238 With a view to future requirements for improved performances, the firms of AEG and SSW in 1943 commenced work on the development of a 300-centimeter searchlight. Field Marshal Milch Chief of Special Supply and Procurement Services, in September 1943 rejected this project. However, six trial models were already so far advanced that work continued on their completion At the end of 1944 two of these models were under field tests west of Berlin . The new searchlight had no casing and its source of illumination was a 1,500 Ampere burner-cavity lamp constructed in line with entirely new principles. Experience with the new burner-cavity lamps was so excellent that from then on the 200-centimeter searchlights were also provided with them.

The main producing firms were:

60-centimeter searchlights	SSW; AEG; Koerting & Matthiesen, Leipzig.
150- centimeter searchlights	the above firms and Elin and Finag
200-centimeter searchlights	SSW; AEG

No more need be said here on the subject of searchlights.

SOUND LOCATORS.

The constantly increasing speed and operating altitudes of target aircraft and the consequent considerable target travel during the sonic lag made reliable target position detection by means of sound locators impossible. Up to approximately 1941, however, no other means were available for the

238 purpose, so that these instruments had to be used to guide the searchlights.

It was only after introduction of the radio locating instruments, and after adequate numbers of these became available that it was possible to do away with sound locating devices.

On this subject mention must also be made of the fact that these Ring-Funnel-Directional Listeners (Ring-Trichter-Richtunghoerer) as the sound locators were officially designated, played a very important role. They were even used to provide firing data for the guns during night or fog conditions or when the target was hidden by clouds. During foggy or cloudy weather at night, when searchlights were unable to spot the target, target spotting by sound locators wlso played an important role They were also used by batteries not within a searchlight zone. However, the traverse and elevation data procured by this means contained a serious error of delay, due to the lag caused by sonic speed. Furthermore they could not be used for range-finding, so that the altitude factor could also not be determined, and these factors were indispensable for effeczive anti-aircraft fire.

Efforts were made by appropriate methods to obtain the necessary target data through sound locators, and the mehtods used for the purpose were the following:

1. The method using two separate sound locators;

238-239 2. The methods using one sound locator sited at a distance from the firing battery.

3. The method using one sound locator operating within the battery firing position.

Each of these three methods had advantages and disadvantages.

With the method using two sound locators it was possible, as in the case of optical range finding with a long base, to use the point of intersection of the two separate sound waves received, adjusted by the sonic lag factor, to obtain range and thus target flight altitude data. However, even with optical instruments this method was not very promising and had therefore always been rejected. It is therefore hard to understand why one field manual stated and even recommended this method. In combat operations at the front all attempts with this method naturally failed very soon, although the troops constructed all manner of auxiliary instruments themselves to improve matters. All of these efforts were wasted, as anyone with any understanding of the subject at all would have known in advance.

In the method using only one sound locator it was no simple matter to determine the target range or altitude; instead, attempts had to be made to solve the problem with approximate factors. As a rule the speed at which enemy aircraft flew was known . From the sound locator data obtained

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239-240 the space travelled by the target within a fixed time was calculated; by comparing this result with the known speed of the target aircraft it was possible to establish the altitude and thereby also the range. However, since our fire control director equipment used target altitude data, there was no need to determine the range. The only question then left open was whether it was better to place the sound locator separately from the battery or within the battery firing position. In favor of the separate site was the consideration that the sound locating activities would escape disturbances and interruption by the fire of the battery. Against the separate site were a number of circumstances: the target data computed by the separately sited sound locator had to be recomputed for the battery position; the sound locator operators were not under direct supervision; the data computed by ~~xxx~~ from the sound locator factors could not be used by the battery, because the sound locator had only a very small effective operating range. The main part of the work of the sound locator operators had to be done prior to firing so that the disadvantage of disturbance during battery fire had to be accepted as an inescapable disadvantage. The whole method was a makeshift anyhow, with many inherent weaknesses, and the fact just had to be accepted that there was no possibility of following the target with directed fire but that the only possibility was to shoot it

240-241 down in a heavy sudden burst of fire based on careful sound locating and careful data computing from the factures thus obtained, or to simply miss the target because the fire directing devices available were simply too inadequate.

Generally speaking it must be admitted in retrospect that most of the planes shot down by batteries operating with sound locators were shot down by units with the sound locator within the battery position: the factors for traverse and elevation could be taken over directly from the sound locator, with a due allowance for sonic lag, and the target altitude could be determined by the battery itself as described above and fed into the fire control director equipment. Success through surprise fire was possible particularly when a unit had moved into a new firing position, or when an enemy unit was on a constant course directed by beam radio. Sudden fire under such circumstances, with no preliminary warning of searchlights and so forth repeatedly produced astonishingly good results. Success in such action naturally presupposed meticulously conscientious work by the sound locator operators and careful data computing by the battery, the guns of which could then usually start firing just prior to the target crossing point.

There was thus some justification for the existence of sound locators and they were to become important again when

240-241 the enemy succeeded in interfering with the functioning of radio target locating instruments and remained important until a remedy had been found. 5,559 sound locators were thus still in use in August 1944.

RADAR EQUIPMENT

At the time when the war started in 1939, trial radar instruments had been completed on the basis of research and development work done by the Antiaircraft Artillery Development Office in cooperation with the firms of Lorenz and Telefunken. These trial models were at the time being tested by Weapons and Equipment Proving Branch 10 at its proving station in Lynow. In addition there was a radar instrument ofxthexdeveloped by the Navy and manufactured by the firm of Gema.

The Gema was primarily a panorama instrument, and had been planned for development as such. It operated on a wavelength of 2.4 meters, had an operating range of between 24 and 45 miles according to target altitude and site of the instrument. In range finding it functioned with a accuracy of plus-minus ZXX 2,200-4,400 yards and in target locating with an accuracy of plus-minus 5-10°. It was designated the A-1 or also the Freya instrument (Photo 110).

The Lorenz instrument was the first equipment of this type developed expressly for antiaircraft artillery purposes.

241-242 It had two parabolic reflectors one above the other, and operated on a wavelength of 62.4 meters. It could locate aircraft at distances between ~~5,000 and 7,500 yards~~ 5 and 7.5 miles, and airships at a distance of 18.75 miles. In rangfinding it functioned with an accuracy of plus-minus 110 yards, in target locating with an accuracy of plus-minus 3-4°. It was designated as A2 and later as Fu. M. G. 39 L or 40 L (Photo 111).

The instrument developed by Telefunken originally also was constructed expressly as a radar instrumen for antiaircraft artillery purposes. It had a full metal reflector with a diameter of 3 meters. Its operating range was 5 to 6 miles. In target locating it functioned with an accuracy of plus-minus 1/4° and in range finding with an accuracy of plus-minus 110 yards. It was designated A 3.

On 25 October 1939 the Antiaircraft Artillery Inspectorate requested supply of 30 radar instruments of the Gema type. The instruments were to be used in antiaircraft artillery operations and the manufacturing contracts were placed immediately. In addition, the Inspectorate requested supply of 1,000 such instruments for firing and target locating purposes. The firm of Lorenz had been awarded a contract for 40 improved A 2 type instruments, twenty to be delivered for field trials with troops by the end of 1940 and designated Fu.M.G.39-L, and twenty only in 1941, designated as Fu.M.G. 40-L.

242-243 Plans provided for each searchlight platoon to have one search radar and for each two heavy batteries to have one detector. These were the reuqirements stated by the AAA Inspectorate at the time with wise foresight. At the same time the Inspectorate requested the C-Office to work out and develope an idenfification system to differentiate between hostile and firendly units.

Soon after the start of the war and the German advance into France, the Western Allies commenced night air attacks and ~~night~~ air penetrations during unfavorable weather conditions, so that usually there was no possibility for antiaircraft fire with optical aiming instruments. The troops insisted on immediate delivery of the radar instruments, shich were still in the experimental stages, and requested that personnel from the manufacturing firms should be assigned with the instruments in order to enable them to profit directly from the experience gathered in actual combat action and thus promote further development of this type of equipment. The outcome was that the first trial instruments, with personnel from the manufacturing firms, from July 1940 on were committed primarily in the Rhein-Ruhr regions. The instruments thus assigned were

Model Fu.M.G. 40 L (Lorenz)

Model Fu. M.G. 62, from the firm of Telefunken.

243 Model Fu.G. 39 L was featured by an operating range of 6-9 miles under average conditions and a maximum of 12-15 miles; It provided target range data with an accuracy of plus-minus 44-50 yards, under optimum conditions with an accuracy of plus-minus 22-27.5 yards; traverse data with an accuracy of plus-minus 2-3° and elevation data with an accuracy of plus-minus 3-4°.

Model Fu.M.G. 40 L showed improved performances. Its operating range for both range finding and position locating had been increased to 15-24 miles and its search sweep to 18-30 miles. Its precision had also been improvedand it furnished traverse data with an accuracy of plus-minus 33-44 yards or plus-minus 12-15 yards under ideal conditions ; traverse data ~~[illegible]~~ and elevation data with an accuracy of between 10/16th and 12/16th°.

The Fu.M.G. 62, better known as the Wurzburg Radar instrument was not constructed initially for antiaircraft artillery purposes but for the Aircraft Reporting Service , and had been constructed under contract for the Signal Branch of the ~~[illegible]~~ C (Technical) Office. Its operating range was almost twice that of the Lorenz instruments and its accuracy factors were also very favorable. Sizable numbers had already been ordered for the Signal Corps and regular supplies commenced from August 1940 on. This latter

243-244 was the decisive point, since it was urgently necessary that the troops should receive radar instruments very soon, the sound locating equipment and unaimed barrage fire having become impossible.

Although the Antiaircraft Artillery Army required greater precision for the direction of antiaircraft gunfire, It was unable to obtain control of the development program, and in 1940 the Signal Branch development section in the C Office still was instructed to handle on its responsibility the development of the radar instruments for the entire XXXXXXX Air Force.

In this way it came about that the antiaircraft artillery in an accelerated program received further Model Fu-M.G. 62 radar instruments, with improvements being continuously incorporated, while the contracts placed for Lorenz instruments were cancelled. It had become essential to furnish standard equipment to all antiaircraft artillery units without delay, and the decision was therefore sound although the instrument did not fully satisfy the requirements for antiaircraft fire.

The Wuerzburg instrument for a long time remained standard equipment for antiaircraft artillery units (Photo 112), and was designated Fu.M.G. 29 T. As a start it was provided wi with an attachment for precise position locating (C-Attachment) and an improved rangefinder (Attachment D), and was then designated Fu.M.G. 39 T (c) or (D). It had an antennae-

244-245 Parabolic-Reflector with a diameter of three meters. Large use was made of light metal in its manufacture, giving it an overall weight of only 3,300 pounds. Consideration had been given throughout to simplicity of structure, and this was also the reason why it used only nine different types of valves.

The average operating range of the Wuerzburg instrument was between 12 and 18 miles. Its average accuracy in range-finding plus-minus 80-120 meters, and its average accuracy in position locating plus-minus 1½-2°, which was definitely inadequate for the direction of antiaircraft fire control equipment. On the other hand, its degrees of accuracy were adequate for the guidance of searchlights when using floodlight, so that in this respect at least it was a great improvement on the sound locating instruments in operations. It also provided the possibility to obtain greatly improved firing data for antiaircraft barrage fire operations.

A report by the Chief Antiaircraft Artillery Officer dated 20 March 1941 sheds light on the tests carried out with the Freya radar instruments of the firm Gema by antiaircraft units in the field. (Appendix 5). The overall critique was that it was suitable for aircraft reporting purposes, but not suitable for the direction of antiaircraft artillery fire.

By 30 June 1941 the following deliveries were received by the antiaircraft artillery:

245	Model Fu.M.G. 39 T (A)	201
	" Fu.M.G. 39 T (C)	74
	" Fu.M.G. 39 L	14
	" Fu.M.G. Freya	5

Use of Attachment C to the instruments insured the following average accuracy in position finding

Traverse plus-minus $5-8^{\circ}$

Elevation " " $7/16th-9/16th^{\circ}$.

It was only after introduction of Attachment C that the Model Fu.M.G. 39 T became a radar instrument suitable for antiaircraft artillery purposes. Using the attachment, it was possible to deliver fire approximating the standards of what could be called destructive antiaircraft fire. The Model Fu.M.G. 39 T (A) was suitable only for what might be called directed barrage or harass fire.

Instruments with the Attachment D only reached the front line units in 1942. With Attachment D the instrument not only supplied considerably improved range data; other advantages were its ~~constant zero adjustment~~ simplified handling, its constant zero adjustment, and its direct link between the rangefinding process and the data transmission mechanism. Its position finding accuracy was between plus-minus 25 and 40 meters.

By April 1942 matters had only progressed so far, however, that approximately one-third of the total number of batteries

245-246 had radar equipment. It is obvious that only Wuerzburg instruments with Attachment D were acceptable for use with searchlights and for antiaircraft fire control. The output in such instruments was still totally inadequate, however, so that use still had to be made of the despised sound locating instruments.

The outcome of the demand for a longer operating range, more accurate elevation and traverse data, elimination of the ground echo factor in the case of small elevation angles, was development of an instrument with a parabolic reflector having a diameter of 7.5 meters. This instrument was naturally so large and cumbersome that it could only be used for permanently emplaced batteries, where it was placed in a revolving casing. The precision of the machanical processes and of the aiming mechanisms had been specified by the antiaircraft artillery and to a large extent were fulfilled in the new instrument. However, its total weight was 18 tons, and the weight of the revolving parts alone was 11 tons. This made stationary use compulsory, for example in support of antiaircraft gun towers.

Known as the Fu.M.G. 75 or more commonly as the Wuerzburg Giant (Riese) (Photo 113), the new instrument had a mean operating range of between 24 and 42 miles and furnished data with an accuracy of plus-minus 1.5-1.8/16th^{o}. Instruments of

246-247 this type were used primarily for purposes of the Air Signal Corps and of the Fighter Command, but the antiaircraft artillery also received a number from 1943 on for its antiaircraft gun towers.

Continued improvements to the Model A 3, developed specificalle for AAA purposes by the firm of Telefunken, finally resulted in production of the Model Fu.M.G. 63, more commonly known as the Mainz Radar, but only a total of 51 of these instruments were manufactured. These were to be used to gather experience in extensive trials with troops, and in the field forces received the designation Fu.M.G. 40 T. It reached the troops in 1940.

The Mainz XXXXX Giant radar was featured by an accuracy of plus-minus 12-24 yards for range data, plus-minus 2.8 to 5° for traverse data and plus-minus 4/16th to 8/16th° for elevation data. Its sweep on an average covered between 15 and 21 miles. In order to centralize maintenance and resupply services the instruments were all committed in the Halle-Leuna region (Photo 114).

In the summer of 1942 first deliveries were received of Model Fu.M.G. 64, more commonly known as the Mannheim radar. It incorporated all improvements based on experience with the Models Fu.M.G. 40 L and Fu.M.G. 40 T, was a completely new construction and can probably be considered as the optimum

247-248 achieved in the stage of progress reached at the time in this field. Its reflector had a diameter of 3 meters, and it could be transported on Special Type Trailer 204. The factors for map distances and altitudes could be fed directly to the fire control director so that there was no delay due to telephonic transmission. It provided range data with an accuracy of plus minus 11-20 yards, ~~and~~ traverse data with an accuracy of plus-minus 2.3 to 4.3° and elevation data with an accuracy of plus-minus 2.5/16th to 5/16th°. T

The performances of the Mannheim radar very closely approached the requirements of the fire control director equipment and considerably improved the prospects of success with antiaircraft artillery fire. At target altitudes between ~~3,3~~ 3,300 and 33,000 feet its sweep extended between 15 and 21 miles. Owing to its extreme sensitivity, the instrument was subject to elevation data errors caused by target reflection waves received by the instrument directly or indirectly (after reflection from the ground). This error had to be eliminated, which was done by providing the instrument with metal deflector rim along the lower rim of the reflector. However, the same results could be obtained by erecting a wall around the instrument, which was intended anyhow during employment with troops in order to provide protection against shell fragments. This circular enclosure had to have a circumference

248 of approximately 8.8 yards and a height of between 1.98 and 2.09 yards. The Mannheim instrument was used chiefly with 105-mm batteries, where it performed very satisfactorily. (Photo 115).

The radar and radio interference caused by the enemy use of tinfoil strips during the attack against Hamburg on 24 July 1943 created the necessity for countermeasures. In this point its must be stressed here that the possibility of such interferences had been recognized in Germany already in 1942. Both Goering and Hitler prohibited the use of this means of interference during German air penetrations over Britain and ordered that everything was to be avoided which might make it known to the enemy. Due to these circumstances no further research had been carried out to develop methods to eliminate such interferences in our own radar and radio instruments.

The outcome of all this was that radar and radio control of the air was suddenly at an end, and also that radar guided antiaircraft fire was no longer possible. It is obvious how fateful the consequences of this ostrich policy of the German side, this assumption that the enemy were not quite as intelligent as we, would necessarily be. The main thing now was to speedily find a way to eliminate these interferences.

The Commando raid at Dieppe in March 1942 against the radar installations there had also revealed that the enemy

248-249 were endeavoring to render our AAA fire directing instruments inoperable. The fact that the raiding party had removed the frequency-determining elements of the radar installation was proof that expert personnel had participated in the raid with the exclusiv mission of procuring data for the development and use of means of radar and radio interference. Massive radio jamming operations presented a possibility to eliminate the equipment of the antiaircraft artillery, since these had no possibility to use alternate frequencies.

Antiaircraft Artillery School III in Berlin/Reinickendorf, under Major Professor Dr. Wever, played an important part in the work done in these fields. Mention must also be made here of the work done by Major Hoffmann-Heyden, who through meticulously detailed work and an thorough understanding of the troops always found a way to furnish them the necessary data which served to maintain them operable.

To eliminate the effects of jamming, it was essential to be able to use alternate frequencies. In the case of the Wuerzburg instrument this was done by installation of a two-phase (<u>zweistufig</u>) ceramic heterodyne attachment which made it possible to operate within the range of variation of the transmitter on alternate frequencies of plus-minus 3 MHz compared with the normally used medium frequency of 560 MHz. Already in 1942 the firm of Telefunken

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249-250 supplied a broad band dipole, and in 1943 came development of the Urechse/Instrument (Wuerzburg), which made it possible to switch over from one frequency to another within 30 seconds. The problem was more difficult for the Mannheim Radar, but the instrument designated as the "Urstier" also made it possible to master these difficulties.

Provisions had thus been made in time to counter jamming activities, the effectiveness of which could thus be eliminated. Far more difficult was the problem presented by passive interference by means of tinfoil. An effective method of deblurring was necessary to eliminate these interferences. Since aircraft show a certain speed and a certain motion, whereas the tinfoil dropped had only a very slow speed and that only vertically, use was made of these known facts to separate the figure of the aircraft from the confusion of reflexes. Making use of the Doppler-effect principle it was possible to distinguish the aircraft as a louse-like blob on the screen from among the irregular pattern of the tinfoil reflections.

At the beginning of August 1943 the Wuerzlaus deblurrer was introduced for the Model Fu.M.G. 39 T radar, known as the Wuerzburg, which for the time being solved the major difficulties. However, it was only in the summer of 1944 that the troops received the improved Tastlaus deblurrer, and even this did not completely eliminate all blurring.

250-251 By the end of 1944 the K-Laus instrument was also placed in service. However, only a few of these instruments were ever manufactured and they could only be used for approximately six months.

The following is a summary of the results achieved:

Even under conditions of intensive tinfoil interference it was possible to locate aircraft and determine the range reliably. The data thus determined was fed directly to the fire control director equipment. The reliability factors as a rule were equivalent with those during normal operations, so that the results achieved by AA fire in point of aircraft downed were also equivalent with those achieved under normal operating conditions.

On the basis of experience in the employment of super-batteries (from 1943 on) and in the use of Model Fu.M.G. 65 (Wuerzburg Giant) radar instruments, it was believed that radar instruments with larger reflectors should be used to achieve better performances in respect to operating range and reliability of the data. One objective was also to separate the electrically operated locating elements and the servicing personnel from the reflector and place them in positions at least protected against shell fragments.

This led to development of the Model Fu.M.G. 68 (Anspach)

251-252 radar instrument, which was to be transportable by road. It had a remote control reflector with a diameter of 4.5 meters. The locating elements were taken over unchanged from the Model Fu.M.G. 39 T (D) radar, while the directional mechanism for the reflector was taken over from Model Fu.M.G. 65 (Wuerzburg Giant) radar. The new instrument was used in trials in 1944 and could detect aircraft at a range of between 36 and 39 miles against the former search ranges of between 15 and 20 miles. Its accuracy performance was improved to plus-minus 3/16th to 3.5/16th° by means of the split-image representation generally introduced in 1944. However, this instrument did not come into general field use since it was superseded by the Egerland AA radar instrument, a fundamentally new development, although experience with the Ansbach did furnish valueable data for this new development.

In December 1943 it was established that ~~the antiaircraft artillery would need~~ 80 Wuerzburg and 40 Mannheim radar instruments were to be manufactured monthly for the antiaircraft artillery, so that these can be considerad as standard AA equipment. It appeared that the output could not be increased, for which reason the decision was taken in August 1944 that within the German interior each such instrument was to serve 24 88-mm guns instead of 12 as in the past. It was anticipated that this would increase the effectiveness of

251-252 antiaircraft fire at night and when aircraft penetrated under cloud protection.

When a British air-ground panorama radar instrument, generally known as the Rotterdam instrument, captured in the spring of 1943 proved for the first time that centimeter waves could also be used, efforts were made to exlpoit this fact in the future for the AAA radar instruments.

As a first step the Berlin air-ground radar instrument was developed and went into serial production already at the end of 1943. Provisionally constructed instruments showed astonishing results. Coordination with the fire control director equipment was improved to a remarkable degree by the very high degree of accuracy in the data obtained, and the instruments were far less sensitive to tinfoil interferences.

On 28 November 1944 it was decided at a conference with the Chief Signal Officer that a small series of radar instruments operating on centimeter wavebands was to be manufactured immediately in cooperation with the firm of Telefunken. The fact that a number of Fu.M.G. 64 instruments converted as Fu.M.G. 77 (Marbach V) instruments were already in use at Hanover and Hamburg before the end of 1944 is evidence of the excellent cooperation between AAA School III and the firm of Telefunken.

Plans provided for an extensive use of existing

252-253 construction elements from other development projects, so that much of the preparatory work had already been done, without which it would not have been possible to find a solution so speedily. The centimeter-band instruments of the Berlin-type installation (air-ground panorama radar) were also used.

The new equipment provided target data with an accuracy of of plus-minus 1/16th to 2/16th^{o}, gave excellent results in use by the troops and was then also fully exploited in the combined installation, the Egerland radar, which had a separate panorama search radar with a separately sited and closely focussed target fix instrument.

The purpose of the Model Fu.M.G. 74 Kulmbach, as a panorama search radar (Photo 116) was to search the entire target area continuously and furnish the battery a panorama picture of all enemy penetrations. Instruments of this tupe were already in use by AAA and fighter commands for advance warning purposes and to orient the troops and were known as Model Jagdschloss (Photo 117) and other models. However, the battery needed this instrument within its zone for a very special purpose, namely, to guide the ~~sk~~ very closely focussed target fix elements. The operating range of 30 miles was adequate for for the batteries; using the 9 centimeter waveband with excellent characteristics for close focussing, the size of the antennae installations was also tolerable. ~~Plans provided~~

253-254 The Model Fu.M.G. 76 Marbach radar instrument was thus directed by the Kulmbach radar to the current target and had the purpose of furnishing precise target position data to the fire control director equipment of the battery. It also functioned on the 9-centimeter waveband and used the reflector of the Ansbach radar with a diameter of 4.5 meters. Initially it was to have a sweep range of 30 miles and an accuracy coefficient of 1/16° was to be achieved. (Photo 118).

The operating wagon contained the control mechanisms for both radar instruments and for the data furnishing instruments

The Kulmbach installation used a one-side-feed slot radiator with a cylindrical parabolic reflector. In the Kulmbach 20 model the reflector made 20 revolutions per minute for all-round search operations.

The Marbach radar was patterned largely on Model Fu.M.G. 77 (Marbach V). Construction elements from the Model Wuerzburg (D) radar installation were used with it for range finding, position locating, and panoramic view. The operating wagon could be separately sited and also could be placed under shelter in a bunker. The entire installation is shown in Photo 119.

Trial models were in the hands of the troops early in 1945. Within one minute the installation could handle as many as seven targets, including all processes starting from

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254-255 the initial target pickup. Its accuracy coefficient was almost equal to that of the fire control director instruments. Very close focussing of the wave beam proved an important means of deblurring; target and tinfoil reflections were very easily identifiable.

From the above it can be seen that shortly before the end of the war a radar installation suitable for AAA purposes had been developed in the Egerland installation, a few of which reached the troops in the field before the war ended.

Besides the above instruments needed strictly for the direction of AA fire, however, there were also instruments needed for preliminary target locating and for the XXXXXXX Air Raid Warning Service, which were also of very special importance for the AAA command, for which reason they will be briefly enumerated here.

Instruments in this class were already in use in 1939-1940for purposes of air observation and for control of fighter operations or to guide fighters to their targets.

These instruments include the Freya radar developed for the Navy by the firm of Gema, previously mentioned on p. 304 (Photo 110), and the Mammut and Wassermann models (Photo 120). All of these instruments operated on the 2.4-meter band and had a sweep range of approximately 180 miles. In 1944 the Model Jagdschloss radio, also previously mentioned (Photo

254-255 117) was also used for all-round search purposes and for compilation of the current air situation report. Fifteen of these installations were in use by the end of the war.

For the purpose of processing the air intelligence data procured through the panoramic radar instruments, AAA and fighter commands had established special data processing offices, with ~~kartographic~~ map reproducing facilities which enabled the unit commander to orient himself on the current air situation at any given time. It was from these offices that the air situation reports and also air raid warning instructions were sent out. It was also from here that fighter operations were directed and the appropriate instructions issued for the AAA units (Photo 124).

It proved a very grave error that we had assumed that were had a lead on foreign countries in this field at the start of the war. Although foreign countries had no experience in the radar direction of antiaircraft fire at the time, a radar target locating network had been under construction along the English coastline already since 1936. Germany's failure in the Air Battle for Britain ~~was largely due to~~ in the autumn of 1940 was largely due to this network.

The German antiaircraft artillery had called for an aircraft identification system already in 1939 and had repeated this demand a number of time later, but unfortunately this

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255-256 problem was not satisfactorily solved by the end of the war. Lacking an absolutely reliable system to identify friendly from hostile planes, however, there was no real possibility for successful AAA fire against targets located by radar. In the case of optical observation and target locating the possibility of friendly planes being taken under fire was naturally also not completedly excluded, but this could to some extent be avoided. With radar locating there were no such possibilities to avoind firing on friendly planes. All solutions tried out proved unsatisfactory, such as firing bans and the creation of separate zones for fighter operations and for AAA fire.

Right up to the end of the war the vast majority of all German AAA units still had only very incomplete radar equipment. The Egerland installation was in use in only two firing positions. All other batteries had equipment which in some respects could not even be maintained at the current level of development achieved in the field. Thus, many units used a method based on a combination of radar and visual locating. Using the radar target location data, efforts were made to sight the target with optical aids. If these efforts were successful, the traverse and elevation data factors were obtained by conventional visual means and used in combination with the range data from the radar. Traverse and elevation

256-257 data factors could be obtained with greater accuracy by visual means, while the radar range data was considerably more reliable, since it was independent of the distance involved.

Before leaving the subject of radar, it is necessary to mention the preparatory work done in the field for future rocket missile operations.

Early in 1944 work started on development of a remote control system for antiaircraft rocket missiles. The outcome was the Fu.M.G 75 (Mannheim Riese--Giant) instrument, which achieved operating ranges which naturally varied according to the target altitude, as follows

At target altitudes of	Effective range of the remote control system
1,650 feet	16-21 miles
3,300 feet	21-24 miles
6,600 feet	24-27 miles
9,900 feet	27-39 miles
13,400 feet	39-42 miles.

The accuracy coefficient of the traverse angle was around plus-minus 1-1.5°, that of the elevation angle plus-minus 0.7/16th to 1/16th$^{\circ}$.

The average constant XXXXX margin of error did not exceed 1/16th$^{\circ}$, compared with 10/16th$^{\circ}$ in the case of the Wuerzburg radar.

However, all of these projects were merely preparatory work, which was by no means completed. The end of the war put a stop to all further work in this field.

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257- MUZZLE-VELOCITY MEASURING INSTRUMENTS AND

THE WEATHER REPORTING SERVICES

The reason why these two subjects are being treated together here is the influence of internal and external ballistic factors on missile trajectory flight.

All internal ballistic influences and variations can be calculated from the initial speed at which a missile leaves the gun--the muzzle velocity of the missile. In antiaircraft fire this is an important factor for success. There is no possibility for adjustment fire, as is the case in fire agains targets on the ground; the first round fired must strike the target or explode very close to it if there are to be any prospects of success at all in antiaircraft fire.

As we have seen in the previous chapters on guns and ammunition, it was also essential to determine in time when a gun barrel was no longer servicable. This had to be done before a stage was reached at which fuze failures or barrel bursts caused damage and a too greatly increased dispersion of effect made successful antiaircraft fire impossible.

For the above reasons it is of far greater importance in antiaircraft fire than in map fire by ground artillery to determine and eliminate all recognizable causes calling for adjustment. In map fire against targets on the ground it is possible by means of balloon or aircraft observation or sound-ranging to check the position of fire again and again and

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257-258 to make the necessary adjustments. Matters are very different in antiaircraft fire, in which the target aircraft would travel far beyond effective range before the first adjustment could produce effects. Furthermore, the value of any adjustments made would have been highly problamatical anyhow because of the constantly changing position of the target.

For the above reasons it was standard practice already from 1940 on to check the guns in action (88-mm AA Model 36 and 105-mm AA Model 39) at specified intervals commensurate with the type and duration of the action in which they were engaged in order to verify their performances by measuring their muzzle velocity. These checks were carried out at special muzzle velocity measuring stations. However, these required specially prepared dummy ammunition, so that the checks could not be made with the ammunition normally in use. This was a weakness in the system and was the reason why the tests were later carried out at the gun's firing position by mobile instrument sections on a constant round from firing position to firing position to measure the muzzle velocity of the guns. This provided a constant picture of the performance capacities of the individual gun barrels and at the same time served as as check on the ammunition. From the results obtained in these tests attempts were made to draw inferences on the barattrition, the object being to determine by how much the

258-259 performance of the barrel declined after firing a specified number of rounds. However, all of these endeavors failed to produce the desired results. This in turn was probably due to the decisively important role played by specific circumstances, One of these circumstances was the inherent characteristics of each individual barrel, another the type of fire delivered (slow, rapid, or continuous fire, etc.) which had a special influence and showed different results in each individual test carried out. Attempts were also made to secure mean average factors by means of instruments to measure the combustion chamber of the guns, but this method also proved inadequate. During the large-scale Allied air attacks against Hamburg and Bremen in 1941-1942 the AA guns maintained barrage fire over an extended period of time. One battery of four guns in these actions within a single night fired 2,400 rounds in four firing series. Due to the consequent overheating of the barrels all four became unservicable and had to be replaced. If these round had been fired in a slower sequence the 88-mm AA Model 36 barrels involved under no circumstances would have been worn out. It was found that when barrel temperature reached 300° celsius or more each individual round fired caused greater attrition than would 100 or more rounds fired at normal barrel temperatures and individually within a longer period of time.

259-260 In the case of guns with higher performances, such as 128-mm AA guns and guns of the 88-mm Model 41 class it became necessary to know the barrel performance capacity if at all possible from individual round to individual round if the fire was to be effective. This was only possible, however, if the muzzle velocity was measured continuously during combat action and thus with the gun firing in any direction and at any angle of elevation. A special field type muzzle velocity measuring instrument had to be developed for this purpose, a task in which an AF staff technologist Lukanow ~~played~~ of Branch E (AAA), Special Supply and Procurement, played a a special role. Numerous tests with these instruments failed, to produce the desired results. The Navy had installations of this type on its ships, but these only had to function at relatively small angles of elevation and could be permanently installed so that the circumstances were different. However, the Navy's instrument provided a starting point for further development in this direction. The instrument had to be adapted to the requirements of the antiaircraft artillery arm and above all, consideration had to be given to its usability under field conditions. The method in this instrument was based on application of the magneto-elastic pressure effect. Holes were drilled into the AA gun barrel at two points marking the measuring course. Magnetic plugs were inserted into these

260-261 holes. During passage of the shell through the barrel the shell rotation bands contacted these plugs. The resultant induction current passed through a cathode ray tube and inscribed two time marks on a speedily rotating film cylinder. This gave the missile speed of passage through the measured distance, from which the muzzle velocity could be calculated. The measuring instrument, called a Karthodograph, permitted the recording of 4 rounds simultaneously, so that one instrument was sufficient to maintain a constant check on four guns at one and the same time. The very great advantage of this method was that it did away with the necessity for special measuring structures in front of the gunand that the measuring could take place during actual firing action.

At the end of 1943 a number of AAA towers with their 128-mm guns were equipped with such installations. The stated requirement was that first all 128-mm gun batteries and then all 88-mm AA Model 41 batteries were to be so equipped. The final target was to provide these installations for all heavy antiaircraft artillery battalions. In view of the fact, however, that gun barrels were always in short supply and that the industries producing high-frequency electrical equipment were already working at full capacity, these plans were nothing but wishful thinking and by the end of the war only the 128-mm batteries had the equipment. In future, however, the use

260-261 muzzle-velocity measuring instruments of this type can probably be considered as a pre-condition for effective anti-aircraft fire.

As far as external ballistic factors are concerned, there are unfortunately no such simple means to determine and eliminate them. For this purpose it is essential to know the weather conditions in the various atmospheric strata through which the missile must pass. For this purpose each German AAA regiment had a special meteorological section, which kept the firing positions constantly posted on atmospheric conditions. These meteorological sections had the normal euqipment in use in the Army. Commensurate with the data furnished by these meteorological sections, the necessary adjustment factors had to be set on the fire control directing equipment. This determined the trajectory required to reach the target.

BALLOON AND KITE BARRAGES

Items of equipment in this field also required constant modifications and constructional work. On the basis of experience gathered in the field the troops constantly called for improvement and supplementation of their equipment.

Raw materials shortages made it necessary to constantly used new substitute materials, and this naturally also often necessitated changes in the various items of equipment. The

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261-262 winches, the power units and also the form of the balloons and kites changed continuously. A particularly disturbing circumstance was that when balloons or kites broke loose from their moorings with long wire cables, they created havoc with overland power lines and electric power stations, in some cases paralyzing entire industrial regions. For this reason special attention had to be paid to the point at which the cable would part if it did so part.

Constant work at development of these items of equipment was thus also necessary. Barrages of this type played a specially important role in the protection of ports in which our battleships were anchored, and after devastating air attack had occurred also in the protection of dams and other important waterworks. To attack the walls of dams, airmen had to operate at very low levels. In addition to balloon and kite barrages, special ~~wire~~ entanglements were also set up on the slopes of the dam walls. These entanglements were formed of lateral and horizontal ropes or cable or wide-mesh wires, which were fastened to the poles on the side slopes usually flanking the actual wall of a dam. Enemy airmen greatly feared areas in which balloon, kite and other barrages were known to exist. Their very presence alone therefore prevented low-level attacks which otherwise would have held out good prospects of

262-263 In 1943 it was planned to render the wire entanglements more effective by attaching to them explosive charges which woul explode when contacted by an enemy unit, and 2,200 such charges were procured for the purpose.

In August there were 2,255 balloon barrage units in operation with balloons of 200 cubic meter capacity and 592 with balloons of 77 cubic meter capacity.

In November 1944 it was found that it was still not possible to dispense with balloon barrages. In fact, it was considered that they might prove very important if the enemy should employ weapons similar to the German V-1 missiles, and preparations were made for protection of the Ruhr region against attacks of this kind.

In the chapter on ammunition mention was made previously of the "flash barrages," which also come within the category of balloon barrages.

Although the number of aircraft actually destroyed by balloon barrages remained small, it is definitely certain that this type of defense prevented many an attack, and the effects on the morale of airmen should not be underestimated.

DUMMY INSTALLATIONS; CAMOUFLAGE

In the chapter dealing with the period prior to the start of the war in 1939, mention was made of the fact that the construction of dummy installations is a science in itself. Instal-

263-264 Installations of this kind require much thought, careful deliberation and a vivid imagination. It was necessary to constantly devise new means of deception which would lead the enemy to deliver their bombloads on the dummy installations. Furthermore, daylight attacks called for methods of deception differing radically from those required against night attacks. Everything had to be rearranged time and again in order to meet current requirements. After the enemy had developed their Rotterdam radio instruments, which enabled them to attack with ground orientation, and to release their bombloads accordingly, completely new methods of deception became necessary.

In the case of all camouflage installations, however, the fundamental requirement was that they had to be in a region which already had antiaircraft artillery defenses, or antiaircraft artillery units had to be assigned specifically to the dummy installation in question, in order to prevent its easy recognition as a dummy installation.

Installations for deception during daylight were usually created by means of dummy constructions. Thus dummy airfields were numerously simulated by the use of damaged aircraft or dummy aircraft. Small factories, command posts, etc., could also be simulated by means of installations of various types. Numerous evacuated AA battery positions were also developed

264-265 as simulated installations in order to conceal from the enemy the departure of the AAA forces. In the field also battery positions were thus built up, but here it was necessary to simulate muzzle flashes, since the enemy would soon have recognized a silent dummy installation for what it was.

Dummy installations to mislead enemy air forces attacking at night were usually created by the use of light effects and fires. Thus, railroad installations or inadequately darkened industrial works could be simulated. Particularly after an initial enemy air attack the opportunities were favorable to simulate large fires and thereby cause the following enemy echelons to drop their bombs harmlessly there. In large air defense areas, such as Berlin or the Rhine-Ruhr region, it happened frequently that more bombs struck simulated installations than actuall factories within a single night. For example, when the enemy reported after a night of devastingly heavy attacks that they had destroyed the large marshalling railway yards of Hamm it ~~would have been~~ was foolish to announce in newspaper articles that not a single bomb had struck the Hamm rail depot area. Reports of this kind served to inform the enemy that they had been misled by a dummy installation.

It was also possible to fire off flash charges or smoke charges to simulate gunfire or bomb hits.

The advent of the Rotterdam radar instruments, however,

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264-265 rendered all of these types of deceptive installations more or less ineffective, and new means had to be sought. Using these instruments, the enemy were able to obtain a map view of the terrain over which they flew (Photos 121 and 122). As a countermeasure, tri-pol reflectors and other devices were set up to contort the radar image (Photo 123), complicate orientation and make it impossible for enemy planes to find th their targets. Time and again measures of ever new kinds caused the enemy planes to misplace their bombs.

One measure which deserves mention here was that of simulating the signals used by the enemy. This was done by means of rockets and it was no easy matter to copy the target marking beacons, bomb release signals and other light signals and to place them at the required altitudes by means of rockets. A faithful duplication of the enemy signals at the proper altitudes was indispensable, however, if they were to serve their purpose and deceive the enemy. Much time and effort was spent in producing these means of deception and probably far exceeded the results achieved.

Liberal use was also made of smoke screening to prevent aimed bombing. The quantities of smoke required for these purposes were enormous and the smoke screening operations had to start well ahead of time in order to obtain the necessary density. As long as no possibilities existed for radar target detection and

265-266 radar direction of antiaircraft fire, however, the protection of a target by means of smoke screening at the same time precluded the possibility of defensive antiaircraft fire. Those AA units which were in positions within the smoke-screened area were also blinded and could obtain no target data, so that they had to restrict their action to barrage fire, which in all cases held out only small prospects of success. The fact is that barrage fire served primarily to calm the civilian population and the officials of the National Socialist Party, who believed that a lot of noise must produce commensurate results. On the other hands, smoke screens also presented certain difficulties to attacking enemy air units, which naturally suspected camouflage maneuvers designed to cause them to release their bombs harmlessly. After the equipment of aircraft with radar instruments, smoke screening naturally was less effective than before.

MOTOR VEHICLES

Mention has been made previously of the fact that the Air Force in general used the motor vehicle types commonly in use in the Army. For this reason only a brief summary will be given here of the various special type trailers used for antiaircraft artillery purposes and their specific uses. The special type trailers in use were as follows:

THIS PAGE DECLASSIFIED IAW EO12958

266-267

Special-Type Trailer	Used for
Model 51, single-axle	20-mm AA guns and 60-centimeter searchlights
" 52, "	20-mm 4-barrel guns, 37-mm Model 36 guns, Fire Control Director Model 40
" 53, "	Auxiliary Fire Control Director Model 35
" 54, "	Recording theodolite
" 55, "	Muzzle-velocity measuring equipment
" 58, "	37-mm Model 43 gun and Foehn Rocket launcher
" 104 2-axle	35-mm Model 18 gun, 150-centimeter AA searchlight, Fire Control Director Model 36, Sound Locator, Machinery for Barrage Balloon winches, Muzzle Velocity Measuring Shed.
" 201 "	88-mm Model 18 gun
" 202 "	88-mm Models 36 and 41 guns
" 203 "	105-mm gun, Undercarriage for 128-mm gun, transportation platform for 2-barrel 128-mm gun
" 204 "	50-mm gun, 200-cm AA Searchlight, Power Unit for 60-Kw. Barrage Balloon Winch
" 205 "	Barrel Carriage for 105-mm gun
" 206 "	37-mm 2-barrel gun, AA Searchlight 200-centimeter, Power Unit 120-Kw, Radar.
" 220 "	128-mm Model 40 gun.

ULTRA-RED, ULTRA-SONIC, AND ANTI-RADIATION DEVICES

Mention must also be made here of German efforts to detect and locate airborne targets by means of ultra-red and ultra-sonic

267-268 rays. These attempts were unsuccessful and did not proceed beyond the initial stages of research. The distances at which the various devices were effective were completely inadequate for antiaircraft fire purposes so that no consideration could be given to their use.

However, in 1943/1944 a laboratory was installed at the Antiaircraft Artillery Proving Station at Brunshaupten to conduct detailed research in the field of radiation and to investigate whether there was any possibility of developing a ray system of defense against enemy air penetrations. The idea was to release energy which would damage the aircraft or at least render their engines inoperable. Even at the time the whole idea appeared utopian, but it was nevertheless thoroughly investigated in the desperate search for effective means of defense.

The purpose in mentioning these two fields of endeavor here is, besides the necessity for such mention for the sake of complete coverage, to show the full scope of research and development activities in the field of air defense and to show that air defense involves practically all scientific-technological fields.

ANITAIRCRAFT ROCKETS

The story of development in this field is the saddest chapter of all and should be headed "How to Inhibit a Development."

As previously mentioned above, the memorandum submitted

268-269 in 1932 (Appendix 2) called for development of the "Barrage-Fire Rocket," but that no positive work was done on this project up to 1939.

During the intervening years the Army had built up a large research station at Peenemuende which, however, concerned itself almost exclusively with the problem of using the rocket propelled weapon to develop a long-range artillery weapon. The idea was to achieve effective ranges of 180 miles and more and the possibility was envisaged of inter-continental rockets.

Funds from the Air Force budget had also been used in developing the installations at Peenemuende. The Air Force had purchased the terrain for the purpose already in 1936 and had also supported the project with funds regularly.

After establishment of the Air Force C-Office, the office responsible for Air Force development and procurement, a branch was established within that office to handle rocketry problems and remote control missiles. This separate branch was headed by Chief Staff Technologist Dr. Bree.

Soon after the start of World War II the subject of antiaircraft rockets was again brought up, since it was anticipated that aircraft would operate at steadily increasing speeds and steadily mounting altitudes. The necessary lead allowances in antiaircraft fire would become greater and greater and the prospects of success with such fire would become smaller and smaller

269-270 At the beginning of 1941 Branch 6 of the Air Force General Staff formulated, in outline, the first tactical-technical specifications for the development of remote-control antiaircraft rockets. An Austrian Major Halder was on the staff of Branch 6 at the time and while at University he had studied rocket problems so that he was familiar with the subject. At the same time a 1st Lieutenant Stoelzel, who was serving with the field forces, had advanced certain ideas on antiaircraft rockets which resulted in his being assigned to the Rocket development Station at Peenemuende under General Dornberger and Professor von Braun.

On the basis of the stated requirement for a remote-control antiaircraft rocket, the handling of the matter was assigned to the C-Office, where the branch under Chief Staff Technologist Brée was responsible for the project. At the same time, however, this branch was responsible for research being conducted on the development of air carried air-air rockets, for use against enemy aircraft.

At this stage Hitler on 11 September 1941 ordered cessation of all long-range development projects. It was probably this order which influenced the C-Office to compile a memorandum proving that development of a remote-control rocket would require greater expenditures than development of the air-air rocket for fighteraircraft, and that the whole

269-270 complex problem presented difficulties far greater than those involved in the development of rockets to be fired from aircraft. This memorandum was the cause of Goering's negative decision and of his order to halt all work on the continued development of antiaircraft rockets.

At the Rocket Reserach Station of Peenemuende, however, the AA 1st Lieutenant continued his work on an antiaircraft rocket. He was left more or less to his own devices at Peenemuende and nobody took any real interest in the progress of work or trains of thought there. He obtained two discarded tanks from the Army and on these mounted approximately twelve rocket projecting barrels. It appears that he had forgotten his own front line experience in antiaircraft fire, since he had apparently given no thought to the problem of how to sight and optically track an aircraft from the interior of a tank. At the time radar controlled fire from inside the tank was still not possible. After thorough investigation by all antiaircraft and Army agencies which might have been interested, this project was finally halted in 1943 and the 1st Lieutenant was sent, together with his two tanks, to the front to gather experience in the field. As was to be expected he achieved no success; his two tanks were dismantled, and much time and labor had been fruitlessly expended because of the lack of proper supervision and control. This whole incident was

270-271 only possible because in matters of weapons and equipment research and development the Antiaircraft Artillery was neither under the Army nor under the Air Force, but fluctuated between the two, a circumstance which was destined to produce other fearful consequences.

The increasingly serious air threat to the German homeland and the fact that enemy air forces were operating at ever increasing altitudes in order to escape antiaircraft fire, influenced the AAA Inspectorate, together with Major Halder of Branch 6 of the Air Force General Staff, to renew its demand for the development of antiaircraft rocket weapons. In the AAA Development and procurement program datedd in April 1942 but only approved and signed by Goering on 1 September of that year, (Appendix 3), the specifications were established for the development of antiaircraft rocket missiles.

At this point responsibility for the work of development in this field was assigned to Branch 2 (AAA), Special Supply and Procurement Service. The C-Office raised no objections, and was probably happy to rid itself of responsibility for the past errors of omission in this field. This transfer of the responsibility for AAA developments was probably also partly due to the fact that General Mertitsch was unjustly blamed for having neglected the rocket problem in the development of AAA weapons and equipment.

271-272 The main point now was to endeavor to make up for lost time. As a start, Major Halder was transferred to the AAA development branch and after brief familiarization was assigned responsibility for rocketry development in a separate branch established for the purpose. He approached his mission with great optimism and really lived in the hope that he now had been given the green light and would be able to work free and without interruption. But once again it was to become evident how harmful the shared competency between the Air Force and Army, with Speer's Ministry now also involved, was to be. The Antiaircraft Artillery was dependent on all three of these authorities. In some cases this was an advantage, since one could approach that authoritiy from which one expected least resistance against a current request. In most cases, however, and particularly in that of rocketry development, in which no spectacular results could be expected within the near future, it was devastating to witness the difficulties each authority thought it had to create, and the way in which these difficulties mounted until they made continued progress practically impossible. It must be said of Major Halder here that he kept his target clearly in mind and adhered to his purpose in spite of all these unpleasantnesses.

The first thing was to secure the cooperation and support of the Army Rocketry Reserach Station at Peenemuende in order

272-273 to be able to exploit the results obtained in research work done there. For this purpose an experimental and development station had to be established in the immediate vicinity of Peenemuende. Since the necessary building had to be adjacent to the Army research station , responsibility for the construction work was assigned to the Army, However, the Air Force had to supply the necessary building materials and this delayed matters until the spring of 1943.

The testing stands already in existence at Peenemuende as well as the wind tunnel had such a backlog of testing projects that it was not possible to include new testing projects for the antiaircraft rocket on their programs and all installations for such purposes had to be newly constructed. However, constantly recurring difficulties in the procurement of materials and manpower so delayed this work that the war ended before installations of this type could be provided for anti-aircraft weapons development.

As in the case of the rocketry projects of the Army and the Air Force, the new ~~Antiartillery~~ Antiaircraft Artilley project naturally also needed qualified personnel to process the various research sub-projects. At the time 100,000 military personnel were released from field service for employment in th aircraft manufacturing industries, but requests for 600 as a start for the antiaircraft rocket development project remained

273-274 unfulfilled, and up to March 1943 only 200 were made available for the purpose. Time and again personnel were withdrawn at very short notice by the recruiting commissions operating under General Unruh and lengthy processes had to be gone through to obtain their return to the project. However, this shortage of qualified personnel affected not only the experimental station at Peenemuende, but also the various firms participating in the development project, so that work could proceed only very slowly. In the autumn of 1943 the station could report at last that it had 80 percent of its authorized personnel strength.

Up to November 1942 Field Marshal Milch had also adopted a negative attitude towards the development of antiaircraft rockets. At that time, however, he probably realized the necessity for a more effective antiaircraft artillery force besides the fighter arm and from then on supported the project.

Major [illegible] Halder calculated that between 2 and 2½ years would be needed for the development work. I, General von Renz, at the time Chief of the AAA Development Office, realized from years of experience in the fieldsof research and development on more conventional subjects in which work had already been done, that this estimate was far too optimistic, and that far longer periods of time would have to be envisaged. However, I wisely maintained silence, encouraged Major Halder in his

274 belief and also confirmed his optimistic views to the responsible ~~quarters.~~ quarters. This I was compelled to do, if for no other reason then alone because Hitler's order was still in force that long-term de elopment projects were not to be continued. If I had voiced my views that more time would be required for the development the antiaircraft ~~development~~ rock try development project would again have been placed in jeopardy, and this would not have served the interest of the work of development.

New difficulties arose when the allocation of raw materials was requested for the antiaircraft rocketry development project. The Planning Office, which was responsible in this field, rejected the request and de anded that the materials should be made available by the Army from its allocations, since the Army was responsible for the development and manufacture of antiaircraft guns and similar weapons. The Army, however, rejected the requests on the grounds that it was not responsible for this specific project.

The overall project involved not only the problem of rocket development; at the same time the whole problem of antiaircraft rocketry was a problem of electronics and remote control.

Just as the Antiaircraft Artillery in its development projects had to specify higher standards of performance than those stated by the Army, the standards of performance required in development of the antiaircraft rocket were also higher than those

274-275 required in the development of rockets for Army purposes or for use as aircraft weapons.

To accomplish its artillery mission the Antiaircraft Artillery in its guns required a greater muzzle velocity than that needed in Army guns, the speed of traverse and ~~akax~~ elevation had to be greater, gun barrel performance had to be more constant, the fire dispersion pattern had to be better--which applied particularly to a reliable fuze-caused dispersion pattern, the burning period had to be shorter and more constant, the lock had to function automatically and reliably, the rate of fire had to be greater, and so forth. All of this applied equally to the antiaircraft rocket. What purpose would an antiaircraft rocket serve if it did not provide better firing conditions than those of the Antiaircraft Artillery with its conventional type of guns? From the start the rocket was indisputably at a disadvantage in point of burning rate and fire dispersion, particularly lateral dispersion. The missile time in flight, for distances under five seconds, was also less favorable than in the case of a conventional artillery shell. Lacking an improvement of the probabilities of hitting the target, responsibility could thus not have been acceptable for the use of rockets. This was all the more the case since rockets would be a greater drain on powder or other propellants than ordinary artillery ammunition.

275-276 and these items were in very short supply. In mass production conventional ammunition was also more easily manufactured, and at less cost than the rocket. The rocket launcher was naturally a less costly item than the gun. But here again, the reocket launcher needed by the Army differed fundamentally from that needed for antiaircraft fire, since the latter had to have a high speed of traverse and elevation movement, while the rocket launcher for Army purposes could be placed in the desired direction of fire and then required only minor adjustments.

In view of all these considerations it came as a complete surprise to the Chief AAA Officer and Branch E (AAA) of Special Supply and Procurement Service when Hitler, following an oral report by Speer, in August 1943 demanded that the 210-mm smoke projector should be used for air defense purposes. Speer had made this offer to Air District Command VI to reinforce the air defenses of the Ruhr region and in sheer desperation that command had clutched at this suggestion as a drowning man would clutch at a straw, failing to realize that the projectors would be completely useless.

This smoke projector had been developed for the purpose of firing sudden bursts of gas or smoke shells into an area of terrain in order to obtain there the density of gas or smoke required for the intended purpose. This could be done

276-277 more easily and more effectively with the projector than with conventional artillery guns and their ammunition. But how was this type of fire to serve air defense purposes. The idea was that the projectors should be so placed that they would close t the enemy approach routes to the Ruhr region. By a simultaneous release of fire they were to create what was envisaged as a fire barrier. The question arises whether it was really thought ~~that~~ that this would be possible without regard for lead factors. As is the case in all antiaircraft fire it would have been essential to determine and adhere strictly to the lead factor since otherwise the whole burst of fire would have served no purpose whatever. The missiles had to be in the target area at the moment the aircraft entered that area. Use of the projectors for this purpose would have held out just as small prospects of success as barrage fire with the conventional types of AA guns with the added disadvantages of a longer missile time in flight, less favorable burning rate, and so forth.

The Chief AAA Officer and also the Development Office protested vigorously against this action, the latter in particular fearing that this action by projectors, the uselessness of which was a foregone conclusion, might again jeopardize the entire antiaircraft rocketry project since all opponents of the pro- ant ject would seize upon it as proof of how useless the rocket was as an antiaircraft weapon. However, all of these protests

277 remained fruitless after Minister Speer had suggested this solution to Hitler and obtained his approval. The underlying reason for this recommendation by Speer was that the Army did not want the projectors being manufactured, since there was to be no use of gas and therefore did not intend activating any more smoke projector units. The projectors were in current production, however, and were now to serve the antiaircraft artillery as an emergency solution after everything possible had been done to prevent the development of a really useful antiaircraft rocket weapon. The statement by Field Marshal Milch that development of the V-1 missile had also taken thirteen years serves but to prove what a serious mistake it had been not to promote the development of antiaircraft rocketry in good time and with all means available.

Development of the antiaircraft rocket now encountered new difficultiesin the matter of the development of steering devices. In February 1943 it was established that instruments were available with adequate accuracy and adequately proof against interference to guide such a rocket, that personnel and materials were lacking for such a development in the industries producing electrical high-frequency instruments, and that for these reasons the search for a solution had to be abandoned. However with the increasing severe and increasingly frequent attacks against Berlin and the industrial regions, this difficulty was overcome and it was realized that the fighter arm

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277-278 would never be able to carry the burden of air defense alone in view of the superior enemy escorting fighter forces. Mention has been made previously in the chapter on radar instruments, above, of the radar instrument intended for the control of antiaircraft rockets.

However, this objection by the electrical industries producing high-frequency equipment was not to be the last against the antiaircraft rocketry project. Objection after objection was raised against continuation of the project. One such objection came from the Air Force Development Office, under Professor Dr. Seewald, who with some justification pointed out that all problems connected with the antiaircraft rocket project had not yet reached a stage for development but were all still in the initial stages of research and should therefore be transferred to the appropriate research agencies. However, this objection might have been justifiable three years previously and the course suggested might then have been the proper one but at the stage now reached and with the need for an effective solution which could be applied immediately it was impossible to restrict research merely to a solution of the various individual problems involved. This would have been tantamount to a further delay and to projecting the final solution into a time still years ahead. If this course had been adopted, development of the missiles and equipment could only

278-279 have started after completion of the preliminary research.

Even as late as in 1944 it became necessary during a conference in May for General Milch to instruct the C Office to give the antiaircraft rocket support equal to that given to fighter procurement.

The individual types of rockets developed will now be dealt with.

The first concrete demand for the development of antiaircraft rockets was made in 1942. An effective range of 24 miles was specified with a peak altitude of 52,800 feet. Attention was drawn to the necessity of a proximity fuze and remote control from a ground station was also stated as a requirement.

It was obvious that if rockets were to be used against aircraft remote control would be indispensable and that it wouldhave to have a proximity fuze and if possible a homing device. Failing solution of these problems the whole idea of rocketry would have remained a half-baked idea and the rocket could never have become an effective military weapon.

In the Antiaircraft Artillery Development program for 1943 provision (Appendix 3) was made, because development had bogged down on these points in 1932, for a step by step progress, the first step to be development of an unguided rocket projectile suitable for firing with the available fire control director equipment. The second step was to be development of an

279-280 optically directed remote-control rocket to be followed eventually by development of a rocket with electronic remote contro which would guide itself automatically into the close proximity of the target and explode there.

It was obvious to Branch E (AAA), Special Supply and Procurement Service, that the intermediate solutions would not represent really effective air defense weapons and therefore might impede work on the final solution, since their obvious inadequacy might provide grounds for halting work on the final solution. Resistance to the whole idea of rocketry had not quite ceased and any failure would be gladly seized upon by the opponents as renewed proof of the uselessness of an antiaircraft rocket, so that all efforts had to be directed to the development of an antiaircraft rocket-propelled missile with remote control.

A differentiation was also made between rocket missiles thavelling at supersonic speeds and those travelling at subsonic speeds. Hopes of solving the problems for the supersonic class rockets were regarded with scepticism, since greater difficulties were anticipated in this field.

Mention has been made previously of the smoke projectors of 210-mm caliber constructed at the Peenemuende Army research station and in use under the designation "Maikaefer." Experiments with this weapon were doomed to failure from the start, 280 if for no other reason then alone because the aiming speed of the projectors was inadequate and because of the low travel speed of the rockets in flight. Minister Speer nevertheless succeeded in having this weapon employed for air defense purposes and they actually then went into action without any provision for special AAA aiming devices. They were to deliver barrage fire and thereby deny the enemy an approachby known routes. The complete failure of this action definitely did more harm than good to the whole idea of air defense rocketry.

In December 1942 powder rockets went into production in the factories of the firm of Rheinmetall and of the Bruenner Armaments Works. These firms were handicapped by the lack of engineering personnelwho first had to be recalled from military service in the field. It was hoped that with the use of single-stage powder rockets it would at least be possible to achieve the performances of the antiaircraft guns so far introduced.

On 11 October 1943 the second firing tests were conducted with the "Foehn" rocket developed there. The rocket launcher was mounted on a trailer chassis and had firing tubes for 36 rockets with a caliber of 73-mm. It could fire either 18 or 36 missiles simultaneously, the hope being that this would insure greater prospects of target hits similar to the effects of shrapnell fire. These powder rockets had an explosive charge weighing 2.2 pounds, and a contact as well as a self-destruction type fuze. Maximum speed was 400 meter/second. Aiming was

280-281 by means of a pendulum-type elliptical sight. Its movement in elevation was 90°. The starting channels were on a split mount so that two separate fire zones could be covered according to the current target. The effective range was 1,320 yards. From the technical view the weapon was well designed and constructed. It was placed in service in April 1942, at which time 50 of these weapons were completed. Production plans for 1944/1945 provided for the following monthly output:

October 1944	25
November 1944	100
December 1944	200
January-March 1945	200 monthly
April 1945	75

However, only 85 of these weapons were in service in February 1945.

Most of the trial batteries were permanently emplaced at airfields, with a few mounted in railcars. Owing to the slow speed of the rockets in flight and the great dispersion of their fire effect the prospects of success were small from the outset and this proved the case in practice. This also remained an experiment with unsuitable means and served merely to prove that this difficult problem simply could not be solved without thorough and logical processes of development work. How fascinating the spectacle of one of these launchers was

281-282 in the act of firing is evident from Photo 125 and I personally fear that this spectacle misled many to overestimate the effectiveness of the weapon.

Another unguided rocket developed was the 50-mm powder rocket "Orkan," which, however, was not placed in service.

Special mention is due to the unguided liquid-fuel "Taifun rocket developed by the Elektromechanische Werke (Electromechmechanical Works). This rocket with a caliber of 100-mm and a length of 193 centimeters had outstandingly good aerodynamic properties with its four tail vanes in a width of approximately 20 centimeters. A starting-track platform for 30 barrels was mounted on an 88-mm AA gun carriage to fire salvos. The missiles were to reach a peak altitude of 16,500 yards in fifteen seconds of flight. Maximum speed was to be 760 meter/second. Strangely enough the origin of this weapon was linked with the experience gained in development of the power unit for the "Wasserfall" rocket, a large caliber guided missile. Its power unit was copied in a technically ingenious way and simplified form, with a high coefficient of reliability in operation, from the power unit of the Wasserfall rocket. At the Mittelwerk Works, Nordhausen, a manufacturing program for the production of the Taifun rocket was prepared already at the end of 1943. In January 1945 plans were established for the creation of a total of 400 Taifun Rocket batteries by October of the same year to be

282-283 used in an expanded trial with troops. Manufacturing operations were pressed forward with all emphasis but were brought to an end by Germany's collapse.

As early as in the beginning of 1943 the firm of Rheinmetall commenced tests at a testing site constructed by itself at Leba on the Baltic coast with a rocket model which was a 1:2.5 scale replica of the "Rheintochter" missile designed for later development. The tests were in the nature of basic research trials serving the continued work of development, and were carried out with admirable speed, thoroughness and devotio[n]. The tests included trials with unguided starts at a starting an[gle] angle of 60° strictly as stability tests, and trials with predetermined steering and using sub- and supersonic missiles. Approximately 30-40 starts proved the complete stability of the missile and proceeded according to program. The trials with predetermined or set steering were with the rudder set at an angle of 6°, with small resistance strips attached to two opposite vanes producing a rolling motion. These tests, which took place between April and November 1943, represented pioneering work of the first order nd their importance was most unfortunately underestimated. Research institutions and the industry from then used the experience gained in these tests as a firm basis. The first successful result of these efforts was the "Feuerlilie" AA rocket constructed for research purpose[s]

283-284 by the Hermann Goering Research Institute in Braunschweig-Volkenrode and brought to Laba, where it was tested.

If those responsible had followed the repeated recommendationsto make 1-3 first-rate designers familiar with aircraft construction available to the firm of Rheinmetall, which was willing to employ them, the promising tests in process probably could have been brought to a promising conclusion sooner. However, the C-Office resisted this measure in the belief that it could not spare these personnel from its own program, which was the only source from which such personnel could have been secured at all.

The development of remote control AA rocket missiles ready for use in the field created ever new problems for the requisitioning authorities and for the manufacturers. Besides the problems of the correct aerodynamic form of the fuselage, the steering and control systems, adequately powerful power-units, acceleration-proof impulse-receiving instruments to be built into the missile, the steering mechanism as such, electricity batteries, the proximity fuze and the stablilzing gearsolutions had to be found at the same time for the proper methods of firing and control. The fire control methods customary in the antiaircraft artillery had to be replaced by a new methodfor which no precedent existed. Only if this was do done could it be assumed that the advantages of the rocket

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284-285 missile could really be fully exploited. The very start of development work thus created a multiplicity of problems, the individual solution of which would have required many years of consistent and uninterrupted research. On the other hand, the increasingly severe and frequent air attacks with their devasttating effects made it inescapably necessary to apply exceptional efforts and to improvize, while dispensing with the necessity for normally proper systematization.

A number of firms commenced work on the development of remote-control rocket weapons for air defense almost at the same time. The four best-known types, which will be described below, were the following: the "Schmetterling" and the "Enzian" sub-sonic rockets, and the "Wasserfall" and the "Rheintochter" super-sonic rockets.

The Schmetterling (Photo 126) had been developed by the firm of Henschel Flugzeugwerke, Berlin-Schoenefeld (Professor Wagner. It had an overall length of 4 meters and a diameter of 280-mm. It was patterned on the shape of a semihigh monoplane with arrowlike wings, and also still featured the lateral ailerons, each 35 centimeters in length. Its overall wing span was 2.8 meters, with a depth of wing profile of 66/32 centimeters. The tail assembly had rigid side fins and the horizontal fin had a span of one meter with a two-part elevator. The overall weight was approximately 450 kilograms (990 pounds); after jet-

284-285 jettisoning its two powder starting rockets, the missile still weighed approximately 270 kilograms (594 pounds), and at target point it still had a weight of roughly 200 kilograms (440 pounds). It carried a 40 kilogram (88 pound) explosive charge. It was propelled by two starting rockets each weighing 85 kilograms (187 pounds) and containing 40 kilograms (88 pounds) of Diglykol powder, which were ejected when burned out. Each starting rocket rocket had a thrust of 1,750 kilograms (3,850 pounds), a burning duration of roughly four seconds and jets set outwards at an angle of 30°. After ejection of the starting rockets, a centrally located jet provided the necessary thrust. This thrust was 60 kilograms (132 pounds) and had a burning duration of up to 70 seconds. Flight speed was below 300 meter/second; peak altitude was 16,500 yards, and the maximum radius of action was in the vicinity of 32 kilometers(35,200 yards). The fuselage and wings were of light metal shell type construction. It was estimated that within twenty seconds after start and thus within a distance of 5,500 yards, the control gunner would be able to guide the missile accurately enough to pass the target at a distance of not more than 7 meters. The explosive charge was effective within this distance and was to be detonated by a proximity fuze. In a series of 80-90 trial shots, some of them air-ground, misses by between 20 and 30 meters were recorded.

The first designs were submitted in July 1943, and in

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285-286 January 1944 the first trial models were completed. However, these were destroyed in an air attack, which caused a further delay in the development project.

The Oberbayrische Forschungsanstalt (Upper Bavarian Research Institute), Oberammergau (Dr.Konrad), developed the "Enzian" AA rocket in the workshops of the firm of Holzbau G.m.b.H in Sonthofen. In its outside shape this rocket missile was derived from the Me-163 (Messerschmitt) manned jet fighter, and was astonishingly simple in point of construction. The fuselage was of timber. Steering was by means of two control surfaces on the rear rim of the wings which, when set contra-wise served as balancing flaps (axial steering--Steuerung um die Laengsachse), when set in one direction, upwards or downwards, as elevators (transverse axis steering--Steuerung um die Querachse). Overall length was 9.65 meters; largest diameter 2.22 meters. It was built as a planiwing missile with a forward rise of 30° and with only one pair of rudders. Wing span was 10 meters. The side fins were rigid. Take-off weight was 1,965 kilograms (4323 pounds). It was fired by four starting rockets from a sloping platform; after a burning duration of four seconds the four starting rockets were ejected. They had a total thrust of 7,000 kilograms (15,400 pound and gave the missile a speed of 250 meter/second or roughly 540 miles per hour. Then propulsion was by the built-in

286-287 power unit which in the first test models ~~XXXXXXX~~ was the same as the Walther power units already tried out in aircraft development, and in later models a more efficient power unit developed by Dr. Konrad to use a vinyl-nitric acid basis fuel. After ejection of the fourth starting rocket the missile weighed approximately 3,300 pounds).The built-in power unit gave it a thrust of two tons. Burning duration was up to 70 seconds. The peak altitude was 44,550 feet and the radius of action about 44,000 yards. Approximately 38 trial flights were carried out before the war ended. Up to May 1944 the tests were subject to unfavorable circumstances. In line with an agreement between Hitler and Speer continuation of the project of developing the Enzian AA rocket was placed under SS Lieutenant General (<u>Gruppenfuehrer</u>) in November 1944. Continued development work on this project was halted early in 1945.

The "Rheintochter" missile developed by the firm of Rheinmetall had undergone a number of modifications. As previously mentioned, basic experience was first gathered with the first trial models. The first design was submitted as early as in May 1943. In September 1943 Speer's Ministry (Official Schieber)refused to provide the powder required for this project. Therefore, it became necessary to provide a liquid fuel power unit burning a nitric acid base fuel, from which it was hoped that the performances would be improved. In mid-January 1944

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287-288 the seventh and eighth trials were fired. Later trials showed that the roll stabilization was inadequate.

The Rheintochter antiaircraft rocket missile featured the following technical data (Photo 127):

It was a two-stage missile. The lower stage was 2.15 meter the upper stage 3.6 meters in length. The diameter of the second stage was 50 centimeters, that of the first stage was 51 centimeters. The first stage had four, the second stage six arrolike fins. Wing span of the first stage was 4.4 meters, that of the second stage was 2.65 meters. Depth of the wing profile was 82.5-30 centimeters in the first stage and 71-12.5 centimeters in the second stage. In the first stage maximum wing thickness was 25-mm, in the second stage 50-12.5 mm. The upper stage had four movable steering vanes placed forward. Starting wieght was 2,200 pounds. The rocket carried an explosive charge of 50.6 pounds. It was launched from a sloping slide rail mounted on a special structure. The initial lift was by ~~txx~~ powder rockets, followed later in the lower stage by two powder rockets with a maximum thrust of 14 tons, using 660 pounds (300 kilogram) Diglykol powder, while the upper stage used a fuel consisting of 193.6 pounds (88 kilogram) vinyl plus 781 pounds (355 kilograms) Salbei (code name for an oxidizing agent containing 98 percent nitric acid; same as Hoko), giving it a thrust of 2.18 tons. Burning duration was 38 seconds. The Maximum speed

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288-289 achieved by this rocket was 480 meter/second; peak altitude when fired at an angle of 70° was 6,600 yards with a radius of action of 44,000 yards. Further development of this rocket missile was finally halted early in 1945.

Basing its work on the rocket development work done by the Army research station at Peenemuende and in cooperation with that station, the AAA Research Station there developed the "Wasserfall" rocket missile. This project from the start aimed at remote control and at the same time the problem of the proximity fuze and if possible that of a homing nose were to be solved in parallel research projects (Photos 128 and 129). The missile had an overall length of six meters and a largest diameter of 70 centimeters. It had four trapezoid stump wings, and a wing span of 1.92 meters. The steering gear consisted of four fins with large air rudders. Take-off weight was 7,920 pounds, and was to carry an explosive charge of 220 pounds ~~xasxtx xarryxthexmissilx~~ to its target. It was to be fired vertically from an unsupported stand on the starting platform. It was propelled by a liquid-fuel rocket with a centrally placed jet, giving it a thrust of approximately eight tons and a burning duration of 41 seconds. It was to use a fuel of 990 pounds vinyl plus 3,300 pounds Salbei.* The maximum speed achieved was 600 meter/second. After six second of ascent, the missile was

* See p. 364, line 3 from bottom.

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288*289 brought from the vertical and directed towards its target. It broke the sound barrier only after twenty seconds of flight

It was to achieve a peak altitude of roughly 60,000 feet and a radius of action of 35,200 yards. Roughly fifty test missiles of this type were fired by the end of the war. The air bombing of Peenemuende on 16 August 1943 caused only slight interruprion in the Wasserfall missile development project. Planning for the later production of the Wasserfall rocket missile was done already in July 1943, and the firm of Henschel-Flugzeugwerke (Director Oeckl) received instructions to prepare the necessary blueprints and other manufacturing specifications. This shows clearly that in this case the Antiaircraft Artillery had to encroach on the facilities available for aircraft production. This was the main cause for opposition to rocketry development by the C-Office, since that office feared it would lose facilities needed for its own research, development, and manufacturing projects.

In December 1943 plans and preparations for production of the Wasserfall missile provided for a monthly output of 5,000 from December 1944 on. These provisions did not include instruments from the high-frequency electrical instrument manufacturing industry nor the work which would have to be done in preparing the firing sites, since this work was not to be

done by t

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289-290 done by the Henschel Aircraft Factories. The first missile of this type was fi ed in February 1944. However, development of the homing device had not kept pace with that of the rocket missile, and no real progress was made. The radar instrument to be used to control the Wasserfall missile was the Mannheim-Riese model, mentioned previously in the chap er on radar instruments. It had been computed that the construction of one such instrument required approximately 500 manpowers hours of labor, so that it would have been necessary to establish a factory with space for 14000 personnel for a monthly output of 5,000 of the instruments.

In order to obtain uniformity in the whole field of remote control instrumentation and not be faced with special desires for each separate rocket missile development projec it had been established at an early stage, already in September 1943, that all AA rocket missile development project were to be based on one and the same standard steering system. This part of the radio-technical program was handled primarily by the firm of Telefunken. The features required were: target locating, AA missile tracking, steering control of the missile, and possibly also detonation of the explosive charge. The best method appeared to be that of a radio pilot beam, which would have dispensed with the necessity for a device to track the AA missile in flight. However

290-291 this would call for great precision in the pilot beam and a secure possibility to use it to guide a number of rockets simultaneously. This problem at the time seemed impossible to solve, and therefore it was decided to provide for separate target locating and AA missile tracking by means of the coinciding (Deckungsverfahren) method, and a separate romote control system.

b In view of the serious shortages in manpower and materials, it was decided in 1944 to recommend for further development those projects which on the basis of tests appeared to hold out prospects of success and to cease work on all other projects. The AAA Department (Amtsgruppe fuer Flakentwicklung) responsible for the development of AAA equipment therefore recommended that work should continue on development of the following AA rcoket missiles

the Taifun, which required practically no electrical equipment;

the Schmetterling, which, of all guided missiles under development, would be the most economical in production;

the Wasserfall, which held out promise of being a development for air defense well ahead of progress in the development of aircraft

and to drop all other projects in this field in order to be able to gain a better concentration of efforts.

Goering made his decision in October 1944, and it

291 is hard to understand that he did so on the basis of superficial impressions gained at a demonstrations of all missiles under development at Peenemuende. Here again it was to becom evident how dangerous it is to demonstrate equipment before laymen. In stead of the recommended "Schmetterling" the choice fell on the "Enzian" missile. However, no tests at guiding this missile had as yet been carried out, so that its development was still far behind the others, so that thi decision had to be rescinded. This incident naturally delayed progress on the Schmetterling project, and particularl so because it was February 1945 before Goering was prepared to change his decision.

In the meanwhile, however, the firm of Rheinmetall had made considerable progress with its Rheintochter rocket missile. In a series of successful tests, in which the missile was guided by optical sighting, the firm had produced concrete evidence of the usefulness of its weapon. This was an important step forwards and the outcome was that work also continued on the Rheintochter project.

At this stage preparations were accelerated for the manufacture and the tactical use of the Schmetterling missil the one which was the most economical in production. This work was already proceeding at high pressure by March 1945,

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291-292 and plans provided for underground factories to produce 3,000 of these missiles monthly from June 1945 on, an output which was more or less insured. The target area to be defended with the new AA rocket weapons was the Halle-Leune region, for which purpose the production site was also in that area.

The end of the war frustrated these plans. Collapse of the German defenses in the east in the spring of 1945 had already put an end to trial with the Rheintochter missile, which the firm of Rheinmetall-Borsig had been conducting on its own, and shortly thereafter all tests with other AA rocket missiles at the Peenemuende research station also had to cease.

It is evident that none of the projects discussed above could have produced a completely satisfactory final solution. But in Mid-1945 a stage would have been reached at which we could have proceeded to carry out extensive trials in the field with troops handling the new weapons. Unfortunately, the war put an end to all of these experiments and also resulted in the loss of much valuable data.

It seemed clear to me at the time that the first trial with troops would be unsuccessful, since the whole project suffered from a lack of any consistent and calm process of research and manufacturing preparations. Time and again outside agencies had interfered in the research and development processes, and time and again it became necessary to

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292-293 improvize, and that in so diversified and direly important a project, involving so many unexplored areas of research, this was bound to have lasting repercussions. Recognition is nevertheless due to all participants for having created something for which there was no precedent in spite of all hindrances and under the difficult conditions of war.

A point which must be mentioned here is that the Antiaircraft Artillery Arm had to provide the personnel for use of the V-1 projectile. These missiles went into action for the first time on 16 June 1944 against targets in Britain. It was not rocket propelled, as has been generally assumed, but had a technologically simple Argus-type intermittent jet power unit. It had a gyrostat-type stabilizer, a length of 7.75 meters, a wing span of approximately 4.6 meters, two wings, and was launched by a catapult(Photo 130) After reaching its cruising altitude of roughly 3,300 feet, it was turned by preset steering into its target course . From then on it flew on a constant compass course and at a constant speed of approximately 175 meter/second, without radio or radar control, to the point of its descent. The descent was pre-set according to the distance of the target. Its maximum range was 210 miles with an explosive charge of 1,100 pounds. Its low speed and low cruising altitude, due to the low performance of its power unit, and its constant

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293-294 course in a straight line because of its simple steering equipment, naturally facilitated the defense for the British. A total of 8,000 V-1 missiles were fired within 2½ months, but only about 29 percent of them reached their targets. 24 percent were shot down by fighters, 17 percent by AA guns before reaching the target areas. Five percent became entangled in balloon barrages specially set up for the purpose, while 25 percent flew on a wrong course due to faulty starts.

TARGET SIMULATING AIRCRAFT FOR ANTIAIRCRAFT FIRE PRACTICE

It has been mentioned repeatedly in the previous chapters of this study that the means employed for target simulation in the training of German AAA units were extremely inadequate. Use was made of outdated aircraft towing target sacks; in individual cases use was also made, from 1938 on, of the reflected-image pick-up method to familiarize personnel with warlike targets. In 1941 the firm of Argus-Motoren in Berlin constructed a small target practice aircraft. It was propellor driven and could take-off from and land on the ground. A special type radio receiver was built in for remote control. However, it was not possible to make manufacturing facilities available for these aircraft since every person available to the industries producing aircraft and

294-295 and electrical equipment was already occupied beyond normal capacities, so that it was not possible to introduce these target aircraft for use by the antiaircraft artillery.

AAA MAINTENANCE AND REPAIR SHOPS

Already prior to the start of World War II in 1939, the chief of the section responsible for heavy AA guns had repeatedly stressed the necessity for the AAA to have its own repair and maintenance shops and in particular mobile maintenance platoons equipped with workshop trucks and tools and equipment of all required types.

b That preparatory work was done in this field although the troops and the AAA Inspectorate had not yet realized the necessity, is due primarily to Colonel Mertitsch. Particularly in distant and isolated theaters of operations, such as Africa, Norway, and the eastern theater, the motorized maintenance detachments formed rendered excellent services and without their support it would have been impossible to maintain the operability of the troop units. The detachments had all specialized personnel and equipment enabling them to handle even difficult repair and maintenance jobs, independently of stationary workshops, to all items of AAA equipment, including those in the precision mechanics class.

In addition to these motorized AAA Maintenance and

295-296 Repair Platoons, the AAA had stationary workshops at Erlangen, Dirschau, Strassburg, and Kostuchna. Besides their mission of maintenance and repair for units in the field, these workshops also had the mission of making all necessary modifications to existing equipment and generally of supporting the manufacturing industries. How important this work was and the scope it assumed during the war is probably best evident in the fact that in June 1943 a Chief of AAA Maintenance Services (Chef des Flakinstandsetzungswesens) was appointed under the Chief AAA Officer. In October 1943 a post was also created for a separate ~~XXX~~ Chief of AAA Repair Services, whose main responsibility was to control and direct the mobile maintenance and repair units.

CRITIQUE

ANTIAIRCRAFT ARTILLERY PERFORMANCES

This chapter will deal briefly with the constant changes in the antiaircraft artillery necessitated by enemy tactics, and with the results actually achieved by the German antiaircraft artillery forces.

Until well into 1940 the enemy air forces confined their action to attacks during daylight, usually by units not exceeding the size of a flight of three aircraft, against targets of an industrial nature, etc., within Germany. Attacks of this kind practically ceased already during 1940 because

296 of the heavy losses incurred through German fighter and AAA action. From then on attacks were primarily at night and directed primarily against oil refineries, aluminium producing works, and aircraft factories. However, these attacks failed to produce the desired results and therefore already in 1941 numerous attacks were directed against industrial regions and towns with little consideration for the civilian population.

Whereas the German AAA initially had to combat visible targets, it now had to adapt itself to night combat action with searchlight support. But even during daylight the enemy airforces increasingly exploited conditions of poor visibility and cloudy weather at least during their approach flight, thereby precluding effective AAA fire. Strictly residential areas also came increasingly under attack.

The difficult problems which the AAA had to solve have been discussed previously in the chapter on searchlight and sound locating equipment, and there was no improvement prior the the advent of radar, which has also been discussed previously in the chapter on radar equipment. The part played by the AAA field forces in advancing development of these instruments, then still in the testing stages, to a form in which they could be used in the field has also been discussed in that chapter.

Although sizable attacks were already flown in 1941

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296-297 against Hamburg and targets in the Ruhr region, the attacks by approximately 1,000 planes against Cologne and Essen in May 1942 must be regarded as the first real large-scale bombing attacks. When German use of radar was just beginning to make itself felt from mid-1943 on, the entire radar system w was disrupted by the first use of tinfoil interference during a large-scale attack against Hamburg. This not only paralyzed all air intelligence operations but, what was more important for the antiaircraft artillery, it made effective AAA defense completely impossible.

Under these circumstances it was once again the AAA School which took energetic action and was able to introduce measures which at least brought some improvement.

Following the first use of tinfoil, large-scale bombings of the aircraft and ball-bearing factories in Germany continued in the second half of 1943. Of these operations the all-out offensive against Wiener-Neustadt and Schweinfurt deserve special mention here. In view of the heavy losses incurred by the defending German fighter forces, it is safe to assume that the good results obtained in defense against these attacks, in point of enemy planes downed, were achieved equally by fighter action and antiaircraft fire. Strong escort fighter forces made it increasingly difficult by the day for the defending fighters to approach the enemy bomber forces. Of

297-298 the 200 aircraft attacking Schweinfurt on 17 August 1943, 36 were destroyed, and of the 228 aircraft attacking the same city on 15 October 1943 62 were shot down, while only 28 returned to their bases without considerable damage. From December 1943 on daytime attacks with fighter escorts again increased, with ~~simultaneous bomb release~~ simultaneous-release bombing (Bombenteppiche) from altitudes of 26,400 feet and higher. The attacks were flown with such superior fighter escorts, that the German defense fighters were powerless against them. The units had been too seriously depleted in numbers, and in point of technical performances the escorting fighters were at least equal to the German fighter aircraft. However, the German antiaircraft with its fire had driven the enemy to altitudes beyond the range of the vast bulk of its guns, altitudes which could be reached only by such guns as the ~~12H~~ 128-mm and the few Model 41 88-mm guns in service.

From the late summer of 1944 on the enemy air forces, while continuing their daytime bombing, again resorted to large-scale night bombing of worthwhile industrial targets, producing centers and above all traffic targets. Systematically directed bombing attacks increasingly disrupted communications and frequently even brought traffic temporarily to a complete halt. Added to the increasing severity of the attacks came the fact that the quality of AAA personnel was

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298-299 steadily declining. At the start of the war all personnel serving with the AAA units, including those committed within the German interior were regular military personnel who had spent an appreciable time in training. The only branch which had taken on older-age classe and also women auxiliaries soon after the war commenced had been the Aircraft Reporting Service. In 1943, however, it was necessary to resort to the use of factory personnel to man the guns of light AAA units at or in the immediate vicinity of the various industrial works, and these personnel were given only brief training. In the case of flying units committed near the fronts, and this applied particularly to the air reconnaissance squadrons, the unit's own ground personnel had to man the light weapons to provide defense against low-level attacks. The release of AAA personnel for assignment to Army units and to the Air Force Field Divisions /used as infantry forces late in the war Note by Translator/ had also created the necessity to assign students and apprentices who were 16-17 years of age as well as youths from the Reich Labor Service to the gun crews of the heavy AAA units. Hungarian citizens and even captured Russians and Croatians were employed in the AAA, initially only to handle ammunition and for other auxiliary services, but under the stress of circumstances very soon also even at handling the gun-laying mechanisms. Units within Germany

299 soon had only 10 percent fully qualified regular military personnel in their gun crews. As will be confirmed by quotations which follow later from enemy reports, the German AAA nevertheless continued to perform well in action. That this was possible under the conditions described above proves that personnel of all ranks and in all assignments fulfilled their duty to the last.

The enemy air forces continuously ~~EKangaN~~ shifted their attack from target to target, and the measure enforced by Speer with support from Hitler under which a large percentage of the AAA guns had been permanently emplaced now produced devastating results, since really effective air defense action always came too late.

From AAA operations ~~atxPalar~~ during German evacuation of Sicily--the fire canopy of Palermo--it had been realized that it actually was possible to provide absolutely effective AA defense by the massing of AAA units. At Sicily the enemy had been unable to take destructive action. Two AAA brigades comprising probably six AAA regiments and thus approximately fifty heavy and just as many light ~~gun~~ batteries, plus a searchlight regiment, had been committed to provide the AAA fire canopy at Palermo, and not a single enemy bombing attack had succeeded in making an effective penetration through this canopy of fire. The crossing from Sicily to the mainland was

299-300 carried out without loss due to enemy air action.

For the same purpose, strong AAA forces were now concentrated in the autumn of 1944 to protect the fuel producing industries, against which the enemy were increasing their offensive operations. For example, as many as 600 heavy AAA guns were committed to protect the works at Poelitz, near Stettin, in 1945, while as many as 700 were committed at the Leuna Works, near Halle, and even 800 to protect the works at Heidebreck in Upper Silesia. These commitments were almost all in the form of super-batteries of at least twelve and in some cases even twentyfour guns, since this insured a better concentration of fire. These units relied primarily on radar for target locating and fire control. In addition, however, they always had searchlight support, since the possibility of serious interference with the radar operations still existed, and since optical direction, both for traverse and for elevation movement was always superior to control by radar. Mention has been made previously of the plans for the commitment of AA rocket weapons to defend the Leuna Works from mid-1945 on.

From mid-1944 on, particularly in the rear zones of the front but also extending far into the German interior, enemy low-level air attacks assumed considerable proportions on a steadily mounting scale. These were directed primarily

300-301 for the time being against troop movements and traffic installations of all types, but later, namely at the beginning of 1945, increasingly also against civilians and even against individual persons.

Also in an increasing measure, low-level attacks were flown against XXXXXX AAA battery positions to hamper their fire action against bombers attacking at high altitudes at the same time. These low-level attacks, which frequently occurred very shortly before the coordinated high-altitude bombing attack, compelled heavy AAA batteries to resort to close range fire, as had also happened in the front areas. For this purpose the guns were not pointed unilaterally but pointed to form an all-round defense position, all guns pointing outward from the center of the battery position. Elevation was approximately 20° and ammunition with fuzes set at approximately 550 yards was held at the guns ready for immediate use. This was the only possibility to be ready at all times to open fire with at least one gun in the event of a sudden low-level air attack from an unexpected direction. In such cases fire was released immediately against the low-level attack aircraft, using a lead factor computed from experience. Although few planes were actually shot down in this way, the action did have a repelling effect on enemy air units and supported morale in the AAA unit concerned. Unit personnel

301-302 did not have to watch idly while their own position was under attack or while nearby targets were destroyed by such low-level attacks.

The immense and increasing significance attached to AAA defense is probably best illustrated by comparative figures on the batteries in service at separate times, as shown hereunder:

Year	Batteries in Service	
	Heavy Gun Batteries	Light Gun Batteries
1939	650	560
1940	791	686
1941	967	752
1942	1,148	892
1943	2,132	1,460
1944	2,655	1,612

Soon after the beginning of 1945 the numbers of batteries in service decreased considerably. This was due partly to losses through enemy action at the fronts in ground action but also due to the fact that so many guns were permanently emplaced in the territories evacuated in the western and eastern theaters. It was not possible to compensate for these losses by corresponding replacements from stocks and from current output.

Mention must still be made here of the desperate commitment of AAA forces in the Oder River line, where they were to change the course of the operations with 500

302-303 gun batteries. What these batteries were really expected to achieve is a problem. Most of them had guns without shields, without adequate means of mobility, and even without adequate supplies of ammunition. Hardly 5 percent of the personnel were regular military personnel, and the vast majority of them lacked even the basic training required for such an assignment. All that this operation did was to weaken the German air defenses and serve as the grave for large numbers of brave AAA soldiers as well as the grave for the entire German Antiaircraft Artillery.

Finally, a review is being offered below of the actual results achieved by the German Antiaircraft Artillery. Unfortunately, no records are available for a compilation of all losses inflicted on the enemy by antiaircraft fire, so that the review has to be restricted to specific zones of operations.

In a single month, May 1940, the units of one AAA corps in the western theater shot down 179 aircraft. In addition, AAA units of the corps destroyed 14 bunker positions, 19 tanks, 1 destroyer, and 1 outpost boat.

In the 1 September 1939 to 1 November 1940 period antiaircraft artillery units shot down 5,381 aircraft, and destroyed 1,930 tanks and 1287 bunkers.

By 31 December 1942 the Antiaircraft Artillery was

303-304 officially credited with having shot down 8, 706 enemy aircraft at an expenditure on the average per aircraft of 5,000 rounds of light and 3,500 rounds of heavy ammunition.

In 1944 one AAA division in the eastern theater alone was able to report having shot down 265 enemy aircraft and de-stroyed 189 tanks in a single month.

The following figures show the number of aircraft shot down by antiaircraft fire in 1944 plus January and February 1945:

Theater of Operations	Aircraft shot down in 1944	Jan 1945	Feb 1945
Western	3,815	218	182
Home Air Defense	2,570	135	350
Southern	1,808	111	115
Eastern	3,438	236	207
Northern	30	-	5
Total number of aircraft shot down by German AAA units	11,661	700	859
Compared with numbers shot down by German fighters during the same period	18,866	1,229	804

According to one compilation the ammunition expenditure per aircraft shot down in November/December 1953 averaged

approximately 6,500 light caliber rounds
" 4,000 heavy caliber rounds.

Besides the above figures taken from German sources, the following information from American reports is illuminating.

According to those reports American aircraft losses were as follows:

THIS PAGE DECLASSIFIED IAW EO12958

304-305

Period	Aircraft Losses Due to German AA Fire	Aircraft Losses Due to German Fighter Action
August-September 1942	5	26
Year 1943	233	676
January-April 1944	379	741
May-June 1944	286	239

The above figures clearly reveal an ascending tendency for the antiaircraft artillery, while losses due to German fighter aircraft show a decided drop in the last period, which was due to the heavy losses the German fighter arm had sustained. This in turn reveals clearly that the significance of the antiaircraft artillery mounts commensurately with a decline in the effectiveness of the fighter defenses.

During the same periods the following numbers of American bombers were damaged by German antiaircraft fire/or fighters but succeeded in reaching Allied territories, so that they were not reported by the German AAA as shot down:

Period	US Bombers damaged by German AA fire	US Bombers damaged by German Fighters
August-December 1942	115	106
Year 1943	4,577	1,950
January-April 1944	8,847	948
May-June 1944	7,920	269

Here again the figures for the antiaircraft artillery show a steadily rising tendency throughout, a factor which the enemy could not afford to overlook. For this reason the Allies assigned special AAA Analysis Officers, whose sole mission was to gather experience data on antiaircraft artillery

306 operations and instruct Allied flying personnel accordingly. Special instructions were worked out, designed to reduce the effectiveness of German antiaircraft fire. These instructions established:

a. How evasive maneuvers were to be carried out;

b. What one should do if flying on a course which corssed over AAAdefsense zones if unable to take advantage of cloud cover or if suddenly exposed to observation by the antiaircraft artillery through a sudden opening in the cloud cover;

c. How to take effective air action with demolition and/or fragmentation bombs against AAAforces, and/or how to attack AAA units with weapons fire and bombs.

A simultaneous and coordinated attack with weapons fire is the only way to create conditions for a bombing attack against AAA units by bombers from otherwise untenable altitudes. In ~~coordinated weapons fire and~~ bombing attacks agains AAA positions without a simultaneous weapons-fire attack, 3.5 percent of the bombers participating were shot down and 57 percent were damaged. In a coordinated wepons-fire and bombing attack against the same targets only one battery, which came under weapons fire too late, succeeded in damaging a number of the attacking aircraft. Emphasis was also placed on fire action by the ground artillery against antiaircraft artillery battery positions. Furthermore, as soon as German fighter defense action was more or less eliminated, the entire

306-307 attacking force regrouped to reduce the effectiveness of German AA fire.

The US Air Force states that it was only due to the adoption of these measures that it was able to reduce its losses due to AA fire. Out of 1,000 bombers operating over German-held territories, the Air Force states, only four were shot down while 117 were damaged by German AA fire but succeeded in returning to their home bases. The heaviest losses were sustained by enemy airforces while bombing from intermediate altitudes during weather permitting observation from the ground. Particularly heavy were the losses suffered in dive-bombing attacks by fire of the German light caliber AA guns. According to the Ninth US Air Force, almost 50 percent of its aircraft losses and practically all aircraft damages during operations over Europe in 1944-45 were due to AA fire. AA fire inflicted 49.6 of all aircraft losses and 92.9 percent of all damages. The Ninth US Air Force admits that its chief opponent was the German AAA, which from May/June 1944 on shot down even more planes than the defending German fighters. The report by the Ninth US Air Force thus confirms the finding stated above.

The American reports also state that throughout the war approximately 24 percent of all bombers participating in any operation returned in a damaged condition. During

THIS PAGE DECLASSIFIED IAW EO12958

306-307 1944 the number of bombers returning from missions in a damaged condition due to AA fire averaged between 3,360 and 4,453.per month.

All of these figures serve to prove that antiaircraft fire remained of great significance and value right up to the end of the war, and that the German AAA was just as successful and effective in action against airborne targets as in action against ground targets.

2.

THE MILITARY-TECHNICAL BRANCHES
(Weapons & Equipment Branch 10; Air Ministry/Air Division/XX Branch E(AAA); Special Supply and Procurement Service/Branch E(AAA)+Chief,Technical Air Armament/Branch E (AAA)).
AND THEIR AAA RESPONSIBILITIES DURING THE WAR FROM 1939-1945

The first object in this chapter will be to show the difference between a thoroughly prepared and carefully considered davelopment under peace conditions and the accelerated handling of developments necessitated by the exigencies of war.

During times of peace the first step was to establish all ~~xxxditions~~ fundamental conditions of the problem from the stated effect required on the target. In the case of gun construction the first stage was thus to develop the ammunition and the gun barrel, in order on that basis to develop the necessary gun.which would meet the specifications of the problem. In stating the requirements it is essential to ~~state~~

307-308 specify the desired effect (penetration, angle of impact, firing accuracy coefficient, blast effect, etc) and at what distances these effects are to be achieved. From these specifications result the caliber, the missile type, muzzle velocity, and the necessary spin. If requirements are overstated in the specifications, it must be borne in mind that the disproportionate increase in weight will be accordingly. Development of the gun should always be preceded by a thorough testing of the barrel and ammunition to be used, a point of particular significance in the case of automatic weapons since these fundamental factors determine the functioning of the ultimate weapon. Later modifications in the shell length, the weight and/or length of the missile, etc., will not be possible. If such changes should become necessary, and entirely new weapon will have to be developed. In stating the specifications it is also essential to establish whether one loading method will be sufficient, as was the case in the anti aircraft artillery guns, or whether various loading methods are required to solve the problems involved.

Development of the suitable gun barrel and ammunition is followed by the designing of the mount with all details. A carefully and logically thought out construction of this type naturally takes time for completion, but when properly designed will have the inherent quality of reliability insuring

308-309 successful use. The more thorough the work done preparatory to the awarding of the designing and development contracts, the more satisfactory will be the final product. In most cases new development projects originated in ideas stemming from front line experience. These were formulated by the General Staff or the appropriate arms inspectorate and turned over to the technical proving branches for effectuation. In many cases the arms inspectorate concerned insisted that it alone should assign development projects or that such projects should at least first be submitted for its approval. This was a mistaken view. In many instances the idea for new development projects evolved from the constant cooperation between the industries and the military-technical offices, for which reason these military-technical agencies should be staffed with technologically qualified officers. Such officers with their front experience on the one hand and their continuous contact with the appropriate industries on the other hand were in particular the bearers of new developments. For this reason they had to have the privilege of assuming responsibility for development work which possibly had not evolved in the General Staff or the arms inspectorates.

Development projects required by military authorities had first to be discussed in great detail with those authorities before a clearly formulated contract could be awarded to the

309-310 appropriate industrial concerns, after very detailed discussions between representatives from those industries and from the military-technical offices. This often required repeated conferences before the designing and constructional specifications could be formulated. Where these preliminaries were neglected, the article ultimately produced generally needed so many fundamental changes that it would have proved better to start again from the beginning. Unfortunately this was often not realized and the outcome was that improvements and modifications were constantly necessary.

Once the contracts were awarded the military-technical agencies had to exercise constant supervision over the designing and constructional work. This was necessarily in order to insure the avoidance of particularly high-quality materials or special types of tooling machinery in the manufacturing processes, which could not provided in sufficient quantities during war, so that the necessary output of the item under development could then not be produced. Firms were only too apt to assume that they could take their own machinery as the basis on which they could work, a view which was acceptable during peacetime, since the designing firm usually also received the contract to manufacture the finished article. In the event of war, however, it would be necessary to make use also of smaller firms not so well equipped with machinery, 310-311 and allowances had to be made for this eventuality already during the peacetime manufacturing processes. Had this not been done it would have been necessary in the event of a war to redesign the items accordingly, and the spare parts then manufactured would not have fitted properly into the items produced prior to the war.

Once the blueprints were completed, the first trial models were constructed, and then followed a period of testing at the appropriate proving stations. Only after these tests showed reliably satisfactory results could arrangements be made to place the first serial, the Zero Series, in production The articles from this series were assigned to units in the field for extended tests with troops. Then it was possible to place the article in mass production, provided the trials with troops had not revealed any necessity for modifications, partial redesigning, or the designing of a completely new article

From the above description of the evolution of an item of military equipment it is obvious that a number of years passed before a stage was reached where it could be placed in the hands of the troops for field use. For this reason a very early start must be made with the necessary preparatory work, which can only proceed with a knowledge of all possibilities of modern technology. This preparatory work must start already at a time prior to that at which the demand could arise

311-312 in field units. Even a general staff or the arms inspectorates, which cannot maintain such constant close contact with the industries are in no position to recognize the necessity for and to call for development work at such an early stage. For this purpose it is essential to have field officers with vision and technical aptitudes for such problems, and not to leave the matter to the industries or even to technologists not having constant direct contact with troops.

Preliminary work of the kind discussed above must be carried out quietly, logically and uninfluenced by any sense of haste or urgency. This is the basic condition for success, which will be all the more marked the more thoroughly everything is first considered and tried out.

If the peacetime development and the advance work have been carried out properly, there will be no need for adaptations if a war should break out. However, research should continue without interruption to avoid the possible enemy gaining any advantage.

Research work of this kind can be interrupted by an order imposing a stop on all research and development projects not intended for completion within two years. This is a simple matter, but it is an irresponsible act which will produce fateful consequences, as events in the war were to prove.

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312 In the event of war, the development projects currently in process must naturally be accelerated. This makes it necessary, within certain limits to depart from the peacetime method of carefully considered research and development progressing step by step. To accelerate work to the stage where the usability or otherwise of the article under field conditions can be proved the peacetime principle of first producing one trial model will beabandoned; instead it will be ~~xxxxxxxx~~ possible and also necessary to produce a whole trial series, in order to try out the manufacturing processes and try out the item of equipment on a wider basis by its use in field units. This method was adopted in Germany, for example, with radar instruments. While the above work is in process, parallel work must proceed on preparations for mass production, so that the most modern equipment will reach the troops as speedily as possible.

In the case of a war of long duration, however, the time will arrive when peacetime plans and preparations will no longer suffice, and when own experience or technological development in hostile countries will create new requirements. Frequently, the industries will not be prepared or equipped to handle such new projects and must be compelled to find a quick solution. In such cases extreme care must be exercised to insure that all experience and requirements of the troops are incorporated and taken into consideration. For this reason, cooperation by

312-313 the field forces is desirable and should be required. For this reason regular officers should be placed in charge of development projects, officers with the closest possible contact with the front, and for this reason it is not advisable to place professional engineering personnel in charge. The only way to insure speed and success in the work of development is to maintain close contact between the industries and the front.

It will often become necessary to place items of equipment in the hands of troops for trial under front conditions before the work of develppment is completed. In such cases it is essential that the troops be made to understand this necessity. Time and again it became evident how reluctant troops in the field are to accept innovations. The more thoroughly they have been trained during peace in the handling of a certain item of equipment, the more reluctant they will be to part with that item and acknowledge an improvement in a newly introduced item. What has been taught in peacetime training is hard to uproot even in the realization that better results can be obtained with other methods. This experience I am emphasizing in such detail here because I consider it essential to learn from that experience in order to avoid repeating the errors of the past. The problems involved here are not confined to newly developed guns, but apply to all new developments.

It has been shown previously, in the chapter on Weapons

313-314 and Equipment Proving and AAA Development that the responsible branch (Weapons and Equipment Proving Branch 10) had to be established at the time when the antiaircraft artillery as such was also being reestablished. Since 1918 Germany had not been allowed to have any antiaircraft artillery, and only very few officers from the former service were still available and in service. There were thus practically no officers with AAA field experience available for assignment to organize the new branch which would handle technical development problems for the new force. But even at the beginning the war, or later when the younger generation of officers had gained their first wartime experience, nothing was done to improve the development branch by assigning it officers with front line experience. The Personnel Office and also the AAA inspectorate evinced no interest whatever. Right up to 1942 almost all officers and technologists who had formed the original staff at establishment of Branch 10 remained in their posts. The brief assignments they served with the AAA in the field during maneuvers naturally could not provide the knowledge necessary for proper development work, particularly since the majority of the personnel concerned had not served formerly in any AAA unit.

Due to the above circumstances, the technological staff members endeavored increasingly to assume control. Since the develop-

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314-315 development office and its whole set-up had been taken over from the Army, the Army type of organization had also been applied, with control of all development work exercised by regular officers. These officers either had received specialized training in studies or special courses, or they had grown into their subjects through years of service as assistants and later as section chiefs. The situation was similar in the Navy, where the technological officers were assigned also under regular naval officers. In the Air Force development branch within the C-Office matters were different. There also, there was a lack of regular officers qualified to direct and control development work, for which reason all development work there was controlled almost exclusively by technologists. The disadvantages of this szstem became evident in the fact that after a new item of equipment was completed the troops, which only then came into contact with it, submitted requests for alterations which could not be made, so that something new had to be designed or, and this was more generally the case, the technical performances of the aircraft were reduced. This was probably also the reason why there was no real mass production in the aircraft industry, because the individual types of aircraft were constantly being changed.

In my opinion the above is the clearest evidence of the devastating effects of not having insured military control in

315-316 in the technical field from the very outset.

The staff in the AAA development branch naturally would have liked to emulate the example of the C-Office, and it was only the firm resistance by General Mertitsch and his successor in office, General von Renz, which averted this.

After the death of General Becker, the clearly defined assignment of Weapons And Equipment Proving Branch 10 under the Army Ordnance Office was relaxed. The branch was redesignated Reich Air Ministry/Air Division/Branch E (AAA). In addition, a procurement agency was established, designated Procurement Branch Reich Air Ministry/AAA Armaments, which had the mission of supervising the manufacturing contracts handled by the Procurement Branch of the Ordnance Office and seeing that they were fulfilled.

Shortly before this, Munitions Ministry Todt had also been established. This was a measure recommended to Hitler by General Becker of the Army Ordnance Office because he knew from experience in World War I from 1914-18 and from the parallel efforts of the Army, Navy, and Air Force that a consolidation in this field was a definite necessity during war. This consolidation was to be under military control, and this had been agreed upon between Hitler and General Becker, but without any warning Todt was placed in control. There was talk at the time of "Self-Responsibility of the Industry," 316-317 "Cont ol of Industries," slogans similar to those which were so popular with the organizations of the National Socialist Party. This measure was probably due partly to influence exerted by the National Socialist Party and certain industrial circles, and was probably the cause for General Beck's suicide.

A top-level coordinating agency of this kind was absolutely essential since there was unfortunately no unified military-technical office in existence. However, since the Air Force Office under Goering/Milch refused to be placed under Speer's Ministry the new arrangement was also only a semi-solution and unsatisfactory. To place control under the industries and to staff the new offices with National Socialist Party members or personnel from the industries was not a sound solution. Industrial concerns released for such assignments only personnel who did not perform satisfactorily, or personnel whom they could rely upon to further their interests. These personnel were thus not free in their action but were dependent on the industrial concerns from which they came. This was a fact which the industries themselves later themselves ~~stated~~, for which reason they frequently voiced the desire for a military control. However, by then it was too late for such a change, which all National Socialist Party personnel on the staffs opposed, since there was already some friction between the Party and the military. This is obvious from notes on a conference between Hitler and Speer

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316-317 in February 1943, to the effect that the staff of the Army Ordnance Office could be reduced by one-third and that Unruh was to take action in this direction--and this at a time when the Todt/Speer Ministry was steadily expanding.

In 1942 General von Axthelm had taken over the AAA Arms Inspectorate from General Steudemann and in cooperation with Branch 6 of the General Staff had compiled a new development program. ~~The the~~ At the same time the General Staff, Branch 6 had severely criticized the Development Office, accusing it of having neglected important developments for the future. This was probably the cause for the removal from office of ~~Branch chief~~ General Mertitsch, who had rendered such excellent services while at the head of the branch. General Mertitsch had come originally from the section for development of heavy AAA guns and even while in office as departmental chief had continued to exercise a major influence in that field. His name will always be remembered when talk turns on the 88-model 36, the 128--mm Model 40 and particularly the 88-mm Model 41 AA guns. It was by no means his fault that he had not had a front assignment since 1929 but had been retained constantly in the Army Ordnance Office occupied with development problems and had finally been assigned ~~him~~ the mission of organizing the new branch for AAA developments. What makes this an all the more serious mistake on the part of the Personnel Office

THIS PAGE DECLASSIFIED IAW EO12958

317-318 is the fact that Mentitsch had not been in the AAA but in the foot artillery and had only commanded XXXAX motor-truck carried battery after 1918. He was therefore in no position to understand the needs of the AAA from personal experience, nor the coordinated functioning of the various items of equipment, such as the fire control director, the guns, radar instruments, and so forth. When he was to receive an assignment in command of an AAA division, his first assignment with troops after thirteen years, he did not feel qualified for the post. After transferring his office responsibilities to me, General von Renz, as his successor, and the moment he was relieved of his heavy responsibilities, the tension which until then had apparently upheld him, relaxed and he had a complete breakdown. He became very seriously ill and had to undergo an operation for intestinal cancer. Barely allowing himself time for full recovery, he reported again for duty. Being found unfit for field servic he was appointed by Speer's Ministry as an inspector of armamen industries. Before the war was over he succumbed to his grievous ailment and died.

My first concern in my new post was to find new officers to handle the problems of developments for the AAA. No technical training had been given since the start of the war. Officers who had received technological training were practically all in my own seniority bracketor were serving in Air Force

318-319 General Staff assignments, where they were allegedly irreplaceable and could not be released for assignment in their proper field, technology.

Four weeks previously a Colonel Loehr had been transferred from the field forces to take over the branch handling the development of AA guns, Branch 4. Colonel Loehr did not feel qualified for this assignment and repeatedly requested me to transfer him back to service with troops. Before long I had to agree that he really was not suitable for his assignment and had to request the Personnel Office and the AAA INspectorate to fulfill his wish and assign him to the field.

The question now arose as to who was to replace Colonel Loehr. Regular officers with the appropriate qualifications were either not to be found or their release from their current assignments was refused. The Personnel Office was thus so short-sighted in its policies that it had made no provisions whatever for the eminently important mission of weapons development.

Finally a Dolonel Gronow was assigned to fill the post. He had a satisfactory record with troops and had formerly worked a lot with industries, in which circles his qualities were recognized. His appointment proved a good choice, since he showed himself capable of working together with industry and with Spper's Ministry and was able to apply his field experienc

319-320 to good purpose. However, Colonel Gronow was an officer of the Reserve, and in the long run it would naturally have been wrong to assign a reserve officer in this post, since he would not have remained in military service and the problem of findin a replacement would have arisen once more.

Chief of the Branch handling optical and surveying instruments, as well as searchlights, was a Colonel Deutsch. He was a university trained officer and therefore had the necessary qualifications for his post. However, he had already served in this assignment for five years, after only a very short assignment in command of an AAA battery immediately after concluding his studies. He was due for promotion in the near future, but could not be promoted unless his record showed service with troops. This compelled me to apply for an assignment with troops for him. After a long search Colonel Schuerman was selected to replace him. Colonel Schuermann had a very excellent record for his performances in the night-fighter arm and also h had experience in searchlights, coordinated radar AA unit action and troop needs in the fields involved. However, the field forces refused to release this officer for the assignment. It took roughly four months for the Chief AAA Officer and the Personnel Office to secure his release, and early in 1943 he was able to commence familiarizing himself with his new field of responsibilities.

319-320 Branch 3 (a staff of engineering personnel who prepared the technical data for manufacturing, etc.)was under Major General of Engineers (Generalingenieur) Graf von Bouillon. He was overworked and his efforts were directed towards a gradual elimination of military control and introduction of the control by the engineer corps in vogue in the C-Office. His work also did not meet with the approval of Field Marshal Milch or AAA Arms Inspector General von Axthelm. I therefore requested his removal, which proved a very difficult matter because the Air Force Engineer Corps, and in particular the staff of the C-Office opposed it bitterly and did everything possible to keep him in his post. After his departure the branch was not again placed under an Engineer Corps officer but under military control by Lieutenant Colonel Marjez,whom I assigned a capable young engineer as assistant.

Finally, mention must be made of the chief of the branch handling ballistics and ammunition. This was a retired officer recalled to service, General Steinkopf-Hartig. He was just about due to be pensioned, so that I also had to find a replacement for him. This was a post which could only be filled by a person with the necessary high qualification, and such officers were hard to find. A good field officer could not possibly have filled this post without the necessary specialized training. I therefore assigned an officer with a good record

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320-321 in the department, where he had at least been able to familiarize himself with the fundamental knowledge required in his new post.

From these difficulties encountered in finding replacements for assignment to the important posts in the development department, the Personnel Office and the AAA Arms Inspectorate also realized that something had to be done to insure later replacements to handle this important work for the AAA. My suggestion that young field officers with a wide experience in service with troops and an understanding for technical matters should be assigned to the AAA development department as assistants received approval and was followed. It was obvious that this measure would not produce results before three or four years had passed, but a beginning had to be made if the industry was not to be allowed a free run in deciding what the troops would have to accept. Twelve regular officers, 1st lieutenants or junior captains, were therefore assigned to the department for familiarization and to prepare themselves for such work. At the same time, however, they were to apply their front line experience to the development projects currently in process and were to participate in those projects. This was no easy matter since the Engineer Corps staff members were unwilling to accept these youthful officers and to teach them what they had to learn.

Since the majority of the section chiefs and sub-section

321-322 chiefs also had little experience in service with troops, the assignment of these young officers to act as their assistants was also an urgent necessity, and it was irresponsible of the Personnel Office and the AAA Arms Inspectorate not to have acted accordingly much earlier. The Development Office itself had stated this requirement repeatedly but had been put off and told that the necessary steps would be taken later.

It was practically impossible to find replacements for the section and sub-section chiefs whenever this became necessary. The younger officers who had now just commenced their assignments in the department would only be ready in about two to three years, and no other suitable officers were available for the purpose. This made it necessary to appoint ordnance officers, particularly for the handling of ammunition affairs, whenever there was a vacancy. These officers at least had a thorough technical trainingbut unfortunately practically no front experience, since they had in the past had practically no service with troops but had served in ammunition depots, etc., or on the staffs of higher level commands. Those who had served with troops had also not been with the combat elements but on battalion or regiment level staffs, where they had administrative missions of were employed at testing equipment. The only contact they had thus had with troops, was when the troops could no longer help themselves in removing equipment failures etc.

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322-323 The troops themselves had no real respect for this type of work and regarded these officers more or less as auxiliaries who were to relieve them of the bruden of looking after their weapons in too great detail.

These circumstances influenced the Chief AAA Officer, in cooperation with the Department Chief, Special Supply an Procurement Service/Branch E (AAA), to stop the assignment of ordnance officers to field units and require of each unit officer that he should himself undergo training which would enabl him to assist the troops under his command in removing difficulties with their weapons. The plan, which was effectuated shortly before the end of the war, was to transfer the ordnance officers to the regular tactical officer corps after they had passed certain tests proving their suitability for such service. Only very few of them failed in these tests, and only one case is known to me personally.

The ordnance officers had received very good technical training. Prior to 1928 thy had been nothing but administrative officers handling the administration of weapons and equipment, and supervising gun tests and the manufacture of ammunition. This condition had changed and these officers now had been required to pass a scientific-technological test following a cours of study at a higher level technical training institution. They had received training as mechanical engineers and in the

323 subjects of weapons technology in courses lasting two years at military artificer shhools. The subjects taught included mathematics, physics, mechanics, ballistics, optics, acoutics, chemistry, and electro-engineering. Since 1933 the certificate awarded upon passing the examination was fully recognized and served as qualification for employment in the higher levels of the technical civil service. Cadidates passing the examination with good marks at the artificer schools and in possession of a matriculation certificate, or who proved themselves suitable in a special course, were then given final training as ordnance officers in a course lasting three months. A better or more thorough course of training is hardly conceivable, and it was completely unjustifiable not to employ these officers in independent and responsible assignments.

The major mission of officers in this category was to direct the various ammunition depots and dumps and the maintenance and repair workshops of all types. However, they were also indispensable as experts and advisors and consultants on the various tactical staffs. In the technical weapons and equipment development agencies they had already found employment as artificer specialists and their industry and superb qualifications made them indispensable assets in these agencies.

In view of what has been said above it was a perfectly logicak step to give these officers full recognition and to employ

323-324 them as experts and section and sub-section chiefs in a status equal to that of tactical officers, as was done in the AAA development department from mid 1943 on. If this solution had not been adopted it would have been impossible for the department to accomplish its missions or to close the gap in available tactical officers with technical training.

It has been mentioned previously that the Air Force Technological Academy had ceased operations already in 1938, so that from then on no officers had received appropriate training in this field. However, during the war it had become necessary to institute a new course of technological training for flying officers in the Air Force. Following the pattern of the Navy, plans provided for a course of Technological Officer Training from the end of 1942 on. Once again the battle started for full recognition to be accorded to officers thus trained. On 20 May 1945 a recommendation was submitted to give the Technological-Officer career recognition as a Technological-General-Staff Officer career. Unfortunately this was not enforced so that only very few officers were willing to enter this career. Only two of these courses were conducted before the war ended, one starting on 1 January and the other on 1 August 1944. Unfortunately, however, the Antiaircraft Artillery was completely forgotten and overlooked in the process, being considered merely as "an adjunct" of the Air Force.

324-325 This subject has been treated in such great detail here, because what has been related shows that in the future things cannot continue in this way. Unfortunately, however, it is a source of serious concern to me when I see how tactics and technology are again being treated as two completely divorced and separate careers under present conditions.

Whereas the AAA development department in 1942 was not merely a lodger unit of but was also functionally under the control of the Army Ordnance Office and at the same time was responsible to the Chief of Special Supply and Procurement, Air Force, this condition was changed in June 1942 in that the department was placed directly under the Chief of Air Force Special Supply and Procurement and under the Air Force C-Office, and was redesignated as Special Supply and Procurement/Branch E (AAA) (GL/Flak E). The object was that the Air Force was to have a stronger feeling of coresponsibility for air defense matters than had been the case in the past; another purpose was to remove the rivalry between the two branches of air defense, defense by air action and defense by ground fire. However, the responsibility for weapons and ammunition procurement remained with the Army Ordnance Office, so that the need continued for very close cooperation with that Office. Deliveries were also still accepted by the acceptance branches of the Army Ordnance Office and not by the

325-326 Construction Supervision Branch (Bauaufsicht) of the Air Ministry. In the case of AA rocket missiles and radar equipment, however, delivery was accepted through the Air Ministry. Branch E (AAA) thus had constantly to deal with these two authorities, and had continuously to negotiate with them and press for fulfillment of its stated requirements.

Accordingly, the first AAA conference took place in August 1942, presided over by Field Marshal Milch. Conferences of this type on matters of the flying branch of the Air Force usually occurred once weekly. The Chief AAA Officer now also demanded this for AAA affairs. However, the impression was always that these conferences were treated as a matter of secondary importance.by the Chief of Air Force Special Supply and Procurement Service. Accordingly, they were held only once monthly. Even after responsibility for the development of AA rocket missiles was transferred to Branch E (AAA), where it was given a status of special importance by establishment of the special branch under Major Halder, there was no increase in the interest shown by the Chief of Air Force Special Supply and Procurement Service. On all occasions we had to force ourselves on his notice with our requests, and were then usually turned away, while the flying branch received constant support. Since we had to depend on the raw materials allocations to the Air Force for our projects, however, it was essential for the Chief of Special Supply

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325-326 and Procurement Service to be brought to understand and recognize our interests, since this was the only in which to obtain supplies of the required raw materials.

When in January 1944 General (Generaloberst) Weise received instructions to consolidate the two branches, Branch E (AAA) and the AAA Armaments Branch, the Chief of Special Supply and Procurement Service took this opportunity to transfer the burden to him.

In contrast, it is necessary here to emphasize the very close cooperation which existed between the Chief AAA Officer and the AAA Development Department (Branch E). Conferences took place at least once each fortnight and served for mutual orientation and discussion in which many points were clarified without the necessity for lengthy and voluminous correspondence. These conferences were a great relief for me, since they dispensed with the need to report directly to Goering, which usually took up much time and were often distinctly unpleasant.

General von Axthelm, as Chief AAA Officer, maintained the viewpoint that nothing should be done by Branch E without his knowledge, so that was probably his desire to hear everything at these conferneces and to insure that he was properly oriented on everything. This was immaterial to me, since the decisively important point was not who furnished the impulse to some advance; the only thing of importance was that we made progress and that

326-327 we were able at all times to serve the interests of the troops by supplying them with what they needed as speedily as possible.

In September 1944 the removal of Field Marshal Milch from his post as Chief of Special Supply and Procurement Srevice created an entirely new situation. Both General Weise and Lieutenant General Von Renz were superior in rank to the newly appointed Chief, Colonel Diesing, who succeeded Field Marshal Milch, and therefore also had to be transferred. Their replacement naturally again created problems, since neither the Personnel Office nor the Chief AAA Officer had made any provisions for such a contingency. All of my efforts in this matter had remained fruitless in the past. The result was that a very poor replacement was found in the person of Colonel Knublauch, who admittedly had served as chief of staff to General Weise since February 1944 but who completely lack the necessary background. However, the war ended before this change could produce any effects, and even in the meantime the destruction caused by enemy bombings created conditions in which little could be done to promote or retard the development of equipment for the AAA.

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CHAPTER FIVE

FUTURE ASPECTS

1.

THE AAA DEVELOPMENT PROGRAM FOR 1942 AND STATUS OF DEVELOPMENT PROJECTS IN 1945

The AAA Development Program for 1942 (Appendix 3) provided the basis for all development work until the end of the war. Important parts of the program were fulfilled, but large parts could not be brought to completion. This was due primarily to constant illogical interference by higher headquarters, but also in part to the fact that the specifications were too high, making no allowance for the circumstance that many of the research projects which were to form the basis for the work of development had not yet been concluded.

The present chapter will give a brief summary of which points of the 1942 program were fulfilled and which were destined to remain merely wishful thinking.

Efforts to improve the range performances of guns failed not because of any inability to bring about the appropriate improvement in gun barrels and/or ammunition, but purely and simply because the manufacturing facilities for the production of low-calory powders were inadequate. In point of structure, the 88-mm Model 36 AA gun was quite capable of performances equal

328-329 to those of the 88-mm Model 41 AA gun. The problem of inserting an 88-mm Model 41 AA gun tube into the barrel of the 105-mm gun was also solved, which would have insured the range performances of the 88-mm Model 41 AA gun, and was ready to go into production. The only trouble was the lack of the proper ammunition and this was due to the lack of the necessary propellant powder. Plans for the range performance improvement of the 125-mm AA gun were also ready for manufacturing. The solution of giving it a caliber of 105-mm was not satisfactory, since this would have reduced the effect of the shell on target. However, an increased muzzle velocity and use of the naval type of conical lug would have produced the desired improvement in range capability. Unfortunately this solution could not be effectuated because of insufficient manufacturing facilities.

The problem of sub-caliber missiles and the possibility to use fin-stabilized missiles was already out of the testing stage and ready to enter the stage of extended trials with troops, but here again the manufacturing facilities were inadequate, since all factories were already employed to full capacity in the current production of the types of ammunition already in use. The specified multiple mount for 37-mm AAA guns had been produced in the 37-mm double-barrel mount Model 43.

329-330 Plans to develop super-caliber AA guns had been rejected finally by the highest authorities (Hitler-Goering) in August 1943, after work on these projects had been prohibited repeatedly and then again demanded.

The problem of smooth bore barrels or guns with conical barrels was investigated, but could not be brought to any conclusion. Here again the industries lacked the necessary manpower.

Continued improvement of the fire control director equipment was progressing in the prescribed direction and in line wit the stated requirements.

On the subject of rocket missile development, the situation has been explained in the previous chapter. Unguided powder-propelled AA rockets were already being manufactured and were in use for AA barrage fire. It was not to be expected that these rockets would produce the desired results, which was confirmed by their use.

The problem of an optically guided rocket missile was also solved--in which respect the firm of Rheinmetall merits special mention, but was not placed in service by the time the war ended

The homing, remote-control AA rocket missile was still under development and there seeme d little likelihood that this problem would be solved within the foreseeable future. Research in this field had commenced too late, a circumstance under

330-331 which the whole development project suffered. Here one can realize to the full that a development project cannot succeed unless it is preceded by thorough research. The more thorough the work of research, the more speedily will it be possible to bring the development project to a successful conclusion. However, this basis of thorough research was lacking in the matter of rocket missile development.

The development of medium-caliber AA weapons was also hampered by objections from the highest authority (Hitler) to such an extent that the projects could not be brought to a successful conclusion.

The question of a 37-mm mountain infantry or paratrooper AA gun was not given much consideration, since in the 37-mm Model 43 AA gun a weapon had been created which would have been hard to surpass in point of weight.

No satisfactory solution had been found as yet for an AA tank, so that the problem of developing for it a special fire control director with wireless data transmission was not acute.

Development of a 6-meter base rangefinder had been concluded, but only a few of these instruments were delivered to the troops by the end of the war.

Radar development for the AAA had been brought to a temporary conclusion in the Egerland radar equipment. This

331-332 equipment showed performances which met the stated requirements. However, new experience and new data were becoming available continuously from the units using the equipment, so that it was to be anticipated that a continuous process of further improvements and modifications would become essential in the near future. In this field the enemy dictated the direction of development by their interference activities. The appropriate authorities had failed to profit from German discoveries in this field by timely research and development, and this omission had placed Germany at a disadvantage, so that it was always one step behind and the enemy were able to dictate the direction and pace of developments. Owing to the lack of qualified engineering personnel little had been done in the field of radar support for light AA weapons, a requirement already stated. The plan at the time was to use radar with light weapons in a manner similar to its use with heavy guns, and it was thought that the problem could be solved by using the same radar instruments.

Development in the field of infra-red rays had not progressed beyond the preliminary research stages. It had been found that no solution could be found within the foreseeable future for the use of these rays over considerable distances, as would have been needed for antiaircraft action.

Searchlights had become a secondary consideration since radar instruments had come into increasing use, although the

331-332 breakdown of the radar system due to the enemy use of tinfoil for interference purposes during their bombing of Hamburg had created renewed interest in this field. 300-centimeter searchlights were therefore constructed and used as experimental equipment, but were not introduced as standard equipment. The development project for a fully automatic self-control for the 150-centimeter searchlights was cancelled since it would have involved too great expenditures. The necessary trained manpower for the purpose was not available and the effort which would hav had to be expended on the development did not appear commensurat with the results which could be expected.

In the field of ammunition recommended methods of improve- were investigated continuously. Fundamental changes in ammunition are hardly to be expected during a war, since the need for current production to meet troop requirements makes it impossible to halt production of existing types in order to convert to the production of new types.

Development of a device designed to set the fuze while the shell was passing through the gun barrel had been concluded. However, the facilities in the electrical industries were inadequate to produce the immense numbers of such devices and the fuzes needed for the quantities of ammunition used.

The problem of firing hollow-charge missiles from heavy-caliber AA guns had been solved and such ammunition had been in-

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332-333 introduced for use by the troops.

Nothing essential remains to be said on the subject of balloon barrages and the use of dark coloured smoke. Improvements were naturally sought constantly and progress was achieved in this field. However, it will be necessary to achieve even better performances in these fields in the future, since those of World War II were never fully satisfactory in use.

The point has now arrived to discuss certain development problems which ~~it would have been urgently necessary to pursue~~ forced themselves on the mind under conditions as they existed in 1945, and which should have been pursued under the retarding circumstances of war which impede development work. It is necessary to emphasize that these developments were not officially stated as requirements , such as those specified in the AAA Development Program for 1942 or that for 1932, but represent views which at the time I would have considered possible to effectuate, basing my opinion on my many years of experience in the field of weapons development.

1. Light AAA Weapons. The single-barrel 20-mm AA gun should remain in production as a weapon of self defense for the troops. For strictly AAA purposes it can be used only as a 4-barrel weapon. The only ammunition for use with this gun should be of the mine-grenade type with the greatest possible blast effect, plus an armor-piercing ammunition with the greatest possible penetrating

333-334 power. The explosive charge of the mine grenade should also have incendiary effects, which it should be possible to achieve by means of a combined explosive-incendiary filling.

Muzzle velocity of the 37-mm AA weapons must be increased to 1,000 meter/second. Construction should be similar to that of th e 37-mm Model 43 AA gun in stamped metal sheeting. Only two ammunition types should be furnished, as in the case of the 20-mm gun discussed above.

A 55-mm AA gun should be developed which can be controlled from a control column piller so that it could receive its fire data from a simplified fire control director. This weapon also should have an explosive-incendiary and an armor-piercing ammunition.

The 1-meter-base range finder is inadequate. All guns in the 20-mm and 37-mm classes should have 1.5-meter-base rangefinders, and the question should be thoroughly investigated whetehr it would be justifiable to provide a rangefinder with a 2-meter base. It would be justifiable to provide a 4-meter-base range finder for the 55-mm gun, and these should be provided for this weapon.

Ring and similar types of sights are not satisfactory. Troops must be trained and instructed to acknowledge the advantages of modern AA sighting devices with lead computers, and the use of these instruments must be enforced. a study

334-335 should be made of the various types of sighting devices in existence to determine their usability under field conditions, and if necessary new sighting devices should be developed with due regard to the experience of the troops.

2. Heavy ~~AAA~~ Weapons. Development work on 105-mm guns should have ceased, and 88-mm Model 41 AA gun tubes should have been inserted in the existing guns of this caliber. Production of the 88-mm Model 36 AA gun should have continued only on a scale absolutely essential for employment in the very foremost positions. Beyond those essential requirements, all efforts should have been concentrated on the production of the 88-mm Model 41 AA gun with its current performances and of 128-mm guns for use in permanent emplacements or to be mounted on railcars. Using naval type ammunition (conical lug) and increasing the muzzle velocity to 1,000 meter/second would have improved the range capability of this gun. To obtain these aims, however, the first condition would have been to provide manufacturing facilities for low-calory propellant powders. Weapons in these classes should have high-explosive, armor-piercing, and hollow-charge ammunition. All shells should have beem produced with dual ignition (time and contact fuze), with efforts to change within the near future to a combined proximity-contact fuze. Only iron rotation bands should have been used. If at all possible the outer barrel should have been in one piece, with a one-piece

334-335 inner tube produced by centrifugal casting processes.

3. Fire control Director Equipment. Production should have been restricted initially to the Model 40 equipment, with the earliest possible changeover to electrical fire control director equipment, providing for target speeds up to 100 meter/second, and also with due consideration given to altitude differentials. Coordinated use with radar should have been insured. The supply of 6-meter-base rangefinders for 128-mm aa guns in permanent emplacement and of 6-meter-base rangefinders for 88-mm guns should have continued..

4. Radar Instruments. One "Egerland" installation was necessary for each battery. Until this requirement could be met, each battery should have had one "Marbach" firing control installation, but at the same time each battalion should have had a "Kulmbach" panorama search instrument with facilities to transmit the data to the batteries. Searchlight batteries xxxx should have had one radar instrument per platoon of three searchlights, for which purpose use could have been made of the old-type instruments with deblurring attachments. The greatest importance should have been attached to the elimination of blurring and other interferences and research in this field should have been promoted vigorously.

5. Searchlights. Production of 60-centimeter and 150-centimeter searchlights should have ceased. Only 200-centi-

335-336 centimeter searchlights should have been manufactured, plus an adequate number ~~xxxxxxxx~~ of 300-centimeter searchlights to provide one per platoon as a pick-up or master searchlight. Co-ordinated use with radar should have been insured.

6. Rocket Missiles. Conclusion of the "Wasserfall" project should have been accelerated. Production of the "Schmetterling" rocket projectile should have been accelerated, incorporating the tactical experience gained with this weapon in use at Halle-Leuna. Work on the "Rheintochter" development project should have continued and if at all possible provisions should have been made for an extended trial of these missiles with troops.

It was essential to bring development of remote control rocket missiles and of a suitable proximity-impact fuze to an early conclusion. It was also urgently necessary to commence a project for research and development of a homing device to be built into t e missile's nose, and provision should have been made for this project.

7. Wire Obstacles. A system of wire barrages should have been developed to take the place of balloon and kite barrages, the barrages wires to be fired at short notice into the air and to remain aloft for approximately fifteen minutes. Firing should have been electrically controlled, using radar data on

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336-337 approaching enemy forces and properly computed lead factors. Rocket launchers would have been used to fire the wires vertically to an altitude of between 10,000 and 13,200 feet, the projectile at its blast point releasing a balloon carrying a wire the one end of which was anchored to the rocket launcher mount.

8. Field AA guns should as far as possible have been on self-propelled mounts, and only armored AAA carriers are suitable for assignment with tank divisions.

A fundamental requirement is to restrict the number of different types of equipment in use, and these should have been produced in large-scale series.

2

PRESENT TRENDS IN RESEARCH AND DEVELOPMENT (1958)

This chapter I must preface with the remark that what I say here must under no circumstances be construed as representing the official views of Bonn or the German Ministry. I am merely presenting what are strictly my own personal views based on years of experience in the field of antiaircraft weapons development, extending from 1912 to 1945, and on developments in foreign countries which have come to my knowledge.

Before enlarging on the individual items of equipment which I consider essential for purposes of air defense, I think it is necessary to state as a basis for my discussion that it is absolutely essential to insure industrial preparation during

337-338 peace in order to have adequate designing, construction, and manufacturing capabilities available in the event of war. This is generally described simply as "preparation for war" and I fully realize that what I have just said will be regarded by many as a faux pas. However, the whole concept has nothing whatever to do with any intent to wage war or even with "preparing for war" in the sense of desiring or intending a future war. Every ~~country~~ nation simply must be prepared to defend its territory and its people, house and home, against any possible encroachments. For this purpose it is essential to make advance preparations, just as it would be impossible to organize a fire brigade to extinguish a fire already raging, or a police force at a time when law and order are so disrupted that disaster is inescapable. The subjects under discussion here therefore have to be discussed during peace if we are to be able at all to protect ourselves against hostile attack.

One of the basic peacetime requirements is to insure the availability, in the event of war, of the resources in manpower which will then become necessary, not only in the military field, as military personnel, but also in the industrial field (engineering personnel, staffs for research institutes, labor, etc.) and manpower for the manufacture of vitally important military materiel.

From events in the past two World Wars it is known that

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338-339 there are certain bottlenecks which cannot be eliminated once war has become a fact. In the case of Germany the two most serious bottlenecks were explosives and propellants (powder as a propellant for missiles and fuels such as gasoline), and electronics. The view is expressed frequently that Germany need have no worries in these fields in the future, since these sources of concern have been removed by the consolidation of the Western Powers. I find myself unable to agree with these views. The unity of the Western Powers undoubtedly had expanded the sources of supply and does insure more diversified resources, but at the same time the missions are greater and the tactical problems have been expanded

The two World Wars have served to show that, lacking thorough technological preparations, there is no possibility of maintaining a war of any duration, and that the capabilities available within Germany are by no means adequate. This is an irrefutable fact and a solid factor and provides an insurance for the entire world that there is no possibility of Germany starting any war in the future.

However, the consolidated powers of the West in their entirety are faced by those of the East, and the question arises here as to which of these two power complexes has the greatest staying power, or the greatest economic power, to meet all the requirements of war.

338-339 For the above reasons the demand must be made on the Western Powers to take all preparatory measures to insure that they will not, in the event of war, find themselves face to face with the problems of bottlenecks which might determine the whole outcome of any such war.

It is specifically in those areas of the economy, of industry, which are not essential during times of peace that preparatory work has to be done.

In the fields of powder propellant and explosives, as well as in the field of motor fuel supplies, consideration must be given during peace to the question of how the increassed requirements of war could be met. In retrospect, we find that in 1914 as well as in 1939 America was in no position to enter the war immediately, but first r quired a lengthy period of preparation to set its machinery for the conduct of war in motion.

In the fields of motor vehicle and electro equipment production the position is less critical, but even here a war would make great demands on the industries involved. This fie l d also involves another very critical problem. Alhtough much has been done in efforts, which will perhaps succeed, to standardize military equipment, the problem of manufacture under licence, which is always propagated by the industries as a panacsea for all ills, involves grave risks.

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339-340 It has been found that even when firms within a country manufacture xxxxxxxxxxx articles under licence from a firm within the same country, the article manufactured under licence does not correspond completely to the article manufactured by the original firm. It was found that the firm manufacturing under licence redesigned certain parts in order to be able to manufacture them with the machinery available in its own factories. This is likely to be a far more frequent occurrence when the licencor and the licensee firms are in two different countries. Certain gun models in use internationally have given evidence of this, for which reason the point must be raised here. In such xases the individual spare parts needed for resupply do not fit properly into the article manufactured by some other firm, in which case standard equipment becomes a disadvantage rather than an advantage. It is in this respect that manufacture for civilian needs differs from the manufacture for military purposes. Much can be achieved through standardization. For example, the electric bulbs manufactured by various firms today are interchangable. But even under peace conditions the various parts of cars manufactured by different firms are not interchangable, and even in the case of older models from one and the same firm the parts frquently are not interchangable xxxx xxxxxxxxxx with those of newer models and have to be spexially manufactured. This would be an impossible situation in the case

340-341 military equipment.

The problem of critical metals also still requires consideration, since metals such as copper would be in short supply when used throughout the world during a war. If these factors are not taken into consideration in the original designing and constructionof equipment, it will be impossible later to avoid serious disruptions. Usually, size ~~requirements~~ considerations make it impossible to so design the individual parts that they can be constructed from either one or another ~~another~~ material for use on the spot to replace the original part. In most cases not only the individual part but the whole unit to which it belongs has to be changed.

This makes it necessary for the industrial concenns engaged in the manufacture of military equipment to give due consideration to thèse points, and supervision is necessary to insure that they do in all details. The manufacturing blueprints must be so prepared that other firms will be able to use them in manufacturing the article concerned. It would be wrong, for example, for a firm to use symbols of its own to specify specific processes, such as a type of surfacing, which other firms would be unable to decipher. In planning, care must also be exercised to insure that all processes of manufacture are based on machinery generally in use and not on any special type of

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341-342 machinery which the designing firm might have in its workshops.

All of the above considerations are of minor importance in the peacetime manufacture of consumer commodities of any type, and in fact most firms intentionally avoid them so that owners of commodities produced by them will also have to purchase spare parts from them, thus insuring the original manufacturing firm increased profits.

The number of guns, tanks, and other weapons and equipment for military purposes manufactured during peace is relatively small; it is therefore quite possible that the designing firm alone will also be given the sole manufacturing contract for a specific item. The question would thus not arise of the work of designing and original construction being conditional on the sole rights of production, at least not during peace. If that firm does have the sole manufacturing rights, difficulties would result immediately in the event of war if that firm is required for other development projects and ~~it it~~ is no longer able to supply the large quantities needed, since it would be necessary then to redesign the article involved.

The above should suffice to indicate the type of preparatory work which has to be done during peace and also to stress the necessity to employ personnel with a military background and completely independent of industry. Only if these conditions are met will it possible to keep the wartime industry functioning

341-342 without interference during a war. Failure to meet these conditions could lead to inferiority under the enemy.

It seems hardly necessary to stress the enormous responsibility these missions involve.

I now come to the individual items required for purposes of air defense.

The question comes up time and again for debate as to whether the AAA is still a matter of importance, and whether it would not be wiser to leave the whole matter of air defense to the flying forces. This matter was a subject of debate ~~in 1918~~ after the end of World War I in 1918 just as it is today. The results achieved by AA fire, however, coupled with the information contained in reports compiled by Germany's former enemies since 1945 serve to show that the German AAA not only did not lose significance but became of increasing significance towards the end of World War II. Although I personally am convinced that against an enemy having complete air supremacy an AAA force could not be of very great significance, and that it would then be justifiable to question its right of existence, I nevertheless do not believe that it will ever be possible to dispense with it. Any power at war will always employ its air power in accordance with the recognized weak points of the enemy. Should the enemy have no light AA weapons, the hostile air force will create havoc and destruction by means of low-level air attacks.

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342-343 Only the presence of AA weapons for use against low-level attacks will compel an air force to decide on high-altitude bombing, which will also be adapted to what is known of the enemy tactics of defense. For these reasons, weapons of all types must be provided, but they should be so developed that their use is not r stricted to purposes of air defense alone, but that they could be used for any other military purposes.

Already in the class of light AA weapons the view is widely advocated that rockets should be used. I differ from this view, firstly because, in my opinion, it would be practically impossible to manufacture adequate quantities of the propellants required, and secondly because a missile which can not be guided at short ranges is worse than guns of the conventional types.

In the first place it will be essential to have as light and handy a weapon as possible for transport columns, infantry on the march, and units at the front, to replace the former machine gun, fire from which is ineffective against modern types of aircraft. A weapon is thus required which can fire a high-explosive shell and the weight of which will be within reasonable limits. For inescapable reasons its caliber will have to be not greater than 20-mm. A weapon with this caliber would admittedly have only a small killing power against aircraft, but any increase in the caliber would make it too heavy.

343-344 Accepting the necessity for a weapon of this type, a more effective weapon should be introduced in the form of a four-barrel gun with the same caliber. The advantages would be those of simplified manufacture, uniformity of ammunition, and, in particular, simplified supply operations.

Weapons of this type exist in foreign countries as single-barrel guns with a muzzle velocity of 1,100 meter/second and a rate of fire of 1,000 rounds per minute. Quadruple mounts also exist or are under construction.

What would be needed is an explosive-incendiary shell besides a high-explosive mine grenade with a larger explosive charge (without tracer element) and an armor-piercing shell. I personally reject the idea of tracer ammunition but fear that the troops will not be willing to dispense with this misused means of self deception. The shell should have a self-disintegrater set at 2,200 yards. The matter of what type of sights to use with these guns will be discussed later together with sights for all light weapons.

I am aware that the 30-mm caliber is quite generally regarded with more favor in foreign countries and also in Germany. The following can be said on this point: this caliber would also not have a killing effect against modern aircraft; it would not be possible with this weapon to meet all demands made on a very light AA weapon, including its use by troops in self defense

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344-345 against air attack, so that a 20-mm weapons would also be needed. Introduction of the 30-mm weapon would thus mean that for two separate weapons, neither of them completely satisfactory, the manufacturing and supply and resupply requirements would have to be satisfied not only in point of the guns alone, but also in point of three different types of ammunition. In my opinion this should be rejected. We were faced by this problem already in 1943, when the German Air Force introduced the 30-mm gun as aircraft armament and the Navy as a submarine weapon. At that time a decision was made against this caliber and in my opinion conditions have not changed since.

However, a light and highly mobile weapon with adequate shell effect will be needed. For this purpose we had during the war the 37-mm gun. As a wartime development, however, this weapon had to use the ammunition of the AA guns already in existence in 1936. Using the performance of the wartime gun as a basis and applying modern methods of weapons manufacture using pressed sheet metal, specifications should be drawn up for the development of a modern weapon of this type. A similar weapon is at present being manufactured by Oerlikon in Switzerland in the form of a 35-mm gun with a muzzle velocity of 1,100 meter/second and a rate of fire of 550 rounds per minute. It will be impossible to do without a weapon in this class.

The weapon should fire an explosive-incendiary shell and

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344-345 with adequate blast effect and an armor-piercing shell should also be provided. The self-disintegrating fuze should be set at 3,800 yards. As far as possible these guns should be produced as double-barrel weapons. The matter of sights for this type of gun will also be treated in the discussion of sights for all light AA weapons.

I do not believe that it will be possible to escape the necessity for another automatic weapon with a caliber of about 55-mm. The Bofors 40-mm gun is inadequate and also can not be considered in its present form as a modern weapon in point of its external ballaitics performances. The muzzle velocity of a weapon in this class must be at least 1,000 meter/second, and the weapon should fire an explosive-incendiary shell and an armor-piercing shell. It would probably be necessary to have two separate self-disintegrator distances in order to avoid shells returning unexploded to the ground and detonating there. The ideal solution would be to have a device for setting the self-disintegrator fuze in the loading action and in accordance with the muzzle elevation. The self-disintegrating distances should be between about 3,300 and 6,600 yards.

All of the ammunition for all of the above weapons should be planned for the use of iron rotation bandsin order to economize in the use of copper.

In the matter of barrel construction importance should be

345-346 attached to simplification of the manufacturing processes; the barrels should be in one piece and manufactured by the centrifugal casting method. The mounts and guncarriages should be designed to ~~axsind~~ avoid jointings, and possibly pressed metal sheeting might be the best.

It is now necessary to deal with the matter of gun sighting devices. In view of the high speed and maneuverability of modern aircraft, the utmost importance must be attached to the question of sighting devices. The old type of ring sights with all their variants are definitely no longer adequate. It will be necessary to provide an optical sight, at least for use in emergencies. It should compute the lead factors automatically and should not require pre-setting for range, etc. This sighting device would probably be the only type~~s~~ for use with the 20-mm weapon, since any other devices would be too bulky and too heavy

In view of the fact, however, that an aircraft flying at an altitude of 1,650 feet can only be sighted optically when it is not farther off than 2,200 yards, optical sights for AA weapons will not be satisfactory. There are also no indications of any possibility being found to use the infra-red principles; the results of research work in this field are still outstanding For the time being, it therefore appears that the only possible way is to use radar.

Since the recommendatio is ~~that~~ to adhere to the principle

346-347 of committing AA guns in platoon-size units, it is recommended that one gun in each platoon should have a panorama search radar, which could transmit the firing data to the fire control radar, with which the other two gund of the platoon would be linked. It would naturally be necessary to introduce factors eliminating the parallel axis and other differentials. The search radar should have a sweep of 30 miles, and the fire control radar should make it possible to open fire at targets at ranges up to 13,200 yards, the computed firing data factors being transmitted to the individual guns by means of a simplified fire control director.

Since all guns in the light AA weapons class (20-mm fourbarrel; 35-mm double-barrel; 55-mm guns) will have emergency sighting devices, they can use these when necessary if they are not yet linked to the ~~fire~~ radar fire control equipment. The ideal would be for all weapons to have radar equipment, but this would hardly be possible for reasons of production. The research mission in the field of radar would be to insured interference-proof functioning and the elimination, as far as possible, of ground reflection.

All light AA weapons must have the possibility to change positions. Permanent emplacement of such weapons can be considered in very exceptional cases, for example within the target to be protected, from where the guns could fire on and destroy

347-348 aircraft in dive attacks. All other guns must change their positions frequently so as to take the enemy under surprise fire from constantly changing directions, which is the best method to insure success. Once AA gun positions are known, attacking aircraft bypass and avoid them. The old system of direct target defense called for such enormous numbers of guns that it would be simply impossible to have enough in the future.

The above ends the discussion of light AA weapons for the future, and it is now necessary to deal with sighting devices for defense against aircraft at altitudes of approximately 16,500 feet. Effective action against targets at such altitudes is no longer possible with weapons in the light class, and the smalest caliber from which any results can be expected is that of 55-mm. Rocket missiles, on the other hand, can only be steered by a guide beam at distances beyond 5,500-6,600 yards. It will therefore be necessary to have an AA gun for defensive fire at these altitudes. These weapons should be as mobile as possible in all terrain. Their weight should not be much greater than that of the old German 88-mm Model 36 gun, the maximum being the weight of the 88-mm Model 41 AA gun.

The gun should have an effective firing range of at least 8,800 yards with a missile-time-in-trajectory of not more than 12-15 seconds. The missile should not be too heavy and nevertheless insure adequate target effects.

348-349 It will thus probably be wisest to retain the 88-mm caliber for these altitudes. The idea of a smaller caliber was rejected already in 1939 since the shell effect on target would be too small. A larger caliber would require too great overall weight of the weapon, for which reason larger calibers xaraxalax xxxxxjxxtxxxxxtxthaxtimax must also be rejected. The ballistic performances of the former German 88-mm Model 41 AA gun should serve as a basis for the new weapon in this class.

However, it is necessary here to recall to mind the promising work done with vane-stabilized missiles, which showed in tests in the wind tunnel at Peenemuende that missiles of this type have only 35 percent of the friction which normal missiles have to overcome at muzzle velocities of 1,400 meter/second. In view of these research findings, it would be wise to xxxxxxxhx resume research and development in this field, since it would be possible in this way to increase the probability of target hits quite considerably. The missile in question would be a fin-stabilized missile fired from a smoothbore gun. Whether the 88-mm or a larger caliber should be used for the purpose depends upon whether the gun problems involved could be solved with the weight of the 88-mm caliber.

The gun should have a one-piece tube inserted in an outer barrel, and the most up-to-date manufacturing process should be used in its production, the method in mind here being the

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348-349 centrifugal casting processes. It is unknown to me whether more modern processes have been introduced, and I am also not aware whether the details of the centrifugal casting processes have been preserved.

The question of fuze setting no longer enters into discussion. The shell must have a proximity fuze with a sidewise sensitivity range of 22 yards, in addition to a contact fuze. At the peak of its trajectory, the culmination point, the shell must disintegrate automatically, and research and development projects should be started immediately to find fuzes of this kind unless suitable solutions have already been found. The types of ammunition for these weapons would be: high-explosive shells with a fragmentation size of 20 grams; shrapnell-type shells, for close range fire and ranges up to 5,500 yards, filled with incendiaries, and with a proximity fuze ~~had~~ having a forward sensitivity range of at least 55 yards; armor-piercing and hollow-charge grenade shells.

All fire control director equipment must be electrical combined with radar. The radar equipment must include search and fire control instruments. The search radar must have a sweep of at least 300 miles, and the fire control radar must make it possible to open fire at ranges of 11,000 yards.

For purposes of home defense weapons in this class must also be mobile, but it would be adequate to be able to move

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349-350 them on trailers. Each battery should have eight guns. In contrast, field batteries should as a rule have four guns, all on self-propelled mounts. Units assigned with tank divisions should have armor protection; the problems involved here can be solved by the use of radar for target locating and fire control. This method of employment should also be adopted as a general rule for light AA weapons.

These solutions for the air defense problem by means of gun weapons of the conventional type would provide the possibility to use AA weapons also for other purposes than air defense. However, they should only be used for other purposes when they have no air defense mission. Tactics should be very flexiblewith frequent displacements of the guns to new positions For this reason AA guns should not be included in plans for barrage fire; they should only be used for support fire designed to achieve a greater density of fire effect in the target area to increase the prospects of success.

All weapons discussed above can also be mounted on railcars. For this purpose, it might be wise to consider guns with larger calibers, greater effective ranges, and greater target effects, such as a 128-mm AA gun. I personally would not favor any such idea but would rather restrict the number of weapon types to the smallest possible minimum in order to simplify and facilitate production and supply operations.

350-351 In order to secure some probability of hitting targets travelling at the high speeds of modern aircraft it is absolutely essential to make use of all available means to compute the lead factor to the point of missile-target impact as precisely as possible. Once this has been done and if the fire-control director equipment is commensurate, an indispensable requirement remains that of determining the internal and extermal ballistic influences as precisely as possible and eliminating them. Failing this, the results of the most highly perfected fire control director equipment will be negative. The faulty data factors for muzzle velocity and weather influences in such case will always result in faulty aiming. Therefore, it is absolutely imperative to determine these sources of error. For this purpose the gun performances must be checked continuously by means of a field-type muzzle-velocity checking installation, one of which should be standard equipment in every battery, and in the case of light weapons possibly in every platoon. In every zone of operations there must be a constant supervision of weather conditions and weather influences by meteorological teams, and the information from their reports must be supplied currently to the batteries for use in their fire data computing instruments. Successful fire can only be expected if all this is done.

For fire against targets at altitudes above 16,500 feet

351-352 preference must go to AA rocket missiles. The missile must be guided by remote control to its target and in the last 110 yards must be drawn to the target by a homing device. The missile must have a proximity fuze with sidewise sensitivity so that, if it should be attracted by two targets simultaneously, it will detonate while passing between the two. To avoid explosion after return to the ground, each missile must have a self-destroying fuze set to detonate at its peak of trajectory or culmination point. The missile should have an effective range of 18 to 30 miles. It is unknown to me to what extent these requirements have perhaps already been met, but I am convinced that all of these problems can be solved by continued research and development work.

Very great importance will still have to be attached to the development of the remote control system for the AA rocket missile. Just as success in AA gunfire hinges completely on the accurate functioning of electronic equipment, remote control of the rocket in flight also depends on such accurately functioning equipment. All possibilities of interference must be closely studied and the results of these studies must be evaluated and followed up and applied in order to make immediate countermeasures possible when necessary, and to provide a basis for further research and development. This matter is of such eminent importance that any neglect in this field could doom the entire

352-353 AAA defense system to failure, and this would apply equally to the fighter defense system and all other defense against air attack.

For the above reasons there must be a constant search for devices which could be used as a substitute if electronic target locating and electronic fire control should ever fail. Here it is necessary to point out ultra-red and ultra-sonic devices as well as the various rays, in which fields research should therefore continue.

The enormous expenditure involved in each AA rocket fired precludes the use of rocket missiles to replace light caliber AA weapons. It would also be impossible to produce them in the same quantities as ammunition of the conventional artillery types. To justify the use of expensive rockets it must be possible to expect commensurate results from that use. I am therefore convinced that AA rockets should be armed with an atomic head capable of destroying airborne targets within a certail radius. This seems to me the only possibility to destroy large bomb missiles being guided over long ranges to their target. There is a wide field here for research and development, since the effect of the AA rocket atomic head must remain restricted to a specific area and to a certain period of time, since otherwise friendly aircraft and remote control missiles would be exposed to the risk of destruction.

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352-353 I think that I have stated clearly enough above problems which cannot be taken under research soon enough. Even if one rejects the idea of general atomic warfare, and I do not consider atomic warfare inevitable, it is nevertheless essential to carry out the the required preparatory work I have indicated above, since it appears doubtful that anyone could suggest some other method of protection against remote-control or uncontrolled bomb missiles.

If a satisfactory solution is found for electronic target locating and fire control, the use of searchlights must be rejected altogether. An attacker would be in the position nowadays to operate above the clouds and deliver his destructive load on his target without any need for ground orientation. This being the case, attacking aircraft are also able to elude the rays of any searchlight, so that this item of equipment must be eliminated.

I also believe that the camouflaging of industrial installations and bridges, and thus of targets fixed by map, is no longer effective. For shifting targets in the fields, such as troops, battery positions, and so forth, camouflage will be even more important than ever before, for which reason the requirement must be stated that all weapons and equipment, including the rocket-firing stations, must be mobile. The more flexible operations are and the more frequent the changes of position, the

353-354 the greater will be the results achieved in operations and the smaller will be the cost in losses suffered.

The problem of air barrages requires special attention. I do not believe that balloon and kite barrages can be used as an effective means of air defense in the future. On the other hand, however, I believe that airfields and industrial and other targets can be protected against air attacks, particularly by means of guided missiles. In addition, use could be made of barrages consisting of numerous wires at various altitudes and in xxx wide belts. These wires would be shot aloft by electrically released projectiles releasing balloons or parachutes when bursting, one end of the wire being attached to the balloon or parachute, the other to be anchored at the firing position. Proper lead data should be used in firing the missiles in order to insure that the approaching enemy missiles or aircraft would necessarily fly into the wire barrage.

I would also like to recall to mind the question of mining certain air areas, a problem which definitely should be scientifically investigated. I consider that it would be wrong to decline such propositions as hopeless without investigation.

I realize that I have not indicated or mentioned all means requiring research, investigation, and development. However, my intention is only to submit suggestions so that we will not at some future date have to accept in resignation whatever

354-355 might happen.

The mission of the professional soldier is to state the problems which require research and investigation by science. In this field very close coorperation between the scientific institutions and the military is desirable and must be promoted. The interjection of a military ~~scientific~~ research authority, headed by a scientist, has produced fateful consequences on one occasion in the past. An agency of this type should exist exclusively to establish and maintain contact and guide the military authorities in the right direction. From that point on, however, scientists and soldiers should endeavour to solve the problem currently involved by mutual effort. In all cases where this happened, the results were fruitful.

It is not always easy to determine the point at which research ends and development commences. Nevertheless the transition from research to development must take place at some point or other. When that stage is reached, research should not be halted if those conducting the research consider that they can still produce improvements. In such cases research must continue unhampered, but those carrying out the development project must be given very precise instruction concerning the form in which the military intend applying the results to their uses. Only if all these considerations have been fully clarified between the General Staff, the Arms Inspectorate, and the

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355=356 and the military technical office should the industries be assigned development projects, and the industrial firms concerned should be called in to cooperate in formulating the development contracts to be awarded. The more thoroughly all this preliminar work is done, the speedier and more successful will be results achieved.

556

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