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 armament 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 underground was impossible. It was only the assumed 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 material 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 engaged in fighter production to properly protected premises. The majority of the Air Force supporting industrial firms still found themselves
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
then at a distance of between 400 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 as-
assemblies for which were manufactured in the tinent workshops
imaginable distributed in each case even on whole rural distri-
cut, 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 factories were instituted too late. There can be no
doubt that better fighter defenses could have been establish-
ed 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-
ground premises and the wide dispersion of factories instal-
al as a result of the Allied air attacks
planation a direct collapse of manufacturing activities was
averted. It was only near the end of the war that the
destruction of transportation systems, which were
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 results of bombing attacks, since the
relocation operations usually caused greater losses in out-
gut than the air attacks themselves.
CHAPTER 2

MANUFACTURING PREPARATIONS

Prior to 1935, the firm -orti unga G. . . . 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 aircraft manufacturing 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 -orti unga G. . . . 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.
By the end of 1932 the directives for aircraft were ready and had been tested in the manufacture of the Albatros L-70 under licence. These directives had been fully applied in the pre-1935 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 Arsenal Plan.

After rearmament commenced in 1935, the Vertriebs 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 inquire 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 were completed. The purpose here was to reduce the time spent between commencement of
the development of a new item of equipment and the time at which it could be placed in service with the units 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 speeded 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 "enemy 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
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, laying, etc., to insure proper final assembly and easy exchangeability. The disconnecting-point drawings clearly showed the proper joinings and all connecting parts, and link-ups.

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—properly fitting—spare parts not exceeding the prescribed 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 were 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 war, in system, to insure parts exchangeability without retooling.

A mutual exchange of experience gathered resulted in the compilation of manufacturing plans; particularly in co-operation 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 conveyer belt equipment of common 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
method had excellent results in starting operations at a
development and manufacturing firm handling production of
the developed item under licence, since it was possible to
furnish not only the MANUFACTURING construction data,
tooling
but also such items as the line and machinery requirements,
and the tools needed, as well as the necessary gadgets, gauges,
etc.

Construction data were also prepared for the installations and so forth the manufacturing firm would require, in
order to ensure 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 manu-
facturing facilities 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 gauges,
with which the machinery and tools etc. used in the separate
factories could be precisely coordinated. Constant checks
were carried out by the official gauge 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 numerical drilling system, and the rubber-forming processes.

What has been said above applies also to the development of large and easily movable frame-lying equipment for full-size construction, the multi-floor aircraft construction methods making it possible to mount individual parts, such as the wings, without the use of cranes by setting them into proper level with wagons.

The construction equipment, or scaffolding, were tube structures furnished in kits, which could be easily set up and greatly reduced the installation costs for new factories.
In the case of the scaffoldings kits for the construction of fuselages, wings, and tail assemblies, 60-30 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 characteristics but of differing composition. In the case of the various manufacturing materials required for aircraft construction by serial production methods, a wide diversity in the manufacture of the required materials was to be expected. The various methods of materials treatment and of preparation, 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 producible within Germany, such as Nickel, Chromium, Molybdenum, 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 (Trägerwerkstoffe).
The approved materials included 95 types of steel, 12
carbon-ferrous metals, and 38 light metal alloys, making a total
of 81 types of metal, representing only 40 percent of the
number formerly used. The lists contained all necessary de-
tails on the chemical-physical, mechanical and technologi-
cal characteristics. These were on special "performance
sheets" (Leistungsaufträge) found in an Aviation Manufacturing
Materials Manual (Flugzeugwerkstoff-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 pro-
ducts, particularly during the war. Furthermore, the smaller
number of materials approved for use considerably simplified
procurement and preparatory procedures and the processing of
manufacturing activities. The system therefore represented
an important measure to secure rationalisation and a control
of raw materials.

In addition to the above, the system reduced the vari-
tions of materials, forms, cross-sections and the consequently
varying methods of rolling, drawing, or pressing-stamping,
used in the production of semi-finished metal items. Constant
pressure on designers in 1941 reduced the number of semi-
processed items used per ton of aircraft deadweight from 1000 to 200.

This consolidation of materials to be used in the manufacture of aviation items was not a precise establishing standard, 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 ranging 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 rationalisation and to simplification in the manufacture of individual parts as well as the manufacturing installations. At an early stage the Production Branch
265 We made the preparatory work for this purpose. The target was to establish what were known as "Aviation Standards" and Aviation Equipment Standards (Luftfahrt- und Luftfahrt-Gerate-Verordnung) for application in addition to the German industrial Standards (Deutsche Industrieverordnung) already established, and in a manner similar to the also already existing Army Luftwaffe Equipment Standards (Sprengstoff-Verordnung). To improve the operating safety of aircraft a course different from the usual was adopted in the establishment of the new Aviation Standards and in preparing 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 general German Industrial Standards in point of quality.

Whenever possible due consideration was given to already existing international standards in compiling with the German Industrial Standards and the Aviation Equipment Standards.
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 selection 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 3,000 various types of roller bearings only 632 were mentioned. Besides the known and urgently usual standard parts it was proved necessary in aircraft construction to standardize power units, nuts, control rods, throttle lever connections, and undercarriages and their types of structure. These items were dealt with by special study groups, and the purpose aimed at and 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 rationalizing measure was the increased use of repeat parts. Here the figure of 2,000 parts was achieved in the case of some aircraft models.

In 1945 the Standards Records of the Polish Air Ministry had reached the stage of four volumes. Including the "cream..."
Industrial Standards and Army Equipment Standards items approved for aircraft construction, these four volumes contained 650 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 these were individual factory standards 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 influence the development of manufacturing equipment that its practicality would be insured and to avert any necessity for adaptation to existing standards only after constructional differences became apparent.
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 Werksmitteln).

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 processes and of welded sheet-metal parts instead of stamped cast or forged parts), and the development of new
266. welding

working processes, such as HAMMERING, instead of drilling or the use of rivets or screws; riveting 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 or labor.

In summarizing it can be stated that the preparatory work done by the Production Branch created the necessary conditions for the introduction of aerial 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
Standards and Aviation Equipment and Parts Standards.

The restrictions which at times had to be placed on
the various firms appear 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 ex-
change 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

PREPARATION, PLANNING, AND PROCESSES

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 tacti-
cal requirements stated by the General Staff. The specifi-
cations were furnished to the industry.

In contrast with serial production processes, develop-
ment work depended less on usage requirements than on intel-
lectual capabilities and was thus less subject to the restric-
tions of labor. It was therefore possible to assign such mis-
sions to a number of firms simultaneously, who worked in
competition one with the other. This was an extremely im-
portant 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 exceed-
ing the requirements on which the problem was stated, the
minimum technical performance 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 design process was to insure
very close contact between the Technical Office and the

1. The text has been added by the present writer in the
   compilation of this chapter.
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 carried out later by the Provin 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 license.

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 use 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.
Numerical requirements in aircraft and equipment were
based on the following authorized strengths:

<table>
<thead>
<tr>
<th>Unit</th>
<th>Aircraft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wing or Group Headquarters</td>
<td>3</td>
</tr>
<tr>
<td>Squadron</td>
<td>9</td>
</tr>
</tbody>
</table>

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 com-
putations was 3 percent during peace and 25 percent during
war, allowing for aircraft totally lost or so badly damaged
that they remained unserviceable 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 computations. During the Air Battle for Britain losses
equalled the quotas allowed, but later in the war they ex-
ceeded the established quotas.

Since the Air Force supporting industries had to build
up from scratch in 1933 it was not possible to procure with-
in the specified time the aircraft, engines, equipment,
weapons, guns, and ammunition required for the units to be
activated nor the required ground equipment. The unit acti-
vation plans of the General Staff therefore had to be coor-
dinated from time to time with the available industrial po-
tential.
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 time to time.

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 with 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, 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 Production Staff and by the Main and Special Committees of
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 wording 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 firm also received the Mobilization Program, which depended on the delivery plan and served as a planning basis for expansion, requests for raw materials, testing machines, and fuels as well as all other essential requirements.

The distribution of the program among the firms was activated 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
resulted in excess burden on the firm producing the various items of equipment and in an unprofitable exploitation of their capacities. Therefore, the O-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 O-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 weapons.

In spite of this partial direct procurement by the Technical Office, responsibility for the proper functioning of the completely outfitted and equipped aircraft has 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
stocks was a responsibility of the Construction Supervisors.

Immediately after commencement of the rearmament program
in 1939 steps had been taken to commence registration of all
available factory space 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 rearmament industries at any given time.

The chart showing the man-hour requirements for the airc-
craft models going into serial production, intended originally
for the first but later revised, also the establishment of the
man-hour requirements for the more important assemblies and
part assemblies,
part assemblies, and the breakdown of the manufacturing expend-
situres according to time spent on cutting, sheet metal, and
assembling operations, and so forth, enabled the subdivisions
of the 'rearmament Office to work out speedily manufacturing
plans for the individual factories.

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 exception-
ally sound procedure, particularly during times of crisis and
during the war, and enabled the General Staff to make quick
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; hence therefore existed that individual sorts and manufacture might be made differently. To avert any such complications it 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 reduced the Technical Office to assign liaison engineers from the developing firms to the firms manufacturing under licence; and later, to the establishment of a Licensed Manufacturing Office, we were responsible for timely delivery of the manufacturing data and all experience data.
The gradually increasing numbers of aircraft models and their variants to be manufactured by serial production methods led finally, in 1933, 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.'

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 expansion of the industry during this period could not yet have any appreciable effect on this execution of the first...
two procurement programs had to depend on the already exist-
ing 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 the promotion of licensed manufacturing operations, the procurement period up to the beginning of the war served primarily to eliminate bottlenecks in the manufacture 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 peace-time production programs, the mission remained of preparing the main factories and their sub-contractors to meet the requirements of mobilisation 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 in-
clude these models in the procurement program at a time.
when they had 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 program, 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. That 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 desired for the government, for the Fuehrer 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 (nullseries) 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 testing 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 develop-
ment of the necessary airborne and ground equipment, to sup-
port development work carried on by industrial firms, to con-
duct 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 produc-
tion operations and repair services, to include the supply
of spare parts for resupply purposes.

All of the above applied to all airborne equipment, essen-
tially, fuselages, engines, items of general equipment, such as
flight and engine control instruments, navigational instru-
ments, parachutes, oxygen equipment, automatic steering de-
vices, mounts for air-carrying units; 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
here was to insure the most rational production possible and the optimum use of the manpower and of materials in short supply. This arrangement applied in particular to weapons, guns, radio and radar equipment, air torpedoes, Caspian 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, various obstacles became evident in the continual development of some items of equipment. Special features required in airborne weapons resulted in newly developed models differing widely from the models Mmmyx initially in use on 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 parts, since Mmmyx manufacturing processes were involved in their manufacture which were similar to those used in the manufacture of artillery shells, gun power
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 different 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 extraordinary serious delays in the specific development and use of air torpedoes.

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
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 Army Ordnance Office for supplies of these instruments. One part for radar instruments was developed directly by the Technical Office, which also handled its procurement. The development and procurement of 

All 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 the Anti-Aircraft Artillery and air units resulted in withdrawal of the Department for Antiaircraft 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 (JMHC) handled the allocation of raw materials and 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.
The procedure adopted by the Joint Military High Command complex was to allocate all material needed for a specific 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 of the 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 authority 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 men power and materials more in keeping with the requirements of the war.
The can be no doubt, however, that a centralised and uniform control would have made a more rational use of available potentialities and thereby increased supplies of equipment possible.
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. 7, 11, 4, 5, 6, 7, 9, 21-uc, 21-uc-2, and 222 and 223, plus the incomplete Programs Nos. 9, 10, 11, 12, 16, 17, 13/3, 18/2, 10/3, 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 NEMI early 1933 and the end of the war, the Technical Office, the Fighter Production Staff, and the Armament 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 capabilities found already in existence.
The other programs were adapted progressively to the progress made in the program of industrial expansion.

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 target was not achieved in a single case.

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

These continual 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 quickly as possible in place of the models developed prior to 1937.

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 IMMEDIATELY concerned should be notified by means of what were called Alteration Statements.
Other contributing factors which probably played an important role were the rapid changes introduced by the General Staff in the operational and tactical conduct of warfare, the changing objectives 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 improvisations had to be introduced at very short notice and often 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 when German troops entered the Rhineland zone demilitarised 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
industrial personnel with specialized skills for military service. Furthermore, in many cases the essential conditions which would have been necessary for the industry to fulfill the program 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 turn 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 various programs.

From 1933 to the end of the war the number of aircraft delivered by the industries totalled 140,886.

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 387, and from then on the annual increase was as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>1934-1935</td>
<td>1,420</td>
</tr>
<tr>
<td>1935-1936</td>
<td>1,913</td>
</tr>
<tr>
<td>1936-1937</td>
<td>2,406</td>
</tr>
<tr>
<td>1937-1938</td>
<td>2,565</td>
</tr>
<tr>
<td>1938-1939</td>
<td>2,866</td>
</tr>
<tr>
<td>1939-1940</td>
<td>3,023</td>
</tr>
<tr>
<td>1940-1941</td>
<td>3,913</td>
</tr>
<tr>
<td>1941-1942</td>
<td>5,025</td>
</tr>
</tbody>
</table>
In 1934 aircraft output increased steadily up to a monthly output of 345 in May, but then decreased again until the figure of 118 was reached in December. The increase was due primarily to the delivery of training aircraft and to 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 year was due to changes in the fighter aircraft under manufacture, through cessation of production of the Ar-61 and a reduced output for the Ar-65 model.

The increase of 1,490 aircraft in 1935 included particularly fighters, dive-bombers, and medium bombers, in a lesser degree naval aircraft, and in particular training models for beginner and advanced trainers. Among the reconnaissance types, He-15 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 Ro-23 model commenced, reaching a figure of approximately eighty per month.
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-15 and 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-63 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 increase of the Heinkel He-701 aircraft in 1937 is accounted for by the fact that the He-46 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 30% smaller by 12% 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
first deliveries of the He-111 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 and by approximately 500 and of fighters by about 470. 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 Rz-109 planes, which by now had been put into regular serial production, the increased number of bombers was due to the larger number of He-111 produced. So far as manufacturers' operations were concerned the only changes were the following:

the He-111 took the place of the He-100
the He-59 was again placed in production because of delays in the development of the He-115
the He-115 went into production, as previously mentioned the He-129 was dropped from production
the He-110 went into production as a new model.

Footnote 1, p. 3-9: To place these figures in proper perspective wartime production must be compared with the aircraft strength of units and the overall ton figures. See Appendix p. 24-25.
1939 again for the first time brought an appreciable increase by 2,366 aircraft over the previous year's output. In 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 unanticipated 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 industrial program approved by Gaering were to remain in force as the industrial target, the only possible way 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
also that preparation of the industry to meet the requirements of mobilization had to be restricted to the most essential measures. 3

This cut in funds was a measure which had an inclusive impact on programs 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 figures for March 1937 were 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 1939-40 was not affected 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 injure German purchases of strategically important

1. See "Deutzwerk oder "Sammlung" in "Die Flugzeugindustrie im Kriege und Ihre Bedeutung" 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.
raw materials from foreign suppliers were beginning to make themselves seriously felt. The decision taken in the previously mentioned conference between Goering and Adlert to release 2,500 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 liason 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 He-116, He-100, Ju-87, and He-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
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 multi-purpose plane and the Ar-196 as a ship-based plane.

The output went in output continued in 1940, namely an increase of 26.2% 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 too so presumed that the reason here was that the systematic mobilization preparations 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, in which case certain production would have ceased, so that the factories involved could be used for war purposes and the man power released from there could be employed in war industries. Furthermore, the change of
Mobilization of the armament industry was dependent on the general economy, but general economic mobilization was not automatically wound up with mobilization of the armament industry. When military mobilization (O-Tor) was proclaimed on 25 August 1939, civilian fields remained on the whole unaffected. A state of economic mobilization was admittedly declared on 5 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 (BAH) 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 needs-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 Ministries-General for National Economy, who opposed use of...
industries for military purposes which were engaged in supplying civilian needs.

Under such circumstances the conditions did not exist 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 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 Seelowow 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
the Public Buildings Program also continued into 1941, at least to a great extent, inducements of personnel in preparation for the campaign against Russia had an extraordinarily hampering effect. To all these complications must be added the manpower difficulty 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 deployment 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 a considerable increase in output could be expected. 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 ksmk 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
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 engines as an alternative. This role prestige problems of Construction Chief Tank, of the firm of Messerschmitt, 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 He-129 series as an armor-protected twin-engine fighter and reintroduction of the He-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
of the Ju-88, part of the output of He-111 planes were used for reconnaissance.

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

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 program, and to intervene in industrial personnel matters, all in deviation from the existing regulations governing war objectives. Undoubtedly this authority did much to bring about an increased output, although the measures
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 con-
trol 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
achieved proved inadequate, and the unfavorable position of
the Air Force in respect to allocation priorities made fur-
ther increases in industrial output for the Air Force impos-
sible.

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
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.

Both

Here it is necessary to point out that and at an early stage already had stressed the necessity for the preferential manufacture of fighter aircraft. As early as in 1940 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 5,000 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
Technical Office, and it had even been possible to make deliveries over and above those required by the programs. Later, and particularly during 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 method 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 have provided for the plane to twice two engines, each pair with one propeller, giving it a flight capability of 1,600 miles.
(6000 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.

An 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 asturdiness, 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 General ingenieur Haldenbek, at the time Chief of Aircraft Development. Final clarification will probably be possible—Continued
Even before the weaknesses described above had become apparent, the Chief of Air Force Special Supply and Procurement Service, while on a visit at Weihrauch, had studied the practicality 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 He-111, achieved only half the operating range with its separately mounted four engines, Goering decided against further development of planes with four separately installed engines.

The modifications referred to above resulted in an extraordinary 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 1943, under Plan 10 in March 1941, under Plan 11 in July 1941, under Plan 122 in October 1942, and under Plan 123 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 1935, so that the deliveries provided for under Plan 9 were too optimistic in view of the size of the plane. However, given the circumstances, the development of the He-177 was considered a worthwhile project.
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.

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 improvised nature of the operations involved, the inadequate ground organization and the inadequate servicing provided.

The first group of these aircraft, using equipment for the He-294, went into service as the 1st "Group, 40th Bomber Wing," on 15 October 1943. It was early 1944, however, before the model went into service as a long-range bomber after the

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.

From the end of June 1944 on it was at least 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 and Baur had already cancelled it from the production program.

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. However, the change-over did not take place and development of the He-277 had to cease under instructions from Baur.

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 Messerschmitt, sitting 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.

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1. See "Verich Befehl Befehl, 23. 1. 1944."
2. See "Befehl Befehl Hitler-Sparent, 12. 6. 1944."
3. See "Befehl Befehl, 27. 5. 1944."

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

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 Heinkel 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. However, this demand had not been met because it would have have necessitated a longer fuselage because of the need to move the engine 20 centimeters further forward. Other flaws were an inadequate lubricating oil circulation which resulted in gear troubles, the development of oil smog, and the faulty placement of the oil cooler, which was a source of trouble through freezing.

1. Information from General ENGINEER Eisenlohr.
It was March 1942 before Heinkel was able to report to
Goring that the deficiencies had been remedied and that serial
production could begin in the summer of 1942, after having
reported months before that the model was in perfect order.

The firm of Daimler-Benz refused to acknowledge the pat-
tern by which the two pairs of engines were mounted as a con-
struction 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 894
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 after the first unit had
been equipped with this model, difficulties occurred in flight
operation due to flat spin, slip, and difficult control
at take off. A study by the Industrial Council produced a
verdict coinciding with the opinions given by the Chief of Section I T of the General Staff and by the Chief of the Flying 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 Seering to cancel this model from the arm and cease its production. Instructions were to complete six aircraft of the model B10 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 500 were stored at the Waslingen air base.

INITIATION 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
proved impossible to provide a conveyer to commencement of
the new series. Production of the series continued on a de-
creaseing scale until December 1941 and was resumed again in Febru-
ary 1942 on a small scale. It was May 1943 before the spe-
cified 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.

After favorable results obtained in tests with a rede-
signed version of the Me-110 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 101 planes in June
1943 and continued until September 1944.

A number of factors contributed towards the faulty de-
velopment of the Me-210:

In his efforts to secure performance advantages, Messer-
schmitt in all designs exposed materials used in the construc-
tion to the utmost strain 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
Development and "paving 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 REPLACEMENT Program, whereupon its inclusion in the program was ordered. 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. 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 designs 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. Statement by Generalinspizier "Einsatzabteilung" and the responsible supervisor Robet.
2. Statement by Robet.
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 fighter 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 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 F109/35 in close contact with the Technical Office. Propulsion by means of two jet engines and without propellers 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.
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 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 side 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
jet fighter was assigned to the firm of Messerschmitt.

The Me-262 was to be powered by the jet engine developed by the Daimler-Benz 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 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 expected 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 the allocation of personnel which would have been necessary to accelerate the work. Work on the project therefore continued only on a restricted scale.
Although it soon became evident that the war would last longer than anticipated so that the necessity existed to continue work on developments requiring a lengthy period of time, work on development 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 manner that the firm was to continue work on the He-209 and "e-410 models, while the He-162 and He-262 were to be handled in a special factory by the firm of Lippisch and Harten. 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 He-410 as much as possible in order to make up shortages in unit equipment due to the faulty development of the He-210.

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

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

1. See "Flugzeugbau F. W. II., 7, 1943."
2. See ibid. 18, 5, 1945.
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 six months after completion of the normal tests needed 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.

Although the order to place the new model on the Aircraft Procurement Program concurrently with the order to cancel Model Me-209 and transfer the priority hitherto awarded to this model to the Me-260 model represented an acknowledgement of the importance of the Me-260 for the conduct of air warfare, the basically unfavorable position of the aircraft industries in respect to priorities within the entire complex of armaments 1. See "Zehn Gespräche vom 13. VII. 1942."
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 new handle the Me-262 was planned for May 1944, but had to be postponed to 15 June and the

\[\text{inserted text}\]

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

1 aircraft in January
3 " 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 "Ju-Beanspruchung", vom 27. 5. 1943.
Planes provided for first deliveries from large-scale serial production from November 1944 on, the manufacturing firms being the Wiener Neustadter 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 forms 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 that recommendations from Speer tank production was to be given
priority over everything else. For this reason it was not possible to comply with the demands by Meerschmitt 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 Ministry 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 Meerschmitt to place the production under special and total protection and also failed.

At the end of 1942 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 ibid., £, 17, 2, 1942.
2. See ibid., 17, 2, 1942.
3. See ibid., 18, 2, 1942.
4. See ibid., 17, 2, 1942.
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 Acgensburg 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 3 degrees for bombing purposes, something had to be done to improve these conditions. This necessitated

1. See "St.-Messerschmitt vom 7. 12. 1943."
2. See "St.-Messerschmitt von Regensburg am 2. 11. 1943."
an entirely new cockpit, construction of which only commenced in June 1944, and a different bombing sight, for which purpose a decision had been made meanwhile to use the late's 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 1945, 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 test by the industry, and one for delivery of the
planes to front line units, besides an inspection 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
of jet engines by serial production methods, and man-power shortages.

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 empennage, 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 limit 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 design and manufacture the new model, known as
the Volksplane or V-Plane (V-Vluchteren). These planes were to be manufactured in addition to the already existing program.

Hitler demanded that all necessary measures should be taken immediately for the manufacture of the largest possible number, which 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 Reckler was appointed to head the new commission. Reckler 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 nconcept 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 fighter was ready.

1. See "Stellungnahme zu 20.9."
carried out its first test flight already on 6 December 1944.

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.

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 on 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 decentralized system of manufacturing which would insure that the loss of individual works constructing the various parts and assemblies would not seriously affect adherence to the deadlines for deliveries.

Because of time and working agitations 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 Perth; Panamint; 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 Übergangsh., Heinkel: Der Volksgäger, 5(zr=12000, 1944)".
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.

These small workshops were organized in groups, each group under an Air Force engineer, whose mission was to ensure 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 gauges.

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.

Planes 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 of the impact of air attack, particularly on communications facilities, and in the meantime assumed such
proportions that it was not possible to have the assembly units ready for final assembly in time in spite of all efforts. An important role was played here by what was called the haversack operation (Haversackaktion) in which individual persons carried individual parts in haversacks to the appointed places. Large-scale use of such methods had been made necessary because whole railway loads of parts had been lost repeatedly when railway trains were destroyed or damaged 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 530 in February and 600 in March. Actually, only 54 of the planes were delivered in March, so that the total delivered mounted to only 116 planes.

Although deliveries fell far short of the planned figures, the execution of this project, which made it possible within
five months after the initial construction contract was
awarded to start deliveries in spite of transportation, tech-
nical, tools and materials procurement, assembly, test flight,
and fuel supply difficulties, can be considered an extraordinar-
ary achievement by the industry and all other concerned.

The effort to provide an effective weapon of defense
against air attack and thereby protect the armaments industr-
ies 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 produc-
tion were bound to fail in their mission because there was no
way to make additional by means of improvisations for the
time which had been lost through faulty decisions in the award-
ing of priorities.

What results a special project to expedite production
of the He-262 jet fighter might have produced if it had come
earlier, because of the earlier juncture at which these fight-
ers then would have been available for action, requires more
detailed study, particularly because it would be necessary
to clarify technical problems of manufacturing possibilities. It is known that the Me-262 had steel parts, for the tooling of which there were not enough tooling machines available. To what extent a special project for the procurement of enough willing 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 spins. It is doubtful whether better results would have been achieved by any such means.

THE USE OF FOREIGN AIRCRAFT FACTORIES

The unfavorable priority classification and the inadequate materials allocations awarded for 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 industrious 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 direct contracts, which was
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 instead or returning to their place of work when their home leave was over. Furthermore, irreplaceable time was lost in the dismantling, transportation, and distribution of the machines among German factories, and the integration of the machinery and personnel into current manufacturing operations.

Quite apart from the social aspects, the results achieved vindicated the soundness of the methods used by the Chief of Air Force Special Supply and Procurement 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-Liasion Staffs.
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 Section to 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 specialized personnel required, and all information necessary for the firms to adapt to German manufacturing methods. The German firms would 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 personnel it 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.
Direct contact and direct contracting, with the Czechoslovak aircraft industries, 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. 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.

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 totaled 400,000,000 mark and included the manufacture of Fi-156, DFS-230, and Fw-189 aircraft, as well as As-10c 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 Avis, Aero, and Mechanisch- Mechanische Flugzeugwerke aircraft factories, the Letov, Kvasz, Bata, Walter, Czechoslovakia factories, the Skoda Works, and the Poldi Iron Works. Furthermore, as part

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 Brunn with a simultaneously expanded contract to manufacture 500 B-301 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 Göring.\(^1\)

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 Göring.\(^2\)

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

<table>
<thead>
<tr>
<th>Italian</th>
<th>German</th>
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<tbody>
<tr>
<td>Savoia-79</td>
<td>He-111</td>
</tr>
<tr>
<td>Fiat-50</td>
<td>He-109-B</td>
</tr>
<tr>
<td>Frecce</td>
<td>Ju-87-B</td>
</tr>
</tbody>
</table>

and from September 1939 on:

| Canto-1007 | He-110   |

Closer technical cooperation, particularly the use of Italian firms for German purposes, apparently only started
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 purposes in 1942-43: 3 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 condensers; and a number of firms on the manufacture of subsidiary items.\footnote{See \textit{Die Italienische Luftwaffe: \textcopyright\ 1935}, p. 123.}

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 kerosene, gasoline, cotton waste, and packing, as well as all 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 manufacture operations for Germany therefore were unavoidable.

An agreement that the Italian firms of Piatt, Alfa Romeo, etc. would supply materials for the manufacture of aircraft in Italy.\footnote{See \textit{Die Italienische Luftwaffe: \textcopyright\ 1935}, p. 123.}
and Isotta Fraschini were to manufacture DB-205 engines under
license 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 procedures. Under these
conditions the only factories which produced satisfactory re-
sults 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 de-
ivered 66 Ju-37 and a number of other aircraft. 1

The Agreement of March 1941 regulated cooperation between
the Hungarian and German air ministries and between the air-
craft industries of the two countries. 2

Among other things it provided as follows:

The firm of Manfred Weils was to manufacture 50

2. See "Verträge sowie der Reichsminister der Luftfahrt
und Reichsverteidigung der Luftwaffe der deutschen Ostlinien
und der Kriegsminister der Königlichen Ungarn von
3. Juni 1941."
Me-210 aircraft per month up to a total of 900;
The firm of Manfred Weiss was to manufacture
200 Dm-603 engines per month up to a total of 3,600;
The Győr Wagon Factory was to increase its
output of Ju-52 aircraft;
The Győr Wagon Factory was to manufacture
50 He-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;

Aircraft industries were
required 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 electro-technical aggregates in
Hungarian factories.

The Hungarian fuselage and engine manufacturing firms
received very substantial support from German factories. This in-
cluded 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 Hung-
arian 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 " " " Dm-603 " " "

All in all, the Hungarian Ministry was authorized to
to receive from Hungarian production a total of
280 Me-210 aircraft
240 109-P
1066 DB-605 engines.

For training purposes the Hungarian Ministry was to re-
receive the following aircraft:
10 At-96 per month up to a total of 55
3 Me-109 " powered by Jumo-210 engines
15 Bae-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-P, 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
40 0 Me-109-P aircraft (approximately).

In addition, the Hungarian factories produced large quan-
tities 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 consider-
able increase in Hungarian deliveries of argillaceous earths,
which delivered finally made up 85 percent of Germany's

total requirements.
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 Noise, which developed and manufactured its own tooling machines.

Initially, French aircraft manufacturing industries were reluctant to accept plans for Franco-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 Czecho-Slovakia had done.
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 the actual 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 North Africa brought 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.

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 St-204 and primarily at the production of individual parts, serving as sub-contractors to the German firms. The engines MWM produced by the firm of Gnome Rhône were used in part to power the Ju-525 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 Hemnack for manufacture of BMW-801 engines.

The firm of Gnome 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
equipment, aircraft weapons, electrical equipment, etc.

National Socialist Party authorities desired to move French skilled personnel from the French industries to Germany and as 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 Sankel 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 those left behind left their work and went into hiding.

The Allied bombing attacks of 1944 brought manufacturing 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
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.

**HUNGARY**

The aircraft and aircraft engine factories in operation at Kronsztadt, Hungary, 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-developed to produce Ju-188 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 Senta 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.
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 they were admirably suited because of their excellent equipment with tooling machinery. The use of those factories for German purposes prevented their removal by the Italians, who had been awarded the right to exploit the Greek economy.

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.
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 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 aircraft was not hampered by any lack of engines, but in which the numbers required by the troops or aircraft repair shops asked the numbers needed as replacements.

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

For the aircraft planned for the first part of the
main rearmament program was to be made primarily of BMW-71 and Sa-22 engines for front-line aircraft and of Sa-11, Sa-12, As-3, 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-901, were included in the procurement programs. Other air-cooled 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-901 was designed as a high-altitude engine.

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

Liquid-cooled types: Jumo-211, DB-601, and Jumo-210

These basic models served as the foundation for further development producing engines with improved performance as Y. See also chapter on aircraft engine development.
variants of the parent models, or with new model designations, such as the DB-605, DB-603, and the June-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.

those designated for

Improved variants of the DB-601 were the DB-605 with its original thrust of 800 horsepower improved to 1,500 horsepower or 1,750 horsepower 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 horsepower. 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 June-211 with a thrust of 800 horsepower. Through a number of variants, this engine was developed to produce the June-213 and its variants A, B, C, and D, with a final performance of 1,500-1,700 horsepower.

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

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 coolings...
for air-cooled engines and the high sensitivity of the cooling systems of liquid-cooled engines to weapons fire, that the BMW-301 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 (Automatische Steuerung) which automatically regulated the propeller pitch change, the compressor switch, the fuel injection pumps, and the oil regulator, besides other functions, and thus considerably relieved the strain of 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-pieton engines, the Ju-205 and Ju-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 than the gasoline engines so that their use was only profitable for long-distance operations. They were therefore used as power units for Ju-36 long-range units, BY-138 naval
reconnaissance, and B7-222 naval transport aircraft.

In order to insure the best field of vision possible, the 20- and 30-liter class engines had been developed with inverted cylinder heads arranged in the pattern of inverted Vs. Another advantage of this cylinder arrangement was the possibility to mount a 20-mm cannon 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-301 engine became evident that new plans provided for installation of the BMW-301 in Pw-190 fighter fuselages instead.

Consequent with their performances the BMW-132-A and the SAM-223 engines were used as ground engines (Bodenwelten) in Ju-52 transport aircraft 
He-114 ski-based reconnaissance aircraft 
He-115 multipurpose 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.
on the corresponding classes of engines. In other words, the
costantly changing demands made by the higher commands on
the tactical capabilities of the various aircraft categories
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 contrib-
uting towards this requirement was the fact that, as arm-
ament progressed, and particularly during the war, the ratios
between fighter, bomber, reconnaissance, and transport air-
craft did not remain static but had to be adapted to the cur-
rent 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 com-
bustion chamber, including such parts as the engine framework
and the engine cowling.

All parts had to be exchangeable, a target which was
to some extent achieved. Here, the need remains for a compa-
norative study of the appropriate engines. It is therefore also
necessary to examine more closely the problem of to what ex-
tent the various aircraft fuselages were powered by specific
engines, with a view to exchangeability or with a view to
1 The author as doubt means that the target was to have
parts interchangeable among the various types of engines.
Note by translator.
to multi-engined use.

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 He-119 aircraft, later powering the same aircraft types with the DB-605 engine and its variants. However, both air- and liquid-cooled engines, namely the BMW-801 air-cooled and the Jumo-213 liquid-cooled engines were used in the Bf-190 fuselage, and the BMW-301 and Juno-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 He-60-3 engines if for basic training, and the AS-10 and He-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 Bucker-131, Bucker-133, Ar-65 and Ar-76 only commenced after mid-1934, and some of them only at the
beginning of 1935. However, main emphasis was on training
during the first years of rearmament, so that it became neces-
sary to fall back on engine types already in use for years in 
the aviation sports schools and the commercial aviation schools

The main engine models in use were the Sh-12 and Sh-14 (the let-
ter still in production in 1938), the Junkers L-5, the BMW-IV 
and BMW-7, in addition to the models used for military pur-
poses, namely, the Blm-132-A, and the Blm-325.

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 train-
ing activities. It was only after the older aircraft types 
were dropped that considerable simplification was achieved, 
since from then on only Sh-14a, As-8, and Ha-60-8 engines 
were used in planes for basic training, and only As-410 and 
Ha-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 avoid repercus-
sions on the operability of troops, was also applied in the 
case of aircraft engines.
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 90-liter class, as well as the BMW-132-A and the S-AM-329.

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 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 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 event 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.
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. 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 undoubtedly gave Germany a lead over other countries in aviation, as was proved by results obtained in international competitions 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 "Erfahrt Übersicht über Motorbaufa., S. 33."
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 Backe, then Chief of the Engine Development
Section, had awarded contracts to industrial firms to develop
more powerful liquid-cooled engines with a cylinder-stroke
context of 42 liters, but in spite of this it had not been in
time possible 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 thrust of 1,750-1,800 horse power. This
ingine, which was installed in the He-219 night-fighter, and
on a small scale in Do-17, He-209, Me-410 aircraft delivered
to the field forces from early 1944 on, made its appearance
too late at the front.

In view of the fact that the industries and received
instructions to develop engines in the 20- and 30-liter class-
on as far back as in 1930, and that aircraft powered by
such motors were already delivered in 1937, the first appear-
ance 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. 29.
the fact that realization of the technical superiority of
the enemy fighter aircraft would 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
in 1939
was delayed in consequence of personnel changes in the sec-
tion handling engine developments.

The Bayerische Motorenwerke had fallen in efforts to de-
velop a 40-litter 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 manu-
facture of BMW-601 engines.1 In order to prevent this change-
over the firm’s directors requested that it should be an-
signed Sachse, in charge of engine development in the Office
of the Chief of Air Force Special Supply and Procurement Ser-
vice and, with approval from Heit, placed Sachse in charge
of the development of a powerful air-cooled engine.

This change was undoubtedly a serious loss for the tech-
nical office, since Sachse had played a leading role in con-
1. Ibid, p. 29.
compiling the specifications for development of the 20- and 30-liter class engines, and 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 negative effect on the progress made in the development of jet aircraft.  

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, Sacke, from the technical office.

Engine development was also influenced by raw materials supply problems as they affected Germany. Due regard had 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 "Gott Back.
2. See "Bericht Generalverwaltungsabteilung, am. Dr. II."
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 conclusion was finally reached that gyro engines might provide the solution. Appropriate development contracts were thereupon awarded in 1936 to the Firms of Bayerische Motorenwerks 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 stage, with a 6 000 horse power thrust, by the Bayerische Motorenwerks.

These engines were installed by assembly like method in He-262 and He-162 aircraft, deliveries of which commenced in May 1944 and January 1945, respectively. There can be no doubt that they were producing a sensation.\footnote{See Dr. Dr. Flamm-A. Kuppe, p. 25.}
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 project.

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 up to 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
machine manufacturing industry. Operating on a seriously
reduced scale, the firms concerned had barely managed to keep
their heads above water producing universal machinery, parti-
cularly 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 1939, par-
ticularly for the aviation industries, it was possible
initially to meet these requirements by using hitherto unem-
ployed 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 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 excep-
tionally serious shortage of the tooling machinery required
for mass production manufacturing operations. The delivery
deadlines for tooling machines mounted in 1940 to as long
as forty-eight months, and the resultant shortage of these ma-
chines had an extremely adverse impact on the output of en-
gines. The long times required for deliveries and the conse-
quent delays in equipping the aircraft industries with the ne-
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 en-
deavored 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, acqui-
sament 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 than existing in
the 61 Division of the Office of the Chief of Air Force.
Special Supply and Procurement Service, was formed in 1941 by the corresponding armament 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 armament 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 Saar, appointed by Hitler as Special Commissioner for Tank Reduction. Acting on the authorities vested in him, Saar confiscated the Kolsa Crankshaft factory established at Danzig by the Air Force and engaged on contracts for the Air Force, and used it for the purpose of tank
production.

To relieve the situation in this respect, the Chief of Air Force Special Supply and Procurement Service had released
number of skilled personnel from the engine manufacturing
industry for assignment in tooling machine factories for
temporary periods, the purpose being to have the factories
work in double shifts to produce approximately 120 tooling
machines for crank shafts soon ending. Unfortunately, efforts
to secure actual action at the Army, Navy and Air Force failed
because of the negative attitude of the Army and Navy.

Unfortunately, the effort to revitalize the tooling
machine industry produced no noticeable results in the engine
manufacturing industries, since Army suddenly used his authori-
sity 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 reasonable staff branch intro-
duced an "advance notification certificate (Vormerkungsver-
richtung)." The purpose of this action was to establish a basis
for procurement planning by establishing needs for "new
items" to the shortage of skilled workers in Germany and the
fact that the Army Ordnance Office, its advance orders had
locked supplies, so no additional increase of tooling machine
production was possible in Germany, so that the appropriate
measures found application primarily in the occupied territories and in friendly and neutral countries.

The work involved in date mining, needs and checking the justification of reported needs, plus the work involved in the allocation of available supplies of tooling machinery gradually assuaged 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 Werke A.G. commonly known as the Delag. 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 impossible to satisfy the needs of the armaments industry, 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 assumed the responsibility for 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 Armament Staff, that a uniform control was established, at a time when it was already too late.

During times of peace the President of the General Staff was responsible for the direction of the tooling machines manufacturing industry and for all preparations to meet 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.
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 (496,000 square meters). Prior to the war 80 percent of Germany's entire output in roller bearings came from Schweinfurt. Following an air attack in August and another in October 1943, both of which caused serious losses in production, this had been reduced to 50 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 Generalinspektor
Bollinger 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 quickest way to resume manufacturing operations. Contrary to those plans, however, the Swedish-owned firm of Vereinigte Kugellager Fabrik 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 Asseler 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 engine-manufacturing industries.

The measures taken by Director General Asseler for the purpose have been discussed previously in this study in the chapter on Industrial Expansion and the Allocation of Industries during the War.
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 concerned was applied first of all in the field of general equipment.

The equipment units considered as general equipment include: 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 1930, 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
fixed installations or as part of the moveable 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 (Austs) for the
procurement of items of equipment not permanently installed.

Procurement of the items installed in the aircraft repre-
sented 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 plan-
ing activities was ensure 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 Equipment Items
Lists (Ausrüstungsgeräte-Listen), which made it possible to
estimate the probable overall requirements. 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 re-
ceived information sheets stating the equipment firms
obligated to supply their needs in the various items of equip-
ment.

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 equip-
ment deliveries to the aircraft factories was the problem of
serial production. The small quantities of equipment items
required prior to 1943 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
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 would produce serious crises. Such 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 vindicated 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
also in the case of items of aircraft equipment to have the items developed by one firm manufactured by another under licence. That 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 war by having the developing firms establish their own factories for aerial production, a measure which produced conditions under which no important difficulties were encountered during the war in 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 1935. Another circumstance 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 rationalised methods of production, so
that it was not possible to take such matters into consideration. The priority thus given to technical perfection found support in the principles adhered to by the higher commands to place quality before quantity. Unfortunately, this principle led to resulting neglect of aerial 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 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 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
been stated previously in this study, all technical branches were headed by engineering 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 effort and material 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.

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-
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 Item Lists, the excessive 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 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
averted if steps had been taken in time to coordinate the
specifications of the aircraft and equipment manufacturing 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 installations and their widespread use that it became possible at last 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 servicing 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
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 Oberstingenieur Kaser plus the personal experience of the present author.
The by aerial 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 M3-0315 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 M3-15 swivel-mount and the M3-17 fixed 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
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-9 had established a developing and a small manufacturing installation at the Siemens-Schuckert-Werke factories in Berlin-Siemensstadt to produce the types of equipment needed for the installation of weapons in aircraft. This firm manufactured the propeller draft controls for the rigidly mounted MG-0815 machine gun to fire through the propeller disk, the rigid source and ammunition boxes, the ringgears including the ammunition boxes and empty ammunition belt guides, and the sights for both weapons.

The fact that the Army Ordnance Office claimed exclusive use of the firm of Schmettler-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 ensure 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 (Jagdgeschützfabrik Krieghoff) in Duhl. 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.
Of the two machine gun models developed as aircraft weapons, the MG-17, swivel-mount gun went into serial production in 1934. A small series of the MG-17 rigid-mount gun was in process in the same year, and in 1935 this gun also went into serial production proper.

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 Ikarus Werke purchased the licence to manufacture the 20-mm weapon patented by the Swiss firm of Maschinenfabrik Gerliikon, and plans were worked out to establish the 'Jeltener Maschinenfabrik' factory in Luckenwalde to manufacture these guns by serial production methods. In addition, the firm of NSchul in Hildburghausen was contracted to manufacture the same guns.

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

- MG-17 7.9-mm rigid mount machine gun
- MG 6-riikon FP 20-mm machine gun manufactured under licence as described above

For further use:
- MG 15 7.9-mm swivel-mount machine gun with twin-magazine containing 75 rounds
- MG 151 13-mm belt feed machine gun.

In the first years of the war, the following models were
developed and placed in service:

MG 151/20 30-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 still almost 900 meters.

The MG 81 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 Augel, and to the Mauser factory at Osterdorf.

To further increase the offensive and defensive fire power of aircraft and acting on recommendations from Udet, Goering ordered development of a 30-mm cannon. 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. This firm was particularly suited to manufacture the new gun, having on its own initiative developed the MG 101 30-mm automatic cannon as early as in 1936, a weapon rejected by the then German Air Ministry.

1. See letter Goering to Udet, 14 July 1939.
chief of the Technical office because of its weight and size.

Although thus rejected, the W.-101 was tested in aircraft
by the firm at the end of 1933 and by the 
Mehlin Proving Station in November 1939. Already on 3 July 1939 the performance
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. It being completely ignorant of the stage
of development reached at the time, Hitler naturally forced
entirely false impressions concerning when it could be placed
in service. Unfortunately, it has not been possible to estab-
lish whether and what statements were made during the test
concerning the completion date for the weapon's tests and
when it would go into aerial production. Responsible repre-
sentatives from the Production Branch were not asked to the
test performance.

Developed
By May 1940 twelve newly mounted weapons were ready for field tests. Mounted in Bf-110-0-0 aircraft, they were delivered
to the troops for a test period to continue from 23 May to the autumn of 1940. However, the troops considered them as useless against
special weapons designed specifically for armor-protected
ground targets. For this reason, the troops preferred their
aircraft with the normal weapons, so that not many W.-101
cannon were installed in twin-engine fighters.
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 remediing 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 mass and aerial 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 welded 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 1 introduction of the new MK-103 was demanded.2

1. See "Vereinigung von 70/45 von 15.7.1941 Goering/Milch.
2. See "Vereinigung von 70/45 von 15.7.1941 Goering/Milch."
Once again serial production of the weapon was delayed, however, this time by威海in raids which destroyed semi-finished parts and as the fact that Hitler had ordered available factory space to be released for an increased production of 37-mm AA guns. Hitler has expected that the weapon would be ready for the field shortly after the demonstration at Schlin; instead, production had now been delayed by years, and this circumstance gave rise to seriousrex 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-109-8, Me-163, and Me-262 aircraft.

Towards the end of the war large numbers of MG-31 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 anti-tank gun mounted in Ju-88 aircraft, and with the auxiliary installation developed by the firm of Junkers, which comprised six MG-31 or 3 MG-FF machine guns.
and was known as the Spray Can (Munzkanne), 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 XXXXX, incendiary XXXXX, shells, antitank (steel-core) XXXXX, and air mine type XXXXX. 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, Soestersda
Haagen, Leipzig and Altenburg
Polie, Magdeburg and from 1941 on at Hellaschen
The following sights were manufactured by aerial production methods:

Reflector Sights Models 3, 15, 16

Ve-Revi 42 Sights for rigid-mount weapons, with specific velocity settings.

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

The firms manufacturing these sights were the following:

Jeans-Jenis, in Salzfeld
Oigec, Osterode
Steinheil, Munich
Weichart, Vienna
Vogtlander, Braunschweig.

BOMBS AND OTHER AIR DROP WEAPONS

The responsibilities of Branch CE/8-2-7 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.
The Air Force Technical Office thus controlled an industrial space 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 obvious 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 responsible personnel in the Office naturally were more interested in meeting the Army requirements in ammunition, more particularly so because they
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 Office, the mission of the Air Force procurement agency, Branch UL/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 not until 20 July 1939 before Seering 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 built-in 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 Hocharmer Verein at Langendreer,
- Stahlwerke Blase at Groeditz,
- Vereinigte Oberhütten at Gleiwitz,
- the Algefer Factory at Ubingen.

\(^1\) See "Versprechungen usw. im Gespräch Generalleutnant Dietrich über den Vertrag vom 20.7.1939."
the Paul Behrke Factory at Wipperfürth,
A subsidiary factory of the Eisenwerk Huelheim/Ruhr,
and the Deutsche Rohrenwerke,
at Huelheim/Ruhr.

For the manufacture of incendiary bombs:
The JSW Factory at Berlin-Spandau,
the SSW Factory at Neustadt/Saale,
the Hgeluck 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
Fresenwerk Lubin at Lubin in Upper Silesia, on its own re-
ponsibility, and the Stahlwerke Braunischweig (Steelworks
Braunischweig) 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 machin-
ery. This applied to all models of SD-10, SD-9/15, SD-50-Stg,
SD-70-Gr, SG-50, Erd-C-50, SC-250, SD-250, SC-500, SR-90,
SR-100, SC-1000, SC-1000-L, PC-1000, PC-1000-Re, PC-1000,
SR-1700, and PC-1300-Re 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.
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:


At the commencement of rearmament activities, the only completely developed and tested bomb types available for the German Air Force were the 2-1-2 electrotion incendiary bomb of 2.2 pounds (1 kilogram), the SB-10 22-pound (10 kilogram) fragmentation bomb, and the SC-50 and SC-250 mine-type bombs.

In 1935 the procurement program was expanded to include the SC-500 mine-type bomb, and in the following year the LKA and LKB ground mines of 1100 pounds (500 kilograms) and 2200 pounds (1000 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 2200 pounds (1000 kilograms), while the calibers of mine-type bombs grew from 110 pounds (50 kilograms) to calibers of up to 4400 pounds (2000 kilograms).

The first armor piercing bombs released for procurement...
the 20-500 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 1939 were the B-1-3 electron incendiary bombs; these were followed in 1939 by the B-1-1-3, in 1941 by the B-2-2. In 1941 the Syp-Brd-0-50 and Str-Brd-0-500 were added.

The purpose in manufacturing concrete fragmentation bombs was to meet the great demand of the Polish campaign by improvised 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 50 bombs, namely, the 22-pound, 110-pound, 550-pound, and 1,100-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 Sudetenland 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. 483.
some release and some ejection devices for oblique bombing.

This brought the number of different bomb types up to
fourteen. Furthermore, the calibers of 80 type airmine type
bombs were increased to 2,000 pounds (1,000 kilograms) and
4,000 pounds (1,000 kilograms) for use in dive bombing attacks
by the Ju-88 aircraft.

The 40-500-82 armor piercing type came into use in 1940,
followed in the next year by the larger 40-1,000-82s and the
super-heavy 80-2 500 calibers.

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

The 40-250, 500, and 1,000 bomb containers served for
mass bombing with small calibers. In particular the 80-1,
80-10s, and incendiary bombs were used with all three contain-
ers; the 80-1 in containers AB-250 and AB-1 000, the 80-10s,
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 procuremen-
t 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 "Gefahrstoffeumgebung am 6. 7. 1941."
2. Ibid.

Footnote 1, p. 497: Stab-Erd, abbreviation for "Stab-Erd;
Explosive-Incendiary.
Gefahrstoffeumgebung am 6. 7. 1941."
Footnote 3, p. 497: See excerpt from "Der Krieg gegen die
bevölkerung von Frankreich", Author: Milch, Band
II, "p. 66."
according to the accumulated stocks held at any given time, 
the changing requirements stated by the General Staff on the 
basis of planned missions, and the current acute fuel supply 
situation.

A comparison of some 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 from 1939 on, while the quantities of bombs procured 
in 1940 was more than three times the estimated minimum require-
ment, and then decreased in 1941. 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 cases 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 "Wagner" by Generalingenieur Marquard.
manufacturing facilities were available to produce the 110-
pound multi-purpose bomb. However, only a small percentage of
the concrete-serving bombs thus produced were ever used. The
rest were scrapped when adequate supplies of multi-purpose
bombs with cast or pressed casings were manufactured.
In the first two years of the war, most 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 oil.

EXPLSIVS

The explosive used for stockpiling purposes as charges
for bombs and shells was trinitrotoluol, which was the only ex-

plosive charge used in American bombs up to 1 September 1947.1

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 best effect best suited for the purpose for
which the bomb type involved was intended. A minimum trini-
trtotoluol content was fixed for each caliber. The rest of the
explosive charge consisted of nitrate of amsonia, and combusti-
able 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 explosive factories filled casings from a caliber of 110 pounds (50 kilograms) up in armaments 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 Heuer, Berlin-Britz

the SSW-Apparate und Maschinen, Berlin

and later also by

the Mechanische Werkstätten Neueranenburg.

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
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aircraft crews and ground servicing personnel, such as normal and emergency speed tanking apparatus with all appliances, air tox wagons (wet oxygen), engine starting equipment, engine heaters, fuel and lubricant wagons, some transport wagons, 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 material, 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 Luffthansa 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. 480. See Report by Generalingenieur Marquard.
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 from the firms manufacturing those 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 insufficient, so that improvised measures had to be used for the execution 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 as far as ground servicing equipment was concerned.

Circumstances 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
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.

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 airfield 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 crane 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 experienced at 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
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 hasty by means of an emergency project after the winter had commenced.

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

AIR TORPEDOES AND GUIDED MISSILES

1. AIRBORNE. 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 improvised technical conditions, the development of this weapon received no proper support.
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 as 1925. 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 re-
moved from all shipping routes. This made them completely
dependent on weather conditions and prevented a consistent
conduct of the necessary test series under constant circum-
stances. Furthermore, the small funds available to the Navy
prior to 1953 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 re-
quirements 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 50 feet, torpedoes in any future
war would be launched from altitudes between 360 and 400 feet
meant that air torpedoes would have to have a far greater
resistance to impact than ship-borne torpedoes. Furthermore,
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 diameter of air torpedoes was also no longer the size and shape of torpedoes; 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 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 corps 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 von 3. 2. 1937, B. 1."
Because of its failure to achieve success, the Navy finally purchased the patents and the right to manufacture under license the air torpedo developed by Norwegian Captain Bull, which appeared to offer a solution to the problems 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.

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 delays because modifications became necessary.

The system under which the Naval Torpedo Ordnance Office (Torpedo-Herrenmat) 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.
If the torpedo failed to function, or in the case of a faulty manufacture of parts, the assembling crew then had the possibility to refuse to accept responsibility.

The Norwegian torpedo, known as the LTP-5-1, was not yet ready for service in 1936, in which year the Torpedo Ordnance Office purchased the licent to manufacture the Italian LTP-5-1 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 220 miles/h. Had shown that these sank to less than 60 feet beneath the water surface. In this Italian model the problem of deflection 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 Eckernförde Torpedo Experimenting Station, for the time being, endeavored to find a solution itself for this problem.

At the beginning of the 1930s, the parts for the LTP-5-1 air torpedo were in production and tests had been carried out with satisfactory results by aircraft flying at speeds of
120 miles and altitudes of 100 feet. However, a speed of
120 miles represented the minimum for the He-115, He-111,
Ju-88, Fw-200, and He-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
Hilfer that he should prohibit any further work on their de-
velopment 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
was not sufficiently interested in the development of air tor-
pedoes because it was too heavily engaged on its own projects,
and the fact that the expenditures appeared too great for the
Air force to establish its own torpedo proving station. Fur-
thermore, it appears that air torpedoes were included in the
1940 order halting development work.

Efforts were now made to find a substitute for air tor-
pedoes by means of a speedy development of superheavy tor-
ades for attack against the British Navy.

It appears that the Naval Torpedo Experimenting Station
at Eckernförde only succeeded in 1940 in developing a launch-
ing and depth control which, by means of a box-like or jet-
2. III. See Letter Generalleutnant Ernst Roth, 12 Sep 54.
Footnote 1, p. 39; Report Marquard, 5 May 1935, p. 15.
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. Whether and to what extent this steering device was mounted in 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 U115-5-e torpedo remained prohibited for some time, since Hitler planned to hold this weapon in reserve for a special operation.²

Seventy-six 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 37, p. 3.
3. Letter Generalleutnant Dr. R. Barth, 12. Sep 41, p. 5.
The Navy transferred to the Air Force a group of personnel familiar with the type of work involved together with the Helgoland 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:

the firm of Schachtarof, Berlin;
the Triebwerk Factory, Holbein in Altona;
the Gornetwerk Ruhe factory, St. Petersburg, a subsidiary of the firm of Aukland, Berlin.

The following factories produced air torpedo parts:
the firm of Mihak, Hamburg;
the Hamburg Eisen- und Walzwerk, Hamburg-Harburg;
the firm of Kluchendorf, Berlin-Sanamu.

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.

Footnotes see p. 504.
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 5,133,500 tons of Liberty ship tonnage with U-boat air torpedoes and damaged ships totalling 122,000, besides sinking 9400 tons of shipping and damaging 15,000 tons with the Italian U-boat air torpedoes.

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:

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity Required per Torpedo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chromium</td>
<td>115.1 pounds (52.3 kilograms)</td>
</tr>
<tr>
<td>Aluminum</td>
<td>251.52 &quot; (114 &quot; )</td>
</tr>
<tr>
<td>Lead</td>
<td>172.23 &quot; (73.6 &quot; )</td>
</tr>
<tr>
<td>Tin</td>
<td>162.25 &quot; (55 &quot; )</td>
</tr>
<tr>
<td>Copper</td>
<td>824.92 &quot; (374 &quot; )</td>
</tr>
</tbody>
</table>

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 figures are per footnote see p. 506.
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, or 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 to 900 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.

One change in the newly developed LT2-5-a air torpedo in comparison with the LT2-5-a was that it had a different middle piece for the use of the Walter system of dual fuel propulsion giving it an effective range of 6-500 yards (6000 meters) with an explosive charge of 440 pounds (200 kilograms). The types of air torpedoes now available were as follows:

The LT2-5-a,

LT2-5-a, designed for a very large range of launching altitudes up to great heights and with a long effective range

LT-1000 for use with fighter-bomber aircraft, with a reduced overall length of 17.24 feet (4350 m), a total weight of 1848 pounds (840 kilograms), an explosive charge of 440 pounds (200 kilograms)
Footnote 1, p. 502: See Report Ministerialrat Dr. Schreiber, 8 February 1957, pp. 5, 6.

Footnote 1, p. 503: See "HE-111-7 Er. 5042/12...[?]. 20/14 (A/25)."

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

Footnote 1, p. 504: See "ErsterGesprach mit Mr. Th. Brauchitsch...von Dr. B. THIS nicht: Brauchitsch oder Dr. Brauchitsch."
528 pounds (240 kilograms) and an effective range of 2 200 yards (2 000 meters).

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

In addition to the above plans were in preparation to replace the LTP-5-8 and LTP-5-a in torpedoes by the LTP-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 delivering 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-36, and Ba-111 types.

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 practice fire with light caliber antiaircraft guns.

Of the numerous remote control equipment developed only a few were approved for procurement from aerial production. These were the air to ground Fritz-X, and the Ba-29.
the ground-ground Fa-105 missile better known as the V-1.

The V-1 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 1,200 and 1,500 feet (4500 meters) to exploit its full penetration power. After release of the bomb, the delivering aircraft had to continue on a straight course while the bomb was falling.

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

After a relatively short time spent on development under direction by Professor Wagner, the ground-ground Glider-Sabk Fa-293 was approved for procurement, the development having taken only one year. This missile consisted of a normal 80-500 bomb with attached rakes, 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 the purpose, that of sinking cargo ships and attack against ships convoys.

The bomb was propelled by a Walter type power unit.
and steered by the Stromberg-Kahl device with a Lightflacht unit. Since the steering was sensitive to interferences, a wire control was also used with a range of 15,000 yards (18 kilometers).

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

After initial success, the conditions for the use of this missile deteriorated extraordinarily because of enemy air superiority, so that it went out of use in the final stages of the war.

Another factor which delayed use of the Ha-293 was the difficulties encountered in development of the Ha-177 aircraft, which was to carry and deliver it. It therefore became necessary to use Do-17 and He-111, which did not have a long enough operating range for the purpose.

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

The project was planned 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, Breslau, and Rostock that orders
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 Sioly/Pommernia.

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
components:

Askania, Berlin and Steering and gyro equipment
Deutz,  

Angus Engine Works
Berlin and Dessau/Niederleitz

Pirks in Reutlingen Outer surfaces and launchers
and Stuttgart

Later, the firm of Deutsche Werksattten Heilerau manufactured the outer surfaces, when wood came into use for the purposes 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 Ha-294, Ha-295, and Ha-296, being improved air-ground versions of the Ha-293
the air-ground Ha-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 none of these appeared very promising could not as completed for time reasons, while so of these had to be
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 armament commenced in 1939, 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, the purposeful direction of all activities by the then Chief of the Technical Office Winner, 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 the Air Force was the political position of its Commander in
Chief, Pershing.

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, airbases 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 specialty 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 these to the appropriate industrial firms.

Up to 1937 it was then 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.
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, 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 59,500 tons, it was no
longer possible to carry out industrial mobilization prepara-
tions 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 bowls, 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, antimony, cadmium, mercury, and in rubber and alu-
minum, allocations now varying between 19 and 50 percent of
actual requirements.

For footnotes see p. 513.
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 1957 on it had not been possible to proceed with implementation of the program unhindered 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 armament programs if the Air Force were awarded a priority in the allocation of materials and the impact this would have on the conduct of AAF 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 Brief vom 21. 2. 1957 unter die Bezeichnung mit Oberstleutnant Piech.


Footnote 3, p. 512: See "Anlage aus Schreiben der Luftschutz-"meister" IV. 56. 2/17. 7/2/7. 7/2/7. 1943.

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."
Generally speaking it can be considered as an established fact that from 1937 on all Air Force armament 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 successful to obtain the required allocations through scoring as Director of the Four years PLAN Plan, but these cases were exceptions.

By exchanging 9,000 tons of its allocation of iron, titanium, 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, 30 percent in that of lead, approximately 50 percent in that of 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.

Quite apart from the generally inadequate allocations, the unfavorable position of the Air Force, progress in the
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 Generalrevisor 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 exceeded available supplies by 8,000,000 tons of steel.

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 Kranich stated that there had been a shortage of 6,000 tons monthly in 1941, and that the
shortage per month would be 15,500 tons in 1943 and 8,500 in 1943, while an excess production was expected in 1945 on the basis of then valid estimates. This last prediction 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 Saar.

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 WpNo 8 from the Army Ordnance Office to the Reich Air Ministry had continued the work this 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 "Verschluß der Zentralen Kurse" 24/7, 1943."
413 efforts were made to produce aluminum from clays found within Germany and other processes in the production of metals were converted so that it could be obtained from German raw materials.

414 Aluminum was used to replace copper, German sources of 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 and vanadium from iron ores mined in Germany, and the replacement of nickel steels with a high nickel content by those with a low nickel content or by chromo-molybdenum steels.

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 and other parts 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 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. (previously known as the R.C.A. Corp.) had initiated already prior to 1933 to reduce the number of manufacturing material types in use, which aimed at 1. See "Typical Professor Book 26. 11. 1944 Trich Law-current Int. 8249/44."


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 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 aircraft needing large quantities of aluminum.

The use of wood gluing or plywood and fabric 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 propellers for aircraft, and the use of substitute materials for air drop weapons and radar equipment.
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 programs of the Air Force, but at the same created serious disadvantages in other fields. The preparatory designing and 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 extent to 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 serial production of any one identical model; the modifications introduced while a model was in serial production; the failure of the He-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
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 program 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 subject 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.

Preference to 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 economic 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
data developed through - - | 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 (JMHC) and their
influence on the conduct of air warfare.

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 ex-
tent allocations were 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 mili-
tary aircraft in service prior to 1939 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-
atively low compression and permitted the use of the fuels
generally in use by the German Luft Hansa 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 performance secured
through higher compression which made higher demands on
the anti-knock value of fuels.