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THE PLANNING AND DEVELOPMENT OF BOMBS

FOR THE GERMAN AIR FORCE

1925-1945

PART A

CHRONOLOGICAL SEQUENCE

CHAPTER I

BACKGROUND 1925-1927

1. Initial Situation. After the end of World War I of 1914-1918 the German Air Force had been completely dissolved, both in the organizational and in the technological sense. The Army and the Navy had been permitted to maintain small staffs and small units, which had only light weapons.

In 1925 the German Government came to an agreement with the Western Allies, under which the last French and British troops withdrew from the Rhineland and the Inter-Allied Control Commissions, which in the past had exercised military and industrial supervision over German disarmament, ceased to exist.

In return, the German Government gave the assurance before the League of Nations that no secret rearmament would take place on German soil and agreed to submit to sanctions which might be imposed if this promise was not kept.

Technical concepts had even been established for civil aviation to prevent possible "misuse" of commercial aircraft for military purposes. These specifications not only prohibited the inclusion of any features of military significance in the body of aircraft, such as machine-gun mounts and bomber cockpits or the manufacture of substitute fuselage sections intended for such purposes, but also placed restrictions on the power of the engines used. Even in multi-engine planes this power was not to exceed 500 horse power.

The large triple-engine Junkers G-23, for example, although it had a central BMW engine of 240 horse power, had two Mercedes side engines of each only 120 horse power. The Udet aircraft factory in Munich even attempted to develop its Condor plane with four Siemens radial engines of each 110 horse power. However, all of these aircraft were completely uneconomical and could not compete against commercial aviation in foreign countries.

German aircraft factories at this time therefore established branches abroad. The firm of Dornier founded a factory at Altenrhein on the Swiss shores of Lake Constance, where it developed and tried out seaplanes, such as the Wal and later the Do X models. The firm of Rohrbach established a factory at Kopenhagen, where the Rodra seaplane and the large Roland Commercial planes were developed. Junkers opened a factory at Limham in southern Sweden, where it manufactured its G-24 model, powered with three Junkers engines of

Xxxdax 300 horse power each, in order, with Swedish approval, to engage later in commercial aviation.

The branches established in foreign countries by the German aircraft factories previously mentioned soon also commenced supplying military aircraft, since Germany at the time had a lead in the construction of all-metal aircraft and such aircraft were vastly superior to those constructed of steel tubing, timber, and fabrics for use under difficult climatic conditions.

The easiest adjustment here was that of the seaplanes mentioned above to adapt them for service as naval reconnaissance planes (long-range), since it was possible to build in circular tracks for machineguns in the nose and tail after appropriate reinforcement of the fuselage.

The types designed as land aircraft required bigger alterations to the fuselage if they were to have bombing installations in addition to mounted weapons.

Even at this early stage it soon transpired that the designs for commercial aircraft of the sizes then in use could not be made consonant with the requirements of aircraft for military purposes.

In commercial aircraft the primary factor is the safety and comfort of passengers. The designs therefore provided for large spaces within the body to insure a relatively

3 even distribution of loads which would remain constant while the plane was in flight and for fuel tanks placed in the wings and close to the engines.

In contrast, the specific weight of bombs is a multiple of that of humans. Therefore, the aim must be to load them one over the other so as to prevent any shifts of gravitation center during bombing, since any such shift could prove a serious flight hazard. Furthermore, large openings must be provided beneath the bombbays and these weaken the overall structure, particularly since the frame joints have to be subjected to greater strains than is the case in commercial aircraft.

To increase the striking range of military aircraft, it is often necessary to install fuel tanks within the body, which was specifically avoided in commercial aircraft. In bomber aircraft this position of the fuel tanks was an advantage, since they could be given better protection against weapons fire by means of armor plating or other coverings which could break the force of projectiles and prevent fuel leakages. As a rule the wing-installed tanks were too flat for this purpose.

4 The firm of Junkers for their Type K-30 three-engine bomber constructed a special middle fuselage section to carry the same type of engine nacelles, wings, undercarriage and controlling surfaces as their Type G-24 commercial plane. Of

4 this model, the firm produced two series of K-30 planes, partly on undercarriages for delivery to Russia, the rest on floats for delivery to South America. In addition to the machinegun circular track on the top fuselage surface, the Type K center section had a retractable floor gun mount (ausfahrbare Bodenlafette) for rearward and downward defensive fire.

For the German representatives at the Geneva Permanent Disarmament Conference the Junkers solution was admirable in every respect. It clearly stressed the fundamental difference between military and civil types of aircraft, and they did not have to counter any argument that aircraft designed for civil aviation could at small cost be adapted for military purposes.

Owing to the complete dismantling of Germany's armament factories after World War I, the foreign branches of the German aircraft factories had to procure abroad the military equipment required for their planes manufactured for export. Junkers used Danish Madsen machineguns and Swedish Bofors bombs, while Dornier procured from Switzerland "Orlikon weapons up to a caliber of 20-mm. These weapons and bombs were still from World War I production and a common feature in all of them was in their designing no allowances had been made for their appropriate storing and/or installation in

5 aircraft. This had a particularly hampering effect on the adaptation of commercial planes to serve as bombers.

None of the foreign branches of German aircraft factories carried out any proper airborne tests of the weapons and bombing equipment; only a few functional tests were conducted on the ground and at low altitudes over water.

In any case, the sections of air warfare specialists formed in the Army and Navy General Staffs at the Troops Office of the Reich Defense Ministry in Berlin could hearn nothing from all of this work on the subject of how a future German air force should be technically equipped. Furthermore, even for the Great Powers of those days, any implementation of Italian Air General Douhet's ideas on future air warfare was still a matter relegated to the far distant future. For the moment there was still another problem to clarify.

2. Concern over Possible Airborne Gas Warfare. In 1924-1925, the illustrated weekly papers frequently and in a sensational manner protrayed the horrors of airborne gas warfare, much the same as they did 30 years later with the subject of war with atomic weapons. According to their published reports, a few aircraft would suffice to poison the entire population of a large city by spraying liquid chemical war agents from great altitudes, which would settle down into

5 the roads and streets as a "Deathdealing Law."

These descriptions were based on the use of Yellow Cross (vesicant) gas, a chemical warfare agent with a physical action similar to that obtained only by subjecting a living body to radiation and fire. It had been fired in shells by the German side for the first time in the autumn of 1917, at the time when the battle of materiel in the plains of Flanders was approaching a critical point.

Whereas the socalled volatile war gases of the Green Cross type, such as phosgene, were only effective in relatively dense concentrations which could only be achieved by means of intensive fire into a closely circumscribed area, Yellow Cross gas (Dichloroethyl sulphide--mustard gas) is effective even in weak concentrations and because of its persistence. Whereas Green Cross gas could only be expected to have an effect lasting for minutes, Yellow Cross gas could contaminate the ground for days.

Against volatile gases, the gas mask could afford protection, but a thick protective suit was necessary against Yellow Cross gas, since it affected the entire surface of the body.

If the claims of the Press, supported by alleged experts, were justified, airborne chemical warfare was more to be feared than concentrated bombing attacks and necessarily must

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6 have an incisive impact on high-level politics, particularly for Germany in her exposed and vulnerable position.

For this reason the most important mission assigned by the military high command of that time--in 1925--to the departments of weapons technology concerned a study of the possibilities of airborne chemical warfare.

In contrast with the Press versions, many alleged experts doubted that a fluid ejected by aircraft would reach the ground at all. To prove their point they quoted the fact that the water carried as ballast by zeppelins, when ejected, was completely absorbed by the atmosphere within a few hundred yards of altitude. It was also held that the slipstream of an aircraft would dissolve even oily fluids, such as Dichloroethyl sulphide into extremely minute droplets, which would be carried far away by air currents and thus be rendered ineffective, since they would become hydrolized by the atmospheric moisture.

Contentions of this kind could only be proved or disproved by means of practical tests. Under the existing circumstances, this meant that airborne tests with large quantities of test gases would have to be carried out at a time when Germany was prohibited from carrying out military air tests of any kind.

For this reason adequate and credible means had to be found to conceal the purpose of the tests even from German authorities. Furthermore, the work could only be done by

7 privat firms.

In 1925 the use of aircraft had been adopted in Germany to combat insect pests in forestry. These aircraft sprayed a poison dust, chiefly clacium arsenic from low altitudes over forest sections infested by caterpillars. The firm of Junkers had received requests from Africa and South America for contact poisons to also be used from aircraft against swarms of locusts in flight and on the ground, and for the development of appropriate chemical spraying instruments.

The possibility thus existed to tackle both problems, that of pest extermination and that of gas warfare, from the same angle, without any fear of accusation that the preliminary tests carried out with aircraft served military purposes.

8 It was only natural that all-metal aircraft were considered most suitable for the purpose because of the greater ease with which they could be decontaminated xfatax after use in tests with poison sprays. The firm of Junkers, in addition to its aircraft factory, also had the large Kalorifer sheet metal works and its geyser manufacturing works.

The Troops Office of the Reich Defense Ministry in Berlin assigned the contract to the main office of Professor Junkers in Dessau, from where a special controller handled the designing of the necessary chemical apparatuses and supervised their construction in the manufacturing works. The

8 work on the problem of pest extermination also commenced in the same office so that adequate concealment was provided in the Junkers concern.

In the insect extermination project the firm of Junkers had a contract with the chemical factory of E. Merck, Darmstadt. The firm of Merck negotiated with the forestry officials and supplied what was called the "Moth Powder."

Junkers designed and manufactured the spray apparatuses, for use in type F-13 and W-33 aircraft and carried out the aviation part of the program. The firm of Merck had only one interest: the sale of its powdered insect exterminator "Esturmit."

The firm taken into consideration for the supply of liquid sprays was that of Hugo Stolzenberg in Hamburg, namely for the supply of contact poisons for use against locusts in the tropics as well as for the supply of Yellow Cross gas for chemical warfare.

At that time--in the spring of 1925--this firm was establishing a factory for the synthetic production of mustard gas in Russia (at Ssamara on the Volga River) under the Rapallo Agreement of 1922, which agreement will be discussed later. The plan was, to use the gas produced there for airborne tests, also on Russian soil.

The apparatus for the spraying of dust poisons consisted

9 primarily of a wind-driven rotor, which ejected the insecticide evenly from the loading bins within the aircraft. Once outside the slipwind spread it out. This apperatus has and had no military importance and will not be further mentioned.

For reasons of safety, the tank for fluid poisons to be sprayed was to be mounted on the outside of the aircraft (Photo 1), to protect the crew against the consequences of a possible leakage.

Junkers first constructed a tank to hold 200 liters (52.53 gallons) with a square base and a wing profile cross section. It was so mounted on the aircraft that it was between the undercarriage with its flat surface on the fuselage and its curved side--the suction side--facing downwards. The profile was cut off at the rear, allowing an ejection slit approximately 12 centimeters wide, which was closed with a firmly sealed flap.

For emptying, the tank was tipped downwards, the front remaining suspended in bearings. Simultaneously a current of air streamed between the tank and the fuselage to prevent the latter being sprayed. When at an angle of approximately 32° the closing flap was opened by pulleys and the fluid flowed out within a few seconds and was vaporized by the slipwind to form a cloud of tiny drops. Even very viscuous fluids could be finely vaporized with this tank without contaminating the

50 the time in the construction of aircraft carriers and cruisers, which had only approximately 2" armor plating plus several upper decks of normal ship construction steel, there were prospects that the penetrating capabilities of armor-piercing bombs with a relatively high (20%) explosive charge ratio would be sufficient. Calculations showed, however, that if bomb calibers were to remain within reasonable caliber limits bombs released in dive-bombing attacks would have to have rocket propulsion to pierce 6 inch armor plating. Prior to World War II German bomber aircraft had a maximum pay load of 2,200 pounds (1,000 kilograms); after the outbreak of the war this maximum increased to 3,740 pounds (1,700 kilograms); at the beginning of 1940 a maximum of 4,000 pound was authorized and during the attacks against London the largest bomb caliber used was that of the super-charge SB 2500 bomb, with a weight of 5,500 pounds, which was possible because German aircraft could take off from airfields in northern France.

51 Credit is due to the irm of Rheinmetall, Duesseldorf, for having made available within a relatively short time in the spring of 1939 apparatus which made it possible to gun fire bombs against armor plating and concrete walls.

The 380-mm missile projector used (see illustration) was a smooth-bore inner tube of a 380-mm cannon with a 210-mm liner. The latter was used to test fire 110-pound

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51 bombs while the larger was used to fire 550-pound bombs.

Instead of using the standard PC-500 armor-piercing bombs, which had a diameter of 400-mm, special model bombs were constructed for tests with the missile projector. These model bombs were approximately 10% lighter, fitted into the 380-mm barrel and were constructed of the same steel and in the same way as the standard bombs.

All firing tests were carried out at ranges of 88-110 yards between the projector and the target. The armor plating and concrete walls used as targets were place upright. In the case of armor plating tests were based on an impact angle of 60°, corresponding to the angle in dive bombing. In the case of the concrete walls, the impact was vertical, which corresponded to the impact angle of bombs released in high-altitude attack.

Instead of armor plating, normal ship sonstruction steel was used in testing mine-type bombs. Since the decks to be pierded by such bombs were relatively thin, the quality of the target material was of less importance than the impact angle so far as the total impact force was concerned.

When bombs pierded the armor plates at an angle the lateral stresses affecting the wall strength of the cylindrical bomb casings were greater than the stresses to which the massive nose section of the mine-type bombs were subjected.

51a Photo

380-mm Missile Projector with
200-mm Inner Tube

52 In spite of these facts the established testing conditions were retained and events in the war served to prove how wise it had been to increase the test requirements, since the various inside installations of transport ships subjected bomb casings to far greater stresses than those caused by the decks and superstructures.

The targets to represent ship construction steel were made of normal construction steel, Quality II, with a tensile strength of 54 kilograms per square millimeter. Homogenic (nor surface-hardened) steel with a tensile strength of 110 kilograms per square millimeter was used to represent the armor plating to be pierced. This steel was known as Quality W,h (Wolfram alloyed) hardened).

The vertically placed concrete slabs were of what was called fortification XXXXX concrete, which had what was called "cubic armoring (kubische Bewehrung)" consisting of 10-mm iron bars, and with a weight of 110 pounds per cubic meter of concrete. A maximum pressure resistance of 2,000 kilograms per square centimeter can be assumed.

For each round fired the barrel was precisely aligned with the "target line tester to secure repeated use of the armor plates and concrete slabs. The missile projector had a field of dispersion of approximately 50 centimeters at a range of 100 meters. However, it proved necessary to

52 re-erect the steel plates after each round, since the force of missile impact tore them from their supports. This caused considerable intervals between the individual rounds.

As is usual with test guns, the Boulangé apparatus xxx and compression measuring instruments (Stauchzeug-Messeinrichtungen) were used for the continuous measurement of gas pressure and muzzle velocities.

The impact velocities selected were 180 meters per second for armor-piercing bombs and 300 meters per second for armor breaching bombs, which corresponded to the impact velocities of bombs released in dive attack from an altitude of 7,200 feet, the former without and the latter with rocket propulsion. The impact velocity for mine-type bombs was 250 meter per second, corresponding to the impact velocity of bombs released in horizontal flight at an altitude of 13,200 feet.

The test missiles used were normal 110-pound and 550-pound bombs, in which the standard stabilizers were replaced by special gunfiring stabilizers adapted to the gun caliber. The attached photo shows specimens of the SC-50 and SD-50 mine-type and multi-purpose bombs thus adapted. Two gas and guiding bands were lightly shrunk on to improve gas pressure and balance in the smooth gun barrel. On impact these rings slipped off.

These missiles were similar to mortar shells and were

266
52a

Photo

110-pound (50-kilogram) Bombs
Adapted for Testing by Gunfire

55 adequately stable in trajectory for the short ranges involved; slow-motion recordings were made of impact and penetration by means of cameras placed alongside the targets. In adapting older types of bombs it became necessary to use a metal plate conus to fasten the stabilizers, and this cone had to be pierced with holes to prevent crumpling by the gas pressure.

Most of the bombs used in these test firings had an inert filling and compression recorder was built into the side fuse chamber to register the lag at impact.

Occasionally, and during demonstration firing, use was made of live bombs. In such cases mechanical fuses were built in which had the same sensitivity and delay factors as the electrical bomb fuses normally used.

Photo 3 shows a 30-mm plate of ship construction steel used as a target for xxxxxxxxxx 110-pound bombs. The out-of-round holes show that the impact angle was less than 60°. The following two photos show the 110-pound bombs after they had penetrated through the steel plates.

The multi-purpose bomb, SD-50, naturally had a greater casing wall thickness and therefore a greater penetration capability than the SC-50 mine-type bomb of the same weight, which, however, carried a 50% heavier explosive charge. The deformation of the bomb numbered "Schuss 6" is due to the fact that its casing was from pressed tempered steel, while

52a Photo

110-pound (50-kilogram) bombs
Adapted for Gun-Firing Tests

53a Photo

50-mm Plate of Ship-Construction Steel II (R_2=54 kilograms per square millimeter) taken under fire with 110-pound bombs. Impact angle 60°; impact velocity 250 meters per second.

53b Photo

<u>Legend</u>:

Sch[uss] 6	= Round 6
Press-Stahl	= Pressed Steel
Stahlguss	= Cast Steel
SD-50 nach Beschuss	= SD-50 Bomb after Firing

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54 whereas that of the bomb numbered "Schuss Nr. 11" was of cast steel, the material normally used for these bombs.

Provided the casing did not kxxxt crack it was considered as having met the requirements in point of penetration hardness.

Multi-purpose bombs of steel Quality 7011 conforming to the German industrial standard (Deutsche Industrie Norm) gave better impact results and a better fragment count at detonation than those with cast steel casings, whereas DIN 3516 steel proved better for mine-type bombs.

The SC-50 mine-type bomb (numbered Schuss Nr. 10) shown in photo No. 5 had a casing of seamless steel, with a pressed-on nose section and a welded-on base (Manufacturing index "L" and Quality Category II). After penetrating through the 30-mm steel plate it was found that a bulge had begun to form at the point of transition from the nose section to the cylindrical middle section (the cross-sectional part endangered at impact) which showed that the bomb with the same wall thickness was at the extreme lime of tolerance.

The following two photos show a 50-centimeter thick, cubically armored, slab of fortification concrete after penetration , and the SC-250 mine type bomb which had penetrated it. This bomb was of pressed steel but also with a welded-in base, and also represented an ultimate tolerance limit.

54a

Photo

SC-50/II Bomb after Firing

55 On the basis of these results, mine-type bombs were developed which, similarly to large-caliber artillery shells, were made of one-piece casings by the Ehrhardt press-and-draw manufacturing process. In this process the casing wall was thickest in the nose section and gradually became thinner towards the rear end, in consonance with the pattern of stresses at impact, and the base was also worked on by hammering, for which reason the bomb "hardness" was consistent throughout.

SC-250 bombs, quality Category I, of this type even penetrated satisfactorily through shipbuilding steel with a thickness of 50 millimeters, an astonishing performance for a missile with a walling thickness of only 8 millimeters. None of the mine type bombs in this caliber class used by the opposing air forces was as well designed and constructed or submitted to such severe tests as this German SC-250 bomb.

Besides the manufacturing process just mentioned, an exceedingly important factor for the high degree of "hardness" of these mine-type bombs was found to be the structure of the massive nose section, which was not weakened by fuse cavities. Already in the Spanish Civil War experience had shown that Russian 110-pound and 22-pound bombs of the older type usually broke at impact, since the strongly constructed fuse-center-section was subjected to shearing stresses which ripped the bomb casing lengthwise.

During World War II many of the American demo bombs
56 even when striking ordinary cobblestone surfaces burst immediately from the nose and thus became ineffective. When it was pointed out to them after the war that when American forces bombed the German Air Ministry in Berlin 50 percent ~~xxxx~~ of the bombs which struck the target burst ineffectively while ineffective bursts in the garden terrain were a rare occurrence, American weapons experts replied that they preferred to deliver a plurality of bombs on a specific target rather then depart from their convenient manufacturing processes available in the tube manufacturing industries. In the German Air Force such an attitude would have been considered wasteful and the greatest possible degree of effectiveness was required of each bomb.

War conditions in Germany made it necessary to depart from the ideal structure of SC-bombs. Here the method of testing the bombs by firing them from a gun barrel made it possible to determine precisely their reduced hardness and, accordingly, to class them in "Quality Categories" for the various operational purposes. Only J type ammunition was used against ships.

When the necessity arose to determine the penetrating capability of the PC-500 armor-piercing bomb, the barrel

55a Photo

SC-250 Bomb after Firing

55b Photo

50-centimeter slab of Fortification Concrete (with 50 kilograms armoring per cubic meter) after Impact of an SC-250 ⊥ n. 250 meters per second.

length of the gun used in the test firings became a matter of particular importance. As previously mentioned, the diameter of the bomb was too large. For this reason use was made of a PC 500/38 model bomb which was 10 percent lighter but which in point of structure and of the materials used conformed precisely to the principles of the standard PC-500 bomb and with the same impact velocity was required to breach armor steel with a thickness of 70 millimeters in order to insure that the original PC-500 bomb would achieve the required breaching capability of 80 millimeters.

Prior to the war only very few steel presses existed in Germany which were capable of manufacturing such bombs and these were fully occupied with Army and Navy contracts.

Until the German Air Force could create the necessary manufacturing installations, bombs of this type were also manufactured of cast steel and designated PC-500-E, the "E" denoting "Export." These bombs were slightly shorter and had an explosive charge of only 176 pounds instead of the 220-pound explosive charge of the genuine PC-500. It was only in this form that the export of these bombs to Japan was authorized.

Armor-piercong bombs were bi-ogivale, meaning that not only nose was a pointed arch but that the rear end of the casing was also much shortened in order to prevent shearing stresses

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57 stresses during passage of the bomb through armor plating. The attached Photo No. 7 shows a PC-500/38 bomb after piercing through 70 millimeters of armor steel with an impact angle of 60° and at an impact speed corresponding to delivery in dive attack from an altitude of 4,000 feet. The bomb withstood the impact and penetration well, but the crack in the nose section shows that tolerance limits had just about been reached.

All test firingswere carried out at velocities close to or above the breaking point.

In vertical impact the test bomb showed a very high degree of hardness, which revealed the advantages of the bomb for delivery on target from horizontal flight. Photo No. 8 shows the reaction of the xxxx PC-500/38 bomb in vertical impact on a 120-mm thickness of armor steel. Contrary to expectations, the bomb did not break, xxtxrsxxinsdxsxbeddsd but remained intact apart from deformation of the point, and remained embedded, and,given altitudes between 13,000 and 16,500 feet, would have pierced through the armor-plated

58 decks of battle ships with a displacement up to 25,000 tons.

In the case of the 2,200- and 4,000-pound bombs developed at the beginning of the war under the large-scale bomb-development program, no possibilities existed fo test them by firing from a gun barrel. In view of the long time it would have taken to construct an appropriate test gun

57a

Photo

PC-500-E/38 Bomb after Piercing through 70-mm of Armor Plating, V_z = 176 Meters per Second, Impact Angle = 60°.

beginnender Anriss = Incipient crack.

57b

Photo

PC-500/38 Bomb embedded on 120-mm Armor Steel Plate, V_z = 186.6 meters per Second.

275
58

and because of the necessity to make use of the ammunition immediately after production reliance had to be placed on tests in actual attack against the enemy.

It was only in 1942 , following the hardly satisfactory results obtained in the bombing of large enemy warships, that instructions received approval for the construction of the Missile Projector 66 (Koerperwerfer 66), illustrated in Photo No. 22, with which it was possible to fire all explosive bombs which had been developed in the meanwhile at the requisite velocitiesin order to check the xxlxxlxtxx target penetration capabilities which had in the past been computed mathematically.

However, only one of these projectors was placed in service by 1944, with a caliber of 562 millimeters. Tests showed that most of the bombs meanwhile introduced for use in combat operations met the requirements stipulated in their designing. The most important of these bombs, the rC-1ö0ö-RS rocket-accelerated armor-piercing and the PC-14ö0 armor-piercing bombs actually showed better capabilities than had been assumed in the past.

In the gunfiring tests, however, the PC-1000 bombs showed less favorable results because it was manufactured from weakly alloyed steel which, in the relatively thick point section could not be properly tempered through to the

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58 through to the core, as previously mentioned. This was due to the foolish stipulation that the bomb had to be constructed to fit into a specified bomb storage space.

59 As described in the previous chapter, the reaction of the three named armor-piercing bomb types when delivered from a high altitude against hard ground was the same as when the bombs were fired against a similar surface from a gun, the only difference being that the latter method of testing made it possible to determine the bomb's breaching or piercing capability.

Photo No. 11 shows the point of a PC-1000 bomb protruding from the far side of a 100-mm armor plate. The point shows incipient cracks, without the bomb having pierced completely through the plate.

Since no enemy warships had protective decks with a 100-mm thickness of steel plating, production of the PC-1000 armor-piercing bombs was halted, and the bomb was replaced by a multi-purpose bomb, the SD-1000-A, using unalloyed materials in the manufacture. This bomb was suitable for general purposes and carried an explosive charge weighing 440 pounds instead of the 350-pound explosive charge of the original PC-1000 bomb; it still had a breaching capacity of 80 millimeters.

Photo No. 12 shows a rocket-accelerated armor piercing

59 ...on, the PC-1800-RS, after penetrating through 180-mm of armor steel at the impact velocity achievable in dive-bombing attack.

The casings of armor-piercing bombs have such thick walling that they can be given a cylindrical outer shape without any disadvantages and at an equal weight are shorter than biogival bombs, which is an important feature with rocket-accelerated bombs since it reduces structural [illegible] length. Because of the extreme stresses caused while penetrating at an angle through the armor plating, the PC-1800-RS shows a slight denting in the rear third of its length without any reduction of its blast effect.

The intention also existed to use Missile Projector 66 in tests with combinations of steel plates representing the structure of the various decks of a warship, as indicated in Photo 12. Owing to its relatively weak/mount, the old Model

60 38 Missile Projector [illegible] could be used only for the testing of PC-500/38 bombs and a missile velocity of 185 meters per second, making it possible to pierce 70 millimeters of steel plating. This naturally was inadequate for any appreciable combination of steel plates.

The maximum performance of Missile Projector 66 was with the PC-1600 (Rocket-Propelled PC-1800-RS bomb minus the

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58a Photostat

<u>Legend:</u>

Koerperwerfer 66) mit Rohr 56.2 cm)	=	Missile Projector 66 with 562-mm barrel
Es koennen verschossen) werden)	=	Can fire
Aus 56,2 cm Rohr	=	Using 562-mm barrel
PC 1000 mit V_z =320m/s Entspr.) ha = 6000 m.)	=	PC-1000 at velocity of 320 meters per second; corresponding to bomb-release altitude of 20,000 feet
etc.		etc.
Aus 68 cm Rohr) (Einsatzbereit 1944))	=	Using 680-mm barrel (Ready for service in 1944)
Hoechste Leistung des) Koerperwerfers bei einem) Bombengewicht von 1600) kg und einer V_z = 400 m/s)	=	Maximum performance of the missile projector with a bomb weight of 3,520 lbs and a velocity of 400 meters per second.

Appendix to p. 27[illegible]

59a Supplementary to pp. 277/278

Photo

Gun-fired PC-500/21 Bomb Lodged in 100-mm Armor Plate (K_z = 110 kilogram per square millimeter) V_z = 321,4 meters per second.

59b Supplementary to pp. 277/278

Photo

PC-1800-RS Bomb after Penetrating through 180 millimeter of Armor Plating; V_z = 289.4 meters per second; Impact Angle = 60°

rocket [illegible], at an impact velocity of approximately 400 meters per second giving a theoretical penetrating capability of 475-mm of armor plating, which would have been adequate for the any thickness of deck armor protection found in warships.

However, this confirmation of the penetrating capability of the large caliber armor piercing bombs by the results obtained with the new missile projector failed to remove the distrust of the German Air Force Command in technology. At a later juncture the use of the penetration capability factors obtained with the missile projector was disallowed to establish the penetrating capabilities of the bomb types involved in service regulations for the troops, when the bombs were introduced. xxxxproduxxxxx. Instead, orders required the erection of a special target, as shown in the attached photo, for use in test bombings from the air. However, this target was only ready for use in 1944 and for various reasons was never used.

This target was only 33 x 66 feet in size and the chances of hitting it with unguided bombs would have been so small that its use would have represented an irresponsible waste of valuable test ammunition.

After occupation of the territory by Allied forces in 1945 both the missile projector and the armor-piercing bomb target were immediately dismantled and taken to England.

6ca Su plementary to p. 281

Photostat

Legend:

Panzerbombenziel	=	Target for testing of air-delivered armor-piercing bombs
(xxxxxxxxxxxx entspricht) annaehernd einem Aus-) schnitt aus dem Haupt-) spant eines USA) Schlachtschiffes vom) Typ "North Carolina")	=	Approximates a cross section of the main bulkhead of a US warship of the North Carolina class.
Materialaufwand:	=	Materials used:
380 to Panzerplatten) (Cr-Mo-Mo))	=	380 tons of armor plating (Cr-Ni-Mo)
86 to Baustahl	=	86 tons Construction steel
141 Eisenbahngleis	=	141 tons Railroad rails
135 m³ Holz	=	135 metric tons of timber
290 to Zement	=	290 tons Cement
Kosten rund RM500000	=	Funds expended: approximately 500,000 Reichsmark
Panzerstaerken:	=	Armor plating thicknesses
Aufbaudeck:6 mm Stahlblech	=	Bridge deck: 6-mm steel sheeting
Oberdeck:40 mm WH-Platten	=	Upper deck: 40+mm Wh-armor plating
Panzerdeck=140 mm "	=	Main armored deck: 140-mm Wh-armor plating
Laengsschott:30 mm "	=	Longitudinal bulkhead:30 mm " "
Querschott: 20 mm "	=	Transverse bulkhead=20-mm " "

The missile projector installations proved a very useful aid in the development of new types of bombs, particularly since weather conditions in no way influenced testing activities; in German climatic conditions, the weather otherwise seriously delays bomb testing if carried out from the air. This testing of bombs by means of firing them from a gun barrel proved indispensable as a severe check on their construction, method of manufacturing, and the materials used.

The armor-penetrating coefficients given for German bombs in bombing charts in each case refer to the minimum release altitude stated in each case, to a specific type and strength of armor, and to a minimum impact angle of 60°and in this form cannot be used for comparisons. In the charts for multi-purpose bombs of the newest German types, the coefficients given referred to a missile velocity of 180-190 meters per second (dive-bombing attacks). This was admittedly correct for the SD-70 and SD-250 bombs; in the case of SD-500 and SD-1000 bombs, however, their structure justifies the assumption of a considerably higher velocity, since in this respect they really represented armor-piercing bombs (see Chapter II, 3). In the charts given in Chapter II, 3, for British cast-steel General Purpose bombs a velocity of 200 meters per second has been

284 has been assumed and for the pressed steel type IV bombs of the same class a velocity of 22- meters per second.
t

In the light of wartime experience the American demolition bombs, which, similarly to their German xxxx SC class bombs, have an explosive charge making up roughly 50 percent of their weight, cannot be expected to have any considerable penetrating capability on resistant targets. American SAP class bombs carry the same explosive charge as the British General Purpose class bombs for which reason they have been computed with an impact velocity of 200 meters per second, while a velocity of 250 meters per second has been assumed for American AP class bombs with their 14 percent explosive charge (SAP = Semi Armor Piercing).

However, it might be more to the point to compute the penetration capabilities of these bombs with reference to the maximum bombing altitude allowed by their structure. For this reason the maximum impact velocity of German bombs, as determined in practice, is entered contingent upon their explosive charge percentage. From the resultant curve it is also possible by comparison to read off the maximum impact velocities of American and British bombs and use these factors in calculating their XXXXXXXXXXX armor-piercing capability by the de Marre formula. The following compilation provides a better concept of the penetrating capabilities of the various bombs.

6 a Supplementary to page 284.

Legend:

~~XXXIXIX~~

Max. Auftreffgeschwindigkeit V_z fuer Panzerdurchschlag in Abhaengigkeit des Ladungsanteiles	=	Maximum impact velocity for armor piercing contingent on ratio of explosive charge to overall bomb weight
PD PC/RS AP	=	Armor-piercing bombs
SS PC SAP	=	Semi-armor-piercing bombs
SD GP	=	General purpose or multi-purpose bombs
SC MC Demo	=	Mine-type bombs
(a)	=	American
(e)	=	British
V_z	=	Maximum impact velocity
Sprengladung	=	Explosive charge.

22 Exploded on the ground at a distance of approximately one meter these bombs pierced a total thickness of 700 n 1000 millimeters, creating apertures with diameters of 12 and 16 centimeters, respectively, in armor steel plating, and this apparently was not a maximum performance. Such thicknesses of armor steel plating do not occur in actual practice, and the test structure was constructed by placing one upon the other steel plates taken from the side armor of the World War I battleship Koenig Albert.

Computing these piercing capabilities by the de Marre armor plating formula, a shell of the diameter mentioned would have required an impact velocity of 1,620 meters per second for the same performance, a velocity which could not be achieved with artillery guns. The larger part of the explosive used in the hollow charges was hexogen anXXXXXXXXXXXXXXX and in view of the detonation velocity of Hexogen, which is 8,400 meters per second, such velocities for the combustion gases

23 of a shaped charge are quite conceivable. The great piercing performances are achieved because the jet of the exploding gases remains weighted by the iron elements of the lining inside the cavity.

To develop hollow-charge bombs for use against ships it would have been necessary as a next step to carry out experimental detonations with steel plate combinations in

23 in order to determine whether the blast actually penetrates to a depth of between 8 and eleven yards. However, quite apart from the great difficulties encountered in construction of the "armor bombing target" mentioned in previous chapters, supplemented by watertight compartments and inside structures, the period following failure of the dive-bombing tactics was characterized by a complete lack of new bombing tactics, particularly for attack against such well protected targets as warships.

Just at the time when experience with the SH1-500 and SH1-800 hollow-charge bombs became available, [illegible] suggestions [illegible] attack with "Mistel" composite aircraft. In carrying out flat-dive attacks from considerable distances, experienced dive-bomber pilots had switched on their three-plane autopilot gear and used it in their target approach runs. The excellent functioning of this gear in the Ju-88 planes produced the idea using this system to place on target these unmanned bomber planes, of which large numbers were held in depots without any prospects of being put to profitable use. For this purpose a manned single-seater Me-109 fighter was mounted above the fuselage of a Ju-88 with releasable struts.

The fighter pilot then flew this composite plane to within visual range of the target, set the steering on a flat

23 dive from a distance of 10 to 1[illegible] kilometers, thereby giving the Ju-88 the proper target course and slope. At a distance of 3000 to 4000 yards from the ship, and thus still beyond range of the hazardous multiple AA guns, the fighter pilot
24 xxkxxxxxxhix disengaged his plane from the unmanned bomber and changed his own course, while the bomber with its set steering continued on its target course.

Test flights with this arrangements showed only very small deviations from target, measuring roughly 11 yards laterally and 22 yards longitudinally, and thus held out good prospects of success in aiming at the silhouette of an aircraft carrier or a battleship.

The weapons development agencies immediately adapted their activities to these new tactics of attack with bomber aircraft. To fill a Ju-88 plane with a few tons of explosives and explode it against a ship would not have caused much damage to a modern battleship. The ideal solution would have been to explode the large charge under the ship, but subsurface bombs, such as the planned Hs-294, were still a problem in themselves, and it was hardly to be assumed that they would have detached from an aircraft disintegrating on the surface. The same applied to torpedoes, which, in addition, were not suitable for such high launching speeds as 360-420 miles. To attain a high speed commensurate with the

360 a

23a

Photo

"Mistel" Composite Aurcraft

with SHL-4000 Hollow-Charge Bomb

24 high speed performances of the fighter aircraft, the outer surfaces of the bomb-carrying plane had to be as smooth as possible, meaning that the explosive load had to be loaded inside the plane.

Efforts had to be made to exploit the effectiveness of the hollow charge in composite plane tactics. The center of gravity was very unfavorably situated in hollow-charge bombs, since they lacked the massive nose section of other bombs and had to be at least of four caliber lengths to obtain stability in trajectory; the SH1-800 was thus already 3.5 meters long. The question now was how long a hollow-charge bomb would have to be to insure that even at a flat impact angle its blast effect would reach to beneath the armor plated decks.

25 The solution to this problem was found by turning the entire Ju-88 plane into a bomb: the crew space in the nose was made detachable and replaced by a hollow charge with a diameter of roughly 2 meters and a total weight of approximately four tons. At this juncture all work on other large caliber hollow-charge bombs was halted and all efforts concentrated on development of the SH1-4000, since this new weapon might prove important in action to repel the threatening invasion. The only other item still under development was the SD-4-H1 antitank bomb, since it was urgently needed for the conduct of the war in Russia.

Construction of the test SH1-4000 hollow-charge bomb presented no difficulties, since it required no large machine tools for shaping or for inner structure. The most important item was the lining of the hemispherical cavity in the explosive filling, which in the SH1-4000 was of 40-millimeter metal sheeting. Experience had shown that the lining must be of an easily malleable material in order together with the flame jet of the combusting gases at detonation to form what might be called a stopper of molten metal. Because of its high specific weight, copper would have served the purpose, but the use of copper had to be restricted because it was in very short supply. Instead of copper, therefore, approximately 25 dome shaped caps, each of 1.2-mm sheet iron, were formed into one hemispherical dome under hydraulic presses. The weight of the finished lining was approximately 1 ton. With an explosive filling of 2.8 tons, and an inner framework and outer casing weighing together approximately 440 pounds, the weight of the entire hollow charge was thus 4 tons.

This was just within the center of gravity requirements for the Ju-88 plane without any necessity for additional trimming loaded. The SH1-4000 hollow charge had the same diameter as the aircraft cabin.

Only high explosive fillings are suitable for hollow-charges and in the case of such large calibers must be filled in in the fluid state in order to fit very snugly to the lining. To this end the form was first placed on the dome and heated and the explosive compound, consisting of 60 percent trotyl and 40 percent hexogen was then poured in. Additional hexogen in the powder form was then stirred in, so that hexogen made up 70 percent of the final explosive compound filling.

Initially, each individual part of the new weapon was tested, but the final test had to take the form of a practice bombing of an actual warship. For this purpose, the German Navy made the French battleship Océan, with a displacement of 25,000 tons, available. This was admittedly an outdated ship, constructed in 1911, but its horizontal protection had been reinforced and brought up to modern standards by the insertion of numerous armor plates.

A great advantage of the airborne SHl-4000 hollow charge was that the composite aircraft team crews could practice so long with a crew in each plane until the three-plane pilot gear of the Ju-88 was properly trimmed to insure the minimum possibility of off target hits.

These target run practice flights took place at AAA range finding posts, with the pilot of the fighter plane initiating the ~~xxxx~~ attack by the composite team consisting of an Me-109 fighter and a Ju-88 plane, setting course and

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26 slopewith due regard for lead factors, and then XXXXXXXX disengaging the two planes. The crew in the Ju-88 plane only took over control shortly before reaching the target aimed at, rising to fly over the target, and then landed the plane. Once the composite was properly adjusted, the crew cabin was removed from the Ju-88, in the same manner as the maneuver head is removed from a satisfactorily adjusted torpedo and replaced by its warhead, in this case the SHL-4000 hollow charge. For combat commitments, plans provided for the hollow charges to be stored at the tactical airfields and to only move in the aircraft when required, which could have been done within a few hours.

To test the proper aiming of the unmanned and combat armed aircraft as well as the proper functioning of the fuses, a number of exercises were carried out with live charges by planes taking off from Peenemuende and using the Danish island of Møen, opposite the island of Ruegen, as a target. The point of this island projects far into the Baltic Sea, forming a steep chalk cliff almost 100 meters in height, known as the Møens Klint, at approximately mid height of which a target triangle with shanks measuring 15 meters was suspended. In these exercises all planes released scored hits within 20 meters from the center of the target triangle, which amounted to 100 percent hits in an attack launched xxx diagonally to te at the longitudinal axis of a large ship. The surrounding sea in this region was easily kept under observation and the peninsula was easily closed to traffic temporarily, so that only small expenditures were involved in these tests.

Besides shots aimed to strike the target at right angles, some were aimed to strike at an angle of less than 30°, so that the wings of the Ju-88 [illegible] contact the target and even in these cases the igniting contacts of the six No.66 electrical impact fuses in the nose of the SHl-4000 hollow charge functioned satisfactorily. Even if a wing broke off, the automatic pilot kept the Ju-88 firmly on course. The moment of impact was recorded photographically not only from the sea but also by a xtxxxkx xypxxlxxixxxxxlxxx vertically installed camera in a Storch type liaison plane flying overhead.

28 In mid-March, and thus barely three months before the Allied invasion in Normandy a final test series was carried out with the SHl-400 hollow charge, in thexxxxxxxxxxxxxxxxx in which the attacking planes took off from Marignane (Marseille) to attack the battleship Océan in the Toulon roadstead

The first test involved exploding an SHl-400 charge alone against the two forward 305-mm gun turrets in order to test the piercing capability of the hollow charge on this part of a ship.

28a Photo

A SH1-4000 Hollow Charge Placed in Position for Blasting

28a Photo

Hole 400 millimeters Wide in Turret Wall

28a Photo

25,000 ton Battleship after Bombing with a SH1-400 Hollow Charge

28c Supplementary to page 364.

Diagram

Legend:

Abwurf und Sprengung SHl-4000 gegen frz. Schlachtschiff Océan (Maerz 1944, Toulon)	=	Detonation of air-delivered and hand-placed SHl-4000 hollow-charge on French Battleship Océan (March 1944, Toulon)
M. 1:1000	=	Scale: 1:1,000
Einschlagwinkel	=	Impact angle
aufgebaute Sprengung	=	Detonation of placed charge
Totale Zerstoerung trotz Verstaerkung Schiff auf Grund gegangen	=	Total destruction in spite of reinforced armor plate protection. Ship settled down to ground.
Beide 30,5 Tuerme "A" und "B" wurden durchschlagen und darin die Kartuschen entzuendet	=	Hollow-charge blast pierded through both gun terrets "A" and "B" and exploded the shells stored there.
"Wandstaerke"423 mm.	=	Turret walls of 423 mm steel.
Océan	=	Data on Battleship Océan
Baujahr: 1911	=	Year constructed: 1911
XXXXXX Bestueckung: 12 x 30,5 cm, 22 x 13,8 cm, 7 x 7,5 cm	=	Weapons: 12 305-mm guns, 22 138-mm ", 7 75-mm "
Geschwindigkeit: 20 Kn	=	Speed: 20 knots

In contrast with a normal explosive bomb, a hollow charge does not carry explosives to detonate below decks. On the other hand, its highly concentrated jet of combusting gases, carrying particles of metal at white heat is well capable of igniting gunpowder and causing it to explode. For this reason, iron powder cases were placed behind the turret walls in the line of the hollow-charge fire, and these immediately exploded.

The hollow charge pierced both 425-mm wall and the gun cradles and penetrated to a depth of 25 meters until it finally came to rest inside the side armor plating after piercing through 2 meters of steel. The hole caused had a diameter of 40 centimeters, with the hollow charge exploding roughly 2.5 meters from the first turret.

The second test involved a launching as it would occur in actual combat. The Ju-88 struck the target ship's stern at an angle of less than 20° to its center line and approximately the same angle to the horizontal, causing a hole about 20 meters across in the ship's side and piercing through and blasting out one armor plated lateral bulkhead (270-mm steel). Presumably, the shot went through the bottom of the ship, which sank in the shallow water.

Naval experts confirmed the results, namely that the ship was completely destroyed and sunk.

However, the Air Force General Staff was no longer

29 interested in this new weapon, since it was not anticipated that the enemy in the expected invasion would use large naval units but hundreds of small landing craft instead, with a tonnage of only 125 tons. In the final event, battleships did participate in the invasion operations, their guns firing far inland. When this happened, orders were immediately given to prepare 300 SH1-4000 hollow charges for use against these battleships, but this measure came too late, as was the case with so many other measures.

Another type of airborne hollow-charge weapon was under development in 1944, namely the SH1-6000. This was a new departure in the field of weapons and was designed for use in Operation Eisenhammer, a grandiose plane for attacks against all power stations situated in European Russia.

The SH1-6000 had an overall weight of 6 tons and, as in the case of the SHL-4000, was to be placed in the nose of an aircraft, the He-177, a four-engine dive-bomber. Several hundred of these were still held in stock and were entirely unsuitable for the originally intended purpose. This enlarged composite plane team was to consist of an He-177 steered to the target by an attached FW-190 fighter.

The explosive filling of the SH1-600 had a diameter of 2.5 meters and it was designed for use against targets such as trubines and generators; during the war the Russians had

2) placed all such installations under concrete protection with thicknesses of 2 meters, which served to show how important they were for the wartime economy. In retrospect it seems astonishing that the Air Force General Staff conceived the plan to destroy these targets only as late as in 1944, but apparently the hope had still existed of gaining possession of them in an undamaged state and using them to exploit the Russian military potential.

While plans provided for the use of new types of large drift mines, which will be described in the next chapter, to put the Soviet hydraulic power stations out of action, the machinery installations were the target for destruction in the steam driven power stations using peat as fuel in the northern regions of Russia. Experience had shown that only large bomb fragments could put heavy machinery of this type out of action, but it had meanwhile become necessary to reach these targets in their thick concrete protective coverings.

After preliminary trials with small caliber ground weapons using a hollow charge to obtain a concentrated fragmentation effect in one direction (the Diskus and Faustkartaetsche) a flat-dish shape was adopted for the explosive filling, the lining, consisting of approximately 800 steel fragments each weighing 2.5 kilograms arranged honeycomb-wise in ~~xxxx xxxxxxx~~ 6 centimeter long 8-cm iron hexagons, weighed

Anlage BII
Seite 29

Supplementary to page 367-368.

Diagram

Legend

Schematische Darstellung der Wirkung von SHl-6000 auf Dampfkraftwerk unter Betonschutz	= Diagram presenting effect of SHl-6000 hollow charge on steam-driven power station under protective concrete covering
M. 1:1000	= Scale 1:1000
Maschinenhaus	= Machine house
2 m starke Betondecke	= Protective concrete covering 2 meters thick
800 splitter zu 2,5 kg	= 800 2.5-kilogram fragments
Rumpfvorderteil He-177	= Nose section of He-177 plane

Anlage B II
Seite 29

Supplementary to pages 367-368.

Legend:

Diagram

Hohlladung SHL-6000 mit gerichteter Splitterwirkung fuer Anwendung mit He-177	= SHl-6000 hollow charge XXXXXXX with one-direction fragmentation effect for use with He-177 planes
M. 1:10	= Scale 1:10
Aerodyn Verkleidung	= Aerodynamic surfacing
Gesamtgewicht: 6 to.	= Total weight: 6 tons
Sprengladung ca 4 to.	= Explosive filling approximately 4 tons
ca 800 Stueck sechskanteisen 80 ∅, 80 lang) zu 2,50 kg Gew. (punktgeschweisst auf 1 cm Einlage	= Approximately 800 8 x 8 centimeter iron hexagons each 2.5 kilograms in weight (spotwelded to 10-mm lining).
Initiierung	= Detonating fuse
Zuendabstand ca 2.50 m	= Explosion distance from target surface approximately 2.5 meters.

30 altogether roughly two tons.

A test detonation on the ground proved the feasibility of achieving good results with a weapon of this kind against the targets discussed above, but after the turn of the year 1944-1945 there was no longer any possibility to carry out airborne tests do to use the new weapon in actual combat.

As previously mentioned, the development of a small bomb for antitank action had become just as important a matter as the development of air-carried hollow charges to repel an invasion by the Western Powers. It is necessary at this point to discuss the situation in the matter of anti-tank air combat.

During the first years of the war fighter planes xxx with their xxxx weapons fire and light dive bombers with 110-pound explosive bombs had quite frequently destroyed smaller types of tanks. Meanwhile, however, stronger and faster tanks had come into service.

Lieutenant Colonel Rudel used a Ju-87 plane in running up his large score of destroyed tanks; this plane had two 37-mm antitank guns mounted in the undercarriage cowlings, which fired special ammunition with a 20-mm wolfram core. Attempts had also been made at using 50- and 75-mm antitank guns suspended under the Ju-88 plane; the disadvantage here, however, was the slow rate of fire of these guns, which

51 permitted the firing of only one round on each target run.

Using 550-pound explosive bombs armed with non-delay fuses dive bombers and fighter-bombers definitely could put a tank out of action--provided they were able to aXXXXXXX place the bomb close enough to the target. However, just as it is easier for the hunter to bring down fowl on the wing with a round of shot rather than with rifle fire, the problem here was just how small a bomb could be to still be sufficiently effective and how many of these small bombs should be combined in order to obtain a greater probability of success with a salvo of small bombs than with one large bomb.

To be adequately effective against a tank a weapon must set the tank on fire, cause its explosion, or kill the crew. To compel the crew to leave the tank because of damage to its tracks cannot be regarded as adequate, unless the tank is captured later. Generally speaking, a tank can only be exploded or set on fire by a hit in its ammunition or fuel tanks, XXXXXXXXXXXXXXXXX and this is possible only in certain parts of the tank making up approximately one-half of its entire surface.

The first step was to secure the tanks necessary for experimentation, for which purpose what might be described as an expedition had to proceed to the eastern front. Finally,

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32 roughly ten T-34 plus one Sherman and three Churchill tanks were available for the purpose and were set up in the training ground of the new Udet bomb proving range in Upper Silesia.

First detonations of SC-250 bombs served to show the greatest distance /author here says "mindestabstand" meaning smallest distance/ at which the blast destroyed the tanks, which contained test animals and fuel. The Churchill tank was only protected by rivetted steel plates and came apart when the SC-250 exploded at a distance of 5 meters. The Soviet T-34 and the American Sherman tanks were about equally resistant against outside explosions; they still remained intact when a SC-250 bomb burst only three meters away, but the animals inside were killed and the diesel fuel in the T-34 tanks was set on fire by the air pressure of the blast.

The next task for bomb development was to so aim a container of hollow-charge bombs of the same caliber as the 550-pound mine-type bomb that the center of the resultant fragmentation field would be not more than three meters /here the author says "mehr als" i.e. greater than/ from the tank and would destroy it.

The attack tactics in 1943 were those of the fighter-bomber:

Approach at a slope of between 10 and 20°; speed roughly 300 miles; bomb release altitude at least 1.650 feet since enemy tank formations at this stage of the war generally included special antiaircraft artillery tanks for protection against low-altitude attack.

The antitank weapon had to have an armor-piercing capability of at least 100 millimeters and this could have been achieved with a hollow-charge weighing only 2.2 pounds. However, large bodies of infantry usually accompanied the Soviet tanks, so that it seemed advisable to combine fragmentation effect with the armor-piercing capability, such as shown for the SD-4-Hl bomb in the hollow-charge table.

In order to be able to pack as many of these bombs in the available types of containers, the SD-4-Hl was given a relatively thick gray cast iron nose section, which shifted the center of gravity forward and thereby reduced the length required in the stabilizing vanes and of the entire bomb. The fuse vent had a diameter of 25mm and could take the No. 66 electrical impact fuse (eAZ No (66) which at impact sent an electric current from point to the base of the hollow-charge by means of a cable. This fuse was made completely of artificial materials and offered little resistance to the directed jet of the combusting gases.

The diameter of the SD-4-Hl resulted logically from the required armor-piercing capability of 100- millimetersand the thick walling ~~of~~ given to the bomb to produce fragments. In test detonations the bomb pierced through 130 millimeters of steel, 33 a thickness found at the gun aperture of the German tank turret, and the hole created was 20 millimeters in diameter at the entry and roughly 10 millimeters at the exit of the blast.

Shortly before the SD-4-Hl bomb went into mass production it unfortuantely became necessary to give it longer stabilizing vanes than had been planned in order to prevent to wide dispersal of the bombs making up a salvo under the existing circumstances of bombing. This meant that the AB-250 container could hold only 40 of the new bombs instead of 50.

34 The Sobiet Type T-34 tank had a surface of 18 square meters, but tests with live bombs showed that only roughly one-half of this surface was vitally vulnerable to hits with the SD-4-Hl, namely those parts of the tank in which the ammunition and fuel would be exposed to the bomb's blast.

Assuming an equal distribution of the bombs of a salvo at impact, two bombs of this size would at least have ~~been~~ had to hit the tank to insure destruction.

The fourteen captured Soviet tanks previously mentioned were so arranged on the target range, namely spaced 6 meters apart, that theoretically one SC-250-non-dely bomb would destroy at least one of them. A group of 4 tanks thus exposed a total target area of 18 x 24 meters = 432 square meters which the SC-250 had to strike to destroy at least one of them. The important thing now was to place forty SD-4-Hl bombs within the same area so equally distributed that at least two tanks would be struck by each two bombs.

All aiming tests were carried out by an experimental air squadron specially activated for the purpose and the tests took up almost an entire year. Because of the unavoidable dispersion which occurred when the bombs left the container, it was decided to adopt the AB-500 container, holding 78 SD-4-Hl bombs as standard antitank bombing equipment.

Tank specialists of the Army considered the effectiveness of the XXXXX SD-4-Hl adequate. The T-34 tank had a surface angle of roughly 50° and the SD-4-Hl when striking these surfaces at an angle of only 20° degrees frequently pierced thicknesses of 45 millimeters. Events showed how right it had been to plan a piercing capability of 100 millimeters of armor steel for the bomb, since a bombs striking a 45-mm steel plate at an impact angle of 20° must pierce through roughly 110 millimeters, which the bombs often actually did in trial bombings.

However, it was too late for any large scale use of these bombs in actual combat and owing to the fluid situation in the summer of 1944 it was rarely possible to check the results reported by the troops.

The troops held a high opinion of the new bombs, but complained about the containers. The bomb containers, originally

31 intended for incendiary bombs, consisted of two shell-like parts which opened apart to release the small incendiary bombs, and the authorities responsible for development realized that they were not very well suited to obtain the desired "shot-gun-fire" effect. However, it was not possible to halt production of the AB containers and small modifications could not serve to solve the problem of dispersion.

In order to further improve on the composite plane method, a series of fast composite plane teams were taken under development, in which the piloting plane was a jet fighter Me-262 and He-163). The plane carrying the hollow charge was a plywood structure powered by a ram jet unit (Staustrahltriebwerk). Striking ranges up to 1,200 miles were possible, since the piloting aircraft during the approach flight could take fuel from the bomb-carrying plane and for its return flight carried reserve fuel tanks. There being no question of the composite landing together, the lower (bomb-carrying) plane had an under carriage which was ejected after the take off, similarly to that of the Ar-234 planes. Booster rockets facilitated the take off.

5. Naval and Drift Mines for Use with Aircraft. In Germany, the development of naval mines to be dropped by aircraft was, prior to World War II, the exclusive responsibility of the Navy, where it was handled by the Sperr-Versuchs-K

31 Sperr-Versuchs-Kommando (Experimental Barrage Command) with headquarters at Kiel. This command produced the following types of airborne mines for the Air Force:

LMA: a ground mine with remote ignition; weight 1,100 pounds
LMB: " " " " " " " 2,200 pounds
LMC: " moored mine with 300 meters cable; " 2,200 pounds.

Of these three types of airborne mines only the LMB went into mass production. Mines of these types had to be dropped at a maximum speed of 210 miles. At release from the plane, a large parachute opened to insure that the mine, with its highly sensitized remote ignition gear would strike the water surface at a maximum falling speed of 30 meters per second.

The fuse systems used in airborne mines were practically the same as those used in normal naval mines. The remote ignition system initially used functioned magnetically;when the mine settled on the ground a compass needle adjusted itself to the local terrestrial magnetic field and if this magnetic field was disturbed ba an approaching ship, detonation took place. The explosive charge consisted of roughly 1,500 pounds guncotton comprising 60% trotyl, 24% Hexyl, and 16% aluminum; it was estimated that the blast effect would sink a medium sized ship (10,000 tons) at a distance of 66 yards. This was also the operating range of the fuse system in the case of targets of this size. The mine casing was of an alloyed aluminium proof against seawater.

37 Later in World War II acoustic fuses as well as combined acoustic-magnetic fuse systems were used in LMB airborne mines, once these systems had been developed, and were laid by aircraft in areas designated by the Naval Operations Staff which naval surface craft were unable to reach.

Owing to their slow rate of fall, it was not possible to aim parachuted mines accurately; consequently, theycould only be used to
be used to mine very large areas, such as the mouth of the Thames River or the sea routes along the east coast of England, but not to block harbor entrances at which sea traffic converged.

Besides other already known mechanisms, such as count contacts, time control units, and devices to safeguary secrecy, the airborne mines had the characteristic that they exploded after 30 seconds if they fell onto dry ground or into shallow water, or if they were heaved up from any considerable depth.

Certain air units used the LMB mines without remote ignition mechanisms, as immediate-detonation bombs. This was because during the first stage of the Air Battle for Britain Germany had no bombs of this size except those with delayed action fuses. This is the origin of the term "air mine."

In order to enable units operating at great altitudes to also mine such areas as port entrances and canals, the Air

37 Force immediately after the outbreak of war commenced de-
38 velopment of a suitable missile under its own responsibility. Missiles of this type were designated bomb-mines (bombenmine) The BM-1000 bomb mine was released in the same way as a conventional explosive bomb, and its deflection in water, which was so undesirable in normal bombs and was caused by its ogival nose section, served in the case of the bomb mine to limit its penetration depth. The xxxxxxxx stabilizing element was of artificial resin in the BM-1000 and broke off on striking water.

The length and diameter of the BM-1000 corresponded to the dimensions of the SC-1000 mine-type bomb, but the casing of the bomb mine was of non-magnetic steel and consisted of a number of sections welded together. The weight of the explosive charge was the same astthat of the LMB airborne naval mine but contained 70% trotyl, 15% hexogen, and 15% aluminum, and was known as trialen 105.

With support from a naval mine development sub-section established in the Bombs Branch of the Air Ministry Technical Office at the beginning of the war and which cooperated clos-els with the AEG (General Electric Company) in Berlin, the first BM-1000 bomb mines from serial production reached the troops already towards the end of 1940.

What was initially a great improvement was the fact that

38 the new bomb mine could be dropped from an altitude of 6,600 feet, the required minimum depth of water being only 8.8 yards. Previously aircraft had only been able to lay mines at night.

However, the Air Force Operations Staff planned daylight mine-laying operations by aircraft operating at great altitudes and in 1941, in time for this purpose, new variants of the BM-1000, namely models H and M, made their appearance. These could be dropped from any altitude and rendered excellent service in the campaign in northern Africa. Owing to the steeper angle at which these new bombs entered the water, however, the minimum water depth requirements had to be increased to 33 feet. Furthermore, it proved essential to reduce the fall speed to approximately 220 meters per second
39 by means of a small brake-parachute, since otherwise the stability of the mine casing and the shock-proof properties of the explosive charge would have been impaired.

Besides the AEG, other firms specializing in electrical apparatus, as well as various institutes, were invited to participate in the ~~development of~~ further development of remote ignition devices required by the expanding conduct of mine-laying warfare. Consequently, the following ignition devices reached the troops successively for installation in the BM-1000 and the new variants of that bomb mine:

M 101 : magnetic ignition
A 105 : acoustic ignition

41 bomb designed for use by ground-attack aircraft, unexpectedly also served as a nuisance fuse when a bomb released with a timed setting impacted prematurely, for example on trees or buildings. Usually, this impact halted the clockwork mechanism, which could be set in motion again by negligible causes and cause the bomb to detonate later.

Experience showed that a small fragmentation bomb lying unexploded on the surface of the ground could at times have a greater nuisance effect than a large bomb in the ground. This led to development of the special SD-2 nuisance fuse which served to "mine" airfields and the coastal auto road in northern Africa. The more usual method was to drop these small bombs in bomb-containers from high altitudes rather than from low altitudes. To cope with these "Butterfly Bombs," as the British called them, two light tanks had to travel over the ground XXXX each carrying one end of a "drag line" so that here again a parallel could be drawn with the use of minesweepers in naval mine warfare.

The No. (70) nuisance fuse was developed from the normal No. (41) fuse; the rotation of the brake vanes on the SD-2 bomb served to arm the fuse, as was the case with the normal No. (41) fuse; however, the fuse did not detonate the bomb but xxxx remained stationary at a very sensitive setting, which detonated the bomb in response to the slightest vibra-

42 vibration of the ground, such as that caused by a motor vehicle or by a plane taking off.

The No. (79) nuisance fuse was a clockwork time fuse which could be set with a delay of 10, 20, or 30 minutes and was released my the force of impact.

Small nuisance bombs were dropped in masses and to make them less easy to find, the brake vanes disconnected during

43 the fall from the bomb proper. It was not advisable to drop bombs of this kind over territory intended for later occupation by friendly troops.

The SD-2 bomb and the three fuses just described were copied precisely by the USAAF already during the war, which indicates that the USAAF expected these to produce great results in certain circumstances.

Mention must now still be made of the fuses, all of which functioned mechanically, used in other small caliber bombs.

The No. (13) fuse used in the 2.2-pound electron incendiary bomb had only one safety device in the form of a plug which secured the xxxxxfiringxpin spiral-spring-driven fuse firing pin for safe transportation. This plug or pin was withdrawn when the bombs were placed in their containers. In the containers the bombs were placed fuse end daxx backwards, so that even in the event of a crash landing by the carrying plane

43 aircraft the shock could not affect the [illegible] firing pin which could result in the pin striking the percussion cap.

On the other hand, fuse No. (15) was so robust in structure that it required a considerable impact force to set it in function. The bomb itself being only poorly stabilized the minimum prescribed release altitude was several hundred meters.

In the newly developed 5.3-pound electron incendiary bomb and in the Brand-10 fire bomb with its flammable fluid filling, both of which had half-shell stabilizers, use was made of fuse No. (23A), in which a securing bolt insured greater safety during flight, similarly to the British IBC 4-lb incendiary bomb.

One should have no qualms about taking over constructions of the enemy which have proved good. Thus, the No (45) membrane fuse for the small-caliber SD-1 and SD-5 fragmentation bombs (adapted 50-mm and 80-mm mortar shells) evolved from a French version. These fuses had a highly sensitized reaction when soft material in the target area (sand, but also water) entered the fuse head, where the front membrane was pierced and the fuse striking pin attached to the second membrane was forced into the duplex cap. The casing with its membranes is of soft steel, so that at impact on a hard surface (paving or concrete) the fuse head was so deformed that the striking pin impinged on the percussion cap.

When packed in the bomb containers, the fuse of the one bomb rested in the open tube of the stabilizing vane section of the bomb in front, which was of the same caliber. This insured adequate safety in the transport of filled containers over short distances of a few miles, as is the case between the ammunition dump at which the containers are packed and receiving airfield, as well as during flight.

However, bomb containers thus packed could not be jettisoned without doing damage.

The old No. (5) mechanical fuse for the 22-pound fragmentation bomb was a bad-construction stemming from the times of the Army Ordnance Office and had caused numerous accidents which made IXXXXpopular. the bomb as such unpopular. It was also unsuitable for packing in bomb containers and in the SD-10A 22-pound bomb was replaced by the No. (66) electromagnetic fuse.

[illegible]

LIST OF GERMAN [illegible]

GERMAN BOMBS

Fuse No.	Used in Bomb Types	Type of Fuse	Remarks
(6[illegible])	SD-4-HL Hollow-charge, SD-9/10A/15	Induction	see Sketch A5-7 (A6-3)
(59)	SD-50	Proximity	not introduced
(50)	SC-250 & 500	Nuisance	remained effective approx. 1 week
(60)	SC-250 & 500	"	remained effective approx. 1 year
(17)A	SC-250 & 500	Long delay	72 hour clockwork
(40)	SC-250 & 500	Disarming obstruction	Mechanical supplement to No.(17) w/ disarming obstruction
(57)	SC-250 & 500	Long delay impact	chemical process
(15)	B-1, 5 E	mechanical (no safety device)	
(25)A	B-1,5E, & Brand-10	as above	Armed by tumble disc
(73)	SD-1, SD-3	mechanical membrane	No special safety device, set before loading
(5)	SD-10	Mechanical impact	1) High sensitivity for high altitude bombing 2) 5 second delay-action for low-altitude bombing
(41)	SD-2-t	Mechanical impact & time fuse	Setting selected before loading
(70)	SD-2-t	Nuisance	
(67)	SD-2-t	Long delay	Clockwork setting 10 - 20 - 30 minutes
(24)	SB-1000/2500	Acceleration	Functioned by deformation of bomb nose

Remarks: The final digit in the fuse designation denotes:

...0 : Nuisance fuse
...1 : Dual function (Impact + time) fuse
...3 Mechanical fuse
...4 Acceleration fuse
...5 For use against shore targets
...6 : High sensitivity impact fuse
...7 : Long-delay fuse
...8 : For use [illegible]
...9 : Time fuse

(89)	Be-C-50 (Bomb container)	Time fuse	Settings between 4 & 60 seconds

Supplementary to pp. 466-467.

LIST OF MOST FREQUENTLY USED GERMAN ELECTRICAL IMPACT AND TIME FUSES

Fuse Type	Used in Bomb Types	Fuse Arming Altitude in High-Altitude Bombing (in meters) Instant	Retarded	Delay	Remarks
(15)	SC/SD-50/250/500	270-670	0.05 sec 340-800	14 sec 14-45	Former version see (25)
(25)	SC/SD-50/250/500	480-1140	0.08 sec 480-1100	14 sec 4-10	Replaced by (25)A
(25)A	SC/SD-50/250/500	44-240	0.08 sec 480-1100	14 sec 4-10	Replaced by (25)B
(25)B	SC/SD-50/250/500	44-240	0.08 sec 150-500	14 sec 4-12	Replaced by (25)C
(25)C	SC/SD-50/250/500	46-230	0.08 sec 150-930	14 sec 4-12	Replaced by (25)D
(26)	KC-250, Flam Fire bomb	45-126			Replaced by (55)A
(28)A	SC-250/500 Kopfring (w/nose ring)	14-40	0.15 sec 0 - 52		Replaced by (38)
(28)B	SC-1000/1800	--	0.12 sec 18-52		w/supplementary acceleration ignition
(35)	PC-1000/1400	w/0.1 sec delay 14-45	0.1 sec 14-45		In semi-AP bombs
(38)	SC-250/500 Kopfring (w/ nose ring)	w/0.2 sec delay 170-320	0.5 sec 240-940	5 sec 8-20	For bombing of ships
(48)	PD-1000	w/0.45 sec delay 270-670	0.75 sec 340-800		In AP bombs
(55)	SBe-50/SB-50/250	44-240	--	14 sec 8-14	As (55)A
(9)	LC, AC, and AB	with supplementary time switch-box for 5 & 40 sec delay			
(49)	PC-1000/1800RS (Rocket accelerated)	Propellent rocket ignited after 2.7 seconds	0.45 sec. retarded bomb detonation		In rocket acc. AP bombs
(59)A	LC and AB	Burn. duration 13 seconds	Burn. duration 36 seconds		Powder train fuse f/bombing from 2000 & 3500 meters altitude
(69)	AB (bomb container)	Burn. time 2 seconds	Burn. time 7 seconds	--	For low-level & dive bombing
(79)	AB (bomb con-	Burn. time 5 seconds	Burn time 30 seconds	--	From 500 & 5000 meters altitude

446 Supplementary to No. [illegible]--continued

Remarks:

Retarded	=	Impact detonation with very short delay
Delay	=	Detonation ... seconds after impact

For definition of bombdesignations see Report A-1 (Bericht A 1)

Last cipher in bomb designation denotes:

...1 - 4 Mechanical type fuses

...5 Electrical fuses for bombing of shore targets

...6 Highly sensitive fuse

...7 Long delay fuse

...8 Electrical fuse for bombing of ships

...9 Electrical time and proximity fuse

...0 Nuisance fuse.

APPENDIX [illegible]

NOMOGRAM OF BOMB PENETRATION [illegible] AND DIRECTION

<u>Legend:</u>

Abwurfhoehe = h	=	Bomb release altitude = h
Auftreffwinkel	=	Impact angle
Bombenart	=	Type of bomb
42 cm Sprgr.	=	420-cm explosive shell
200,250 etc m/s	=	200, 250 etc. meters per second
2, 3, 4 etc Km	=	2000, 3000, 4000, etc. meters
Druckfestigkeit	=	Pressure resistance coefficient
Panzerstahl	=	Armor steel
Granit	=	Granite
Beton	=	Concrete
harter Kalk	=	Hard limestone formation
weicher Kalk	=	Soft limestone formation
Sand	=	Sand
Lehm	=	Loam
Eindringvermoegen Z = q . 4	=	Penetration capability Z = q . v
Eindringweg in versch. Zielmaterial	=	Penetration depth and direction in various target materials