gain momentum, namely,

1	aircraft	in	January
8	"	"	February
20	"	"	March
40	"	"	April
60	"	"	May,

so that the target of 100 aircraft of the new model could only be achieved in May 1944.

1. See "GL-Besprechung vom 22. 5. 1944.

318 Plans provided for first deliveries from large-scale serial production from November 1944 on, the manufacturing firms being the Wiener Neustaedter Flugzeugwerke, the firm of Erla, and the Messerschmitt factories at Augsburg and Regensburg.

In July 1943 already the firm of Messerschmitt reported another delay in production of the advance series by three or four weeks because the required former and fuselage construction personnel had not been allocated.[1]

Finally, interference in the whole aircraft production plan necessitated by Hitler's order to retain the Me-209 in production had an extraordinarily adverse impact on the planned sequences of work, since it was now no longer possible to convert Me-209 manufacturing plant for the manufacture of the Me-262.

The manufacturing and construction data for the Me-209 were only 60 percent completed and this work now had to be brought to an end, and the designing and construction facilities needed for this work were lost for the Me-262.[2]

In view of the new situation Messerschmitt demanded priority of the new plane over all other models and complete protection of his personnel. However, this demand contrasted with the order given by Hitler already in February 1943 on recommendations from Speer that tank production was to be given

319 priority over everything else.[1] For this reason it was not possible to comply with the demands by Messerschmitt and the Chief of Air Force Special Supply and Procurement Service that production of the Me-262 should be awarded the highest priority.

Raw materials supply difficulties and the constant loss of personnel from the Air Force supporting industries through induction for military service finally influenced the Chief of Air Force Special Supply and Procurement Service to request the Armaments and Wartime Economy Minsitry to appoint a commissioner for production of the Me-262. Prior to this he had appointed a commission made up of representatives from his own office, from the Industrial Council, and from the aircraft manufacturing and subsidiary firms, which had failed to create the necessary conditions for production of the Me-262, while an application by the firm of Messerschmitt to place the production under special and total protection had also failed.[2]

At the end of 1943 Hitler personally witnessed demonstration flights by the new model and ordered it placed in the top priority bracket within the Air Force production programs. Nevertheless, it was only possible after establishment of the

1. See "GL-Besprechung vom 17. 8. 1943."
2. See Ibid 16. 2. 1943.

Footnote 1, p. 419: See "Fernschreiben Fa Messerschmitt vom 20. 7. 1943."
Footnote 2, p. 419: "See GL-Besprechung vom 17. 8. 1943."

320 Fighter Production Staff in March 1944 that it was possible to place the model in the fighter category with top priority over all other armaments production.[1]

During the demonstrations Messerschmitt had assured Hitler that the plane could carry a bomb, and this led to the order that all Me-262 planes were to be converted as fast bombers. Messerschmitt gave his assurances in a generalized manner which necessarily created false impressions. Although the reasons given by Messerschmitt for doing so were his concern that Hitler might reject the new model, his action reveals once more his unilateral interests for his firm, which had also become apparent in other cases and had led to sometimes false impressions.

In actual fact the form in which the Me-262 was in production made it useless as a fast bomber, and when Goering visited the works at Regensburg as a result of Hitler's decision, Messerschmitt stated that he would need another two weeks to complete the necessary extra constructional work involved in its adaptation for the new purpose.[2]

Since the fuselage as it existed provided an angle of vision of only 8 degrees for bombing purposes, something had to be done to improve these conditions. This necessitated

1. See "GL-Besprechung vom 7. 12. 1943."
2. See "Besuch Goering in Regensburg am 2. 11. 1943."

321 an entirely new cockpit, construction of which only commenced in June 1944,[1] and a different bombing sight, for which purpose a decision had made meanwhile to use the Lotfe bombing sight. However, this in turn created the necessity for specially trained bomber aiming personnel.

Reconstruction of the already completed model was delayed considerably and it would require a more detailed study to determine whether the model ever actually went into service as a fast bomber.

In conference with Hitler in May 1944 Field Marshal Milch insisted that the Me-262 could be used only as a fighter, but approval to produce it as a fighter was withheld until November 1944 and then only on condition that it should be so constructed that it could carry at least one 550-pound (250-kilogram) bomb.

Actual deliveries from the advance series commenced with one plane in March 1944, eight in May, then another 22 and 55, mounting up to 127 in December. By March 1945 a total of 1 294 Me-262 aircraft were completed, but only a small number of these went into service as fighters by the end of the war.

In February 1945 the Fighter Production Staff appointed a special commissioner for production of the Me-262, one flight tests by the industry, and one for delivery of the

1. See "Jägererstabbesprechung vom 6. 5. 1944."

321 planes to front line units, besides an inspector with troops. These measures were designed to expedite and insure production of the Me-262, but they came too late, as did the appointment of a Plenipotentiary General For Jet Propelled Aircraft by Hitler.

With energetic support in spite of the order to halt its development, and if it had been placed in the top priority brackets in time, earlier and larger production of the Me-262 undoubtedly would have been possible. How much earlier deliveries from the industry could have commenced can only be determined from source material not yet available to the present writer.

Due to its superior technical performance and its strong weapons, the Me-262 as a fighter could have proved a decisive weapon of defense against enemy daytime air penetrations. Hitler's decision to reconstruct the planes already in production so that they could be used exclusively as fighter-bombers frustrated the hopes which the Air Force High Command had placed in this new model. Since all efforts to have the order revoked or at least moderated failed, a solution was sought in the construction of a single-engine jet fighter of simplified structure. Other factors contributing towards this decision were the steadily worsening raw materials supply situation, difficulties encountered in construction

322 of jet engines by serial production methods, and man-power shortages.

323 The exceedingly difficult materials supply situation resulting from extensive damage by bombs to aluminum works and to occupation by enemy forces of the countries supplying bauxite necessitated substitute solutions. Plans provided for the use of wood for the wings and tail empannage, while the rest of the fuselage was still to be of aluminum. The target being to produce the largest possible number of aircraft within the smallest possible space of time, the new model was to have only one jet engine instead of the two used in the Me-262.

Manufacturing specifications called for the simplest structure possible, dispensing with all items of equipment not essential for daytime operations. This made it possible to to limite the deadweight of the new model to 2.5 tons compared with the 7 tons of the Me-262.

From the designs tendered by the firms instructed to develop the new model, those submitted by the firm of Heinkel were selected.

Pursuant to a decision by Hitler, this firm was commissioned to to design and manufacture the new model, known as

323 the Volks Plane or V-Plane (V-Flugzeuge).[1] These planes were to be manufactured in addition to the already existing program.[2]

Hitlers demand that all necessary measures should be taken immediately for the manufacture of the largest possible number could only be met by a special project, which would have to be very comprehensive and had priority over all other projects.

The project could be achieved as a mutual effort by selected engineers from the Reich Air Ministry, the industries, and the various federal authorities involved. Director General Kessler was appointed to head the new commission. Kessler had had the opportunity to gather experience in his management of the special project for the manufacture of containers for air-drop supplies to Stalingrad, and in his management of the special project for the relocating and control of the ball-bearing industries after the attacks against Schweinfurt.

Although the first conference on planning for the new midget fighter only took place at the Air Force High Command on 5 September 1944, and although the firm of Heinkel only received the contract to construct the new plane on 20 September with the condition--pursuant to agreement reached in an armaments conference on 25 September--that it was to be produced in very large numbers, the pilot model of the new

1. See "Ruestungsabsprechung vom 20.9."
2. See Ibid 25. 9.

fighter

324 carried out its first test flight already on 6 December 1944.[1]

The plane crashed in its first test flight, and this caused a setback in the second test, and also revealed the necessity to have stronger surfaces, but these setbacks did not delay preparatory work for serial production.

325 The target of delivering as many of the new aircraft as possible to front line units as speedily as possible would have called for production o the most rational basis possible, that is, as centralized as possible, in order to avoid loss of time through transportation and inadequate communications between a number of constructing factories and the resultant need for alterations, and so forth. Unfortunately the current air situation made this impossible. Instead, the air situation necessitated a widely d centralized system of manufacturing which would insure that the loss of individual works construct- ing the various parts and assemblies would not seriously affect adherence to the deadlines for deliveries.

Because of time and working operations considerations, it was not possible to divide construction of the fuselage among a large number of sub-contractors. However, complete fuselages were manufactured at three different places,namely, Heinkel, in Parth, Pomerania; Junkers, in Dessau; and in the underground works near Nordhausen. The final assembly was carried out by Heinkel in Rostock; Junkers, in Dessau;

1. See "Bericht Oberingenieur Heinl: Der Volksjäger, Schnellaktion He-162".

325 and in the Mittelwerk Factory in underground premises near Nordhausen.

The wooden structure of the planes and tail empennage made wide decentralization of work on these parts possible, a large part of which was carried out by small furniture manufacturers although they had no experience whatever in aircraft construction.

326 These small workshops were organized in groups, each group under an Air Force engineer, whose mission was to insure smooth cooperation and execution of the manufacturing contracts. The groups organized in Silesia, Thuringia, and southern Germany manufactured wings and tail empennages independently one from the other. Contrary to expectations, excellent results were achieved with these small firms, some of whom developed exemplary working installations and gages.

Very serious difficulties were encountered in the manufacturing of the necessary tools and in their synchronization to insure easy exchangeability of the parts and construction units coming from various works.

Plans provided for the completion of 1 000 of the new aircraft by 31 March 1945, the first delivery of eighty to take place in January of that year. This target was not achieved because the impact of air attack, particularly on communications facilities, had in the meantime assumed such

326 proportions that it was not possible to have the assembly units ready for final assembly in time in spite of all effrots. An important role w s played here by what was called the haversack operation (Rucksack-Aktion) in which individual persons

327 carried individual parts in haversacks to the appointed places. Large-scale use of such methods had been made necessary because whole railcar loads of parts had been lost repeatedly when railway trains were destroyed or dam ged in air attack. The system had been used successfully on previous occasions in the manufacture of other aircraft models, engines, and items of equipment and became of steadily increasing importance with the increasing scale of damage to communication routes. In the end an extremely large number of persons were employed in such operations.

It was February 1945 before the eighty aircraft intended for delivery in January were actually delivered, and owing to the general disorganization of the economy which set in towards the end of the war there was no longer any possibility to achieve the planned increase to 320in February and 600 in March. Actually,only 34 of the planes were delivered in March, so that the total delivered amounted to only 116 planes.

Although deliveries fell far short of the planned figures, the execution of this project, which made it possible within

328 five months after the initial construction contract was awarded to start deliveries in spite of transportation, technical, tools and materials procurement, assembly, test flight, and fuel supply difficulties, can be considered an extraordinary achievement by the industry and all others concerned.

329 The effort to rpovide an effective weapon of defense against air attack and thereby protect the armaments industries by means of a speedy project for the manufacture of the He-162 jet fighter was bound to fail, since it was no longer possible to break the numerical superiority of the British and American air forces.

Although all concerned did their very utmost to carry this special project through successfully, it was doomed from the outset to failure, just as the the Fighter Production Staff and the Armaments Staff established to step up fighter production were bound to fail in their mission because there was no way to make up by means of improvizations for the time which had been lost through faulty decisions in the awarding of priorities.

What results a special project to expedite production of the Me-262 jet fighter might have produced if it had come earlier, because of the earlier juncture at which these fighters then would have been available for action, requires more detailed study, particularly because it would be necessary

328 to clarify technical problems of manufacturing possibilities. It is known that the Me-262 had steel spars, for the tooling of which there were not enough tooling machines available. To what extent a special project for the procurement of enough milling machines would have succeeded it will no longer be possible to determine. Under the circumstances as they existed at the time, a special project for the increased production of this model would have depended for success on a modified construction with light metal spars. It is doubtful whether better results hould have been achieved by any such means.

THE USE OF FOREIGN AIRCRAFT FACTORIES

The unfavorable priority classification and the completely inadequate materials allocations awarded for air armaments made it impossible to carry out the necessary extensions to existing factories or to establish new factories on the scale required for execution of the production programs. Available factory spaces thus lagged far behind the needs of the Chief of Air Force Special Supply and Procurement Service. Therefore, everything possible had to be done to increase available capacities by using the industroes of friendly or occupied countries.

The best method here proved to be that under which the Chief of Air Force Special Supply and Procurement Service awarded the foreign firms diredt contracts, which was

329 the method adopted although it was contrary to the policies of the National Socialist Party authorities. The Party authorities endeavored to increase German production by closing down the factories in occupied territories and moving the tooling machinery and the skilled personnel to Germany.

Superficially, it might have seemed that the Party policy would insure safer production operations. However, it proved disadvantageous, since the work performances of the foreign personnel, separated from their families, declined radically, and since many such personnel when on home leave joined partisan units insted of returning to their place of work when their home leave was over. Furthermore, irreplacable time was lost in the dismantling, transportation, and distribution of the machiners among German factories, and the integration of the machinery and personnel into current manufacturing operations.

Quite apart from the social aspects, the resulsts achieved vindicated the soundness of the methods used by the Chief of Air Force Special Supply and Procu ement Service.

A basis for cooperation with friendly or occupied countries was established by means of Government-Government agreements or by means of direct contracts with the firms. Organizational contact with the foreign manufacturers was usually established by field agencies known as GL-Liaison Staffs

330 (GL-Verbindungsstelle).[1] Such staffs were established in the various countries, each staff under an engineer, and with an organizational setup identical with the branches of the Office of the Chief of Air Force Special Supply and Procurement Service. In special cases a staff of this type could be assigned a Special Sectionto handle matters connected with contracts and finances.

Operational contact was insured by assigning responsibilities to German firms, which were responsible for furnishing to the foreign firms all necessary construction data, the

331 specialized personnel required, and all information necessary for the firms to adapt to German manufacturing methods. The German firms XWXX sub-contracted directly with foreign firms.

Unfortunately, no reliable records are available on the volume of foreign deliveries to Germany, a subject which requires closer research.

With the exception of Hungary, no foreign country manufactured important models of German armament equipment on any appreciable scale. However, by having the foreign firms manufacture training, liaison, transport, and commercial planesit was possible to keep the German capacities available for the more important aircraft models. The very large volume of individual parts manufactured by the foreign firms was a particularly valuable support for the German industries.

331 Direct contact and direct contracting with the Czechoslovak aircraft industries[1] also proved of advantage to the Czechoslovak firms, since the Czechoslovak Ministry of Finance after conclusion of the Munich Agreement ceased providing the funds required for continued work on current contracts.[1] In order to avoid disruptions, the Chief of Air Force Special Supply and Procurement Service ordered continuation of work on these contracts and made the necessary funds available.

332 The aircraft thus completed were used by the German Air Force, for example to tow target planes. As current contracts came to an end it was possible in the summer of 1939 to adapt the Czechoslovak aircraft industries to handle German contracts.

The value of German contracts under execution by the Czechoslovak industries in March 1939 totalled 400 000 000 Reichsmark[2] and included the manufacture of Fi-156, DFS-230, and Fw-189 aircraft, as well as As-10-c and DB-601/605 engines, besides engine accessories, crank shafts, light metal castings, and various parts for aircraft manufacture. The firms thus employed on German contracts were the Avia, Aero, and Boehmisch-Maehrische Flugzeugwerke aircraft factories, the Letov, Mrasz, Bata, Walter, Czechomoravska factories, the Skoda Works, and the Poldi Iron Works. Furthermore, as part

1. See "Bericht Oberstabs.Ing.Diederichs, p. 10).
2. See "Schreiben Generalluftzeugmeister an Goering GL 1905/39 Adj. geh. vom 27. 5. 1939."

Footnote 1, p. 432: GL-Abbreviation of Generalluftzeugmeister: Chief of Air Force Special Supply and Procurement Service.

332 of the program after the 1940 campaign in France to increase aircraft engine production to 14 000 per month, factories which had manufactured textile machinery in the past also received contracts and certain factories commenced manufacturing tooling machine models in short supply, and the Humboldt-Deutz-Werke factory was transferred from Hamburg to Bruenn with a simultaneously expanded contract to manufacture 500 B-801 engines per month.

Although the Reich Ministry for Economy reduced the contracts which were to be awarded to Czechoslovak firms, work on the contracts continued under orders from Goering.[1]

333 Cooperation with Italy extended initially only to the exchange of aircraft already in service with troops on the basis of an agreement negotiated on 27 June 1939 between General Valle of the Italian War Ministry and Goering.[2]

Under this agreement a start was to be made at exchanging four aircraft each of the following types:

Italian	German
Savoia-79	He-111
Fiat-50	Me-109-E
Breda	Ju-87-B

and from September 1939 on:

Cant-1007	Me-110.

Closer technical cooperation, particularly the use of Italian firms for German purposes, apparently only started

333 in 1942, obviously in connection with military operations in Africa. Besides aircraft repair hangars used by German troops, the following factories were employed for German supply purposesiin 1942-43: 4 on fuselage, 3 on engine, and 3 on torpedo construction; 2 on fuselage and 4 on engine repair contracts; 3 on weapons equipment; an unknown number on the manufacture of parachute silk; 1 on the manufacture of condensors; and a number of firms on the manufacture of subsidiary items.[1]

The execution of German contracts by Italian firms caused exceptionally great complications, since all materials needed for the purpose had to be furnished by Germany including all subsidiary supplies such as a pro rata share of the fuels used, of f ts, gasolin, cotton waste, and packing, as well as all

334 materials such as cement, lime, and building stones, needed for the expansion of factories. The use of raw materials supplied to Italy as an ally was not permissible for these purposes, nor were Italian firms allowed to use their own materials for the execution of German contracts. In view of the existing transportation difficulties delays in manufacturing operations for Germany therefore were unavoidable.

An agreement that the Italian firms of Fiat, Alfa Romeo,

1. See "Bericht Oberst.Ing.e.D. Thomas ueber die Besichtigung von Luftfahrtgeraet in Italien."

Footnote, p. 434: See "Schreiben Generalluftzeugmeister an Goering GL I905/39 Adj. Gen. vom 27. 5. 1939."
Footnote 2, p.434: See "Protokoll ueber die Besprechung beim Generalluftzeugmeister am 29. 6. 1939."

334 and Isotta Frascini were to manufacture DB-605 engines under licence in 1942 was not put into effect. Germany delivered a large part of the tooling machinery demanded by Italy for the purpose, but these machines were not used for that purpose and later made their appearance on the market in Hungary.

Another complication was that work on German contracts in Italian factories proceeded side by side with normal Italian manufacturing work, so that the Italian factories had to operate by two widely differing ptocedures. Under these conditions the only factories which produced satisfactory results were those in Upper Italy.

Apart from the partial use of Hungarian industries for the German Air Force, the purpose of the German-Hungarian Agreement of March 1941 was to create industries supporting the Hungarian Air Force. This Agreement was preceded by a Supply Agreement of 1939, according to which Germany had delivered 66 Ju-87and a number of other aircraft.[1]

335 The Agreement of March 1941 regulated cooperation between the Hungarian and German air ministries and between the aircraft industries of the two countries.[2]

Among other things it provided as follows:

The firm of Manfred Weiss was to manufacture 50

1. See "Mitteilung des Min.Dirigenten Mueller LF-Amt."
2. See "Vereinbarung zwischen dem Reichsminister der Luftfahrt und Oberbefehlshaber der Luftwaffe des Deutschen Reiches und dem Honved-Minister des Koenigsreiches Ungarn vom 6. Juni 1941.

338 Me-210 aircraft per month up to a total of 900;

The firm of Manfred Weiss was to manufacture 200 DB-605 engines per month up to a total of 3 600;

The Győrer Wagon Factory was to increase its output of Fw-58 aircraft;

The Győrer Wagon Factory was to manufacture 50 Me-109-F aircraft per month up to a total of 900;

The firm of Pirth, Budapest, was to manufacture 25 Ju-52 aircraft per month;

Another firm was to manufacture 20 Ju-52 aircraft per month;

The German aircraft industries were to receive further support through the manufacture of parts in short supply, such as crank shafts for aircraft engines, optical and other precision instruments, and electrotechnical aggregates manufactured in Hungarian factories.

The Hungarian fuselage and engine manufacturing firms received very able support from German factories. This included thorough training for Hungarian engineers and skilled workers in German factories, and the supply of raw materials, semi-finished, and finished parts.

Plans provided for the following allocation of Hungarian manufactured planes, engines and parts to the German and Hungarian air forces in the following ratios:

1:1 in the case of Me-210 aircraft
2:1 " " " " 109-F " in Germany's favor
2:1 " " " " DB-605 " " " "

All in all, the Hungarian Ministry was authorized to

336 to receive from Hungarian production a total of

280 Me-210 aircraft
240 109-F "
1066 DB-605 engines.

For training purposes the Hungarian Ministry was to receive the following aircraft:

10 Ar-96 per month up to a total of 55
3 Me-109 " " powered by Jumo-210 engines
15 Bue-131.

The raw materials, semi-processed materials, semi-finished and finished parts which Hungary was not able to provide were to be furnished by the German Air Ministry for the manufacture of the Me-109-F, aircraft and the DB-605 engines.

The arrangement produced the following actual output:

60 Me-210 aircraft (50 percent to Hungary)
150-200 DB-605 engines per month up to about 1942
400 Me-109-F aircraft (approximately).

In addition, the Hungarian factories produced large quantities of aircraft weapons, instruments, and construction units for aircraft and aircraft engines, and radio equipment.

The Pirth Factory was very slow in starting operations and did not succeed in producing complete Ju-52 aircraft.

One result of the very close cooperation was a considerable increase in Hungarian deliveries of argillaceous earths, which deliveries finally made up 85 percent of Germany's total requirements.[1]

1. See Bericht Oberst-Ing. Zobel vom Juli 1945, p. 16, ibid.

337 The output actually achieved in so short a time represents an exceptionally good achievement by means of cooperation between the Hungarian and the German industries, particularly in view of the fact that existing factories had to be completely readapted to handle aircraft manufacturing, and the necessity to provide new sheds and airfields. The difficulty resulting from the fact that tooling machines were also in short supply in Germany was relieved by the action of the firm of Weise, which developed and manufactured its own tooling machines.

Initially, French aircraft manufacturing industries were reluctant to accept plans for France-German cooperation in this field. Due to Udet's influence, however, it was possible to overcome French distrust and, in a conference in the spring of 1941, to create a basis for a State Agreement on the matter. The conference was attended by representatives from the entire French aviation industry and from the French Government.

The agreement thus reached provided that Germany was to receive five-sixths of the entire French output, while France was to retain one-sixth to supply the French air forces stationed in colonial territories still under French rule.

This agreement entered into by the French and German Governments again provided employment for the population and averted the danger of unrest, just as the arrangements in Czechoslovakia had done.

339 Firms producing the French share of the output were in the southern parts of France, while firms in the northern parts produced the German share. A mixed commission of four French and four German members under a German chairman was responsible for for smooth implementation of the agreement.

The agreed distribution was not carried out, since the factories in the southern parts of France were able to continue operations, while those in the northern parts first had to be rebuilt, so that a ratio favoring France resulted.

Unfortunately, no reliable records are available on the actual deliveries made by the French factories.

German action in occupying the southern parts of France because of the Anglo-American landings in Northern Africa brough the period of smooth collaboration to a sudden end. From then on the factories in the southern parts also produced for Germany, since the purposes for which they had hitherto worked no longer existed.

Similarly to the arrangement in Hungary, German firms were assigned responsibility to support the individual French firms. The German firms thus appointed were responsible for adaptation of the factories to German requirements and for proper operations.

Footnote 2, p. 437: See "Bericht Oberst.-Ing. Zabel vom Juli 1955."

340 As was the case in other countries, the French factories were employed to release German capacities for the manufacture of the more important aircraft models. They were employed at the manufacture of transport, liaison, and passenger planes of the models Ju-52, Fi-156, and Si-204 and primarily at the production of individual parts, serving as sub-contractors to the German firms. The engines ~~MMMM~~ produced by the firm of Gnôme Thône were used in part to power the Me-323 large transport planes; when the series currently in production came to an end, the factory installations were readapted for production of BMW-132-A engines. This released the installations of the Bayerische Motorenwerke factory at Eisenach for manufacture of BMW-801 engines.

The firm of Gnôme Rhône delivered approximately 420 BMW-132-A engines monthly.

The forward repair shops established in France and Belgium proved a valuable support in maintaining operability of the units of the German air fleets stationed in France.

A spirit of loyal cooperation developed between the German and French industries, and the total annual turnover, in 1943 for example, can be estimated at 1 500 000 000 Marks. Besides the aircraft models previously mentioned, French deliveries included argillaceous earths and items in all important fields, such as precision instruments, bombing

341 equipment, aircraft weapons, electrical equipment, etc.

National Socialist Party authorities desired to move French skilled personnel from the French industries to Germany and so at least partially relieve the strained personnel situation there. These efforts were thwarted for some time by the emphasis placed on the importance of the manufacturing operations and of the repair installations in France for the German war effort.

Later, however, the compulsory movement of French skilled labor to Germany under the Saukel Program destroyed the existing good relations and seriously reduced the output of the French factories. In addition to those removed by force to Germany, large numbers of these left behind left their work and went into hiding.

The Allied bombing attacks of 1944 brought manufactruing operations in France to a standstill although measures had been introduced to move important factory installations to caves and other sheltered premises.

At the beginning of the war Poland had no important aviation industries. German firms were able to continue work on two factories currently under construction and use them for German purposes. They were managed by the firms of Heinkel and Daimler-Benz. These two factories employed several thousand workers and gave good results. In addition

341 the repair installations established within Poland proved a valuable support in maintaining the operability of the units of the air fleet committed in southern Russia.

RUMANIA

The aircraft and aircraft engine factories in operation at Kronstadt, Rumania, were adapted to produce Me-109 aircraft and a German engine model, and operations commenced in 1942-43. Forward repair installations were also established in these factories to serve the German air forces in the Balkans and in southern Russia.

YUGOSLAVIA

The situation was similar in Yugoslavia. Besides an engine factory, which was re dapted to produce Sh-14-a engines, a few small fuselage and equipment factories were operating. They were aligned with German factories and placed in operation within two to three months. One factory at the Semlin airfield served as a repair shop for Junkers aircraft.

The Serbs had blasted the fuselage factory established by the firm of Dornier at Kraljevo for the production of Do-17 fuselages prior to the war, but it proved possible to install the factory as a repair shop for Dornier aircraft. Parts of the factory also continued to manufacture.

342

GREECE

In Greece the premises of the Government-owned ammunitions and shell-case factories were used as premises for forward repair installations, a purpose for which theywere admirably suited because of their excellent equipment with tooling machinery. The use of these factories for German purposes prevented their removal by the Italians, who had been awarded the right to exploit the Greek economy.

343

RUSSIA

Aircraft and engine factory premises found in Russia were used almost exclusively for forward repair services for units of the German air fleets committed in the theater.

SUMMARY

The manufacture of less important aircraft and engines by foreign firms made it possible for the German firms to concentrate more on the manufacture of the more important models needed for German armaments. The large volume of subsidiary parts manufactured by foreign factories proved an exceedingly valuable support.

More extensive research would be necessary to gain at least an approximate estimate of the extent to which the use of foreign factories increased the production of armaments for the German Air Force.

343 ENGINE MANUFACTURE

Engine procurement requirements were ruled by the aircraft procurement programs. The number of engines to be delivered corresponded to the monthly deliveries of aircraft, the only difference being that the engines had to be delivered a little ahead of the aircraft delivery schedules to make allowance for time spent in transport, aircraft assembly, and factory test flights. Furthermore the engine procurement programs contained a reserve factor of 33 1/3 percent, which made them one-third higher than the aircraft deliveries. This percentage was based on experience factors but was not always maintained, since manufacturing difficulties and ~~xxxx~~ changes introduced from time to time sometimes made it impossible to deliver the numbers required for installation in fuselages. This gave rise to a situation in which the current output of
344 aircraft was not hampered by any lack of engines, but in which the numbers required by the troops or aircraft repair shops lacked the numbers needed as replacements.

Engine procurement included, besides the engines as such, the various starting and take-off aids, air propellors, rocket propellants, radiators, exhausts, engine cowlings, and engine fuel pumps.

For the aircraft planned for the first part of the

344 main rearmament program[1] use had to be made primarily of BMW-VI and Sh-22 engines for front line aircraft and of Sh-11, Sh-12, As-8, BMW IV, BMW-V, and L-5 engines for training planes. The aircraft types planned for the second half of the program were to be equipped with the 20- and 30-liter engines given out for development in 1930. This development work produced the DB-600 and DB-601 by Daimler-Benz and the Jumo-211 by Junkers as 30-liter models, and the Jumo-210, also by Junkers, as a 20-liter model. The firm of Bayerische Motorenwerke did not compete in this development contract and was employed exclusively in the manufacture of air-cooled engines, of which the BMW-132 engine, and later also the BMW-801, were included in the armament procurement programs. Other air-colled engines used for military purposes were the SAM-22 and SAM-323 developed by the Brandenburgische Motorenwerke, Berlin-Spandau.

Of the air-cooled models just mentioned, only the BMW-801 was designed as a high-altitude engine.

The following aircraft engine models were thsu available for the second phase of the rearmament program:

Liquid-cooled types: Jumo-211, DB-601, and Jumo-210
Air-cooled types : BMW-132-A, SAM-323, and BMW-801.

These basic models served as the foundation for further development producing engines with improved performances as

1. See also chapter on aircraft engine development.

345 variants of the parent models, or with new model designations, such as the DB-605, DB-603, and the Jumo-213.

The DB-606 and DB-610 were twin-engine variants of the DB-605 and DB-603, and were used primarily to power He-177 fuselages.

Improved variants of the DB-601 were those designated up to the DB-605 with its original thrust of 800 horsepower improved to 1 500 horse power or 1 750 horse power with a methanol injection.

In its original form the DB-603 had a cylinder content of 42 liters and a performance of 1 750 to 1 800 horse power. It was accepted in tests in 1942 and went into serial production in 1943. The first engines coming from serial production were installed in fuselages in 1944.

The second model in the 30-liter class was the Jumo-211 with a thrust of 800 horse power. Through a number of variants this engine was developed to produce the Jumo-213 and its variants A, B, E, and F, with a final performance of 1 500-1 700 horse power.

The only model accepted in the 20-liter class was the Jumo-210, which in its original form had a performance of 600 horse-power.

346 Initially, only liquid-cooled engines were available as high-altitude power units for the flying forces. It was only due to the development of aerodynamically favorable cowlings

346 for air-cooled engines and the high sensitivity of the cooling systems of liquide-cooled engines to weapons fire that the BMW-801 was developed as a high-altitude power unit and installed in fighter aircraft.

As a special attachment this engine had an automatic fire control device (Kommandogerset) which automatically regulated the propellor pitch change, the compressor switch, the fuel injection pumps, and the oil regulators, besides other functions, and thus considerably relieved the strain on the pilot. Various faults became apparent in the fire control device when the first engines coming from serial production were installed in Focke-Wulf-190 fuselages, and this resulted in delayed deliveries of this highly important model. However, these difficulties were remedied within a relatively short time by means of a special project started for the purpose.

The engines mentioned above were the most important types in use. In addition, the firm of Junkers produced double-piston engines, the Jumo-205 and Jumo-207, for heavy oils, a small number of which were also installed in aircraft fuselages. The advantage of these engines was their small fuel consumption. However, these were considerably heavier t than the gasoline engines so that their use was only profitable for long-distance operations. They were therefore used as power units for Ju-86 long-range units, BV-138 naval

307 reconnaissance, and BV-222 naval transport aircraft.

In order to insure the best field of vision possible, th 20- and 30-liter class engines had been developed with inverted cylinder heads arranged in the pattern of inverted V's . Another advantagement of this cylinder arrangement was the possibility to mount a 20-mm canon and the possibility to fire through the propeller shaft. The engines had been developed primarily to power fighter aircraft. It was only when the factors which resulted in development of the BMW-801 engine became evident that new plans provided for installation of the BMW-801 in Fw-190 fighter fuselages instead.

Consonant with their performances the BMW-132-A and the SAM-323 engines were used as ground engines (Bodenmotore) in

Ju-52 transport aircraft
He-114 ship-based reconnaissance aircraft
He-115 multi-purpose naval aircraft.

Another use for the SAM-323 was to power Do-24 air-sea rescue and long-range naval aircraft, and Fw-200 fuselages as long-range bomber aircraft.

In planning for engine production during the build up of the Air Force supporting industries, engine classes had been classified in accordance with the subdivision of aircraft in different categories. It is only natural that continuing development of the aircraft types resulted in changing demands

347 on the corresponding classes of engines. In other words, the constantly changing demands made by the higher commands on the tactical capabilities of the various aircraft categories

348 also influenced the various engine classes. This necessitated reconstruction work and the use of various classes of engines in one and the same type of fuselage. Another factor contributing towards this requirement was the fact that, as armament progressed, and particularly during the war, the ratios between fighter, bomber, reconnaissance, and transport aircraft did not remain static but had to be adapted to the current requirements of General Staff planning.

These circumstances finally produced a situation which required the Engine Procurement Branch to concern itself not only with the engines and their original aggregates, but with the entire power unit including all parts outside of the combustion chamber, including such parts as the engine framework and the engine cowlings.

All parts had to be exchangeable,[1] a target which was to some extent achieved. Here, the need remains for a comparative study of the appropriate engines. It is therefore also necessary to examine more closely the problem of to what extent the various aircraft fuselages were powered by specific engines with a view to exchangeability or with a view to

1. The author no doubt means that the target was to have parts interchangeable among the various types of engines. Note by translator.

348 to multi-purpose uses.

349 When the Jumo-210 engine series currently in serial production came to an end it was perfectly logical to use the DB-601 engine and its variants in Me-109 and Me-110 aircraft, later powering the same aircraft types with the DB-605 engine and its variants. However, both air- and liquid-colled engines, namely the BMW-801 air-cooled and the Jumo-213 liquid-cooled engines were used in the Fw-190 fuselage, and the BMW-801 and Jumo-211, and their variants, were used in the Ju-88 fuselage.

In the case of training aircraft the diversity of engines used was even greater, since it was only after the second phase of tactical requirements had been stated that Branch WaPrw 8 of the Army Ordnance Office commenced, just before 1933, to exercise an influence on the development of these engines and issued directives to the industry. From these developments came the air-cooled in-line As-8 engines of the firm of Argus and the HM-60-R engines mf for basic training, and the AS-10 and HM-506 for advanced training aircraft.

The engine models just mentioned were intended for the aircraft types developed to meet the second phase tactical requirements. However, deliveries of these aircraft types, namely, the Buecker-131, Buecker-133, Ar-66 and Ar-76 only commenced after mid-1934, and some of them only at the

349 beginning of 1935. However, main emphasis was on training during the first years of rearmament, so that it became necessary to fall back on engine types already in use for years in t the aviation sports schools and the commercial aviation schools

350 The main engine models her were the Sh-12 and Sh-14 (the latter still in production i 1938), the Junkers L-5, the BMW-IV and BMW-V, in addition to the models used for military purposes, namely, the BMW-132-A, and the SAM-323.

The relatively large variety of engines thus used for aviation training purposes necessitated the maintenance of large stocks of spares and made extraordinarily heavy demands on the equipment of military air bases and on personnel training activities. It as only after the older aircraft types were dropped that considerable simplification was achieved, since from then on only Sh-14a, As-8, and HM-60-R engines were used in planes for basic training, and only As-410 and HM-504 engines in planes for advanced training.

The principle followed primarily by Field Marshal Milch of whenever possible having two models to rely on for each category of armament equipment in order to be able to fall back on the one if the other failed because of development or manufacturing reasons, and thus be able to avert repercussions on the operability of troops, was also applied in the case of aircraft engines.

350 The DB-601 and Jumo-211 model engines served one and the same purpose, which applied equally to the DB-605 and the Jumo-213, in the 30-liter class, as well as the BMW-132-A and the S SAM-323.

In the case of fuselages the principle was to adopt only one model, and there can be no doubt that adherence to the same principle in the case of engines could have simplified

351 supply and resupply operations considerably. This would have improved the operability of units. In the case of the Jumo-211 and the DB-601 engine models a decision in favor of one o or the other could easily have been made, since both of these models had been thoroughly tested both at the proving sites and in service with units prior to the war. As a safety measure one of these engines could have been placed in small scale production with possibilities to step up the output and use it in the evnt of manufacturing or other difficulties arising with the adopted model. In such case, however, the second-choice model would only have been used for partial supply purposes.

If supplies of one of the two models had for some reason or other failed completely, it would not have been possible to switch production of one model in a factory handling the other model without an extensive program of procurement for tooling machines and other installations.

351 This became strikingly evident when Goering decided to halt production of the Jumo-213 engine and have the firm of Junkers manufacture the DB-605 instead. The Jumo-213 had just gone into serial production and the first trial runs of the factory had already been made. The reason for Goering's decision was that manufacturing operations on the DB-605 were slightly ahead of the Jumo-213. [1] The difficulties encountered in efforts to put this order into effect were so markedly great that it was possible to have the order rescinded. This proved fortunate in the long run, because the troops had serious difficulties with the DB-605 in the field.

Development of the 30-liter class engines indubitably gave Germany a lead over other countries in aviation, as was

252 proved by results obtained in international competions for military types of aircraft.

Further development of the adopted basic models proceeded step by step, the improved versions being considered as variants of the original model, and each such variant being designated by the original designation plus an affix showing its position in the sequence of variants, or its special features.

A consolidation of all experience gained finally led to production of the DB-605 and Jumo-213 engines, which only went

1. See "Bericht Generalinge Jeur Mamke, p. 33."

352 into service in the field in 1942 and 1943.

However, this step by step improvement of the 30-liter class engines had not been sufficient to enable the German Air Force to maintain its position of superiority. As early as in 1935-36 Sachse, then Chief of the Engine Development Section, had awarded contracts to industrial firms to develop more powerful liquid-cooled engines with a cylinder-stroke content of 42 liters,[1] but in spite of this it had not been possible in time to oppose penetrating enemy air forces with aircraft having the same or superior power performances.

Development work on a 42-liter class engine produced the DB-603 with a thurst of 1 750-1 800 horse power. This engine, which was installed in the He-219 night-fighter, and on a small scale in Do-217, Me-209, Me-410 aircraft delivered to the field forces from early 1944 on, made its appearance

353 too late at the front.

In view of the fact that the industries had received instructions to develop engines in the 20- and 30-liter classes as far back as in 1930 , and that aircraft powered by such motors were already delivered in 1937, the first appearance of the DB-603 engine installed in aircraft fuselages in 1944 indicates that an exceptionally long time had been spent in developing and producing it. The reasons for this long delay require closer investigation, particularly in view of

1. Ibid, p. 2).

353 the fact that realization of the technical superiority of the enemy fighter aircraft should have led to more emphasis being placed on this development work.

A factor which may have played a role here was the lack of a suitable fuselage which could have been made available in time. There is also no doubt that work on the project was delayed in consequence of personnel changes in 1938 in the section handling engine developments.

The Bayerische Motorenwerke had failed in efforts to develop a 20-liter engine, and had made little progress on the radial engine they had been instructed in 1935-36 to design. Also, the capabilities of the firm's factory installations were not fully exploited for the production of the number of BMW-132 engines needed. For these reasons plans were under consideration to use the factory installations for the manufacture of DB-601 engines.[1] In order to prevent this changeover the firm's directorate requested that it should be assigned Sachse, in charge of engine development in the Technical Office of the Chief of Air Force Special Supply and Procurement Service and, with approval from Udet, placed Sachse in charge of the development of a powerful air-cooled engine.

This change was undoubtedly a serious loss for the Technical Office, since Sachse had played a leading role in com-

1. Ibid, p. 29.

354 compiling the specifications for development of the 20- and 30-liter class engines, had the necessary vision to insure progressive development of engines, was a good negotiator, and carried influence in industrial circles. These gifts his successor without question did not have to the necessary degree. For this reason it seems justifiable to assume that the change had a negative influence on continued development of engines. It is also to be assumed that the change had a negavtive effect on the progress made in the development of jet aircraft.[1]

In 1941 Goering ordered a military court investigation into the reasons which had led to the inferiority of the German Air Force, but the investigation produced no tangible results. A point which was clarified, however, was that one important reason was the departure of the former Chief of the Engine Development Section, Sachse, from the Technical Office.[2]

Engine development was also influenced by raw materials supplies problems as they affected Germany. Due regard had

355 been given already during the phases of preparatory work, and particularly so during implementation of the armament programs, to these problems in deciding on the uses of alloys which presumably would not be available to Germany in the event of a mobilization. The additional development work thus necessitated in the field of manufacturing materials

1. See Report Beck.
2. See "Bericht Generalingenieur Mahnke, pp. 30-31."

355 and on the use of alternate and substitute materials had cost a considerable expenditure in effort and funds , which had had a retarding effect on the progress made in general development projects. The substitute materials used also had an important influence on the intervals at which engines needed overhauling, which were considerably shorter in the case of German engines than in that of British and American engines.

Development work had made it clear that it would not be possible to produce piston driven engines with a power exceeding 2 200-2 500 horse power, and that the only possibility to increase aircraft speeds to the vicinity of sonic speed was to have considerably more power. For these reasons the engine development section took under consideration plans to use other power units, and a conslucion was finally reached that gyro engines might provide the solution. Appropriate development contracts were thereupon awarded in 1936 to the firms of Bayerische Motorenwerke and Junkers, in terms of which the first stage, with a thrust of 3 000 horse power was to be achieved by Junkers, and the second phase, with a 6 000 horse power thrust, by the Bayerische Motorenwerke.[1]

These jet engines were installed by assembly line methods in Me-262 and He-162 aircraft, deliveries of which commenced in May 1944 and January 1945, respectively. There can be no

1. See "Bericht Generalingenieur Mahnke, p. 22."

356 doubt Hitler's order to halt development work had an unfavorable influence on progress in the development of these two jet engine models, since there was no longer any possibility to make designers, construction engineers, and materials available in sufficiently large numbers and quantities to expedite the projects.

In view of the fact that these turbo-air power units were an entirely new departure in a hitherto completely unexplored field, the time taken upto introduction for use in the field must be considered exceedingly short and as an exceptional performance on the part of the industrial firms. The same must be said in regard to the short time required to place them in serial production, particularly when one considers that exceptionally serious difficulties had to be surmounted in the manufacture of the turbine blades from extremely heat-resistant materials.

What played a far more important role in the production of engines than in the case of fuselages was the timely procurement of tooling machines in the numbers necessitated by the current procurement programs. These machines were the fundamental requirement for the proper execution of engine and power unit procurement programs.

However, the economic depression of 1929-1933 had produced adverse repercussions particularly on the tooling

356 machine manufacturing industry. Operating on a seriously reduced scale, the firms concerned had barely managed to keep

357 their heads above water producing universal machinery, particularly for foreign markets. There had been no incentive for them to develop the mass-production machinery which was the very foundation for the manufacture of engines.

When production requirements increased largely in 1933, particularly for the aviation industries, it was possible initially to meet these requirements by using hitherto unemployed personnel. However, the current lack of specialized machinery made a large scale employment of men with special skills essential. Since only very few of these were available in practically all fields connected with aircraft manufacture, they had to be taken from other industries, and particularly from the tooling machinery manufacturing industries. This was made possible by the funds advanced to the industrial firms by the Technical Office as the direct contractor.

Later, however, the expanding procurement programs created large requirements for special types of tooling machinery needed in the manufacture of engines. The Technical Office therefore endeavored to influence the Director of the Four Years Plan to prevent any further drain of personnel from the tooling machine manufacturing industry. Unfortunately, these efforts were not successful because of the large numbers of unemployed

still available. This circumstance produced very harmful results at a later juncture, since the outcome was an exceptionally serious shortage of the tooling machinery required for mass production manufacturing operations. The delivery deadlines for tooling machinery mounted in 1940 to as long as fortyeight months, and the resultant shortage of these machines had an extremely adverse impact on the output of engines. The long times required for deliveries and the consequent delays in equipping the aircraft industries with the necessary tooling machinery resulted in the user firms placing orders far in excess of their actual requirements. This was done because the purchasing firms in each case received only a percentage of what they ordered, so that each of them endeavored to obtain as large a share as possible of what was available by overstating its needs.

The resultant circumstances, which made a reliable insight into actual requirements impossible, were exploited by certain industrialists to round out the equipment of their factories with tooling machinery with an eye to their ability to compete against other firms after the war.

Difficulties in the field of tooling machinery procurement mounted seriously in particular after the beginning of the war, and this resulted in a more concentrated treatment of this field by all technical branches then existing in

358 the GL-1 Division of the Office of the Chief of Air Force Special Supply and Procurement Service, and from 1941 by the corresponding branches of the Planning Office. The mission of this Planning Office was to plan far ahead, in cooperation with the tooling machine manufacturing industries in Germany, in the occupied territories, and in foreign countries, for the production of such machinery, and at the same time to handle the allocation of such machinery released from factories in the occupied territories to firms of the German industry.

During this work it was found that the Army and the Navy, particularly the Army, had cornered the future output of some of the most important tooling machinery used in armaments production for years ahead, by means of advance orders placed with firms in Germany, in the occupied territories, and in friendly countries.

The acute situation in the field of tooling machine supplies , and particularly in respect to the machines needed for the manufacture of crank shafts, was rendered even more acute by the action of Saur, appointed by Hitler as Special Commissioner for Tank Production. Acting on the authorities vested in him, Saur confiscated the Kuhs Crankshaft Factory established at Hamburg by the Air Force and engaged on contracts for the Air Force, and used it for the purpose of tank

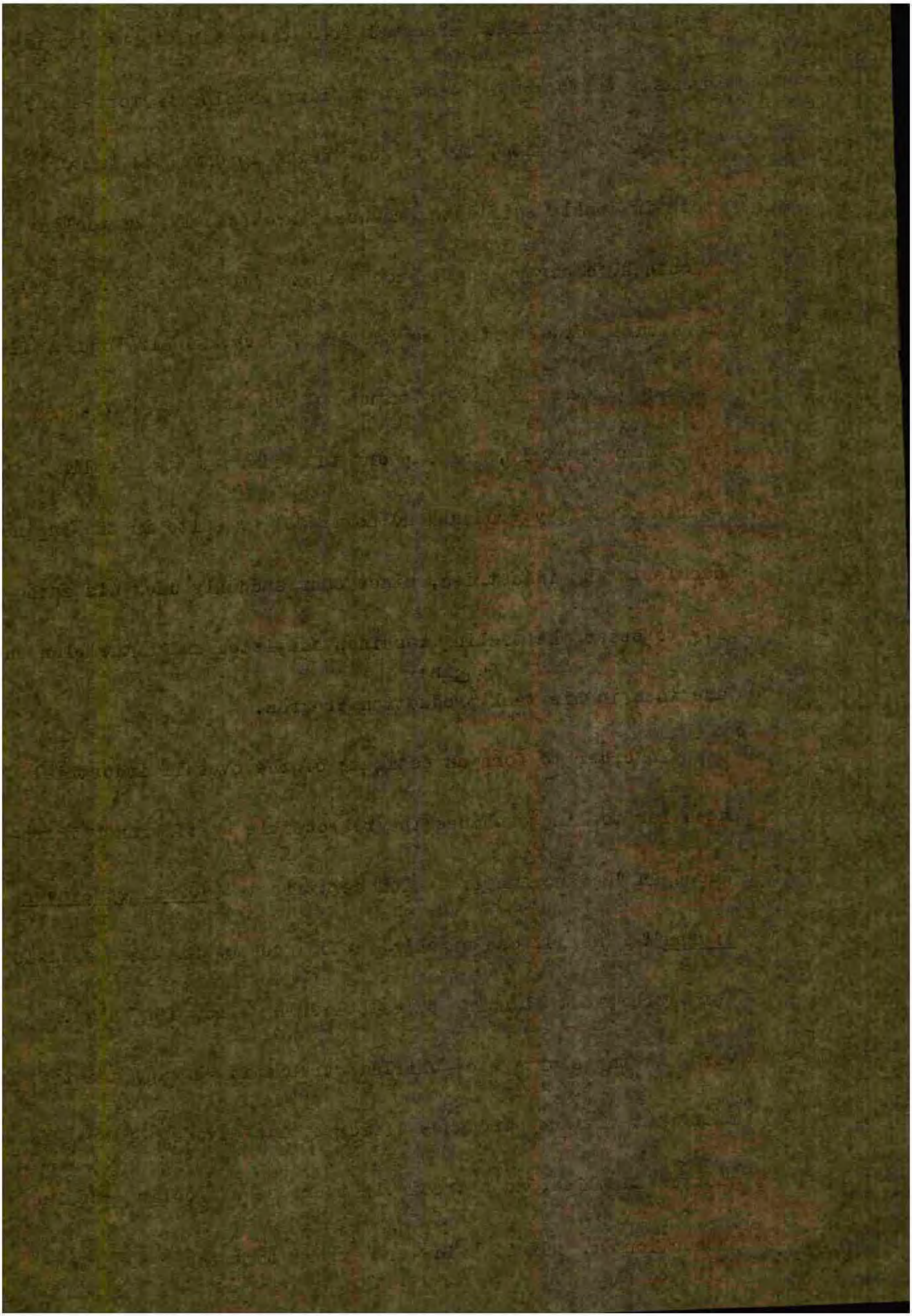
359 production.

To relieve the situation in this respect, the Chief of Air Force Special Supply and Procurement Service had released a number of skilled personnel from the engine manufacturing industries for employment in tooling machine factories for a temporary period, the purpose being to have the factories work in double shifts to produce approximately 120 tooling machines for crank shaft processing. Unfortunately, efforts

360 to secure mutual action by the Army, Navy, and Air Force failed because of the negative attitude of the Army and Navy.

Unfortunately, the support thus given to the tooling machine industry produced no noticeable results in the engine manufacturing industries, since Saur suddenly used his authority to seize the tooling machines completed under the plan and use them in his tank production program.

In order to form an estimate of the overall industrial need for tooling machines the responsible staff branch introduced an "advance notification certificate (Vormerkscheinverfahren)". The purpose of this method was to establish a basis for procurement planning by establishing needs far ahead. Owing to the shortage of skilled workers in Germany and the fact that the Army Ordnance Office by its advance orders had blocked supplies, no appreciable increase of tooling machine production was possible in Germany, so that the appropriate



360 measures found application primarily in the occupied territories and in friendly and neutral countries.

The work involved in determining needs and checking the justification of reported needs, plus the work involved in the allocation of available supplies of tooling machinery gradually assumed such a scope that it was no longer possible to cope with them within the Ministry. This finally resulted in the establishment of a field agency, the Deutsche Luftfahrt und Handels A.H. commonly known as the Delhag. The primary missions of this agency were to handle the financial part of the tooling machinery procurement programs, to check the justification for supply requests, and to control the production of spare parts in and for this branch of industry. In spite of all these measures it remained i possible to satisfy the needs of the armaments industries, for which reason the Industrial Council received the mission of stepping up the production of tooling machinery, a measure followed later by Minister Speer's appointment in 1943 of a Chief Commissioner to control the allocation of all machinery. After its establishment the Fighter Production Staff assumed responsibility for these functions and later passed on that responsibility to the Armaments Staff.

In spite of all these organizational measures tooling machinery remained a seriously dangerous bottleneck

throughout the armament industries. The most serious difficulties were of an organizational nature. Since the whole industry was in civilian hands, it was in no way subject to military controls or influences, and therefore from the very beginning did not receive the necessary support. The lack of a uniform control made itself very seriously felt, particularly during the war, and finally created conditions in which each branch of the military secured the largest possible share of the output for itself, without any regard for the overall situation, by placing large contracts with the various firms concerned.

It was only after appointment of the Fighter Production Staff, followed by the Armaments Staff, that a uniform control was established, at a time when it was already too late.

During times of peace the Plenipotentiary General for National Economy was responsible for the direction of the tooling machines manufacturing industry and for all preparations to meed the needs of any possible mobilization. As previously mentioned that office was relieved of these responsibilities at the outbreak of the war because of its failure to produce results. Owing to the lack of concentrated preparations against the eventuality of mobilization, the industry lacked the capabilities it needed to meet the military requirements, particularly during a war.

363 Another serious bottleneck which threatened to develop in the field of engine manufacture with a consequent impact on the whole aviation industry, including the manufacture of aviation equipment, was that of ball bearings after the Allied air attacks against the town of Schweinfurt.

The manufacture of ball bearings was a major factor influencing the manufacture of aircraft, aircraft equipment, and aircraft engines. If any serious interference occurred in the production of ball bearings, serious repercussions had to be expected on the deliveries of completed aircraft.

Out of a total of 1 219 200 square yards (635 000 square meters) of the factory space available to the ball bearing manufacturing industries, the factories located in Schweinfurt had 933 120 square yards (486 000 square meters). Prior to the war 80 percent of Germany's entire output in roller bearings came from Schweinfurth. Following an air attack in August and another in October 1943, both of which caused serious losses in production, this had been reduced to 60 percent, by means of a relocation of certain factories.

Plans had been prepared earlier to reduce the factory spaces for ball bearing manufacture in Schweinfurt to 40 percent, with provisions that each of the two factories remaining in the town was not to produce more than 25 percent of total requirements. The responsible branch under Generalingenieur

368 Bullinger in the Reich Air Ministry had planned a movement to existing factory premises currently vacant or to be vacated for the purpose, since experience showed this to be the speediest way to resume manufacturing operations. Contrary to these plans, however, the Swedish-owned firm of Vereinigte Kugellager Fabriken endeavored to restrict measures to an expansion of its own factories, but failed in all cases to obtain allocations of the man power and building materials required for the purpose.

The second air attack, in October 1943, caused damages which seriously disrupted production in the Air Force and Army supporting industries and created the necessity for measures of a special nature to be as speedy and fundamental as possible. Director General Kessler was selected to direct this project, as he was also selected later to head the project to speed up production of the He-162 jet aircraft. The speedy action taken under this project averted serious repercussions on the engines manufacturing industries.

The measures taken by Director General Kessler for the purpose have been discussed previously in this study in the chapter on Industiral Expansion and the Relocation of Industries during the War.

364

GENERAL EQUIPMENT

The principle of relieving the Technical Office of as many responsibilities as possible and transferring responsibility for the delivery of completely equipped aircraft to the industrial firms concernedwas applied first of all in the field of general equipment.

The equipment units considered as general equipment included the flight control category, the engine control instruments, the navigational instruments, the hydraulic and electrical equipment, the photographic equipment categories and several others. Each of these categories or units comprised such a large number of individual instruments and parts that their individual procurement by the Technical Office would have required a staff far exceeding the scope of a Cabinet ministry and would have made scheduled deliveries and proper functioning problematical.

The outer dimensions of control instruments had been standardized already prior to 1933, so that it was possible to use instruments from various firms for one and the same purpose and to interchange them. On the whole, however, time and labor considerations had not yet permitted large-scale standardization measures prior to 1933.

Because of the development stage of the individual items of equipment and their nature as part of the

365 fixed installations or as part of the movable equipment of an aircraft, the procurement responsibility was divided between the industry and the Technical Office.

The industry was responsible primarily for all permanently fixed installations of an aircraft, while the Technical Office had the responsibility for procurement the spare parts needed by the Air Force ordnance depots (Luftzeugämter) and for the procurement of items of equipment not permanently installed.

Procurement of the items installed in the aircraft represented by far the largest share, so that here the Technical Office was able to restrict its action to basic planning and control of procurement activities. The object of these planning activities was insure uninterrupted production of the steadily mounting supplies of equipment items needed in spite of the initially small manufacturing capacities available.

A basis for this work was provided in the EquipmentItems Lists (Ausruestungsgeraete-Listen), which made it possible to estimate the probable overall requirementsx, [illegible] These overall requirements were subdivided among the appropriate firms, which received their instructions in accordance with a properly timed schedule. The firms responsible for final delivery of the aircraft received information sheets stating the equipment firms

365 obligated to supply their needs in the various items of equipment.

Serious difficulties were encountered with this method when it was found that the Equipment Items Lists on which the whole system was based were not always quite accurate and in some cases incomplete. This resulted in far larger equipment requirements than provided for in planning. Energetically handled special measures became necessary to remedy these difficulties and prevent serious delays in the deliveries of completed aircraft. However, even these measures failed to eliminate difficulties encountered in supplies to troops.

What made things difficult under this system was that when the aircraft firms placed their orders for equipment items too late, the sub-contracting firms were unable to comply with the requirement to commence production three months ahead of the deadline for delivery. This difficulty remained up to the end of the war.

Another difficulty encountered during the initial stages of the rearmament program in efforts to insure timely equipment deliveries to the aircraft factories was the problem of serial production. The small quantities of equipment items required prior to 1933 had made it seem unnecessary to give any consideration to the principles of mass production. In consequence, equipment items as a rule were produced by

366 individual item hand-manufacturing methods, work which could only be done by properly qualified personnel. The necessary numbers of such skilled personnel were not available to meet the rapidly mounting requirements, and this produced the inescapable necessity to reorganize for mass production methods.

In view of the high degree of precision required in aircraft instruments even very minute changes would necessarily result in functional disturbances because of the physically changed conditions, and in view of the serial production of the various items of equipment and their supply for whole series of aircraft, this could produce serious crises. What complicated matters even more was that any modifications which became necessary would have to be carried out while an instrument was in serial production, with all the necessary changes and adaptations to existing installations and the retraining of employees.

All of the above vindivated the soundness of the methods followed by the Production Branch, in which due regard was given to the principles of mass production while an item of equipment was still under development.

The difficulties described above were only mastered after a considerable time, and it was only in about 1936 that the principles established by the Production Branch for serial production could be put into effect and conditions created

367 also in the case of items of aircraft equipment to have the items developed by one firm manufactured by another under licence. What made matters extremely difficult here was the desire of the individual firms to maintain their monopolies in certain fields, a tendency even more pronounced in the firms manufacturing various items of equipment than in the case of aircraft fuselage manufacturers, and the efforts of such firms to avoid passing on their experience to their licensees. This difficulty was overcome in part by having the developing firms establish their own factories for serial production, a measure which produced conditions ~~xhixxxixxxxxx~~ under which no important difficulties were encountered during the war in

368 the production of aircraft equipment.

The considerably increased military requirements for aviation equipment made development activities on a relatively wide basis necessary. This was possible because of the unemployed engineer and other personnel still available in 1933. Another circumstances which made this comprehensive work of development essential was the necessity to make up the lead which foreign countries had over Germany in this field, a fact which was making itself adversely felt.

For the main emphasis was initially on the development of improved instruments, etc. No experience was available at the time concerning rationalized methods of production, so

368 that it was not possible to take such matters into consideration. The priority thus given to technical perfection found support in the principle adhered to by the higher commands to place quality before quantity. Unfortunately, this principle resulted in a neglect of serial production or mass production requirements and thus contributed largely during the war towards Germany's defeat.

The broad basis on which the development of aviation equipment proceeded produced parallel developments in the XIXI fields of electrical, hydraulic, and pneumatic equipment. Because of the special specifications with which they had to conform, the aircraft manufacturing firms stated specific requirements concerning the items of equipment needed and exercised a strong influence on the types developed. This resulted in a large number of special designs adapted to the individual

369 types of aircraft involved. This proved unavoidable in spite of the efforts of the Technical Office to standardize the widely diverging requirements stated by the various aircraft manufacturing firms.

These developments, which were contrary to the principles of rationalized production received strong support from the organization of the Technical Office and the Office of the Chief of Air Force Special Supply and Procurement Service during General Udet's tenure of office because, as has

369 been stated previously in this study, all technical branches were headed by ~~xxxxxxxxx~~ development or designing engineers.

The outcome of all this was that no less than 3 500 models of items of equipment were in production, which required an expenditure of efforts and materials which could not be justified. These conditions resulted from the initially one-sided preference for electrically driven gears for the various subsidiary installations, such as the aircraft weapons, and resulted in an excessive use of electrical installations even for processes which could have been handled by far simpler methods.

For this reason the Technical Office placed great stress on the development and use of hydraulic and pneumatic equipment, fields in which industrial experts had done much research and development work, partly working individually and partly in combined efforts.

370 The conditions which had thus come about in the fields of manufacturing and supply operations called for special measures. Since the Technical Office could not alone handle the whole problem of control and standardization it was essential to awaken all official agencies and all firms concerned to a realization of the existing circumstances by means of a tabulation of all designs in existence.

In most cases the only way to coordinate the specifica-

370 specifications of the various aircraft and equipment manufacturing firms was by means of an entirely new model, in order to obtain participation by all and by means of an exchange of experience make rationalized production possible. The Technical Office directed the execution of this program of simplification, a measure which was later extended to all fields of activity in which the office engaged. The first step taken was the establishment of three main groupings, one for aircraft development, one for engine development, and one for the development of equipment. These groups continued their work after the responsibility for all armaments had passed to the Fighter Production Staff and the Armaments Staff.

Apart from the previously mentioned inaccuracies discovered in the Equipment Items Lists, the excessively large number of individual items of equipment had created serious difficulties in resupply operations. These, in turn, for a long time caused unsatisfactory equipment deliveries to the troops, who therefore at times found themselves compelled to cannibalize temporarily inoperable aircraft. These conditions were

371 also in large measure due to the unfavorable treatment of the Air Force supporting industries in the matter of priorities.

Within the fields of responsibility of the Technical Office the conditions described could in part have been

371 averted if steps had been taken in time to coordinate the specifications of the aircraft and equipment manufacturing XXXX firms with armament requirements. However, the emphasis placed on development and the neglect of manufacturing requirements during this period had relegated the necessary measures to the background.

It was due exclusively to the simplification of pneumatic XXXXXXXXX installations and their widespread use that it became possible finally to reduce the large number of different items and parts of equipment needed and considerably facilitate servicing and repair work, particularly since it was possible, with pneumatic installations, to use unskilled personnel after a relatively short period of training instead of the highly skilled personnel needed for the ser icing and repair of electrical equipment.

WEAPONS AND AMMUNITION.[1]

The responsibilities of the Weapons Procurement Branch included the procurement of aircraft and ground weapons, weapon mounts, sighting devices, and ammunition.

Under the conditions of the Treaty of Versailles, the

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only German firm authorized to develop weapons and manufacture

1. This section on weapons and ammunition procurement is based on reports by Oberstingenieur Mix and Oberstabsingenieur Lauser plus the personal experience of the present author.

371 them by serial production methods was the firm of Rheinmetall-Borsig, which was controlled by the appropriate branch of the Army Ordnance Office. All development and production contracts with this firm therefore had to be handled through the Army Ordnance Office. Since no other capacities were available in this field, Branch WaPrw-8 and up to 1934 the Technical Office thus had to rely largely on this firm, negotiating through the Army Ordnance Office. Lacking a machine gun specifically designed for aircraft, use had to be made of the Army MG-08/15 model to arm aircraft of the first emergency program and some of the aircraft of the first stage of the main rearmament program. Even after establishment of the Air Ministry procurement of these weapons still had to be handled through the Army Ordnance Office. The same applied to the MG-15 swivel-mount and the MG-17 rigid mount machine guns developed specifically for aircraft under instructions from Branch WaPrw-8 of the second division of the Army Ordnance Office.

The direction of weapons production by one single agency might have made it possible to insure rational production, but it was questionable whether the features required in a weapon for air combat and for installation in aircraft would have found proper consideration. Furthermore, in view of the small manufacturing capacities available, it would not have been possible to take speedy measures, of the nature air

373 warfare would necessitate, if the situation was retained under which all negotiations had to go through the Army Ordnance Office.

The subdivision of responsibilities, with the Technical Office responsible for the computation requirements and for planning, while the Army Ordnance Office handled the execution of programs and exercised the controls, would have remained ineffective as long as a centralized control over all armament activities was lacking.

Against opposition by the Army Ordnance Office the Air Force Technical Office therefore in 1934 assumed responsibility for both the development and procurement of aircraft weapons and aircraft ammunition.[1]

Already prior to 1933 Branch WaPrw-8 had established a developing and a small manufacturing installation at the Siemens-Schuckert-Werke factories in Berlin-Siemensstadt to produce the items of equipment needed for the installation of weapons in aircraft. This firm manufactured the propellor shaft controls for the rigidly mounted MG-0815 machine gun to fire through the propellor disk, the rigid mounts and ammunition boxes, the ringgears including the ammunition boxes and empty ammunition belt guides, and the sights for both weapons.

1. See "Besprechungsnotiz ueber Besprechung Generalleutnant Udet mit Goering vom 20. 7. 1939."

374 The fact that the Army Ordnance Office claimed exclusive use of the firm of Rheinmetall-Borsig created a technically exceedingly difficult manufacturing situation for the Technical Office of the Air Force. For a weapon not yet completely out of the development stages and with which the first tests had as yet hardly been completed, preparations had to be made for large-scale serial production, including all measures to insure proper mass production and easy exchangeability of parts, and all this had to be done in factories still to be established.

The only way out of this difficulty was to have smaller factories engaging in similar manufacturing activities participate. The first firm thus engaged was the Hunting Weapons Factory Krieghoff (Jagdwaffenfabrik Krieghoff) in Suhl. The mission of this firm was to act as a lead firm and place orders with other smaller firms to manufacture individual parts, to supervise these firms, and to carry out the assembly of the complete weapons in its own factory.

In spite of all misgivings this method proved to be the speediest and most favorable, and the weapons thus produced functioned excellently.

Parallel with these measures a start was made at planning and establishing a new factory at Wittenberge.

374 Of the two machine gun models developed as aircraft weapons, the MG-15, swivel-mount gun went into serial production in 1934. A small zero series of the MG-17rigid-mount gun was in process in the same year, and in 1935 this gun also went into serial production proper.

375 Plans to give aircraft weapons of steadily increasing strength created constantly changing problems for the Technical Office. To accelerate progress in this respect, and because no heavier weapons of German development which would have been suitable were available, the Ikaria Werke purchased the licence to manufacture the 20-mm weapon patented by the Swiss firm of Maschinenfabrik Oerlikon, and plans were worked out to establish the Veltener Maschinenfabrik factory in Luckenwalde to manufacture these guns by serial production methods. In addition, the firm of Haenel in Hildburghausen was contracted to manufacture the same gund.

At the beginning of the war the weapons available to the German Air Force to arm aircraft were as follows:

MG-17 79-mm rigid mount machine gun
MG Oerlikon FF 20-mm machine gun manufactured under licence as described above

For defensive purposes:

MG 15 7.9-mm swivel-mount machine gun with twin-magazine containing 75 rounds
MG 131 13-mm belt feed machine gun.

In the first years of the war, the following models were

375 developed and placed in service:ß

MG 151/20 20-mm machine gun, a Mauser model, to replace the FF model and developed from the 15-mm and 20-mm guns hitherto in use

MG 81 machine gun to replace the MG-15 machine gun.

The MG-151 had the smallest caliber which could still be used effectively with explosive ammunition. The MG 151/20 had an extremely high muzzle velocity of 1 000 meters per second with a 15-mm bore. The muzzle could be exchanged for a 20-mm bore muzzle, and the muzzle velocity was then still almost 900 meters.

The MG 80 had a considerably increased rate of fire of 1 400 rounds per minute.

These weapons were manufactured in extensions to the Rheinmetall-Borsig factory at Tegel, and to the Mauser factory at Oberndorf.

To further increase the offensive and defensive fire power of aircraft and acting on recommendations from Udet, Goering ordered development of a 30-mm canon. The originally planned output of these weapons by the firm of Rheinmetall-Borsig was soon doubled, at the expense of the 20-mm, and 35-mm AA guns hitherto manufactured by this firm.[1] This firm was particularly suited to manufacture the new gun, having on its own initiative developed the MK 101 30-mm automatic canon as early as in 1936, a weapon rejected by the then

1. See Letter Goering to Udet, 14 July 1939.

376 chief of the Technical Office because of its weight and size.

Although thus rejected, the MK-101 was tested in aircraft by the firm at the end of 1938 and by the Rechlin Proving Station in November 1939. Already on 3 July 1939 the performances of the weapon, mounted in a Bf-110 fuselage on the ground, had been demonstrated before Hitler, although it had not yet been completely tested, and although the data for its manufacture were not yet ready.[1] Being completely ignorant of the stage of development reached at the time, Hitler naturally formed entirely false impressions concerning when it could be placed in service. Unfortunately, it has not been possible to establish whether and what statements were made during the test concerning the completion date for the weapon's tests and when it would go into serial production. Responsible representatives from the Production Branch were not asked to the test performance.

By May 1940 twelve newly developed weapons were ready for field tests. Mounted in Bf-110-C-6 aircraft, they were delivered to the troops for a test period to continue from 25 May to the autumn of 1940. However, the troops considered them as special weapons designed specifically for use against armor protected ground targets. For this reason, the troops preferred their aircraft with the normal weapons, so that not many MK-101 canon were installed in twin-engine fighters.

1. See "Schreiben GL C Az. 72 d 7019 Nr 10422/43 gKdos v. 22.3.43" [illegible]

377 The firm nevertheless received a contract to manufacture a limited series of 220 of the guns, and development work on the project continued with a view to remedying the weak points of the MK-101 in newly developed variants.

The difficulties of the MK-101 were mainly manufacturing complications. It would have been necessary to produce the parts in masses, and serial production of the weapon would have resulted in a seriously reduced output of automatic AA and aircraft guns of other types. For this reason only another 100 of the guns were ordered, and work commenced on preparations ~~commenced~~ for the manufacture of the newly developed MK-103 gun.[1]

However, redesigning of the MK-101 as the new MK-103 apparently caused considerable difficulties. In order to facilitate mass production, the new technical manufacturing data specified a change to molded parts, and these resulted in faulty functioning of the weapon, a weakness which took considerable time to remedy.

In contrast with the initial impressions of the troops it had been discovered in the meanwhile, however,(in the winter of 1941), that with the use of a considerably improved armor piercing shell the MK-101 was a good weapon for antitank action, for which reason introduction of the new MK-103 was demanded.[2]

1. Ibid
2. See "Besprechungsnotiz 70/43 vom 13.7.1943 Goering/Milch."

378 Once again serial production of the weapon was delayed, however, this time by bombing raids which destroyed semi-finished parts and by the fact that Hitler had ordered available factory space to be released for an increased production of 37-mm AA guns. Hitler had expected that the weapon would be ready for the field shortly after the demonstration at Rechlin; instead, production had now been delayed by years, and this gave rise to serious censure of the Air Force by Hitler.

Finally, the 30-mm gun was used in two variants: the MK-103 as a high-velocity weapon in daytime operations, and the MK-108 for use in night operations. It was mounted in Me-109-G, Me-163, and Me-262 aircraft.

Towards the end of the war large numbers of MG-81 machine guns were procured, on improvised mounts, to protect industrial and mixed airfields. Both single-and double-barreled guns were used for this purpose, as well as the old MG FF machine guns still available in the various Air Force ordnance offices.

To increase the fire power of aircraft, tests were carried out with the 55-mm tank gun mounted in Me-410 aircraft, and contracts were awarded for the delivery of 400 of these guns complete with mounts. For the same purpose tests were carried out with the 75-mm antitank gun mounted in Ju-88 aircraft, and with the auxiliary installation developed by the firm of Junkers , which comprised six MG-81 or 3 MG-FF machine guns

379 and was known as the Spray Can (Giesskanne), mounted in Ju-88 aircraft, as well as with 88-mm AA guns, also mounted in Ju-88 aircraft.[1]

No records are available at writing on operations with aircraft thus armed.

AMMUNITION

Parallel with the development and procurement of weapons of a steadily increasing caliber and with an increasingly rapid rate of fire, ammunition for these guns had to be developed and procured, namely, demolition shells, incendiary shells, antitank (steel-core) shells, and air mine type shells. Just as in the case of the weapons, the necessary factory spaces for these purposes had to be newly established, since the Army Ordnance Office provided only 79-mm shells.

Some of the firms participating in the production of Air Force ammunition manufactured only individual parts; others at the same time handled the filling; again others, such as firms of the clock and watch making industry of the Black Forest, manufactured shells and detonators.

The following is a list of the more important ammunition manufacturers:

Rheinmetall-Borsig, Soemmerda
Hasag, Leipzig and Altenburg
Polte, Magdeburg and from 1941 on at Hollaischen

380 DMW, Luebeck-Schlutup and from 1941 on at Holleischen
Mauser, Berlin.

SIGHTS

The following sights were manufactured by serial production methods:

Reflector Sights Models 3, 15, 16

Ve-Revi 42 Sights for rigid-mount weapons, with specific velocity settings (mit einstellung der Eigengeschwindigkeit)

EZ-Revi 42 Sights, for all weapons types, with range finder and specific and target velocity setting.

The firms manufacturing these sights were the following:

381 Zeiss-Jena, in Saalfeld
Oigee, Osterode
Steinheil, Munich
Reichert, Vienna
Vogtlaender, Braunschweig.

BOMBS AND OTHER AIR DROP WEAPONS

The responsibilities of Branch GL/C-B-7 included the development and procurement of bombs and other air drop weapons, bomb-sighting devices, close range weapons, and demolition charges and detonators.

In meeting the stated requirements of the General Staff, the branch had to rely largely on the Army Ordnance Office, since the Joint Military High Command (OKW) had assigned that Office responsibility for the direction of ammunition production and for control of the industries involved.

381 The Air Force Technical Office thus controlled no industrial spaces of its own for the manufacture of ammunition prior to the war.

The lack of a controlling agency superior to all three military branches made itself just as adversely felt in the field of bombs and other air drop ammunition as in the case of ammunition for aircraft mounted weapons. The appointment of the Army Ordnance Office to direct all ammunition production could have created favorable technical conditions for manufacturing. However, it was not to be expected that the Army Ordnance Office would be non-party in its administration and in the allocation of factory spaces and so forth if a situation should develop in which the available potentials were inadequate to meet the requirements of all three military branches. This situation developed as early as in 1938.

Just as was the case with ammunition for aircraft mounted weapons, it was ovvious that the Army Ordnance Office, because of its complicated organization, could not react with the necessary speed in considering urgent special requirements or requirements for modifications.

Although the Army Ordnance Office did endeavor to meet Air Force and Navy requirements, the r sponsible personnel in the Office naturally were more interested in meeting the Army requirements in ammunition, more particularly so because they

382 were controlled by the Army in matters of discipline and promotion.

In executing orders involving matters which fell under the authority of the Army Ordnance Officethe mission of the Air Force procurment agency, Branch GL/C-B-7, was to formulate the requirements of the Air Force General Staff in technical specifications, forward these to the Army Ordnance Office, maintain contact with that Office while the project was under execution, and to follow up the execution. No direct contact existed with the industries involved.

Because the Army Ordnance Office gave Army projects preferential treatment the Air Force endeavored to obtain authority to handle its own procurement of bombs and other air drop ammunition, but initially without success. It was as late as 20 July 1939 before Goering was able to issue orders to assume self-responsibility for the manufacture of bombs and other air drop and special Air Force ammunition types.[1]

Using Air Force buildin allocations and Air Force budget funds the Army Ordnance Office had established the following factories:

For the manufacture of High-explosive bombs:

a subsidiary factory of the Bochumer Verein at Langendreer,

a " " " " Stahlwerke Riese at Groeditz,

a " " " " Vereinigte Oberhuetten at Gleiwitz,

the Algaier Factory at Uhingen,

1. See "Besprechungsnotiz ueber Besprechung Generalleutnant Udet mit Goering vom 20.7.1939.

383 the Paul Bohnke Factory at Wipperfurth,
A subsidiary factory of the Eisenwerk Muehlheim/Ruhe,
a " " " " Deutsche Roehrenwerke,
at Muehlheim/Ruhr.

For the manufacture of incendiary bombs:

The SSW Factory at Berlin-Spandau,
the SSW Factory at Neustadt/Saale,
the Hageluck Factory at Kiel.

For the manufacture of incendiary fillings:

A subsidiary factory of the IG Farbenwerke at Bitterfeld.

During the war the Technical Office established the Presswerk Laband at Laband in Upper Silesia, on its own responsibility, and the Stahlwerke Braunschweig (Steelworks Braunschweig) at Salzgitter in cooperation with the Army High Command.

Under the original organization the Air Force had to procure through the Army Ordnance Office all calibers of bombs the manufacture of which required heavy tooling machinery. This applied to all models of SD-10, SD-9/15, SD-50-Stg,
384 SD-70-Pr, SC-50, Brd-C-50, SC-250, SD-250, SC-500, SD-500, SB-100, SC-1000, SC-1000-L, PC-1000, PC-1000-Rs, PD-1000, SD-1700, and PC-1800-Rs types of bombs.

In addition the Air Force, contrary to orders by the Joint Military High Command, had procured newly developed types of ammunition for special operations, since deadline considerations made it impossible to procure these in time

384 through the Army Ordnance Office and because their manufacture necessitated factory installations differing from those needed for the types of bombs mentioned above.

The special types of ammunition involved here were as follows:

Bomb types Sd-1, SD-2, SD-3, SD-10-dw, 4-HL, SBe-250, B-1-E11, B-2-EL, Brd-C-10, Brd-C-50, Str-Br-C-250, KC-250-w, KC-250-Gr, KC-250-II-Gr, KC-250-III-Gr, AB-250, AB-500, ZC-10, ZC-50, ZC-250, ZC-500, LC-10-F, LC-50-F.

At the commencement of rearmament activities, the only completely developed and tested bomb types available for the German Air Force were the B-1-E enectron incendiary bomb of 2.2 pounds (1 kilogram), the SD-10 22-pound (10 kilogram) fragmentation bomb, and the SC-50 and SC-250 mine-type bombs.

In 1935 the procurement program was expande to include the SC-500 mine-type bomb, and in the following year the LMA and LMB ground mines of 1100 pounds (500 kilograms) and 2 200 pounds (1 000 kilograms) developed by the Navy were added.

Fragmentation bombs were developed in calibers of 2.2 pounds (1 kilogram) to be used in containers against live targets to calibers of 2 200 pounds (1 000 kilograms), while the calibers of mine-type bombs grew from 110 pounds (50 kilograms) to calibers of up to 4 400 pounds (2 000 kilograms). The first armor piercing bombs released for procurement

385 the PC-500 type approved in 1939. In this class calibers increased in time up to 3 000 pounds (1 400 kilograms). Armor piercing bombs with improved penetration with calibers of 1 100 pounds (500 kilograms) and 2 200 pounds (1 000 kilograms) only went into production in 1943.

As previously mentioned the only incendiary bombs available in 1933 were the B-1-E electron incendiary bombs; these were followed in 1939 by the B-1-3-E, in 1941 by the B-2-E. In 1941 the Spr-Brd-C-50[1] and Str-Brd-C-500[2] were added.

The purpose in manufacturing concrete fragmentation bombs was to meet the great demands of the Polish campaign by extemporized means, since Hitler had prohibited the production of bombs and only authorized their manufacture on 12 October 1939, although Field Marshal Milch had stressed the importance of their manufacture as early as in May 1939.[3]

For practical purposes it can be said that up to 1937 only four types of SC bombs, namely, the 22-pound, 110-pound, 550-pound, and 1100-pound (10, 50, 250, and 1 000 kilograms, respectively) calibers with three types of detonators had been introduced in the German Air Force.

Since war with Britain was thought likely after the Sudeten Land crisis, the General Staff demanded primarily armor-piercing bombs up to a caliber of 2 200 pounds (1 000 kilograms, air mine type bombs, underwater detonators, and

For footnotes 1, 2, and 3 see p. 488.

386 bomb release and bomb aiming devices for oblique bombing.

This brought the number of different bomb types up to fourteen. Furthermore, the calibers of SC type airmine type bombs were increased to 2 200 pounds (1 000 kilograms) and 4 000 pounds (1 800 kilograms) for use in dive bombing attacks by the Ju-88 aircraft.

The PC-500-Rs armor piercing bomb came into use in 1940, followed in the next year by the larger PC-1 000-Rs and the super-heavy SB-2 500 calibers.

In 1943 the bomb procurement program thus included 18 standard models, not counting special types developed.[1]

The AB-250, 500, and 1 000 bomb containers served for mass bombing with small calibers. In particular the SD-1, SD-10a, and incendiary bombs were used with all three containers, the SD-1 in Containers AB-250 and AB-1 000, the SD-10a, in contrast, only in Container AB-500.[2]

In that year the same circumstances ruled in compilation of the bomb procurement program as in the aircraft procurement program. The number to be procured depended on the current number of bomber aircraft and their missions.

Frequent changes occurred in the bomb procurement program

1. See "GL-Besprechung am 6. 7. 1943."
2. Ibid

Footnote 1, p. 487: Spr-Brd, abbreviation for "Spreng-Brand": Explosive-Incendiary.
Footnote 2, p. 487: Str-Brd, abbreviation for "Streu-Brand": Scatter-Incendiary.
Footnote 3, p. 487: See Excerpt from "Der Prozess gegen die Hauptkriegsverbrecher in Nuernberg, Aussage Milch, Band IX," p. 60.

386 according to the accumulated stocks held at any given time, the changing requirements stated by the General Staffon the basis of planned missions, and the current materials supply situation.

387 A comparison of bomb procurement figures with figures for the numbers of aircraft delivered from production shows that the number of bomber aircraft manufactured for a while mounted steadily fro 1933 on, while the quantities of bombs procured in 1940 was more than three times the estimated minimum requirement, and then decreased in 1941.[1] Since various categories of factories were to commence operations at the beginning of the war in line with the provisions of the Mobilization Plan, and since bomb manufacturing was permitted by Hitler from 12 October 1939, the bomb output could be stepped up more speedily than the output of aircraft, because the labor involved was less.

Over 60 percent in weight of the bombs produced in 1940 were of the 550-pound (250 kilogram) mine type, with welded casings, or 110-pound (50 kilogram) concrete bombs with a filling of shrapnel. Both types were filled with substitute explosives. Production of these types was soon halted.

Contracts for the 110-pound concrete-casing bomb had been given out at the beginning of the war because no adequate

1. See Report by Generalingenieur Marquard.

387 manufacturing facilities were available to produce the 110-pound multi-purpose bomb. However, only a small percentage of the concrete-casing bombs thus produced were ever used. The rest were scrapped when adequate supplies of multi-purpose bombs with cast or pressed casings were manufactured.

388 In the first two years of the war great importance was still attached to action affecting the morale of the enemy. The means devised for this purpose included increased calibers of fragmentation bombs and the use of oil bombs with a filling of gasoline and heavy oils.

EXPLOSIVES

The explosive used for stockpiling purposes as charges for bombs and shells was trinitrotoluol, which was the only explosive charge used in German bombs up to 1 September 1939.[1]

Ammunition expenditures in 1939 and 1940 showed that it would not be possible to adhere to the exclusive use of this explosive charge, since supplies of toluol were limited. It was therefore necessary to use compounds.

In each case the explosive mixture used was calculated to produce the blast effect most suitable for the purpose for which the bomb type involved was intended. A minimum trinitrotoluol content was fixed for each caliber. The rest of the explosive charge consisted of nitrate of ammonia, and combustible materials such as aluminum, flour or meal, gums, coal,

and hydrocarbon.

Ammunition depots handled the filling of bomb casings up to a caliber of 22 pounds (10 kilograms). Up to the end of 1939 the explosives factories filled casings from a caliber of 110 pounds (50 kilograms) up in departments specially maintained for the purpose. From the beginning of the war on the factories also handled the filling of smaller calibers in order to economize in transportation and packing materials.

BOMB RELEASE EQUIPMENT

Aircraft for the emergency rearmament program and for the first phase of the main rearmament program had special equipment in most cases for the storage of bombs. This equipment was developed by

Kurt Heber, Berlin-Britz
the SSW-Apparate und Maschinen, Berlin

and later also by

the Mechanische Werkstaetten Neubrandenburg.

The practice of carrying mixed bomb loads finally necessitated the provision of simplified and exchangeable installations.

GROUND EQUIPMENT

The category of "Ground Equipment" included all items of movable equipment needed to maintain the operability of air units. This also included the technical outfits of

389 aircraft crews and ground servicing personnel, such as normal and emergency speed tanking apparatus with all appliances, spur tow wagons (Spornwagen), engine starting equipment, engine heaters, fuel and lubricant wagons, bomb transport wagons,

390 jacks, fire extinguishers, tool boxes for mechanical and electrical work, medical kits, signal pistols, signal flags, camouflage netting, and all materials needed in operations, such as repair materials, cotton waste, leather cloths, greases, outfits for ordnance work, and so forth.

In addition to the above the appropriate procurement branch was responsible for the proper provision of all Army type items of equipment needed, of motor vehicles, and all other items to be furnished by the Army Ordnance Office.

Owing to the lack of time and facilities not much was done prior to 1933 to promote the development of items of ground equipment, particularly since it was possible to use the items introduced for use by the Lufthansa Airways, with the exception of special items.

In the first stages of rearmament after 1933 main emphasis had to be on training, so that the equipment used by the German commercial and sports aviation schools met all needs.

Hand in hand with the gradual establishment of air units work could also begin on development of the necessary special items of equipment.

Footnote 1, p. 490. See Report by Generalingenieur Marquard.

390 The ground equipment needed for the photographic services had already been developed at an early stage.

Most items of ground equipment needed could be procured

391 from the firms manufacturing these for the Lufthansa Airways and for the German Commercial Aviation School. The existing firms were expanded and new firms were established to cope with growing requirements.

In the field of ground equipment on the whole, no serious difficulties occurred during the campaigns in Poland and France, nor during the air offensive against Britain.

Unfavorable circumstances in the matter of ground servicing in Norway were due to supply difficulties, lack of adequate ground service personnel, and the fact that the existing ground organization was insufficiet, so that improvized measures had to be used for the ex cution of air missions.

Similar difficulties were encountered in the campaigns against Yugoslavia and Crete.

In the above theaters of operations temperatures were as a rule normal and the missions flown were of relatively short duration, so that no serious complications developed so far as ground servicing equipment was concerned.

Circumstance were very different in the campaign against the Soviet Union. Here, the heat and dust of summer and the extreme cold of winter, particularly in the winter of

391 1941-1942, created conditions which German ground equipment could not meet. The lack of shelters for aircraft also had an adverse impact on the operability of German air units.

392 German ground equipment had been developed to meet climatic conditions approximating those of the areas of Central Europe, and they were completely adequate for missions flown from prepared tactical airfields and emergency airfields and air strips. In the cold and constant wind of the Russian winter of 1941-42, however, this equipment was by no means adequate to keep engines in operable order, or even to start them.

The heating hoods generally in use proved unmanageable when frozen stiff and also in other respects were inadequate; other items, such as the tripod cranes used for changing engines, proved too heavy.

The experience gained in that winter season resulted finally in the development of simplified equipment; this applied particularly to the engine heating hoods, which were now more suitable since they functioned without electricity. It must be borne in mind, however, that the winters of the following years were not as severe as that of 1941-42.

In many cases the difficulties ascribed to the ground equipment were in reality due to the inadequate training of ground service personnel. In many cases the excuse that the equipment was not adequately developed served to cover up

392 the ignorance of such personnel and their faulty handling of the equipment.

In summarizing it can be said that German equipment was designed for operation under conditions differing radically from those encountered in the campaign against Russia. No general preparations had been made for winter operations under Russian winter conditions, since it was obviously assumed that the campaign would be of only short duration. Measures had not even been taken to design or procure the snow skids which were indispensable for aircraft operating under winter conditions, and had to be procured hastily by means of an emergency project after the winter had commenced.

The inadequate preparations made created the necessity to rely largely on improvisations so far as ground equipment in the Russian campaign was concerned.

AIR TORPEDOES AND GUIDED MISSILES

1. Air Torpedoes. The development, proving, and production of air torpedoes were responsibilities of the Navy, and were largely influenced by the organizational set up within the German military establishment.

In spite of the success achieved in World War I in the use of air torpedoes under improvized technical conditions, the development of this weapon received no proper support

393 before or after 1933. Although the Navy had again taken up the problem of air torpedoes as early as in 1924, it had achieved no useful results by 1933.[1]

It is beyond doubt that the need for strict secrecy and the lack of the necessary means had a retarding effect on all efforts in this field. Tests could only be carried out during weather with poor conditions of visibility and far removed from all shipping routes. This made them completely dependent on weather conditions and prevented a consistent conduct of the necessary test series under constant circumstances. Furthermore, the small funds available to the Navy prior to 1933 were barely adequate for the most pressingly urgent matters, so that less urgent matters naturally had to wait.[1]

Another factor was that the exceptionally rapid progress made in aviation after World War I naturally affected the requirements which would determine air torpedo development.

Under the changed circumstances the surface torpedoes used in World War I were in no way suitable for the planned future purposes. Alone the fact that instead of the World War drop altitude of roughly 30 feet, torpedoes in any future war would be launched from altitudes between 260 and 400 feet meant that air torpedoes would have to have a far greater resistance to impact than ship-borne torpedoes. Furthermore,

394 there were the aerodynamic requirements for the drop, and the need for torpedoes to resist temperatures as low as minus forty degrees Fahrenheit when aircraft had to approach at very high altitudes. The determining factor for the length and XXXXXXX diameter of air torpedoes was also no longer the size and shape of torpedotubes; instead the size had to be adapted to the principles of aircraft construction.

All of these required features which differed so radically from those of ship-borne torpedoes meant literally that air torpedoes had to be an entirely new development. Only that 395 military branch which was to use them could give proper consideration to all these essential features on the basis of experience.

Another factor which complicated the development and manufacture of suitable air torpedoes was the traditionally bound technical organization in the Navy, in accordance with which the Navy itself prepared the constructional and manufacturing designs, and the gages and installations. The Technical Office of the Air Force had learned from experience that the appropriate industrial concerns could handle this work far more speedily and with more initiative, a system which had contributed largely to make the rapid build up of the Air Force possible.

Footnote 1, p. 396: See "Bericht Ministerialrat Dr. Schreiber vom 8. 2. 1957, p. 1."

395 Because of its failure to achieve success, the Navy finally purchased the patents and the right to manufacture under licence the air torpedo developed by Norwegian Captain Bull, which appeared to offer a solution to the problem of high-altitude launching. However, this construction also failed to meet all requirements: for use in the North and Baltic Seas with their shallow waters, in which a certain percentage of the torpedoes launched struck ground, they were not unconditionally usable. The demonstration tests carried out in Norway had been in areas with a water depth of 140 feet, whereas depths of only 66 feet had to be taken into consideration in the North and Baltic Seas.

396 Here again, the Navy did its own work of redesigning after the necessary funds became available in 1934 and awarded contracts for the individual parts to industrial firms. However, the execution of these contracts suffered considerable delay because modifications became necessary.

The system under which the Naval Torpedo Ordnance Office (Torpedo-Waffenamt) awarded manufacturing contracts for individual parts necessarily resulted in confusion on who was to be responsible for the completed torpedo in a condition ready for service. Since the Torpedo Ordnance Office assumed responsibility for the proper manufacture and timely delivery of the individual parts.

397 If the torpedoes failed to function, or in the case of a faulty manufacture of parts, the assembling firm thus had the possibility to refuse to accept responsibility.

The Norwegian torpedo, known as the LTF-5-b was not yet ready for service in 1938, in which year the Torpedo Ordnance Office purchased the licence to manufacture the Italian LTF-5-w air torpedo, after tests carried out in the presence of Air Force representatives with torpedoes picked at random from factory production and launched from an altitude of 330 feet by aircraft travelling at 210 miles [illegible] had shown that these sank to less than 66 feet beneath the water surface. In this Italian model the problem of defelction tion in the water had found a purely mechanical solution in the form of a kinetically properly shaped torpedo head and a proper placing of the center of gravity.[1]

However, the terms of the licence contract did not cover the proximity detonating device required for use against large warships protected by anti-torpedo bulges and torpedo bulkheads. The Eckernfoerde Torpedo Experimenting Station for the time being endeavored to find a solution itself for this problem.

At the beginning of the war the parts for the LTF-5-b air torpedo were in production and tests had been carried out with satisfactory results by aircraft flying at speeds of

397 120 miles and altitudes of 100 feet.[1] However, a speed of 120 miles represented the minimum for the He-115, He-111, Ju-88, FW-200, and Do-217 aircraft, which were suitable to carry air torpedoes.

It was apparently due to these circumstances that Goering lost interest in air torpedoes and in 1939 recommended to Hitler that he should prohibit any further work on their development or manufacture, since all development work done in the past had failed to produce a serviceable model.[2]

From all the above reasons it must be assumed that the cause for this decision was obviously the fact that the Navy

398 was not sufficiently interested in the development of air torpedoes because it was too heavily engaged on its own projects, plus the fact that the expenditures appeared too great for the Air Force to establish its own torpedo proving station. Furthermore, it appears that air torpedoes were included in the 1940 order halting development work.

Efforts were now made to find a substitute for air torpedoes by means of a speedy development of superheavy bombs for attack against the British Navy.

It appears that the Naval Torpedo Experimenting Station at Eckernfoerde only succeeded in 1940 in developing a launching and depth control which, by means of a box-like or jet-

1. Report General-Ingenieur Marquard, 5 May 1955, p. 18
2. XXXXXX.See Letter Generalleutnant Ernst Roth,12.Sep 54. Footnote 1,p.489: Report Marquard, 5 May 1955, p.15.

398 jet-shaped air rudder secured a good surfacing action and a speedy setting at the planned depth course without the torpedo sinking too deep under the surface.[1] Whether and to what extent this steering device was mountedin air torpedoes it has not been possible to clarify satisfactorily.

It appears possible that this modification of the steering apparatus finally produced better results in test launchings, since air torpedo launchings in 1940 showed favorable results and since the Air Force General Staff planned to resume the halted manufacture and requested production of 150 air torpedoes per month.

However, the use of the LTF-5-w torpedo remained prohibited for some time, sonce Hitler planned to hold this weapon in reserve for a special operation.[2]

Seventysix of the new torpedoes were ready for action at the time, 115 were completely assembled but not yet armed, and 100-110 were available in parts.

It was only the success achieved by the Japanese and Italians with air torpedoes in 1941 that influenced Goering to again place emphasis on this weapon.[3]

The outcome of this decision by Goering was that the Air Force took over the development and production of air torpedoes in the summer of 1942.

1. Report Ministerialrat Dr.Schreiber, 8 Feb 57, p.5.
2. " "Generalstab,Quartiermeister, 6.Abt. 27.11.1940 Auszug A/25.
3. Letter Generalleutnant Ernst Roth, 12.Sep 54, p. 5.

399 The Navy transferred to the Air Force a group of personnel familiar with the type of work involved together with the Hexengrund Torpedo Firing Range.

Contrary to Naval practices, the whole organization of development and procurement was now changed to the system customary in the Air Force. Responsibility for the finished article was assigned to the final assembling firm, which also assumed responsibility for negotiations with and support of its sub-contractors. This brought industrial initiative into play, with good results in the manufacturing processes.

Three main firms handled the manufacture of air torpedoes for the Air Force, namely,

400 the firm of Schwartzkopf, Berlin;
the Trippelwerk Factory, Molsheim in Alsace;
the Geraetewerk Pommern Factory, Stargard, a subsidiary of the firm of Askania, Berlin.

The following factories produced air torpedo parts:

the firm of Maihak, Hamburg;
the Hamburg Eisen- und Walzwerk, Hamburg-Harburg;
the firm of Kluessendorf, Berlin-Spandau.[1]

A number of minor firms also participated in the manufacture of parts.

Unfortunately, the few details contained in the records available at writing are insufficient for a reliable reconstruction of the procurement program, which would require additional research.

For Footnotes see p. 504.

400 One point which does become evident, however, is that an appreciably increased output was only achieved at a time when the German Air Force no longer had air superiority and the German defences had so far decreased in effectiveness that measures, which had been introduced too late, could no longer produce any appreciable results.

By 20 October German aircraft sank ships with a total tonnage of 5 133 500 tons with LTF-5 air torpedoes and damaged ships totalling 122 000, besides sinking 3 400 tons of shipping and damaging 15 000 tons with the Italian LTF-5-w air torpedo.[1]

401 During the first stages of the Air Force air torpedo program, production proved extremely difficult because of the use made by the Navy of materials in short supply. The first thing for the Technical Office of the Air Force was therefore to determine substitute materials to eliminate or radically reduce the use of the following metals:

Metals	Quantity required per torpedo
Chromium	113.1 pounds (51.3 kilograms)
Aluminum	251.32 " (114 ")
Lead	172.28 " (78.6 ")
Tin	121.25 " (55 ")
Copper	824.52 " (374 ")[2]

The reason for this large use of metals in short supply was obviously the long time torpedoes might have to be held in storage and the risk of corrosion due to seawater. These

For footnotes see p. 504.

401 1 Since these risks did not apply in the case of the Air Force, work proceeded speedily to determine what substitutes could be used to bring about a large saving in rare metals, on the basis of experience gained in the use of substitute materials already in use for other Air Force equipment.

The fact that work to speedily increase the output of aircraft was a top priority project, plus the fact that the Air Force General Staff had increased its stated requirements

402 to 800 German and 400 Italian air torpedoes per month while plans for production provided for a monthly output of 3000 made it possible to include the development and production of air torpedoes in the first priority brackets.[1]

One change in the newly developed LTF-5-u air torpedo in comparison with the LTF-5-b was that it had a diefferent middle piecefor the use of the Walter system of dual fuels propulsion giving it an effective range of 6 600 yards (6 000 meters) with an explosive charge of 440 pounds (200 kilograms). The types of air torpedoes now available were as follows:

The LTF-5-b,

LTF-5-u, described above

LT-1000, designed for a very large range of launching altitudes up to great heights and with a long effective range

LT-5 for use with fighter-bomber aircraft, with a reduced overall length of 15.94 feet (4830 m), a total weight of 1648 pounds (740 kilograms), an explosive charge of

~~Footnote 1, p. 502: See "GL-C-E-7 Nr. 3952/41 geh. (IV)~~.Cont!

Footnote 1, p. 502: See Report Ministerialrat Dr. Schreiber, 8 February 1957, pp. 5, 6.

Footnote 1, p. 503: See "GL-C-E-7 Nr. 3952/41 geh. (I-V) vom 10. 12. 1941 (A/25)."

Footnote 2, p. 503: Compilation by the German Air Torpedo Arm (Deutsche Luftwaffe) A/25.

Footnote 1, p. 504: See "Besprechungsnotiz I45/42 geh.Kdos. vom 8. 8. 1942 ueber Besprechung mit Goering/Milch/von Brauchitsch."

402 528 pounds (240 kilograms) and an effective range of 2 200 yards (2 000 meters).

Further research would be necessary to determine to what estent the above models were actually manufactured.

In addition to the above plans were in preparation to replace the LTF-5-b and LTF-5-u ir torpedoes by the LTF-950, which was to be a glider-type air torpedo for launching at greater altitudes and greater ranges less dependent on the speed of the deliverin aircraft.

2. Guided Missiles. The development of guided missiles of the unmanned type was preceded in some respects before World War II by tests with remote-control aircraft of the Ju-52, Ju-86, and He-111 types.

403 In 1940 a successful trial had been carried with an unmanned Ju-52 plane in remote-control take off, flight, and landing. The purpose of these trials was to gain basic experience on the use of remote-control devices. The purpose was served by the development of very small aircraft with small engines and remote control instruments as target aircraft, used primarily as aircraft targets for practise fire with light caliber antiaircraft guns.

Of the numerous remote control equipment developedonly few were approved for procurement from serial production. These were the air to ground Fritz-X, and the Hs-293, and

403 the ground-ground Fi-103 missile better known as the V-1.

The Fritz-X air-ground missile was a normal armor-piercing PD-1 400 bomb with a special steering device including remote control elements. These latter made correction of the normal fall curve possible within relatively narrow limits.

The missile had to be delivered from altitudes between 13 200 and 16 500 feet (4-5 000 meters) to exploit its full penetration power. After release of the bomb, the delivering aircraft had to continue on a straight course while the bombs was falling.

Technical difficulties in the manufacture of these missiles were caused by the great construction precision needed for aerodynamic reasons. The firm of Rhein-Metall Borsig manufactured these missiles.

After a relatively short time spent on development under direction by Professor Wagner, the ground-ground Glider-Bomb Hs-293 was approved for procurement, the development having taken only one year. This missile consisted of a normal SC-500 bomb with attached vanes, steering gear, and propelling unit which gave it the character of a flying bomb.

Both the time at which this missile was developed and the method of its delivery reveal its purpose, that of sinking cargo ships and attack against ship convoys.

The bomb was propelled by a Walter type power unit

404 and steered by the Strassburg-Kehl device with a tracer light ~~Lichtleucht~~ unit. Since the steering was sensitive to interferences, a wire control was also used with a range of 13 000 yards (12 kilometers).

This missile went into serial production, but the details contained in the records available at writing are inadequate for a reliable re onstruction of the production program.

After initial success, the conditions for the use of this

405 missile deteriorated extraordinarily because of enemy air su periority, so that it went out of use in the final phases of the war.

Another factor which delayed use of the Hs-293 was the difficulties encountered in development of the He-177 aircraft, which was to carry and deliver it. It therefore became necessary to use Do-217 and He-111, which did not have a long enough operating range for the purpose.

The ground-ground Fi-103 or V-1 missile was destined to gain far greater importance than the Fritz-X or the Hs-293.

The project was palnned as early as in 1939, plans providing for radio-beam steering. These plans were initially rejected because of the need to protect the enemy civilian population, since the nature of the missile made it useful only for extensive area bombing. It was only after the air attacks of 1942 against Cologne, Luececk, and Rostock that orders

405 were given to proceed with the project with the utmost urgency. Within two years the developing and proving work was completed, the missiles were in production, and troops were under training for their use.

This quick progress was only possible because the whole project was taken out of the normal system of development and procurement. Production of the missile was placed under a special staff not required to adhere to normal official channels, which had all necessary funds and other means available.

Serial production commenced with an output of 500 in March 1944, increasing rapidly to 2 600 in July.

Just as has been described in the case of the He-162 aircraft, the individual parts for the V-1 were given out to a large number of small and very small workshops for manufacture widely dispersed throughout Germany, most of the firms concerned not even knowing what the parts they were manufacturing were to be used for. Final assembly of the missiles was at Fallersleben, Schoenbeck/Elbe, and Stolp/Pomerania.

As part of the general movement of important works to underground premises, assembly of the V-1 was moved to the Mittelwerk premises near Nordhausen.

Work committees directed the work of the various firm units and were also responsible for their support.

The following firms manufactured the more important

406 components:

Askania, Berlin and	Steering and gyro equipment
Deuta, "	" " " "
Argus Engine Works Berlin and Dobern/ Niederlausitz	" " " "
Firms in Reutlingen and Stuttgart	Outer surfaces and launchers

Later, the firm of Deutsche Werkstaetten Hellerau manufactured the outer surfaces, when wood came into use for the purpose instead of steel.

The total number of V-1 missiles produced was 8 000.

The following projects were also under development during the last two years of the war, but were not completed in time for procurement:

the air-ground X-4 missile for antiaircraft action
the Hs-294, Hs-295, and Hs-296, being improved air-ground versions of the Hs-293
the air-ground Hs-298
the ground-ground X-7 antitank missile
the air-ground BV-246 missile for area attacks
the BV-143 missile for use against ships.

Another project which was not completed was that of various aircraft rockets, a project supported primarily by the newly established branch of the Department for Development of Antiaircraft Weapons.

Although some of them appeared very promising could not be completed for time reasons, while some of them had to be

407 postponed because of the lack of man power and materials.

The work done nevertheless represents an outstanding performance by all industrial participants and by the Technical Office, particularly in view of the steadily decreasing possibilities during the last phases of the war.

RAW MATERIALS AND SYNTHETIC MANUFACTURING MATERIALS

Apart from man power, the factor which will determine the scope of any armament program is the materials potential available.

When rearmament commenced in 1933, the Air Force in its first build-up stages had the advantage that it could within a very short space of time utilize the available reserves of the basic industries for its purposes. This was due to the preparatory work done beforehand, the appropriate organization of its Technical Office--which was adapted to modern requirements, and the purposeful direction of all activities by the then Chief of the Technical Office Wimmer, later promoted to the rank of Lieutenant General (Air) (General der Flieger) . What facilitated matters here for the Air Force was that the other two branches of the military, the Army and the Navy ,needed far more time for the compilation and preparation of their planning work because of their cumbersome organization.

Another valuable support for the armament activities of t the Air Force was the political position of its Commander in

Chief, Goering.

Initially, adequate supplies of manufacturing and building materials were available for the build up of the aviation industries, for the manufacture of items given out under contract, and for the expedited construction of such installations as airfields, billets and shelters, ordnance depots.

The small capacities of the manufacturing materials and semi-processed materials producing industries at the time necessitated an extensive program of investigation to determine requirements and establish allocations in order to implement the planned program with as few interferences as possible. The purpose here was to prevent faulty dispositions by the finally assembly firms in their sub-contracting activities which would have caused a wastage of materials.

On the basis of the data gathered it was possible within a very short time to establish the necessary plans for these purposes and deliver them to the appropriate industrial firms.

Up to 1937 it was thus possible for the Air Force procurement programs to proceed without complications so far as manufacturing and semi-processed materials were concerned. This remained so even after the newly established Military Economy Staff of the Joint Military High Command began to make itself felt as the agency responsible for the allocation of raw materials.

409 As previously mentioned the year 1937 brought a drastic reduction of the military budget. In addition, a serious shortage of steel occurred in the same year because of the reduced reserves in foreign currencies,[1] which necessitated the introduction of control over iron and steel supplies by means of a number system.

Besides the necessity to now adapt the aircraft production program to the new allocation of 21 000 tons of unprocessed iron per month instead of the former 58 500 tons[2], it was no longer possible to carry out industrial mobilization preparations on the planned scale. Furthermore, the programs for items of equipment to be procured through the Army Ordnance Office had to be radically curtailed. This involved equipment such as antiaircraft artillery, signal, infantry weapons, ammunitions, explosive bombs, motor vehicles, and so forth.

The impact of the reduced materials allocations and of the curtailed budget on the numerical production of aircraft has been discussed previously in this study. June 1939 brought a further reduction in materials allocations, primarily in the metals used as alloys, namely, copper, tin, lead, zinc, nickel, antimonium, cadmium, mercury, and in rubber and aluminum, allocations now varying between 19 and 80 percent of actual requirements.[3]

For Footnotes see p. 513

410 It had already not been possible to meet fully the requirements of former programs, so that the Chief of Air Force Special Supply and Procurement Service now found himself compelled to express his doubts about whether it would be possible under existing circumstances to complete the armament program as a whole in the planned scope. From 1937 on it had not been possible to proceed with implementation of the program unhampered by interferences due to materials shortages.

With the information available at the time and with further particulars gathered through investigations it proved impossible, however, to form an estimate of the overall military requirements on the basis of planned programs. Such an estimate would have been essential to judge the progress which could be made in completing the air armaments programs if the Air Force were awarded a priority in the allocation of materials and the impact this would have on the conduct of air warfare. Only few details are available concerning the overall military requirements and the corresponding allocations to the Air Force so that reliable deductions are not possible.

Footnote 1, p. 512: See "Aktennotiz Udet vom 21. 2. 1937 ueber die Besprechung mit Staatssekretaer Koerner und Oberstleutnant Ploch."

Footnote 2, p. 512: See Letter "Der Reichsminister der Luftfahrt u. Oberbefehlshaber der Luftwaffe LC III, 2304/37 geh. Kdos. III/5 B 2. Angelegenheit v. 24. 12. 1937."

Footnote 3, p. 512: See "Anlage zum Schreiben 'Der Luftzeugmeister' Az. 66 GL II, 2533/6 38 geh. vom 20. 6. 1939."

+ It seems that the author her is discussing his ability to form an estimate and draw conclusions, in which case the words "of writing" should be inserted after "at the time."

411 Generally speaking it can be considered as an established fact that from 1937 on all Air Force armaments programs suffered from short supplies in materials. In most cases assurances were given that the necessary materials would be allocated to carry out the programs based on the stated requirements of the General Staff, but after the necessary manufacturing operations had been initiated in the industries, these promises were not fulfilled. In a few cases of particularly important projects efforts proved succesful to obtain the required allocations through Goering as Director of the Four Years ~~Fxd~~ Plan, but these cases were exceptions.

By exchanging 9 000 tons out of its allocation of iron, ~~xxxxxxxxxxxx~~ and the use of this iron for low-current electric wires, the Air Force succeeded in meeting part of its requirements, namely 90 percent in the case of copper, 80 percent in that of lead, approximately 80 percent in that of ~~xinx~~ tin, and 100 percent in that of zinc, but no more than 50 percent of the required aluminum could be allocated.

The necessity to revise production and procurement programs at such short intervals was due not only to the changes in Air Force General Staff planning but also to the failure to furnish the promised allocations of materials.

412
372 Quite apart from the generally inadequate allocations, the unfavorable position of the Air Force programs in the

412 the sequence of priorities had an adverse impact on allocations for Air Force projects. Furthermore it became a practice to create new priority categories usually at a time when it was not possible to fulfill allocations awarded.

The materials supply situation is strikingly illustrated by a statement of Generalreferent Kehrl in May 1942 that the sum of the programs necessitated by the war exceeded the possibilities of the raw steel output to meet them and that the rationing of raw steel products did not produce the expected results, particularly because the raw steel output in 1942 was smaller than had been anticipated. The result was that requirements to meet allocations exceed available supplies by 8 000 000 tons of steel.[1]

Since the total amounts called for by the supply certificates in possession of the industrialists exceeded the possibilities of delivery, the holders of such certificates did everything possible to secure their materials in time to meet their deadlines. This led to a general struggle in which everyone was the enemy of everyone else.

Similar conditions ruled in the case of aluminum supplies. In a conference in March 1942 Professor Krauch stated that there had been a shortage of 6 000 tons monthly in 1941, and that the

1. See "Sitzung beim Rüstungsminister am 15. 5. 1942, Vortrag Generalreferenten Kehrl."

412 shortage per month would be 15 500 tons in 1942 and 8 500 in 1943, while an excess production was expected in 1945 on the basis of then valid estimates.[1] This last prediction

413 proved false. Supply conditions continued to deteriorate during the war, so that it proved impossible to meet Air Force requirements even after establishment of the Fighter Production Staff and the concurrent placing of the fighter production program in the top priority category, and in spite of the curtailment of the production of larger aircraft with any considerable aluminum requirement, and also in spite of all assurances given by Saur.

Measures taken in Norway to increase aluminum production there also did not result in the expected increased deliveries. The exceptionally large amount of funds and effort expended on this project had practically no effect whatever.

Realizing the difficulties which were to be expected in the matter of raw materials supplies in the event of war, the Technical Office immediately after transfer of Branch WaPrw 8 from the Army Ordnance Office to the Reich Air Ministry had continued the work that branch had commenced on projects to find substitutes for materials which would be in short supply.

In addition to measures of simplification and standardization in the field of manufacturing materials, extensive

1. See "Besprechung der Zentralen Planung 25. 3. 1942."

413 efforts were made to produce aluminum from clays found within Germany and xxxxxxxxxx processes in the production of magnesium were converted so that it could be obtained from German raw materials.

414 Aluminum was used to replace copper, German sources of wh which were inadequate. Other measures had to do with the metals used as alloys with iron for aircraft and aircraft engine construction, such as the development of processes to produce ferromanganese xxxx and vanadium from iron ores mined in Germany, and the replacement of nickel steels with a high nickel content by such with a low nickel content or by chrome-molybden steels.[1]

As work proceeded an aluminum alloy was developed with a reduced copper content of only 3 percent instead of 4.5 percent. In addition, cylinder heads xxxxxxxxx for aircraft engines were made from non-copper light metal alloys and the usual lead-bronze bearings with their copper content were replaced by non-copper bearings, while aluminum wire was used with a coating of copper.

Measures dealing with manufacturing techniques and with construction also served to economize in short-supply metals.

Besides the work which the Manufacturers Ltd (Fertigungs G.m.b.H.) had initiated already prior to 1933 to reduce the number of manufacturing materials types in use, which aimed at

1. See "Vortrag Professor Bock 25. 11. 1934 LC Chef Ingenieur Nr. 8128/34."

simplification of the manufacture of semi-finished products and of holding spare stocks, the Technical Office under instructions from Field Marshal Milch launched a project to reduce materials consumption without any constructional changes, solely by means of more thorough preparation for manufacturing
415 operations, a project which produced excellent results.

In the end, however, the lack of certain manufacturing materials made redesigning an imperative need. A committee under the Industrial Council assumed responsibility for this work. The main projects here were as follows:

The use of steel in place of aluminum for various construction elements or units in aircraft manufacturing; This applied primarily to spar flanges and the outer covers for airplanes needing large quantities of aluminum.

The use of wood planking or plywood and fabrics for outer covers.

The situation was more complicated in the field of engine construction. Here the use of substitute materials created the risk of considerably increased weights and of reduced serviceability, for which reasons no major changes were introduced.

Other measures concerned the construction of hollow or wooden propellors for aircraft, and the use of substitute materials for air drop weapons and radar equipment.

415 Plastics and other synthetic materials came into widespread use in constructional modifications, since they could be produced readily from raw materials available within Germany.[1]

The measures thus introduced from mid-November 1942 on were a valuable support in the execution of the procurement

416 programs of the Air Force, but at the same created serious disadvantages in other fields. The preparatory designing and co construction work deprived other important processes of technical personnel already in very short supply. Furthermore, the use of new materials in some cases required comprehensive changes in the manufacturing installations and processes.

It has not been possible for the present writer to determine with any degree of accuracy the scope in which the conversion to substitute materials and the reconstructed models for this purpose actually went into serial production or what quantities of short-supply materials were saved in this way.

Frequent changes in the procurement programs; the relatively small series produced of any one identical model; the modifications introduced while a model was in serial production; the failure of the Me-210, and the large quantities and varieties of spare parts which had to be stocked and supplied to repair shops and other installations because of the numerous aircraft models in service all undoubtedly contributed towards

For Footnote see p. 518a

1. See "Zusammenstellung Industrierat des Reichsmarschalls fuer die Fertigung von Luftwaffengeraet, Umstellungsausschuss vom 21. 11. 1942."

416 increased materials requirements and thus held down the industrial output of aircraft, engines, and items of equipment. It is not possible to form even an approximate estimate of the loss in production thus caused from the source material available at writing. It would be more important to examine how the procurement programs might have progressed if the materials needlessly expended during the first two years of the war for building projects and the peacetime economy which was retained, particularly because records on this subjects still seem to be available at official depositories.

AVIATION FUELS

Aviation fuels were included under the general heading of fuels. The level of stocks held at any given time prior to World War II depended on the value of available foreign currencies and exchangeable services, during the war it depended on the German producing capacities.

Preferential supplies awarded to one user thus necessarily produced disadvantages for other users. For this reason it was not possible to decide allocations by technical means but solely on the basis of command considerations.

To form any opinion on the most favorable allocation and exploitation of available potentials would necessitate a clarification of everything that happened in the whole complex of fuels in general. However, the available records and the

417 data developed through test investigations are by no means adequate for this purpose.

For this reason the present section on aviation fuels must be based exclusively on the aviation fuel allocations awarded by the Joint Military High Command (OKW) and their influence on the conduct of air warfare.

418 There can be no doubt that fuel allocations to the Air Force were adversely affected by the unfavorable position of the Air Force in the sequence of priorities, and to what extent allocations more in keeping with the significance of air power might have changed the course of the war is a subject which would require a special study.

The aircraft engines installed in the few types of military aircraft in service prior to 1933 made no demands exceeding general technical standards as they existed in those days on the quality of the fuels used. The engines used had a rela relatively low compression and permitted the use of the fuels generally in use by the German Lufthansa Airways, the German Commercial Aviation School, and the Sports Aviation Schools. For this reason special measures to develop special fuels did not appear necessary.

It was only the increased engine performances secured through higher compression which made higher demands on the antiknock value of fuels.
