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a floating night interceptor station designated as Zone. This belt, called the Kammhuber Line by the British, was approximately 200 kilometers in width. During 1943 the channels of main flight penetrations were covered by continuous, overlapping night interception areas extending as far as the coast. In this way, a barrier against enemy aircraft was maintained the entire way from the coast of the Atlantic to the chief defensive objectives, including Berlin.

Success was not lacking. Gradually the night fighter pilots became accustomed to using the Lichtenstein B/C as an effective airborne radar, and ground control techniques were refined and improved. The only factor which prevented decisive success at this time was a lack of night fighter planes and trained night fighter crews. In Churchill's Memoirs,[18] it is stated that three-quarters of the British losses in bomber planes were due to the German night fighter forces, and the conclusion is drawn "that they were in a position to paralyze our [the British] bomber offensive in time." That was precisely the goal of the German night fighter command, but dark night interception was a thoroughly suitable countermeasure only as long as it could be employed without interference. On 24 July 1943, concurrently with the start of large-scale attacks on Hamburg, the British began "window" jamming German radar by dropping metal strips. This sealed the fate of the German night fighter command, since no countermeasure was available for immediate

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[18] German edition. Volume IV, page 335.

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use. A German countermeasure would certainly have been technologically possible.

__German Interceptor Technique.__ German dark night interceptor technique was called night limited area contact or __Himmelbett__ (four-poster bed).[19] Its main element was a night interceptor headquarters, in which all controlling elements were effectively combined, the plotting of enemy aircraft and the directing of friendly fighter planes. The focal point of the night interceptor headquarters, in turn, was the __Seeburg__ plotting table.

Data reported by the aircraft reporting stations and by the long-range aircraft reporting centers were entered on a special aircraft reporting chart. Even though its location was not coordinated with that of the aircraft reporting station, the night interceptor headquarters utilized the normal aircraft reporting network set up for local early warning. Each night interceptor headquarters also had its own local aircraft observer stations to eliminate the possibility of a local surprise attack in case all equipment and communication lines were put out of action. The aircraft observer stations served simultaneously as close-in protection in areas close to the enemy ground forces.

Each night fighter area had its own radar station, consisting of one __Freya__ set (usually with AN direction finding equipment) and two __Wuerzburg Riese__ sets, one of which was used for the plotting of enemy aircraft (red), and the other for friendly fighter aircraft

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[19] The name was adopted from the canopy-type cover of the old four-poster bed, the technique providing a similar air cover over an area.

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(blue). Each night fighter interceptor stations had one or more low-powered radio beacons commanding the stand-by area or areas, and one shortwave air-ground transmitter for picking up radio telephony between the ground station and the night fighter plane. The forward night fighter interceptor stations continuously searched the sky for enemy aircraft, but the radar stations situated farther to the rear could wait for the early warning alert before going into action in order to save material and personnel.

The Freya and Wuerzburg-Riese (red) sets were directly linked together, so that the Wuerzburg could immediately take over a target, picked up by the Freya to determine azimuth and distance, as soon as the aircraft came within its range. In this way the Freya sets were freed and could search for targets which were still farther away.

The data furnished by the Freya sets were entered on a special chart in the night interceptor headquarters. In the hands of an experienced crew, the Freya was able to plot several enemy targets at the same time, so that the fighter control officer in night interceptor headquarters could determine which target was the most favorable. The determination of targets was based on two considerations: First, favorable position in terms of the range of the Wuerzburg (red) set, and second, favorable position of the night fighter plane. The target determined as most favorable was then picked up and followed by the Wuerzburg-Riese (red) set. In this way it was possible to a certain extent to avoid false starts by friendly aircraft, unless the enemy completely invalidated the computations of the fighter control officer by substantially

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altering his course.

The readings from both Wuerzburg-Riese (red and blue) sets were projected from below onto the glass screen of the Seeburg plotting table (two by two meters) as small points of red and green light. Azimuth and distance data were projected by one individual and altitude data were transmitted by another person using other special equipment.

The direction of the fighter plane was maintained as long as possible, or until the pilot could actually see and recognize the enemy plane. Bringing the fighter into a favorable position became proportionately less attainable the closer the approach angle of the two planes approximated a right angle. The least favorable situation existed when the planes approached one another head on. It was most desirable for the friendly fighter plane to overtake the enemy aircraft from behind, flying on the same course, at the same altitude, and at a not too much greater speed. To insure this ideal situation was the objective and purpose in setting up a night fighter interceptor headquarters using the Himmelbett method.

As soon as a night fighter plane had taken off, the station's second Wuerzburg-Riese (blue) set picked it up and, from that moment on, did not let it out of its eagle eye until it had landed. The point of green light which represented it also soon appeared on the Seeburg plotting table, so that the fighter control officer was continuously oriented on the position of the fighter plane. The fighter pilot, when poor visibility prevailed, could orient himself by one of the low-powered radio beacons. The pilot could also fly about freely over the area, disturbing no one, but still always on

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a visual lead.

Immediately after the take-off the fighter control officer established radio communication with the fighter pilot in the air, but after the sets were adjusted radio silence was maintained, except for occasional checks by either one to ascertain whether communication was still possible.

When an enemy target was picked up by radar, the night fighter pilot was sent to meet it without delay, so that he could engage it as early as possible. The situation was most favorable when the night fighter plane was already in position on a pursuing course by the time the enemy aircraft came into the range of the Wuerzburg-Riese (red) set. Under these conditions the entire range of 100 kilometers was available for directing the fighter aircraft. Sending the fighter plane out in advance was made possible by the preliminary warning furnished by the Freya equipment. The night fighter was directed into a pursuit curve on the same course as the enemy aircraft, and his speed adjusted in such a way that the night fighter would be about three kilometers behind and a bit to one side of the enemy plane. A somewhat lower altitude, 200 to 300 meters, than that of the enemy plane was selected so that the enemy plane would stand out against the night sky and the friendly fighter would be difficult to see, especially when it was painted white. Once the flight position was attained, the fighter pilot was informed of it by a code word by the ground station. He then knew that he was on the same course as the enemy plane, three kilometers behind and approximately 200 to 300 meters below it,

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and that if he increased his speed by so much, he would see the target appear in front of and above him after so many minutes or seconds. He could now concentrate on preparing himself psychologically for the approaching encounter and could choose the moment for his attack. Since he was continually being oriented by the ground station whenever the enemy plane deviated from its heading, he was able to correct his own course accordingly. If the target threatened to escape because it was already approaching the limit of [illegible] range, he was urged to hurry. As soon as the two dots had [illegible] touched on the *Seeburg* plotting table, he was given the order "*Pauke, Pauke*."[20] This meant that the ground station's role was at an end, that the optimum position had been reached, and that the pilot ought to be able to see the target if he had his eyes open.

When the two dots touched on the *Seeburg* plotting table, the theoretically calculated distance between the two planes was still 400 meters--if there had been no errors in measuring or transmission. Assuming normal visibility, it was possible in most cases to identify the target with the naked eye at this distance, especially since the distance was decreasing with every second of flight. Once the night fighter had identified his target, he reported to the ground station "Ready - *Pauke, Pauke*." Thereupon the ground station ceased communication with the plane, but continued to follow the data on the plotting table. If the night fighter pilot lost his

[20] Code name for a series of airborne blind-firing devices.

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target for some reason, he was immediately redirected to it. This was very frequently necessary, especially with inexperienced pilots. It was not true, as has been stated in several books, that this method permitted only a single directed start and then abandoned the fighter pilot to his fate. On the contrary, the progress of the entire combat was followed until the enemy plane had been shot down or until it had finally left radar range.

If the _Lichtenstein B/C_ equipment was functioning correctly, the target was frequently located by the fighter pilot long before the green and red dots touched on the _Seeburg_ plotting table. Once the night fighter had located his target, he could then follow it independently. Since the search cone of the _Lichtenstein B/C_ was very narrow and extended only fifteen degrees to either side, targets were very frequently lost, and the fighter plane had to be continually redirected from the ground.

The advantage of the _Himmelbett_ method was that every single night fighter pilot could be accurately observed from the ground station. One could tell exactly how he was behaving in the air, and whether or not he was developing a technique of attack. A "lemon" among the pilots could be very quickly recognized as such and eliminated. The pilot's degree of success could also be checked, because the outcome could be watched on the _Seeburg_ plotting table. At the point where the red point of light disappeared near the ground on the plotting chart, a search would be made for the wreck and it could usually be located quickly. The pilot's success in downing the enemy, therefore, could very

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soon be confirmed--a psychological factor which cannot be overestimated. There could be, no quibbling, no argument, no argument over who should be given credit for a downed plane, for the evidence furnished by the radar was incontrovertible.

In passing it should be mentioned that so long as the Himmelbett method was in use the figures of downed enemy planes which were reported by the night fighters, and subsequently reported by the German Wehrmacht High Command, were always lower than the ones listed in British reports as "failed to return from flight into enemy territory." This was to be expected, since at that time the night fighters reported only those downed planes which were confirmed by radar data and by location of the wrecks. Enemy aircraft unaccounted for included planes which had been hit in aerial combat but which could not be followed to the point of crash-up if it were outside the range of the radar equipment; planes which had crashed in [illegible] whose wreckage and crew could not be located; and damaged aircraft which crashed while crossing the Channel or after reaching England.

There were, of course, disadvantages and weaknesses in the Himmelbett method; weaknesses which could have been overcome by appropriate measures, and weaknesses which were inherent in the system and which could be corrected only if technology was able to provide the means of developing a night pursuit effective against mass penetration flights.

The weaknesses which could have been overcome if procedures had been developed further--and which were already on the way to

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being overcome—, were the following:

a. Mechanical errors and errors in calculation of transmission of data from the radar instruments to the Seeburg plotting tables.

b. A time lag in the transmission of data because the human operators' reactions were too slow.

c. Interference, interruptions, and misunderstandings in radio communication.

d. Errors in directing the fighter aircraft on the part of a fighter control officer.

e. Radar jamming by the enemy and the tendency of radar equipment towards self-interference.

f. Only one night fighter plane could be directed by a single radar station.

g. The too short range of the Wuerzburg-Riese radar, which limited too narrowly the range of action of the night fighter aircraft.

It was found that the mechanical, calculation, and transmission errors and human time lags could be eliminated completely by the use of the fully automatic transmitter, the Askania[21] control instrument. With this, data were fed directly from the Wuerzburg-Riese radar into the projection equipment under the Seeburg plotting tables. Aside from the very significant improvement in accuracy and speed, the time lag was completely eliminated. The

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[21] Askania-Werke A.G., a firm manufacturing aircraft equipment. Date of introduction is not known by General Kammhuber.

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services of the six people previously required per Seeburg set to transmit data were eliminated. The [illegible] night fighter stations which were equipped in this way achieved outstanding results.

The introduction of an instrument known as the Bm (Bn) 2 in 1943[22] made it possible to eliminate almost entirely the interception of radio communication by the enemy, which theretofore had annoyed and disrupted the entire fighter aircraft control system. With this instrument a night fighter aircraft could be guided from the ground automatically toward the enemy plane until the two dots of light touched on the Seeburg plotting table. During this process, verbal radio communication was necessary only in two instances. Shortly after the take-off and as soon as the night fighter was picked up by the [illegible] (tiso), the pilot was ordered by radio to switch the Bm 2 over to automatic pilot. When the converging dots indicated a successful interception the code words "Pauke, Pauke" were repeated. The enemy had no opportunity to tune in on the radio channel and disrupt the communication. Since the Bm 2 was so easy to handle and its operation simple to learn, the training time of a fighter control officer, hitherto so time-consuming, was considerably shortened.

[illegible] made by insufficiently flexible fighter control officers were also eliminated by using the Bm 2. An experiment

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22 Exact date is unknown and the information is not available in Germany. General Kammhuber states that the Bm 2 did progress beyond the experimental stage in the summer of 1943. The use of the Bm 2 was discontinued after General Kammhuber was relieved of his command on 15 September 1943, because its extraordinary importance was not realized.

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using [illegible] and revealed [illegible] a completely untrained person, acting as the fighter control officer and handling the [illegible] at the Seeburg plotting table, observe an enemy contact within an extremely short time. Therefore it can be assumed that it would also be successful in those cases where, because of an unfavorable relationship between the course flown by enemy aircraft and the [illegible] of friendly radar, it had been impossible to guide [illegible] planes to the enemy aircraft. The few [illegible] instruments employed in 1943 proved to be effective.

Allied [illegible]. Radar jamming will probably always be a major technical problem; it is impossible to utilize radio communication entirely; air [illegible] and it is only a matter of time until the enemy [illegible]. The important thing is to have an immediate answer to interference when it occurs.

German radar equipment in use until 1943 utilized wave lengths which were comparatively easy to jam; the Freya used [illegible] forty centimeters and the Wuerzburg fifty-four centimeters. The top-level command of the German Luftwaffe had been warned of the possibility of window jamming by the use of metal strips for quite some time before its actual introduction. Their decision was to classify the information as highly secret, which was in part correct but in part catastrophic. It was [illegible] extremely strict measures to keep the possible [illegible] from the troops in order not to destroy their confidence in the equipment and from all agencies and persons not concerned with it in order to ensure secrecy. It was wrong, [illegible] by extending the

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security restriction into the fields of scientific research and development.[23] On 24 July 1943 almost all German radar equipment was suddenly jammed, not only were the fighting forces bewildered but also the scientists and technical men. It was months[24] before even a temporary solution was found in the Wurzlaus[25] which produced the Doppler effect.

This period was a terrible strain on the nerves of both the fighting forces and the command as they were forced to stand helplessly and watch the great cities of their country, which it was their duty to protect, go up in flames one after the other.

The tragedy was greater for being to a large extent avoidable. Today, ten years after the first use of window jamming the problem of countermeasures has been solved--as the writer heard for himself on the occasion of the Radio Navigation Congress in Frankfurt on 16 April 1953.[26] While technology had not progressed so far in 1943, a great deal could have been achieved even then if, as soon as the possibility of such radar jamming was recognized, intensive efforts had been made. It was obvious that the enemy

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[23] This restriction on scientific research was inaugurated in January 1943 according to Dr. Eichelmeier, whom General Kammhuber considers the outstanding German authority on the use of Duppelstreifen (tinfoil strips used in window jamming).

[24] This occurred sometime in the autumn of 1943, the exact date is not available.

[25] Code name for a device accessory to the Wurzburg.

[26] Lecture given by Prof. Dr. Ing. Runge of Telefunken G.m.b.h., Berlin who explained the American method.

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would start jamming sooner or later, for experience reveals that new ideas tend to turn up at several places in the world at the same time, as if they exerted a mutual attraction upon one another. As is mentioned in Churchill's *Memoirs*,[27] the British waited long before making use of this method of radar jamming, because they were afraid of the effects on their own defensive measures in case Germany should renew the bomber offensive against England and utilize the same method. This is an indication that at that time they also had no countermeasures which could have nullified window jamming.

Limitations of Control Equipment. The radar then in use had a tendency towards self-interference, which caused radar stations to drop out of action frequently, and opportunities to down enemy planes were frequently missed. This defect was due to the too hurried setting up of the radar system as necessitated by the events of the war. It was a minor defect which would have gradually disappeared.

The limitation of being able to commit only one night fighter plane from each night fighter station was an inherent difficulty which could not be completely overcome. Two planes could have been committed immediately and without difficulty by introducing the *Benito* control system or using the *Uhu 2*. The two methods differed only in that the *Benito* was not automatic. In both systems the *Wuerzburg-Riese* sets could be trained on enemy targets and two red dots of light would appear on the Seeburg plotting table. Two

[27] German edition, Volume IV, page 330.

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night fighters could then be directed against the two targets simultaneously since the positions of the fighter aircraft could be projected on the plotting table.

Another possibility was to send up two or three night fighters at the same time and anchor them to two or three low-powered radio beacons, where they would wait until called into action by the ground station. Each night combat area had been equipped in the beginning with two or three low-powered radio beacons in order to keep this possibility open. If several enemy targets flew over his area at the same time, the fighter control officer was able to send up several night fighters.

He would guide the first fighter only until the pilot had picked up his target, either with the naked eye or by airborne radar. Subsequently the control officer would direct the second fighter to another enemy target, and then a third fighter, if available, in the same fashion. If the first night fighter had returned to the stand-by area in the meantime, the whole process could be repeated so long as there were enemy targets in the area. This method required, of course, very great ability on the part of the fighter aircraft control officer and strict radio discipline on the part of all three night fighter pilots, since all were tuned to the same radio frequency.

This procedure was repeatedly successful where night fighter stations were manned by particularly good aircraft control officers. Its general use was not feasible because of the lack of able fighter control officers and the shortage of night fighter planes

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which did not permit assigning three to each night fighter station.

The limited range of the Wuerzburg-Riese was a real disadvantage, and the failure to extend it was, along with window radar jamming, decisive in the fate of German night aerial combat. Even if all the other weaknesses and defects of the Himmelbett method had been overcome, there still remained the tremendous disadvantage that the night fighter was confined to a too small combat area, since the extent of a night combat area depends entirely upon the range of the radar equipment. If, for example, the range of the Wuerzburg-Riese could have been increased to 300 kilometers, the problem of the limited area would have been immediately solved. If this longer range had been supplemented by an airborne radar with a range of six to eight kilometers, a near resolving power of up to 200 meters, and an aperture angle of at least 120° to the front and thirty degrees to the rear, the problem of defense against a large-scale attack by a continuous stream of bombers on a relatively narrow flight course could have been more than adequately solved.

But this equipment was not yet available, although the need for its development and manufacture had been emphasized again and again since 1942 by the men in charge of the night combat organization, supported by the commanding general of the German Luftwaffe Signal Corps. When the first large-scale night bombing attack on Cologne took place on 30 May 1942, an attack in which more than one thousand planes participated according to Churchill's own statement, the German night combat organization was caught at the most unfavorable moment conceivable, since it was still working out dark

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night fighting techniques after having had all its searchlights suddenly withdrawn in the spring of 1942. The gap opened by the withdrawal of searchlight units had not yet been closed, and the first bomber stream demonstrated clearly and unequivocally--first only to the men in charge of night combat operations--the defects, weaknesses, and disadvantages naturally inherent in the Himmelbett method. Outsiders rejoiced initially over the indeed impressive figure of thirty-six enemy planes shot down, a record number, yet this amounted to only 3.6 percent of the penetrating aircraft, if one assumes a total of one thousand. The penetration had been carried out over a limited area, utilizing narrowly confined flight courses, and in a continuous stream. Only those night fighters committed in the actual combat zones through which the enemy planes were flying had any chance of success; their neighbors were forced to watch helplessly. A concentration of effort, that is, the commitment of all available night fighter aircraft at the point where everything was literally in flames, was impossible because of technical reasons. The defensive aircraft would have had no chance of striking at the enemy from favorable attack positions even if they had flown in from their stand-by areas.

At that moment the future problem of night aerial combat was defined clearly and definitely: How is it technically possible to commit the mass of the night fighters at the most tactically necessary location, the point of the main effort of enemy bomber operations? How can the night fighters be sent en masse into the midst of the bomber stream, and once in it, how can they hunt and

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find their targets independently without getting in each other's way?

It is necessary to make a distinction between single approach flights or, essentially similar, approach flights of several enemy aircraft in loose, dispersed formation and mass approach flights in the form of a bomber stream. The Himmelbett method promised to be effective against the first type of flights, and the successes achieved by it until it was given up in 1943 proved this opinion correct. But the necessary technical aids could not be procured in time to cope successfully with the second type, mass approach flights in a bomber stream. One of these aids would have been a radar to take the place of the Wuerzburg-Riese with the longest possible range, at least 300 kilometers, and ideally with landscape scanners. As soon as an evaluation of the first large-scale attack on Cologne[28] revealed its decisive importance, the commander[29] of night fighter operations, together with the commanding general of the German Luftwaffe Signal Corps, placed a request for such equipment. It was impossible, however, to procure panoramic radar in time, and it was not until 1944 that the Jagdschloss[30] became available. By then, it was too late to influence the course of events.

An airborne radar, with the characteristics already discussed plus the ability to distinguish between friendly and enemy aircraft, would have enabled the night fighter independently to hunt and find individual enemy targets within the bomber stream. Not until the

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[28] Presumably the RAF 1,000-plane raid which took place on 30-31 May 1942.

[29] General Kammhuber.

[30] Code name for a type of PPI and IFF ground installation with rotating antenna. See Appendix G.

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end of August 1943, did a radar which came fairly close to meeting these requirements, the Lichtenstein SN 2,[51] become available in very short supply (six instruments). By then, since it utilized the same wave length as Freya equipment (2.4 meters), its usefulness was limited by enemy radar jamming, which had begun in the meantime.

Nonetheless, it would still have been possible, although much more difficult, to direct the mass of the night fighters from the available night combat stations to the enemy bomber stream by means of the Benito control system, and then to let them hunt their targets independently with the help of the Lichtenstein SN 2. To accomplish this, it would have been necessary to expend every effort on technical devices to nullify enemy jamming. The prerequisites for achieving this existed.

Limitations Imposed by Official Policy. The Commander in Chief of the German Wehrmacht [Hitler] had other plans in mind, however, and since these were symptomatic and struck at the roots of the problem of home air defense, they should be mentioned.

It is obvious that the night fighter command had to create a vast technical apparatus and an immense organization of both materiel and personnel and that the demands were bound to increase as the number of enemy penetrations grew. So long as enemy planes continued to be shot down in greater and greater numbers, the top-level command of the German Wehrmacht approved. But in July 1943

[51] Code name for a series of DF and IFF radars and search equipment.

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when the enemy began to make use of radar jamming, putting an end to such successes, and the destruction at home assumed catastrophic proportions, the expenditure no longer seemed justified in the opinion of the country's leaders. After all they were facing a very difficult decision. In order to assure home air defense the development it needed, far greater expenditures would be necessary. Technical assistance, material, and personnel would have to be provided if air defense was to perform its increasingly difficult mission. It meant that the primary effort in the conduct of the war would have to be shifted to home air defense for a fairly long period of time.

When the Commander in Chief of the German Wehrmacht realized that the alternatives were either to continue the offensive in the east and defeat that enemy completely but neglect home air defense or to switch the main effort to home air defense and renounce the eastern offensive, he decided definitely to continue the offensive in the east, upon which he was obstinately set. This decision was made in the summer of 1943, at the peak of the crisis in home air defense.[32]

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[32] This decision was made at the end of June or early July 1943 at Hitler's headquarters at Wolfsschanze on the occasion of a verbal report submitted by General Kammhuber to Hitler in the presence of Air Marshal Goering. With the support of Goering and Generaloberst Jeschonnek, Chief of the Luftwaffe General Staff, Kammhuber proposed a 300 percent increase in night fighters. Hitler brusquely rejected the proposal asserting that such a measure would make a continuation of operations in the east impossible. Any increase in air armament for home defense would have to wait until Russia was defeated—expected to happen within the year. Kammhuber believes that as a result of his controversy with Hitler he fell into disfavor and consequently was relieved as commanding general of the XII Air Corps on 15 September 1943 and as commanding general of night fighter operations on 15 November 1943.

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For home air defense, this meant being refused additional funds, simplifying the vast technical apparatus, managing with primitive improvisations, and releasing personnel to the Eastern Front. Not only was the further development of night combat halted but also the fate of home air defense as a whole was sealed. The centralized control for day and night aerial combat, the XII Air (night fighter) Corps, which had been until 15 September 1943 the central headquarters, was discontinued. A series of new fighter corps staffs were set up, but no approval was given for urgently needed reinforcements to supplement the combat-weary air personnel.

The _Himmelbett_ method was considered by the top-level command to be old-fashioned and out-moded and was rejected completely. Instead of utilizing the existing organization to great advantage and developing it further, practically no use was made of it. The attempt to release the night fighter forces against the bomber stream in free commitment, in most cases, quite naturally failed. It was, practically speaking, a return to the free, uncontrolled night fighting employed at the very beginning of the night bombings. The only difference was that now almost all night fighter aircraft were equipped with an airborne radar--either the old _Lichtenstein B/C_, which was almost completely jammed since it had the same wave length as the _Wuerzburg_ (approximately fifty centimeters), or the new _Lichtenstein SN 2_. It was more or less left up to chance whether or not the individual fighter found his way into the bomber stream. An old, experienced night fighter ace could down some enemy planes. Series of three or four planes downed were not rare, and some of

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the best fighter pilots chalked up records of eight planes in a single night.

This type of commitment anticipated a development based on an idea which was, to be sure, tactically correct but which could not be carried out because the technological foundation was still completely lacking. The idea was night formation flying, but technical developments lagged. Not only were the technical aids lacking, but also the fighter aircraft units had never been trained in night formation flying. Even though the plan was tactically quite correct, the technical obstacles encountered in carrying it out had not been taken into consideration. Tactics and technology must go hand in hand if success is to be achieved.

British Dark Night Combat. In England the problems of night aerial combat were comparable to those in Germany only during the first two years of the war. However, British night combat forces were concerned with only one aspect of the problem, a defense against single plane penetrations in widely dispersed, loose formation, which permitted combat against a single target. Germany never committed bomber streams in large-scale attacks. By the time this type of attack was developed by the British, German bomber forces had already become hopelessly ineffective. The British were also spared the intensive radar jamming, to which German home air defense was exposed suddenly in July 1943. For these reasons, the British were able to concentrate their full attention on paralyzing German night fighter operations, and thanks to the catastrophically wrong decision made by the Commander in Chief

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of the German Wehrmacht, their efforts were finally crowned with complete success. Since the neutralization of enemy night fighter activity was a problem with which the Germans had not concerned themselves at all, the writing or evidence of one side can supplement the other when brought together.

From the beginning the British night fighter system worked under more favorable technical conditions having a panoramic radar (Mark IV). Even so, when German night bombers attacked England in the autumn of 1940, there were few instruments available for effective dark night combat.

In early 1941, however, a British dark night combat technique began to develop, based on ground control by means of a landscape scanner (panoramic) and an airborne radar, the Mark IV, with a range of approximately six kilometers. British night combat forces enjoyed technical superiority from the beginning, for it was not until 1944[33] that landscape scanners made their appearance in Germany, and the airborne Lichtenstein B/C, which had a range of only two to four kilometers and a beam of only fifteen degrees, did not come out until the fall of 1941.

In England as early as autumn 1940, Prime Minister Churchill assigned to the development of night combat instruments, especially radar with a landscape scanner, the rare priority designation "Crash Program." In Germany the writer, as commanding general of the German night fighter corps, did not succeed until 22 July 1941 in obtaining the priority designation "Fuehrer" for the development

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[33] The day and month cannot be recalled by General Kammhuber.

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of such equipment, and this designation was by no means rare but was assigned to almost all fairly important armament programs. In England it was possible to fall back on the vast reserve of 100,000 radio "hams"; in Germany no such reserve existed, since the German organization of radio amateurs had been abolished in 1933. In England, basic research was exploited to its fullest extent by the mobilization of all scientists under the leadership of Watson Watt; whereas in Germany at the same time an order was issued to cease work on all scientific projects which could not be completed within one year.

<u>Conclusions and Recommendations</u>. Let us now turn our attention to the conclusions which can be drawn from this glance at the historical development of night combat activity on both sides during the last war. The historical development had to be reviewed in some detail, because out of it arises the formulation of the problem of home air defense as it must be conceived in the future. The conduct of night aerial combat in both its technical and tactical aspects represents one of the most difficult problems we have to solve. If the technological problems of night aerial combat are solved, then solutions are also automatically provided for the problem of all-weather combat. Day aerial combat can also be solved without further ado by the utilization of the same apparatus, because day visibility does simplify defensive aerial combat.

Home air defense may be reduced to two points: combat against single targets, or even several targets which approach in loose,

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dispersed formation; and combat against massed targets which approach in a relatively narrow front in more or less close formation, such as in a bomber stream.

An organization must be found which, if at all possible, is capable of fulfilling both missions with the same technical apparatus. Is this possible, and if so, how would such an organization look?

A solution is possible, if certain conditions are met technically as well as tactically.

<u>Combat against single targets</u>: Each night fighter must be guided individually by the ground station to the enemy target until he can either see and recognize it with the naked eye or pick it up on his airborne radar and continue to follow it independently.

Location of the enemy is accomplished by a large-size, panoramic radar, maximum ideal range 500 kilometers, minimum 300 kilometers.

The night fighter plane is guided by a fully automatic control apparatus of the <u>Sha 2</u> type. Automatic control solves several problems which could be otherwise overcome only with difficulty, chief among which is identification. The position of the friendly night fighter, which can be integrated with enemy position on the oscilliscope where it retains a constant light intensity in contrast to the after-glow effects characterizing the latter, can be easily distinguished. The fact that the ground control is switched to the automatic pilot in the night fighter plane is an additional indication for the fighter control officer that

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he is controlling the movements of his own night fighter.

A control system of this kind has the further advantage that in case the panoramic radar should suddenly drop out of action, either because of its own tendency to self-interference or damage inflicted by the enemy, the friendly fighters are not left completely without direction. Even though the picture of the enemy's position has disappeared for the moment, the ground control station still knows the positions of the friendly aircraft. Contact with the enemy can sometimes be regained by reference to the general picture of enemy activity available in the night fighter headquarters, especially if the night fighter pilot himself has a panoramic radar in his plane.

If, on the other hand, the fighter control apparatus is put out of action for some reason, the night fighter plane can always be guided to an enemy target by normal radio communication on the basis of information furnished him by the fighter control officer. The double control thus provided has an advantageous psychological effect on the pilot.

Ground control of the fighter plane is continued until the pilot has picked up the target on his radar. In order that this can be accomplished as early as possible, a radar with an ideal range of twenty-five kilometers at all altitudes is required. In order to enable the fighter plane to approach his target from the best tactical position, all-round scanning is absolutely necessary. The problem of warning is also solved by panoramic scanning provided the radar is able to distinguish between friendly and hostile aircraft and indicates this either optically or acoustically.

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<u>Combat against massed targets</u>: It is technically hopeless to attempt to guide each night fighter plane individually to a target. A mass flight can be met effectively only by a mass defense, and then only if a way can be found of directing the night fighters, not individually but in complete formations, into an enemy bomber stream. To do so presupposes that technical aids will be found to aid formation flying at night.

In this situation the ground station, in the manner described above, directs only the formation leader up to and toward the enemy bomber stream until he can pick it up on his radar. The rest of the pilots merely follow their leader until he has entered the bomber stream; then with the aid of their long-range panoramic radars, they hunt their own targets independently.

Success depends upon finding a way to achieve night formation flying by means of appropriate technical aids, and upon the efficiency and performance of the panoramic, airborne radar.

The first requirement can be met, since it merely involves imitating what bomber formations have been doing since 1943. If bomber formations are capable of flying in a bomber stream, there is no reason why night fighter formations should not be able to fly in a night fighter stream. They would not be flying as in an aerial review, but their formations would always assume whatever form offered the best opportunities for picking up enemy targets on radar. The right formations will have to be worked out in practice, but all night fighter planes must be provided with the same control equipment, so that any one of them can be assigned to replace the formation lead plane in case it should be forced out of action.

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Whether the airborne, panoramic radar plane is sufficient to enable a formation to fly at night without danger of collision, or whether other special airborne equipment is needed to indicate optically or acoustically the positions of neighboring aircraft, are questions which will have to be answered by experience.

A system for ground control of night aerial combat may also be deduced. Since night combat control must depend upon the availability of a large-size, panoramic radar and since in every case control is limited to a single night fighter plane, even though an entire night fighter formation may be led by this single plane, the logical night fighter headquarters is in an air defense division[54] headquarters. A division headquarters, which incorporates a long-range aircraft reporting service, could advantageously include a headquarters for night, day, and all-weather aerial combat units and the antiaircraft artillery and rocket units, whose close co-ordination with night fighter units is particularly important. Since the air raid warning service is also represented in a headquarters of this type, the close coordination of all the agencies concerned with home air defense is guaranteed as fully as possible.

Using radars with landscape scanners with a minimum range of 300 kilometers, overlapping coverage of the entire home air defense area could be assured, and an unbroken control of night fighter aircraft by the division headquarters guaranteed. Because a division headquarters must be in extremely close contact with neighboring division headquarters, an overlap of one area to another is quite

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[54]Apparently the equivalent of an <u>air defense sector</u> as used in AFF 5-1-1.

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possible, which would allow a night fighter plane, or an entire formation, to be switched over by the ground control station to a neighboring area.

The next higher headquarters for the night aerial combat units is the corps, which is also located in the next higher air defense headquarters[35] and includes an extended area aircraft reporting center. In these headquarters there is no individual direction of night fighter planes or formations except in an emergency. Instead, these headquarters are the locations for the tactical command of night aerial combat operations. Their mission is to direct the night fighter formations in time to the areas threatened by enemy mass flights, and allocate them to the division headquarters for action.

The commanding officer of home air defense working from his headquarters is responsible for keeping himself oriented on the entire picture of air operations in his home air defense region; for supervising the proper tactical commitment of night fighter forces by the division commanders; and, if necessary, for effecting an equalization of the total available forces by timely assignment when necessary of night fighter units to a division commander for the purpose of concentrating for the main effort.

By following these principles an organization can be created which is capable of meeting all technical and tactical demands. The highest possible degree of precision and safety is achieved in

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[35] Apparently the equivalent of air defense region as defined in AFF 5-1-1.

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directing individual night fighter aircraft and at the same time guiding night fighter formations against enemy bomber streams is assured. The old tactical principle of concentrating the main effort at the decisive point is effectively applied, since in extreme cases the method permits a single night combat station to direct all available night fighter forces into a bomber stream, with the greatest possible chances for success. It is upon this contingency that the entire technical organization of night combat must be built.

V. COMBINED NIGHT COMBAT

Description and Technique. Combined night combat is not actually a new, independent night combat technique, but a combination of night aerial combat and antiaircraft artillery action for the purpose of direct defense of fixed installations. It can only be employed when the antiaircraft artillery units are equipped with searchlights, when the enemy target is illuminated. However, since antiaircraft artillery and rocket units will replace searchlights completely in the future with electronic spotting and aiming devices, this type of commitment will be discontinued.

During World War II, however, it still played a large role, and since the experience gained in this sort of action is interesting, especially in those cases where it proved to be on the wrong track, it is briefly mentioned here.

During 1941 a technique of combined night aerial combat was developed, because of the harassing raids of single approach flights on such large cities as Berlin, Hamburg and Cologne and because antiaircraft artillery proved incapable of bringing down the enemy

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aircraft despite the fact that they were often held for five minutes or more in the searchlight beam. The failure of the antiaircraft caused great indignation, for at that time the populations of these cities still could and did watch the entire spectacle in the night sky. Therefore Hitler ordered the night fighter command to work out a technique which would permit the night fighter aircraft and antiaircraft units in areas where defense objectives were under attack to work together.[36]

The technique consisted in dividing the defense area into sections; for example, the city of Berlin was divided into six sectors of sixty degrees each beginning from the center of the area, with the center of the city forming a seventh sector by itself. At the outer edge of each of the six sectors a night fighter plane was stationed in a stand-by area near a low-powered radio beacon. If, in one of the sectors, an enemy target was picked up and held by the searchlights, then this particular sector stopped its antiaircraft artillery fire, and the night fighter plane could fly in without danger and attack the illuminated target. In all the other sectors, the antiaircraft artillery continued to fire at other enemy targets until these were also picked up by the searchlights. In this way the enemy plane was prevented from turning his attention too early to an approaching fighter aircraft. As this technique improved, the time during which antiaircraft artillery operations were stopped grew correspondingly shorter. If the target moved into another sector during combat with a night fighter, the antiaircraft artillery

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[36] Documentary evidence not available in Germany.

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fire was halted in the new sector and resumed in the former one.

A common headquarters controlled the combined night fighting. To insure success, the operating procedures of this headquarters were carefully organized. The halting of antiaircraft artillery fire in the sectors was controlled by a so-called antiaircraft transmitter, which was monitored by all antiaircraft batteries and searchlight units within the particular area. Control of the individual night fighter aircraft was accomplished as usual by a fighter aircraft control officer at the Seeburg plotting table by means of ground-to-air radio communication, the same radio frequency being used for all the fighter aircraft. The Seeburg table, the antiaircraft control headquarters, and the antiaircraft transmitter were located in a single room for supervision and coordination. In Berlin it was located in the large air-raid shelter near the Zoological Garden.

The degree of success attained by this method in terms of enemy planes downed was approximately the same as that attained in illuminated night combat. The entire procedure became proportionately less effective, as the enemy gradually managed, by improvement of navigation aids, to switch over to flights when the area was under a total cloud cover. When this occurred the emphasis was transferred to dark night aerial combat.

"Wild Boar" Operations. Combined night combat enjoyed a resurrection in the summer of 1943, when large-scale attacks on cities became a usual thing, and it had become perfectly obvious that the existing defense organization was not adequate. Instead of drawing the only logical conclusion and strengthening the home air defense

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organization by giving it additional personnel and putting it technically in a position to meet the large-scale attacks with correspondingly large-scale defense measures, the previously established organization was abolished, and the humanly impossible was demanded. This was to resist an enemy who had succeeded in creating a technological masterpiece in the form of the so-called Rotterdam target location device, by means of which large-scale aerial attacks were carried out independently of the range of radar equipment located at the home bases. Resistance, moreover, was to be accomplished with wholly inadequate means, without even the technical apparatus previously set up, since this was believed to be too complicated to retain.

The reasons behind this catastrophic decision by Germany's top leaders have already been mentioned, and unfortunately the top leadership did not encounter a united opposition. There were, in fact, certain persons who served rather to convince them of the correctness of their thinking. Among these was a young major, Herrmann who was typical of those individuals who had enjoyed great success as bomber pilots and who now saw no satisfying field of endeavor before them. Herrmann suggested the commitment of single-engine night fighter aircraft above the defense objectives under attack.[37] Since this suggestion coincided exactly with what top leadership wanted, it was accepted.

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[37]Suggestion submitted in summer of 1943. No other data available in Germany. In late 1943 Colonel Herrmann became commanding officer of the newly organized 30th Fighter Division which included all single-engine night fighters. See Rise and Fall of the German Air Force, page 277.

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"Wild Pig" was the name soon given to this method of night defense combat by single-motored planes. Utilizing the superior speed and maneuverability of the single-engine day combat planes, the crews were sent up into whatever area was under attack with orders to attack any aircraft they happened to see and could identify as an enemy plane. Based on the assumption that the antiaircraft artillery never hit anything anyway, its fire was no longer stopped in the sectors, and as a result everyone was flying and shooting madly all over the place. If there was an unbroken cloud cover above the defense zone, it was illuminated from below by searchlights in vertical position and by flares above, so that it lit up if not too dense and formed a sort of illuminated screen, the so-called shroud against which the silhouettes of planes stood out.

Despite the tremendous feats required by such a commitment and actually performed by individual crews, individual successes bore no relationship whatsoever to the total performance or to the damage caused by this "organized chaos." Not only did German losses far exceed any bearable extent, but the entire aircraft reporting service, the antiaircraft artillery, and the normally conducted night combat by twin-engine aircraft were thrown into complete confusion. The antiaircraft artillery was shooting wildly and naturally sometimes hit its own fighter aircraft; and no one could reproach it for this. Since the single-engine night fighter pilots were forced by this to revise their opinion of the efficiency of the antiaircraft artillery and to attribute more success to it than its commander was willing to admit, they now adopted the -

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procedure of shooting at illuminated targets from as far away as possible, which, in turn, endangered the twin-engine night fighters who, as they had been taught, approached the target closely enough to attack from the shortest possible firing range. In this way losses caused by our own fighters were frequent and very painfully felt. The lack of an effective system of identification made it more and more difficult for the ground crews to distinguish between friendly and hostile aircraft. The name "wild pig" was certainly aptly applied. Only when German losses mounted so high that they seemed unbearable, even to the Commander in Chief of the German Wehrmacht, was this method discontinued.

Extremely great damage had already been done, however, to night combat in general. For at the most decisive period, the summer months of 1943, the top leadership was looking exclusively to this new technique to save the situation, and thereby missed what was perhaps the last opportunity to obtain valuable technological aid from German industry. Immeasurable harm had likewise been done to daylight aerial combat because it was predominantly the day fighter planes which cracked up one after the other, and were lost to day combat operations.

Combined night combat, however, can have decisive importance in the future, though of course not in the old form of illuminated night combat, either by single- or twin-engine aircraft. This future form will be discussed separately with the coordination of day and night combat with modern antiaircraft rocket units.

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CHAPTER 5

PROBLEMS IN ALL-WEATHER DEFENSIVE AERIAL WARFARE

1. DESCRIPTION

The concept of all-weather combat is a new one and may require some explanation. It is interpreted to mean combat in weather which ranges from a cloudless sky to one completely cloud-covered and from low-lying clouds to ground fog. The characteristics distinguishing all-weather combat from other types are as follows: The enemy may be flying:

a. Above an unbroken cloud cover which may be more or less dense, but which in any case requires blind flying. The clouds may be so low that a take-off with only partial visibility is possible, or the clouds may be lying at ground level requiring a blind take-off.

b. In the clouds, either singly or in formation; the formation may be either loose and dispersed or close together as in a bomber stream in a large-scale night attack. Between these two extremes there are countless variations which are altered in greater or lesser degree according to the important factor, the condition of visibility.

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II. TRAINING, TACTICS, AND TECHNICAL EQUIPMENT

All-weather combat above a cloud layer is primarily a matter of training. Where the enemy is flying above the clouds, in other words in full daylight visibility, the all-weather fighter can expect aerial combat under normal conditions once he has risen above the cloud cover. In this case control, as in normal daylight combat, is accomplished from the ground.

The question of how to penetrate an unbroken cloud cover is not one of training alone. It is also related to the choice of aircraft. If it is a thin layer of clouds, high enough to permit a take-off with visibility, a normal day combat group will be well enough trained to accomplish this without difficulty. If there are very dense cloud layers, however, lying almost or even at ground level and if visibility is so poor that a complete mastery of instrument flying is required, then only fully trained pilots with completely equipped planes can be used.

In the one instance ordinary daylight combat aircraft can be employed, but in the other it will be necessary to provide special planes, and give the pilots specialized training in all-weather flying.

Where the enemy is flying in the clouds, combat conditions are similar to those of night aerial combat, and the same fighter control organization can be used for both. Night combat planes can also be used if supplementary airborne equipment to permit blind firing is added. Such an instrument was under development in Germany during World War II, the [illegible], a modification of

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the _Lichtenstein_ airborne radar, but it was never tested in action. This airborne search apparatus must have a near resolving power of up to five meters and be automatically coupled to the aircraft's offensive weapons to permit complete blind firing. Automatic firing equipment of this sort is a _sine qua non_ for the all-weather fighter pilot who is expected to shoot down an enemy plane flying in the clouds. In contrast to the night fighter, the all-weather fighter cannot count on seeing his target, and he must rely entirely upon electronic firing equipment.

The same blind-firing equipment is also necessary for night aerial combat. An enemy bomber may be flying inside cloud banks at night, too, so that there is no possibility of seeing him with the naked eye. It may become tactically necessary for the night fighter pilot to open fire from a considerably longer distance than has been usual in the past, since the tail guns in heavy bombers have become more powerful, and their long-range warning instruments may preclude a visual approach.

Since the type and instrumentation of all-weather combat planes correspond to those required for night combat, both classes of fighters can be equipped with the same types of aircraft.

III. MISSIONS

It would not be feasible to get along without special all-weather aerial combat units by merely assigning their mission to the night fighter forces, although the two have so many points in common. There are serious considerations against such a solution.

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It is, of course, true that all-weather and night fighter pilots fly the same types of aircraft with the same kind of instrumentation, that their general flying training will have been the same, and that both must be supported by the same ground control organization; but their tactical training and tactical commitment will of necessity differ. The all-weather fighter pilot, for example, must receive complete training in daylight combat in addition to the night combat training. For after having penetrated a cloud cover, he may find himself facing, in full daylight, a bomber group flying in closed formation and accompanied by a fighter escort. In such a situation, he could accomplish nothing with night combat tactics alone, since these always presuppose combat against a single plane, even when the engagement takes place within a bomber stream. The all-weather fighter pilot must be the most versatile of all fighter pilots, and his training must be planned accordingly.

It is always a disadvantage to have to assign two diverse missions to a single group. The night fighter pilot is committed at night. During the day he should, in fact must, be able to sleep. If both missions are united in a single group, there exists too great a temptation for commanders to overwork their personnel. And precisely this overworking can have a disastrous effect on a group trained to such a high degree of technical performance. Where excellence is required, the conditions conducive to such performance must also be created. Only well-rested, fully fit personnel are eager or ready for commitment. Technology alone is not enough, man must make use of his technical aids with clear, calm, and sound judgment. Run-down, tired, overworked men soon reach the

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point where they are no longer capable of using sound judgment, let alone fight effectively. They become nervous and irritable and precision instruments become useless or even dangerous in their hands. Everything goes wrong, failure follows failure, and in the end, catastrophe. Thousands of such examples in Germany during World War II could be cited , caused by top-level commands' over-burdening the troops.

The better solution seems to be the establishment of a number of all-weather fighter groups. Just how important this can be, becomes clear, when it is considered that the planes carrying the most dangerous bombs, atomic or thermonuclear bombs, may be precisely the ones which fly inside the clouds and cannot be attacked by any other type of fighter aircraft.

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CHAPTER 6

PROBLEMS OF TACTICS, TECHNICAL CAPABILITIES, AND ARMAMENT IN DEFENSIVE AERIAL WARFARE

I. TACTICS OF DEFENSIVE FIGHTER AIRCRAFT

Within the framework of the theme under discussion, the offensive tactics of fighter aircraft, day, night, and all-weather fighters, should not and cannot be dealt with except incidentally, since they present a far-reaching problem in themselves; and these tactics must be touched upon insofar as they are directly concerned with the actual control of home air defense operations. The problem here is to investigate whether combat conditions have changed sufficiently through the development of new aircraft and armaments to affect the control of fighter aircraft formations.

Combat between individual fighter planes and combat against enemy fighter escorts, have probably not been altered, but the methods of attack by fighter aircraft against heavy bombers undoubtedly was. In this connection it is not so much the increased speed and the higher service ceiling of bombers, since these are merely relative concepts, but rather the enormous increase in the

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stability of these heavy bombers and in their defensive armor and armament. The long-range, panoramic radar of the modern heavy bomber practically precludes a surprise attack by a night or all-weather fighter.

A recognition of this situation leads to various conclusions applicable to aircraft control techniques. A successful attack by a single fighter plane against a heavy bomber will probably be attributable only to a fortuitous accident. The standing procedure will be to have several fighter planes attack a heavy bomber simultaneously, in order to divert and thereby neutralize its defense so that the decisive burst of fire, which actually results in downing the plane, can be delivered from a fairly great distance away. The lowest ratio possible will be three fighter aircraft against each heavy bomber, which means always committing at least three times as many fighter aircraft as there are attacking bombers. For the fighter pilots it means developing a coordinated, threefold attack.

The same procedure applies, as far as the number of aircraft to be committed is concerned, to the night and all-weather fighters, since here, too, "many dogs will kill the hare." Here, however, there is a further factor which makes combat difficult. Since they cannot count on visibility with the naked eye, as the daytime fighter can, but must rely on their airborne radars, night and all-weather fighters cannot choose any direction of attack they wish, but are forced to approach the enemy target from behind, flying on more or less the same course. Since, however, the tail gun of a

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heavy bomber will certainly also be equipped with a panorama scanning radar as a warning device, the determining factor will be which plane opens fire first.

Aerial combat is rapidly becoming a battle based solely on the effectiveness of armaments. If both planes are so technically advanced that they have an automatic firing device coupled with their airborne radars and if both have the same number and caliber of guns or rockets, the result is a state of equilibrium. If, however, under the same circumstances, several fighters coordinate their attack, it is possible for them to win. Armament and tactics, then, must be considered, as well as the number of fighter aircraft, if fighter planes are to gain the advantage over bombers.

These fighter plane tactics can be supported by an appropriate arrangement of weapons in all fighter aircraft types. It seems practical, in addition to the fixed frontal weapons, to install in all fighter aircraft stationary, lateral guns "Schraege Musik"[1] which can fire diagonally upwards at a fixed angle of seventy degrees. This topic is discussed in the section on armaments.

The combined attack of a group of three fighter planes against a heavy bomber might look like this: Two fighter planes keep the bomber's defensive weapons, the heaviest of which are located in the tail, engaged from behind or the sides, while the third fighter parallels the course of the enemy plane to the side and below it.

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[1]Specially devised term to describe the fire from these guns; can be translated as "hot music."

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The fatal burst of fire is delivered from below by its obliquely fixed guns. Since, in this case, the entire length of the enemy machine offers a barn door type of target which can hardly be missed and since the fire enters the non-armored parts of the plane, the enemy aircraft can usually be hit and downed with very few shots-- as the experience of the German night fighters proved conclusively.

The chances of downing enemy planes can also be considerably increased by equipping fighter aircraft with rockets. The use of rockets is discussed in the next chapter.

II. TECHNICAL CAPABILITIES OF DEFENSIVE FIGHTER AIRCRAFT

Since the defender will have to expect an appearance on the enemy's side of three basic types of planes: very fast, fast, and slow, it is logical that at least two types of fighter aircraft be produced in order to meet adequately all requirements.

A supersonic fighter plane will be needed, and also a fighter with a speed less than the velocity of sound. Whether or not it is necessary to construct a third type, which is capable also of slow speeds, in order to deal with such extremely slow-flying enemy planes as transports and helicopters, will have to be determined by experiment. Most of the friendly fighter aircraft will have to be of the type which corresponds to the enemy type of the greatest number. The regular, non-supersonic fighter plane will probably be adequate for quite some time, since the potential enemy is limited by the same factors as anyone else. Supersonic planes do not yet form the core of the enemy's air fleets, but only the advance guard.

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While night and all-weather fighter aircraft need special equipment, their other requirements are the same as for daylight fighter planes. These requirements are as follows:

a. A speed at least 100 kilometers per hour faster than that of the enemy plane to be engaged.

b. A service ceiling at least 1,000 meters higher than that of the enemy plane.

c. Flight range of six to eight hours, if possible.

d. Offensive armament: in the front, ideally six guns, caliber 20- to 30-mms, centrally placed around the gun turret; at the side, a two- to four-barreled gun, caliber 20- to 30-mms, located in the fuselage at an oblique angle of seventy degrees.

e. Defensive armament: placed according to type so that all-round defense, especially from behind and below, is obtained.

f. An airborne panorama scanning radar with a range of twenty-five kilometers at all altitudes, a clear image to as close as five meters, and the ability to distinguish between friendly and hostile aircraft.

g. An electronic, automatic firing apparatus, ideally connected with a radar device which maintains a clear image to within five meters, and synchronized with the stationary, frontal weapons.

h. A fully developed sighting device for the guns permanently set at an oblique angle.

i. A periscopic sighting device for the weapons located in the tail.

j. An instrument for formation flights at night or inside

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clouds, in case a panorama scanning radar is not yet available for this purpose.

k. A warning device in the tail to indicate the approach of aircraft, especially from behind and below, in case the panorama scanning radar is not adequate.

l. Complete equipment for night flying—dimly illuminated instruments, ultraviolet lighted instrument panels, completely muffled exhaust pipes.

m. Absolutely reliable de-icer system, cockpit heater, and pressurized cockpits for high altitude flying.

n. Fighter aircraft control equipment needed for whichever particular control method is going to be used; radio direction finding and instrument landing devices.

o. Provisions for loading small fragmentation bombs, used by long-range night interceptors for harassing enemy flight activity.

III. ARMAMENT OF DEFENSIVE FIGHTER AIRCRAFT

Conventional Armament. In contrast to the many problems which found no solution, or at best an unsatisfactory one, in Germany during World War II, were the offensive fixed armaments of the fighter aircraft which fulfilled from the very beginning the demands made on them. In night combat the important thing was to down the enemy plane with the first short burst of fire, since one might lose sight of the target if it did not burst into flames immediately. Planes of the Me 110 and the Ju 88 types consequently were equipped from the beginning with six guns which ranged from

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the heavy machine gun to a 30-mm gun. Each plane was equipped as follows:

a. Six heavy machine guns, or
b. Four heavy machine guns plus two 20-mm guns, or
c. Two heavy machine guns plus four 20-mm guns, or
d. Six 20-mm guns, or
e. Four 20-mm guns plus two 30-mm guns, or
f. Two 20-mm guns plus four 30-mm guns, or
g. Six 30-mm guns.

In the future, of course, it will no longer be possible to attain success with heavy machine guns alone.

But even the 20-mm gun, its effectiveness steadily improved by the use of especially suitable ammunition, was adequate against all models of enemy planes in use at that time, including the four-engine bombers. In those days no enemy plane was able to withstand the massed fire of six 20-mm guns.

The 30-mm gun, which was employed for the first time in the beginning of 1943, proved to be such an effective weapon even against the very largest four-engine fortresses, that old experienced night fighter pilots, who knew their business thoroughly, seldom fired all six guns at once. Since the night fighters usually came in close and opened at ranges of less than 100 meters, they were occasionally endangered by pieces of the disintegrating enemy plane. For this reason, night fighter aces fired usually only two of their 30-mm guns and used the remaining guns only if the first hits had been badly placed.

A 50-mm gun was being developed, but it was not produced in time to be employed. During tests it demonstrated a devastating effect on the target plane, and it may be assumed that it would

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be adequately effective against the most modern and most heavily armored "air cruiser."

Assuming the frontal armament to be six fixed guns, a distribution of two 30-mm and four 20- to 30-mm guns would probably furnish completely adequate firepower.

For the oblique angle armament, two to four guns of 20- to 30-mm would be quite sufficient. With these the fuselage of the enemy plane could be ripped open from end to end, causing it to crash immediately. The "Schraege Musik" technique will be a surprise to the enemy, inasmuch as he does not expect an attack from this position. Using this method, a night fighter, having made his way into an enemy bomber stream, can attain particularly great successes--as experience has shown--because he flies on a parallel course beside the enemy plane and is usually taken by the latter for a friendly aircraft.

In determining the effectiveness of weapons, the decisive factors are not only the caliber and muzzle velocity of the projectile, but also the selection of proper ammunition. In the 20- and 30-mm guns, three types of ammunition were used: explosive, armor piercing, and incendiary. A proper spacing ratio of these three types is most important. Experience indicated that the ratio 1 : 1 : 1 was the most effective. The explosive shell tore the target open, facilitating the penetration of the armor-piercing shell into armored parts, and the incendiary shell set the target on fire.

A special type of ammunition, which combined the effects of the explosive shell and the incendiary shell in a single cartridge and made certain that the target caught fire in every case, proved

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to be especially effective. A dark night tracer, which was so dark that the firer could just barely see it and was not blinded by it, was attached to the incendiary shell. The reflector sight was dimmed by a dark-blue filter, as a result of which the cross-hairs were not fully marked, but only indicated.

__Rocket Armament.__ Rocket ammunition for fighter aircraft was very effective, and intensive developmental research must be continued.

Rocket armament must meet three requirements: an installation of the highest possible number of projectors, at least twelve firing 50- to 70-mm rockets, ideally arranged centrally around the nose of the plane, which can be fired simultaneously in order to increase the chances of scoring a hit; linking the projectors to an automatic firing device by a localizer beam in order to insure accuracy even at long distances; and, equipping the rocket heads with a target searching device, so that the probability of scoring a hit is increased to the maximum possible limit.

A fighter plane equipped in this manner can bring down even the most powerful, long-range, super bomber. Of course an enemy bomber can also make use of these same weapons, and even more easily since it has more space available than a fighter plane. It is for this reason that, as was brought out earlier, the fighter pilot can count on having an advantage only if he is able to carry out his attack in tactical coordination with others.

IV. CAMOUFLAGE OF DEFENSIVE FIGHTER AIRCRAFT

The question of how to camouflage a night fighter plane in

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such a way as to avoid its being seen by an aerial observer as long as possible, is a matter of life and death for the fighter pilot. Camouflage measures are of value only so long as the enemy depends upon his own naked eye for shooting and does not work exclusively with an electronic firing device. Since it is impossible to know with any degree of certainty which of the above methods will be used, for there is nothing to prevent an enemy pilot firing visually even though his plane may be equipped with an electronic firing device, camouflage paint on night fighter aircraft will continue to have a certain importance, even if it only serves to set pilots' minds at rest. Experience has shown that a dingy white on the upper surface of the wings provides the best camouflage. Under conditions of poor visibility, it was possible for a camouflaged fighter plane approaching from below to come extremely close to an enemy plane without being seen at all, this, despite the fact that the enemy tail gunner expected and was keeping a close watch for the fighter, after its presence was betrayed by the warning device (the so-called Monica) in the enemy plane. This situation has been confirmed repeatedly by the reports of crew members of enemy aircraft.

If the "Schraege Musik" firing technique is used, camouflage painting is particularly advantageous. In a cloudless night sky, a white surface can be discerned only with difficulty from above, whereas a dark color stands out.

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V. NAVIGATIONAL AIDS FOR DEFENSIVE FIGHTER AIRCRAFT

It goes without saying that an extensive network of airfields, furnished with the best possible equipment, is a necessity if fighter aircraft units are to carry out effectively their mission of home air defense. A fighter pilot, whether he be in a day, night, or all-weather combat group, must feel confident that everything has been done to make sure that he can land again safely even though he has lost his bearings completely and all his instruments, either through enemy jamming or battle damage, have become useless. A method must be worked out by which the pilot can accomplish direction finding from the aircraft itself--a method utilizing the simplest means which will permit not only a safe approach to any airfield the pilot may choose but also the landing of several planes in rapid succession under bad weather conditions.

The practice of relaying bearings directly to the aircraft from the ground station is a necessary one in the control of fighter aircraft. Without it control is impossible since, with the speed of enemy aircraft increasing up to and beyond the velocity of sound and with flight ceilings lying between 10,000 and 20,000 meters, the fighter planes must be guided by the shortest possible course to the enemy targets. Any other method of direction would simply be too slow. If we assume for the enemy plane a speed of no more than 1,000 kilometers per hour and a ceiling of only 15,000 meters, the enemy will have already covered a distance of approximately 250 kilometers by the time the friendly fighter plane, with a speed of 100 kilometers per hour faster than the enemy and a climbing time

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of approximately fifteen minutes, has reached the altitude of 15,000 meters. If the fighter pilot then has to hunt his target by taking bearings on two or more radio stations and waiting for the enemy's position on the grid network to be radioed, he might just as well have stayed on the ground. He will never contact the enemy.

No matter how indispensable a fully automatic fighter aircraft control organization based upon direction finding by the ground station and subsequent transmission to the plane in the air may be in a future aerial war, it must inevitably be supplemented by an absolutely reliable method by which the pilot can accomplish direction finding for himself. This is necessary for his own personal safety, not only for use as a navigational aid but also for landing under bad weather conditions. By the end of the war Germany had already developed some excellent systems for direction finding from the aircraft itself, systems which served outstandingly well. <u>Bernhardine</u>[2] was such a navigational instrument, which, operating on the principle of telereception, indicated the base lines of any radio beacon selected by the pilot. An ultra-short wave beacon landing instrument was available for use in bad-weather landings, which enabled the pilot to land without outside help on any airfield equipped with such a beacon.

Direction finding from the ground is necessary for fighter aircraft control, and direction finding from the aircraft itself for

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[2] <u>Bernhardine</u> code name for a type of airborne blind-landing and receiver equipment used in conjunction with <u>Bernhard</u>, code name for a type of rotational radio beacon.

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flight safety. Once this principle has been acknowledged and recognized to be logically correct, it is only a matter of formulating the tactical and technical requirements which must be met by science in such a way that both systems can be developed simultaneously to a point of perfection. This point will have been reached when both systems, characterized by the highest possible degree of precision and operational reliability and taking up a minimum of room, can be installed in all types of fighter aircraft. Installation presents no problem in night and all-weather combat planes, both of which are larger and roomier, but it may well be more difficult in the case of the day fighter plane, which cannot be permitted to lose the advantage it possesses in greater maneuverability, speed, and climbing ability. The future usefulness of the day fighter plane, however, depends upon the solution of this problem.

The tactical and technical requirements which must be met by an ideal system of direction finding from the aircraft itself may be formulated approximately as follows:

a. The indication of any [illegible] base lines of radio marker beacons selected by the pilot, an indication of the aircraft's distance away from the beacon, and of visibility conditions at the beacon.

b. The capacity of a radio marker beacon to serve up to fifty planes simultaneously; blocking the beacon in case more than fifty planes should attempt to come in on it at once; a warning device,

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whenever more than six planes come together at the same time in the immediate vicinity of the beacon.

c. Immediate entry from the radio marker beacon into the bad weather approach lane of an airfield.

d. An ultrashort wave landing beacon.

e. The minimum possible degree of liability to interference on the part of the radio marker beacon and the ultrashort wave landing beacon.

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CHAPTER V

PROBLEMS OF ANTIAIRCRAFT ARTILLERY AND ROCKETS IN DEFENSIVE AERIAL WARFARE

1. COORDINATION WITH FIGHTER AIRCRAFT

As has already been pointed out, the two active defensive weapons in home air defense must supplement each other as closely as possible. It is a serious mistake for each to consider the other superfluous and to refuse to see salvation in any but its own type of defense. It must be recognized that the main emphasis of active defense must be placed on fighter aircraft until the point is reached at which a mass penetration flight of hostile air forces can be met by a correspondingly massed barrage of antiaircraft rockets whose effectiveness can be relied upon. The latter situation seems possible only in the far-away future, and to bring it about will require tremendous expenditures for technological development and technical aids.

Antiaircraft artillery is no longer effective against high-flying targets. Its fate was sealed when planes reached altitudes above 10,000 meters and speeds which reached and passed through

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the sound barrier. The ineffectiveness of antiaircraft artillery under such conditions is sufficiently well-known to preclude any argument.

In home air defense, antiaircraft rockets must take the place of antiaircraft artillery. They alone offer a possibility of development to a point which can assure antiaircraft weapons at least a chance of success.

As far as army and navy antiaircraft artillery is concerned, other considerations are still applicable, inasmuch as completely different aiming and firing conditions exist. These problems, however, are of no concern here.

Whether the use of light or medium, multiple-barreled, antiaircraft rocket launchers will finally prevail against low-flying aircraft is a question which cannot be answered yet but which must be determined in the future by practical experiment. Competition between these two types of weapons for the final decision can have only a favorable effect on their development.

II. CAPABILITIES OF ANTIAIRCRAFT ROCKETS

Once it has been agreed that antiaircraft rockets are the only weapons which have any prospect of success against high-flying targets (over 10,000 meters), consideration must be given to the tactical and technical characteristics which the weapon should ideally have. They can be formulated approximately as follows:

a. Range: up to twenty-five kilometers
b. Maximum velocity: 900 meters per second
c. Rate of fire: One rocket from each launcher every twenty seconds.

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d. Bursting charge of at least twenty-five kilograms with the greatest possible fragmentation area.
e. [illegible] or automatic control
f. Target seeking head
g. [illegible] timed self-destruction fuse.
h. Minimum production costs, especially for individual rocket ammunition.
i. Simplest possible method of operation by as few personnel as possible.
j. Extremely fast action readiness of rocket batteries.
k. Storage-resistant rocket ammunition.

Even though the technical requirements may not seem capable of fulfillment at the present time, still they must be set up as requirements, since the tactical value of antiaircraft rockets depends upon their being met. The technique of fire, which can be worked out in several different ways, requires thorough study and experiment. The guiding principle is maximum tactical efficiency with the minimum technical outlay; for the lower the costs can be kept, the more rocket ammunition will be available for use against the enemy; and this is the decisive factor.

III. LOCATION OF ANTIAIRCRAFT ROCKET BATTERIES

The principles which determine the selection of the best tactical locations for antiaircraft rocket batteries must be clearly defined. During the last war, antiaircraft batteries were arranged in a circle around the objective to be defended. Should this method be retained by antiaircraft rocket batteries, or does another method promise more success? An unequivocal answer can be given.

With enemy aircraft flying at speeds of 1,000 kilometers per hour and more, the time available for firing at a target from antiaircraft units arranged in a circle is so short that success

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is hardly likely. The amount of ammunition necessary for success simply cannot be fired at the enemy within the period of time available. The most varied computations on the subject can be advanced but they all lead to the same conclusion, which is also dictated by common sense. An antiaircraft unit could be stationed near a defense objective and be unable to fire a single shell, while the objective is hit and destroyed by the enemy bomber. This might be the case if the enemy should drop a glider or self-propelled rocket from a plane flying at a speed of say 1,000 kilometers per hour, since these rockets are released twenty-four kilometers or more before reaching the target.

It becomes abundantly clear that antiaircraft rocket installations will have to be located differently than artillery units have been. The ideal situation, which corresponds to that for fighter aircraft, would enable continuous fire against the target during the entire time of its flight above the home air defense area.

In order to accomplish this, the antiaircraft rocket batteries must be distributed in a checkerboard pattern uniformly over the entire home air defense area. The density of the network must be determined by two factors: first, the radar operations of the individual batteries must not be permitted to interfere with each other; and second, the desired effect on the enemy target, dependent upon adequate amounts of ammunition, must be attained. Determination of the best way to satisfy both these requirements must be left up to practical experimentation. A third, not unimportant factor in determining the density of the network is the consideration that the technical aids might also, in the interests of economy, be utilized

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at the same time by the other elements of home air defense, such as the aircraft reporting service and the fighter aircraft control organization. This consideration for economy reasons applies in particular to costly radar equipment and the ground communications network.

On the basis of these factors, it may be concluded that a network of antiaircraft rocket batteries placed approximately ten to twenty kilometers apart (perhaps fifteen kilometers as a theoretical average) would come closest to meeting the local requirements. Subsequent reinforcement of the points of main effort in home air defense by setting up additional batteries is not precluded. Reinforcements could be organized into mobile groups, so that a point of concentration could be built up for a limited time at whatever place seems to need it. The result would be a stationary defense system of antiaircraft rocket batteries distributed almost uniformly over the entire home air defense area and, in addition, a mobile reserve force with which points of main concentration could be formed. The reserve force should be placed, for purposes of technical control, under the jurisdiction of the stationary control organization.

The establishment of light or medium antiaircraft artillery or rocket batteries for defense against low-flying aircraft will be subject to the same considerations in the future as in the past, irrespective of whether antiaircraft guns or rockets are used. Their tactical mission, the direct defense of an objective against low-flying aircraft, presupposes close proximity to the defense

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objective, since in a low-level attack the enemy plane must continue to approach very close to its target.

For control purposes, the light antiaircraft units must be attached to the existing stationary defense network from which they receive their orders to go into operation, their preliminary warnings, and the assignment of their targets. The majority of these light and medium antiaircraft artillery or rocket units can be made up of so-called alert units. The creation of a mobile, active reserve for reinforcing the defense against low-flying planes is also extremely desirable.

An organization of the antiaircraft rocket units for defense against high-flying aircraft would probably be as follows: The basic unit would be the antiaircraft rocket battery, distributed in a checkerboard pattern over the entire home air defense area. Nine batteries could be combined into a rocket battalion, four battalions into a regiment and four regiments into a division. Other methods of combination could also be possible.

As has already been discussed in detail in the section on the aircraft reporting service, the headquarters of the antiaircraft rocket divisions could be installed in the plotting centers of the aircraft reporting service; the headquarters of an antiaircraft rocket battery would be united with the plotting center of an aircraft observation station; and a rocket battalion headquarters joined with the plotting center of an aircraft observation center. The headquarters of a rocket regiment could coordinate with the aircraft observation center located in the unit's area. In this

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organization maximum use of costly technical equipment is guaranteed, since the local air-raid warning service would also work in the plotting centers.

The headquarters of an antiaircraft rocket division would coincide with the headquarters of a long-range aircraft observation command and also with the fighter control stations for day, night, and all-weather combat. The control measures of such a consolidated division headquarters will be described later.

These division headquarters would exercise coordinated control of both fighter aircraft and antiaircraft ground weapons. These headquarters would use as a model the headquarters of a "combined night combat" force which has the same mission, to bring both active weapons, fighter aircraft and antiaircraft ground weapons, to the point of maximum defense effectiveness in such a way that they do not interfere with but supplement each other. It would be the mission of these headquarters to decide which weapon has the better chance of success in a given situation and to order its commitment.

Antiaircraft rocket units would be in a position to fire upon and bring down enemy aircraft only. They would not be suitable for defense against guided or remote-controlled rockets; for this purpose a separate defense organization would be necessary.

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CHAPTER 5

PROBLEMS OF COMMAND, ORGANIZATION, AND TRAINING IN DEFENSIVE AERIAL WARFARE

1. COMMAND HEADQUARTERS IN WORLD WAR II

A headquarters, such as the required for home air defense, developed in Germany during the last war from modest beginnings to a large, centralized, division headquarters.[1] Soon after the first large-scale night bombing attack on Cologne on 30 May 1942, the night fighter aircraft command, which at that time already had under its jurisdiction some of the day fighter personnel stationed in Holland and western Germany, began to set up a central headquarters at Deelen near Arnhem, Holland. In this super-headquarters, day and night fighter combat control were combined for the first time; the antiaircraft artillery was included, also for the first time.

The positions of enemy aircraft and of the friendly fighter planes were indicated by points of light on a vertically placed map with a scale of 1:500,000 and with "fighter aircraft grid divisions" superimposed. Enemy data were received by telephone

[1] See Appendixes 8 and 1.

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from the night combat control stations of the division area. Data for plotting the position of friendly fighter aircraft were transmitted by telephone from the Benito control ground stations. The points of light were projected onto the position map from behind.

In front of the map were located the work tables of the fighter aircraft control officers who guided the friendly fighters to the enemy aircraft by means of the Benito control system. At that time, day combat control was already being efficiently carried out with the use of this system. It was the intention of the commanding general of the German night fighter corps to utilize, in time, the same system for the control of night aerial combat, and thus find a solution to the problem of defense against mass penetration flights at night. This planning doomed to failure because the necessary technical requirements, long-range, landscape scanning radar for use on the ground and in the plane itself, could not be met in time.

Using Deelen as a model, six more division headquarters were established. These were located in Stade near Hamburg, Grove in Denmark, Doeberitz near Berlin, Treuenbrietzen south of Berlin, Schleissheim near Munich, and Metz. They all performed well, despite the fact that they could no longer be fully utilized after the events of 1944. As a result of Hitler's "simplification" of command these headquarters, instead of being developed to the point where they could meet adequately the ever increasing demands made upon them, were gradually dismantled.[2]

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[2] Dates for the establishment of the division headquarters cannot be ascertained from sources available in Germany. In order to provide greater manpower for the eastern fighting personnel were drawn from the home defenses.

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11. HEADQUARTERS FOR THE FUTURE

If these headquarters are to be used as models, their development, at the point at which they stopped at the end of 1943 must be resumed; the establishment must be modernized in line with new facilities, and conform to the dictates of future necessity.

Division Headquarters. In considering the problem, we must take as our point of reference that headquarters, which, seen from the point of view of subordinate elements, incorporates all the agencies employed in home air defense operations; such as the division[3] headquarters.

In this headquarters the following agencies are incorporated:

a. One long-range aircraft observation center.
b. The fighter aircraft control organization--day, night and all-weather combat.
c. The headquarters of one antiaircraft division.
d. The office of the air-raid warning service.

The central core of the division headquarters is the long-range aircraft observation center. Its mission is to compile a complete picture of air operations, based upon a combination of the following:

a. Data transmitted by oscilloscope from a large-size, landscape scanning radar with maximum range, ideally 500 kilometers but at least 300 kilometers.

b. Information furnished by the radio intercept service.

c. Reports submitted by subordinate aircraft observation stations and by neighboring long-range aircraft observation centers.

d. Position data on friendly aircraft formations in the air.

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[3]For comparison purposes may be considered as an air defense sector as defined in AFT 5-1-1.

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The picture of air operations can be projected by direct transmission from the large-size, landscape scanning radar onto a survey screen of maximum dimensions, at least four by four meters, so that the time lag is completely eliminated (a procedure similar to that being developed under the Hasslnuss[4] project in Germany at the close of the war). Until this ideal can be realized, the blips of the cathode ray tube of the large-size, panoramic set, received on the oscilloscope, can be photographed, immediately developed and, using a movie projector, projected as enlargements on the vertical survey screen. The time lag of approximately thirty seconds need not be considered a disqualifying factor inasmuch as it is a matter of providing only an over-all picture of air operations. The actual control of day and night fighter aircraft is not based upon this position map, but is exercised directly by means of separate oscilloscopes to which data are transmitted from distant radars, in order that the time lag in this important operation may be entirely eliminated.

The positions of friendly fighter aircraft in the air, so important for antiaircraft artillery or rocket units, can be added to this picture of air operations by means of a special projection technique.

The data supplied by the radio intercept service, as well as the reports submitted from subordinate aircraft observation stations and neighboring long-range observation centers, are recorded on special survey maps.

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[4]Hasslnuss project was concerned with the development of a panoramic indicator.

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The physical arrangement of the long-range aircraft observation center within the division headquarters must be such that the picture of air operations compiled by it is readily visible from all work tables.

The control of fighter aircraft in day, night, and all-weather combat is carried on from special operating areas, which are in front of and have a full view of the plotting map. Each operating area consists of one oscilloscope attached to the large-size, landscape scanning radar belonging to the division headquarters, and a fighter aircraft control apparatus (an ordinary ground-air radio telephone, a Bonito control instrument, an Uhu 2-type device, or any other suitable system). Each work area is manned by a fighter aircraft control officer who is responsible for controlling day, night, and all-weather aerial combat. The control points are the same for all three types of aerial combat, and they are operated day and night by control officers working in shifts. Each controller is connected by telephone with the airfields to which fighter aircraft formations have been assigned.

The operating area assigned to the division meteorologist is located near those reserved for the aircraft control officers, and to the side, so that his weather reports and maps can always be seen by all the control officers. It goes without saying that he is also continuously at the disposal of the control officers for advice on weather conditions.

The commanding officer of the antiaircraft division (or his assistant, as the case may be) has his place in front of the air

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position map. As the air operation develops, he orders his subordinate units to open fire or to hold fire. Since the speed of air operations in the future will be so great, the use of any form of verbal communication will not only be too slow but also too liable to errors of an acoustical nature or in transmission. For these reasons the transmission of orders must be accomplished automatically by means of electrical and optical channels as far as battalion level. The antiaircraft officer on duty would have a series of push-buttons to operate, which, by flashing lights simultaneously in the antiaircraft rocket battalion headquarters, would indicate whether firing was free or restricted for that particular battalion. The battalion commander would direct his batteries by the same method. In this way the time lag can be reduced to a few seconds, permitting ideal coordination between antiaircraft weapons and fighter aircraft. A radio teletype might also be used for the transmission of orders, in case it should be more practical. The use of an "antiaircraft transmitter," which was employed in Germany in the combined night combat technique, is out of the question because it is far too vulnerable to enemy interference. It can probably be used to advantage, however, during the preliminary setting up of this system.

The areas used by personnel in the air-raid warning service are provided with the warning devices and signal equipment necessary for the transmission of reports and orders to subordinate elements.

A considerable amount of supplementary equipment will be needed for the internal operation. Here, only the basic principles are

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indicated which enable a modern division headquarters for home air defense to perform its task adequately.

One important operational area, perhaps the most important of all, has not yet been mentioned, that of the commanding officer of the headquarters itself. His place is easy to determine physically. He must be centrally located, in a position from which he is able to survey comfortably the air position map and the operational areas of the various participants. Near him are the centrally located communication channels.

Much more difficult is the determination of who should be the commanding officer. For here a problem is touched upon which has a very decided psychological aspect. Three interested parties, three different types of weapons; air signal units, fighter aircraft, and antiaircraft units, rely on the direction and coordination of a single headquarters and a single director. For this reason, the selection of a commander is very difficult and requires extremely careful consideration and thorough evaluation of all factors involved if all parties concerned are to be satisfied. This will be dealt with in greater detail in a later section.

The number of operating areas for fighter aircraft control officers in a division command headquarters depends naturally upon the number of oscilloscopes which can be attached to the large-size, landscape scanning radar. Tactical requirements indicate twelve oscilloscopes: one to be used in the projection of the picture of air operations, one as a control apparatus for the commanding officer of the headquarters, and ten for the aircraft control

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officers. If there are ten division headquarters, each equipped with ten seats for aircraft control officers, it is possible to control 100 individual planes or 100 formations in the air at the same time. Assuming a range of at least 300 kilometers for the large-size, lumiscope scanners and by placing the instruments in such a way that each overlaps half the range of the ones adjoining it, unbroken and continuous control of fighter aircraft is possible for a linear distance of 3,000 kilometers. This presupposes that the planes are able to change their frequency ten times, a capability which must be considered and set as a tactical and technological requirement.

A headquarters, organized, equipped, and integrated in the manner discussed above, is also in a position to direct a mass commitment of fighter aircraft against mass penetration flights by day or night, and to maintain directional control over the entire home air defense area. Penetration flights by individual aircraft can also be met most effectively by this same organization; and these individual flights may be more dangerous than mass flights, if the planes involved are atomic bomb carriers, which approach flying above an unbroken cloud cover, inside it, or at stratospheric altitudes. Effective opposition is possible, because the headquarters organization is based upon the principle of ground control of individual aircraft with the maximum degree of accuracy.

Should a day or night combat formation be committed, only one plane, that of the formation leader, is controlled from the ground, while the other members of the formation are guided by the leader.

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Fighter control equipment, however, must be installed in each plane so that, in case the leader's plane drops out of action, any other member of the flight can take his place.

If such a control organization had been at Germany's disposal near the end of World War II and if the required number and quality of day and night fighter aircraft had been available, this discussion would be based on quite a different set of wartime experiences. Examination of the events at the end of the war leads too easily to wrong conclusions, for the attacking side had gained such superiority in quantity, and in part also in quality, that the efforts of the defending side could no longer be taken seriously. Military experience on which future operations can be based can be considered reliable only when two approximately equal forces have met in battle; and this was true of the last war only until about the middle of 1943.

<u>Sector Headquarters</u>. Let us consider now the organization of the headquarters of a higher command. The division headquarters are subordinate to the headquarters of the sector[5] (corps) commands. The sector headquarters must be equipped to accomplish the sector's mission, which is to exercise tactical command over subordinate fighter aircraft and antiaircraft units. In a division headquarters, the fighter aircraft commander is responsible for ordering, through the aircraft control officers, the commitment of fighter aircraft,

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[5] Not to be considered as an <u>air defense sector</u> as used in <u>FM</u> 5-1-1. Apparently the equivalent of an <u>air defense region</u>.

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and the emphasis is placed on the technical aspects of ground control. In a sector headquarters the fighter aircraft commander has responsibility for the tactical command of subordinate day, night, and all-weather aerial combat forces. This is to be interpreted as meaning the selection of the tactically correct target and the building of a point of main effort. For this reason the sector fighter aircraft commander needs a more comprehensive picture of air operations than the commander in a division headquarters. This is why the sector headquarters is combined with a longest-range or extended area aircraft observation center, which then forms the central core of the headquarters.

The picture of air operations, prepared by the observation center, is compiled from the following:

a. The data, furnished by oscilloscope from several large-size, landscape scanners so located within the sector that the entire area is covered without a gap; the ranges of the individual radars overlap several times.

b. Information provided by the radio intercept service.

c. Reports submitted by subordinate long-range observation centers and by neighboring longest-range observation centers.

d. Positions of friendly fighter forces in the air.

This picture of air operations can be produced in the same manner as in a division headquarters, but with the difference that data from individual radar sets must be projected in sequence onto a survey screen at least two by two meters, so that the resulting picture of hostile and friendly air operations is as comprehensive as possible. In other respects the equipment and arrangement are

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the same as in a division headquarters.

The operational area assigned to the fighter aircraft commander must be located in front of the air situation map so that he can, by observing the air situation, actually exercise tactical control over the fighter aircraft through orders to the aircraft commanders in the division headquarters. In a sector headquarters there is normally no direct technical control exercised from the ground over an individual fighter plane or formation, but merely indirect tactical control through orders to the fighter aircraft commanders in the division headquarters.

Nevertheless, it is a good idea to equip a sector headquarters, too, with two operating areas for fighter aircraft control officers and to keep them on duty. There are two reasons for this. In the first place it provides a control apparatus in reserve, which can close the gap immediately in case one of the division headquarters should be forced out of action, or can be utilized to increase the density of the control network for building a concentration. In the second place, the sector fighter aircraft commander can make certain computations himself if speed is of the essence; or in the case of a particularly important target such as an atomic bomb carrier, where it may appear necessary that the target be kept in view during its entire flight by one and the same station and that the commitment of forces against it also be directed by that same station.

The sector antiaircraft commander or his deputy, as the case may be, is also assigned a place in front of the air situation

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map. In contrast to the antiaircraft commander at the division level, however, his activity has no direct, immediate effect on combat, but is limited more to supervising and checking. His part in tactical leadership, dictated by the course of events reflected on the air situation map, consists in shifting his mobile antiaircraft groups, that is, the antiaircraft rocket reserves, to make a main effort at a defense objective in special danger. These shifts are not carried out during an engagement, since they would certainly come too late, but would make themselves felt in subsequent operations.

The operational areas for the officers of the air-raid warning service would follow the pattern of those in the division headquarters.

The commanding officer of a sector headquarters is the sector (corps) commander. Since all the agencies concerned in air defense within the sector are subordinate to him, no problems are presented.

If one assumes that there are three sector headquarters to every ten division headquarters, there is a gain of thirty more control points for fighter aircraft, and it becomes possible to control a total of 130 individual planes or formations in the air.

<u>Commander of Home Defense Headquarters</u>. Superior to the sector headquarters is the headquarters of the commander of home air defense.[6] In this headquarters there is no direct control of air operations, either technical or tactical, only supervision and

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[6] The equivalent of <u>air defense area</u> as used in <u>AFM</u> 5-1-1.

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coordination. The headquarters consists simply of one longest-range aircraft observation center, but this one center is responsible for including the entire home air defense area in the most comprehensive, over-all picture of air operations.

The problem of the selection of a commanding officer for this headquarters is also simple. He is the commander of home air defense. The entire headquarters is built around his desk, for it is here that all phases of home air defense must be centrally coordinated. This will require no additional equipment for the direct operational control of forces in the air, but it does necessitate an extensive command and communications organization for the control of all ground operations for home air defense. This includes contact with the higher level military agencies and with the numerous civilian offices which are more or less direct participants in home air defense activities and those which merely have an incidental interest in them.

His functions in the conduct of operations consist in the issuance of directives which, long before actual combat begins, must be given to the troops, verbally and in writing, and in the assignment and reapportionment of air force signal units, fighter aircraft, and antiaircraft artillery and rocket units. His direct tactical intervention in an engagement already in progress is out of the question. Such intervention would always come too late to be of any use, and would only cause confusion. If the commander of home air defense wishes to have a hand in the conduct of a particularly important engagement or in the making of especially

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farreaching decisions, he goes to that sector headquarters in whose area the main battle exists. There, if he feels it is necessary, he can intervene personally in the tactical conduct of operations.

__Summary.__ A distinction must be made, then, among three types of headquarters which control the home air defense and in which all branches of the air force are united in coordinated combat. The first is the headquarters of the commander of home air defense. This has at its center a single, longest-range aircraft observation center, which is responsible for covering the entire home air defense area, and it has the facilities which enable the commander and his assistants to carry out their mission of supervision and control over the tactical conduct of operations.

The second is the sector headquarters, where tactical control is exercised over the fighter aircraft forces, and where the coordination of antiaircraft units with the fighter aircraft forces is controlled and supervised. Decision as to which of these two should take precedence in combat is also made here.

The third is the division headquarters, in which is vested the technical control of individual planes and formations, as well as the transmission, down to battalion level, of orders to open or hold fire to subordinate antiaircraft artillery or rocket units. In case of an argument during the course of an engagement, it is decided immediately by the commander of this headquarters, and his decision is binding on all parties concerned. An appeal against his decision must not be allowed to delay any action in progress. If there should be an appeal against the decision of

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the division commander, the final determination would be made by the sector commander.

Wartime experience has shown that it is absolutely necessary that all of these command posts be constructed on the same principles as air-raid shelters, and protected from the effects of gas and radiation. They are the backbone of home air defense, and if they were forced out of action, it would paralyze the entire conduct of air defense operations.

The combining of antiaircraft rocket regiment, battalion, and battery headquarters in the installations of the aircraft reporting service has already been discussed in detail.

The fighter wing, group, and squadron headquarters have no role in the conduct of air operations, and can therefore be set up according to general military principles. The establishment of any special sort of headquarters for them would be, in this case, superfluous.

III. TRAINING REQUIREMENTS

<u>Importance of the Human Factor</u>. From the preceding discussion it should be clear that home air defense represents a whole, whose parts are very closely connected. This is most clearly evident when the component parts are also physically installed in a single room at a headquarters, such as at division level.

With all due respect to technical side, the success of a weapon depends upon the men who operates it. When several types of weapons must be coordinated, as is the case in home air defense

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operations, a balance must be attained in which the different weapons do not obstruct or compete but supplement each other. The men, who come from several branches, must be interested in each other and must all pull together, if they are to attain successful air defense. This, however, is much easier said than done. There are a great many personnel problems involved, many of them old and familiar, some new, and some which the future will bring to light.

The most serious personnel evil, one which can act like a slow poison on the whole organization of home air defense, is an unhealthy rivalry between the fighter aircraft crews and the antiaircraft artillery and rocket men. Both groups tend to use the air signal [communications] troops, which serve them both, as a scapegoat when things go wrong.

Integration. This evil of inter-branch rivalry must be attacked at its roots by appropriate distribution and organization.

How far down the line from the commander of home air defense, the common head of both branches, must integration be carried in order to obtain complete cooperation? Purely from the point of view of command, the most favorable solution would be to provide for this integration at the division level. In other words, "air defense divisions" in which all three branches of the air force are represented might be established. This would also solve the problem of selecting a commanding officer for the division headquarters; he would simply be the commanding officer of the air defense division. Such a solution presupposes that the training of officers, from division commander and up, would be such as to

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give them complete mastery over the employment of all three types of weapons. They would have to be selected early enough to give them an opportunity during their military careers to become acquainted with all three branches by serving as a group leader in each branch for an appropriate period.

Military experience, however, opposes such a solution, tempting though it may be at first glance. Universal geniuses, capable of complete mastery of the requirements of all three branches of service, which after all differ quite considerably from each other, are rare. "Once a fighter pilot, always a fighter pilot"; the same is true of antiaircraft artillery and rocket men, and even the air signal people have their own particular mentality.

For these reasons, it seems to be more practical to establish distinct fighter aircraft divisions and distinct antiaircraft artillery or rocket divisions, and to leave integration for the next higher level, the sector (corps) command.

<u>Appreciation of Technology</u>. Another extremely important personnel problem in home air defense is the awe of technology apparently inherent in the fighter pilot. This seems incomprehensible, and yet experience has shown that a very real psychological problem does exist. Perhaps it can be attributed in great part to the literature appearing in the wake of World War I which glorified aerial combat and led readers to see in it a sort of remnant of the ancient, knightly code of warfare. This attitude led to deep disillusionment for many during World War II, and it has lost any validity it may have had, so far as warfare in the

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f.ture is concerned. A single calculation brings one to the conclusion that the fighter pilot has no time for a lengthy search for an enemy target, what with speeds comparable to the velocity of sound and approach altitudes of approximately fifteen kilometers. Without the help of technology, air operations today are an impossibility. The fighter pilot who does not wish to let himself be guided via the shortest course to his target by the ground station, for fear of sacrificing his "pilot's initiative", might just as well stay on the ground.

The practical application of technology as a means to an end must be taught fighter pilots by thorough instruction and training. Once the aerial target has been sighted, the final outcome still depends enormously upon the initiative and personal courage displayed by the fighter pilot in launching and carrying out his attack. The fact remains, however, that he must not be held up by having to locate the target himself; that must be the task of the ground control station.

After an aerial engagement, the fighter pilot must use technical aids to enable him to find his way independently back to his home base or to some other airfield. This time, however, it is not the technical aids used in ground control which interest him, but those used in direction finding from the aircraft itself. A formation leader cannot always reassemble his group and lead it home again, and the fighter pilot must be prepared to meet this contingency. Each day fighter pilot must master the technique of making instrument landings by radar or electronic aids, which of course is also required of each night and all-weather fighter

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pilot. Extensive flight safety measures, which can be carried out only by recourse to direction finding on the ground, must be dispensed with. While under very poor weather conditions there is danger of collision in coming in on a beacon, this danger is negligible in comparison to the fatal crashes which can be expected if pilots, without any technical guidance at all, break through the cloud cover to make forced landings. This was confirmed by experience during World War II. If both the plane and the airfield are equipped with the navigational aids discussed in the preceding chapter, this danger can be reduced to a minimum.

Formation Flying. Another subject which must be included in the day fighter pilot's training is the technique of flying in formation through a thin but unbroken cloud cover, following the lead plane which is controlled from the ground. Time will tell what degree of proficiency in this technique normally gifted fighter pilots can attain with training. If they are not able to meet the required standard of proficiency, plans to commit them under weather conditions of this type will simply have to be rejected, and all-weather fighters with special training and equipped with special planes for instrument flying will have to be used in their place.

In addition to the special night aerial combat training taken by night fighter pilots, it is vitally important that they be trained in night formation flying, for their chances of success against enemy bomber streams depend to a great extent on their mastery of this technique. Intensive consideration must be given to such training.

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Mutual Confidence Between Ground and Fighter Personnel. That personal confidence exist between the aircraft control officers and the fighter pilots is essential. One can be sure that operations will go well if the persons involved in it are friends; friendship and comradeship should be fostered in every way possible. It is naturally a comforting feeling for a fighter pilot to know that his buddy, the man with whom he sat and talked just yesterday, is sitting down there in the division headquarters and guiding his course. This is true of the day fighter as well as of the night fighter, and perhaps even more so of the all-weather fighter, who has to fly under conditions which force him to rely completely upon the aircraft control officer on the ground. It goes without saying that ground control must be just as careful and just as sure when the pilot being guided is not known to the aircraft control officer; and since pilots will have to cross over from one area of control into another, it must be possible to guide them without interruption over the entire home air defense area. But wherever it is possible, a feeling of belonging together should be fostered, and a mutual, personal interest in each other must be encouraged.

All fighter pilots should be able to step in and function as aircraft control officers. In this way they are forced to acquaint themselves with the technique of aircraft control and with its merits as well as its limitations.

The requirement for mastery of the technical aspects of each type of weapon applies equally to officers in all branches of the air force—to those of the air signal troops as well as of the

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fighter aircraft and antiaircraft artillery and rocket groups. It is not necessary, or even desirable, that all become engineers. It is necessary, however, that officers should not regard as particular merits a lack of understanding of things technical and the conviction that tactics only are worthy of consideration. This again is a very simple statement on the surface, but a great deal of bitter experience from World War II lies behind it.

It is true, of course, that an all too complete faith in the efficacy of technology can be fatal for a pilot. Nothing should be carried to an extreme.

At this point two basic principles diverge. One envisions making all control processes, from beginning to end, fully automatic; the other demands maximum proficiency in the art of flying, not only for aerial combat but also in the event that the equipment necessary for a bad-weather landing should fail. Pilots must be made to understand clearly the importance of both principles in combination. One-sidedness in either direction is bound to be fatal sooner or later. Both principles must be applied in their full significance.

<u>Physical Limitations of Personnel</u>. Accurate estimation of individual capabilities also represents a personnel problem whose seriousness cannot be overestimated. Just as a conductor cannot have his orchestra play <u>forte fortissimo</u> for hours on end without turning both musicians and audience into candidates for an insane asylum, a commander cannot require from troops, whose every action represents peak performance of mind and body, this same top performance uninterruptedly without incurring serious damage.

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Germany committed grave sins during World War II in precisely this field. Two and two are four, and not five, not even when accompanied by encouraging words or by punishment. Command elements must learn to think rationally and objectively, to calculate correctly and not to require continuously peak performance from personnel. A decisive battle may occasionally require more than is otherwise expected of personnel, but it must be recognized that there are limits to the possible, and it must be realized that a period of superhuman exertion must be followed by an equally long period of relaxation in order to restore lost strength. A commander who fails to take this into account will soon have nothing but human wrecks on his hands.

This will be especially applicable in the case of supersonic aircraft fighter pilots. The physical performance required of them will be so demanding that a question arises as to whether average pilots will ever be able to meet these requirements. It may be necessary to establish a separate branch in the air force for pilots of supersonic fighter and bomber aircraft. The operation of supersonic planes may have to be established as a special field, which can be mastered for a certain length of time by some few, usually younger, men who have trained their bodies and kept them trained to a point which enables them to meet the requirements of peak physical performance. Whether or not to establish a separate branch can only be determined by experience.

Esprit de Corps. Special attention must be given to the creation of a healthy esprit de corps. Although a discussion of *esprit* and

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morale among troops does not belong within the framework of this study, the development of a healthy desire to succeed definitely represents a personnel problem. This esprit can be termed "healthy" if its goal is the attainment of a common success through cooperation. It is the responsibility of the commander to promote this feeling of common interest and to foster it by practical measures designed to awaken a healthy ambition on the part of the individual. All members of a group, who have contributed to a group success, must be given a proper share of the credit. The commander in combat must have the authority to apportion credit for success, since this is the only way to guarantee that a fair evaluation, good or bad as the case may be, will be given to a unit's performance.

Female participants in home air defense must also be given a fair measure of credit. They, too, must feel rewarded for their self-sacrificing devotion to an often very difficult task by inclusion in the esprit de corps of the group. The statements made by Churchill in his Memoirs, Volume III, Appendix 3, confirm the fact that this is by no means so easy as one might think.

Electronic Engineering. Another field which may well be decisive is electronic engineering. The form of defensive air warfare in the future will be essentially determined by this field which has developed so many weapons of war. Electronic engineers must continuously develop new equipment which will be unaffected by enemy interference. When changes become necessary, and it can be assumed with certainty that they will, it will be extremely

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important that all equipment be appropriately modified as soon and as quickly as possible.

Field units, consequently, need their own staffs of engineers who can direct the modification and maintenance of new-type electronic equipment and who are capable of installing it. Such engineer staffs were shown to be an urgent necessity during the last war, for the most beautiful equipment is worthless, if, although available in the supply depot, it cannot be installed through lack of a sufficient number of trained experts. It is precisely during the process of installation at the front that all sorts of defects and sources of error come to light. To remedy such defects is the task of these engineering staffs. Therefore, they must be provided for in the organizational set-up of all the units employed in home air defense. Without them there is no guarantee that technical equipment, especially high frequency equipment, will be supplied or maintained in the quantity needed.

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CHAPTER 9

NEW DEVELOPMENTS IN DEFENSIVE AERIAL WARFARE

I. GUIDED MISSILES

Defense against guided missiles is the top priority defense problem, and its solution is the most important task of home air defense. It does not behoove the soldier, assigned to defend the homeland, to give up in the face of the potentially catastrophic effects of this weapon which can carry an atomic bomb at great speeds. On the contrary, he must devise countermeasures. Are there such ways and means, and if so, what are they?

Let us recall the figures on guided missiles as they appear to be today:

a. Range: up to and beyond 700 kilometers
b. Altitude: up to and beyond 400 kilometers
c. Striking velocity: up to and beyond 2,700 meters per second
d. Bursting charge: approximately one ton
e. Potential effects: those of an atomic or hydrogen bomb

It is obvious that these figures are only temporarily valid. As yet no limit can be visualized, beyond which further improvement is impossible. Increases in range, altitude, and speed can be expected during ensuing years.