The GAF System of Weapons Sub-Series
Part II by General ~~Deichmann~~ [illegible]
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P. R. C

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~~Volume Two~~

THE SELECTION OF BOMBS AND FUSES FOR AIR ATTACKS

P R E F A C E

The study "Selection of Bombs and Fuses for Air Attacks" corresponds to the technical progress made by Germany at the end of World War II and would have replaced the Luftwaffe Directive 8/4 and 8 of June 1941. The general principles analyzed in Part I and the tactical objectives indicated in Part IV have been partly extracted from other regulations, insofar as they agree with my own ideas. In Part III A the directive (study) gives a general description of aircraft ammunition including tables and statistics. In Part III B every bomb is briefly described with cross references to the illustrations in Part V.

Part III A suffices for preparing a bombing attack, insofar as the technical training of the user is advanced enough to give him the capability to use these data.

Part III B offers an opportunity to become more thoroughly acquainted with the components of bombs destined for targets that are not dealt with in Part IV or for the event that the effect of the ammunition is not fully known.

The data given in Parts II and III C and D concerning the effect of bombs are based on the results of technical tests and on mutual wartime experience.

A certain amount of repetitiousness was inevitable, if important technical and tactical details were not to be omitted in each part.

February k5, 1954 (signed) E.A. Marquard, Genraling.aD.
former Branch Chief, Luftwaffe Ministry, in
charge of developing bombs and release items.

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The Selection of Bombs and Fuses for Air Attacks

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The Selection of Bombs and Fuses for Air Attacks

I. General Principles

Certain principles have to be observed in selecting bombs and fuses for air attacks so that powerful and lasting results may be ontained. The experiences of World War II have frequently shown that the effects of attacks would be doubtful if some of the following principles are violated.

Moreover, it is absolutely necessary that the staffs and unit commanders down to the squadron leaders level be technically oriented on the construction and effect of aircraft ammunition as specified in the following parts II and III of this study.

~~Attacks on Ground Targets~~

The bombs that are used should not be of a larger caliber than is absolutely essential to destroy or effectively damage the objective under attack. But to use calibers that are too small would be equally wrong unless there are such compelling limitations as limited carrying capacity of the available aircraft or the accidental nonavailability of certain types of bombers.

1. The overhwelming majority of naval and ground targets that are not particularly well protected can be most appropriately attacked with High-explosive Bombs because this category of bombs is capable of hitting the target with the maximum quantity of explosives in comparison with other bombs.

The main production effort in high-explosive bombs therefore resides with types SC 250 and SC 500, which may be considered as standard type bombs.

2. Armor-piercing bombs are to be employed only if the high-explosive bombs are not capable of penetrating targets that offer more resistance, and then only from such altitudes of flight that the necessary impact velocity can be achieved. Armor-piercing bombs are primarily suited for attacking armor-plated ships; they are produced from special steel alloys that contain precious scarce raw materials. They can therefore only be used against such ground targets that attack of which justifies the expenditure of materials that are difficult to procure.

3. Armor-piercing and high-explosive bombs should not be used for fragmentation effect, if fragmentation bombs proper are available. When employing the latter, one should always use the smallest possible caliber unless the resistivity of the target requires larger fragments, which however can be more effectively produced by multiple purpose bombs. The latter are particularly advantageous when used during low-level attacks with delayed fuses because they do not break up as easily as the thinly coated high-explosive bombs.

4. Incendiary bombs are to be used when the target that is to be attacked is more vulnerable to fire than to explosive effect.

5. The selection of the fuse and the type of ignition -- with or without delayed- action -- is made with a view to direct hits. Ignition must be achieved at that point of the target

on which the greatest effect can be scored. The use of the so-called nuisance fuses cannot be left to the field forces but must be specially ordered in accordance with detailed plans prepared by the air force headquarters staffs.

In calculating the quantities of bombs needed to destroy a certain target on land and in establishing the distances to be held in stick bombing, one can use the data on effectiveness of individual bombs given in Part III. The above-mentioned principles could not be adhered to in every case in preparing the tables for ground targets contained in Part IV because other factors such as the particuliarities of the target, the effect of the dropping altitude on target accuracy, the various loading capabilities of the aircraft, etc., played an important part.

General Principles for Attacking Naval Targets

The main purpose should be to produce such damage that the attacked ship will sink. This will usually be achieved only by affecting those parts of the target that are under water. To produce damages below the waterline of a ship requires that the bomb detonate as low as possible in the ship. Bombs that explode next to a ship -- so-called near misses -- and the most effective distances from the side of the ship are explained in detail in Part III, tables included. To be considered in this connection is the factor that these bombs should not sink to too low a level.

The amm nition storage areas of a war hip are situated below the armor plating , and every effort must be made to place the bomb there because the surest and quickest manner to destroy a warship is to explode its stock of powder and explosives.

Even though some modern warship have been sunk by one single large bomb, attacks of heavily armored ships generally require the use of various types of bombs the dropping of which must be properly coordinated and will depend on the conditions prevailing in the target area. Such ships usually are heavily armored and have numerous watertight compartments. The first attack wave of planes will ordinarily not succeed in sinking the enemy ship unless the caliber of bombs employed is extremely large or the ammunition storage areas are hit directly by a smaller but very penetrating bomb. On the other hand, minor damages inflicted upon important parts of the ship often resulted in the eventual destruction of the vessel by air or naval attack forces. The most effective way to attack large modern warships is therefore to launch coordinated assaults with high-explosive and armor-piercing bombs.

The ship data sheets in Part IV of this study indicate the bombs that are particularly suited for sinking each specific ship. This does not exclude, however, the use of other calibers or weapons for this purpose.

Combined attacks of aerial torpedoes and heavy bombs against a group of warships have proved effective and have made it possible to achieve the rapid destruction of the enemy forces. The available data regarding the quantities of ammunition expended in such attacks, however, do not permit proper analysis, as mentioned in Part III petaining to separate employment.

It might also be desirable to render useless the flight-deck of aircraft carriers by fragmentation bombs and aircraft mounted weapons in an effort to eliminate counterair and anti-aircraft resistance prior to staging the main attack with the most devastating weapons.

As to the ~~effect of fire on ships~~, the employment of incendiaries on ships is normally out of question. Direct hits with explosive bombs usually cause heavy fires of fuel, facilities, or the cargo carried on board ship. For this reason no larger bomb than an 1,100-lbs high-explosive will be used against even the largest unprotected vessel.

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II. General Discussion of the Effect of Bombs

1. The Pressure and Fragmentation Effect

The principal effect of a bomb is caused by the detonation of its explosive charge by which the target is damaged or destroyed as a result of the pressure of the explosion or the penetration of explosive fragments of the bomb casing into the target. At minor distances it is usually the air or dirt blast which causes lasting and irreparable damage to buildings. At longer distances only the air blast of large explosive charges will be felt, and the fragmentation effect is the most commonly used method in attacking live targets and sensitive ~~xxxxx~~ "dead" targets. For practical considerations it is good to remember that the pressure effect of bombs is proportionate to the explosive charge and inversely proportionate to the square of the distance. The term "pressure" generally means the effect of an explosive charge in the air, on the ground, and under water.

In open air, the explosive flame, shockwave, excess pressure, and subpressure appear in tunr, sometimes emphasized by reflection. Aside from dirt blasts, explosions on the ground result in the creation of craters or, if the bomb penetrates very deeply, in the formation of subterranean caves. In bodies of water explosions result in gas bubbles, thrust and pressure waves as well as impulses and blast waves.

The term "pressure" in the following parts of this study has only general significance and no scientific importance.

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2. Penetration into the Target

The effectiveness of a bomb is often determined by its power of penetration before its detonation. With a given caliber, this depends on the diameter ("sectional load"), the shape of the nose cone, the impact speed, and the resiliency of the target.

Most ground targets are easily penetrated by explosive bombs. Protected objectives or structures that are capable of resistance because of their construction will have to be attacked with armor-piercing bombs dropped from high altitudes so that they can penetrate more easily. In any event, the bomb case must remain undamaged until the detonation occurs.

3. Fuses

The various types of bombs are provided with those fuses that correspond to their tactical use and the most effective results; the delivery of these fuses is a logistical function.

Most bombs, such as the 550- and 1,100-lbs high-explosive bombs, are equipped with electrical side-fuses. Ground targets will be attacked with No. (25) and naval targets with Nos. (28) A or (38). Depending on the condition of the target, one can select immediate-action or delayed-action fuses before the attack.

(25) fuses have the special advantage that one can set them for long or short delays just before the bombs are loaded into the aircraft. The more recent (38) fuses can be set for three different delays, but not for immediate action. Multiple purpose bombs are usually equipped with No. (55) fuses that can be used

with or without setting the timing.

The principal categories of fuses are as follows:

a. Highly Sensitive Fuses. This is achieved by inserting the fuse in the nose of fragmentation bombs or by using special devices for bombs with electrical fuses on the side. The latter is a prerequisite for the proper functioning of chemical and napalm as well as hollow-charge bombs. Originally, the former were equipped with No. (26) fuses, with a pounder in the inside of the bomb establishing contact with the side fuse. Later models, however, were delivered with simpler No. (55)A fuses. In these fuses immediate-action contact was established by a box with a membrane, which was screwed in at the head of the bomb. One can even set the explosion point above the ground by attaching the membrane to fixed or telescopically expandable distance-tubes. This method is useful when there is a high layer of snow, particularly in the case of the multiple purpose bombs SD 70 and SD 250. In this manner one can even reach into covered trenches or foxholes from the top, by using SD 250 Tel bombs even into dispersed aircraft shelters. Massice distance sticks, which transmit the impact percussion to the entire body of the bomb, are used when only (55) fuses are available for this purpose.

b. Nondelay Fuses

This is a fuse type used with the ordinary electrical side fuse; an inertia contact inside the fuse is activated by the impact, which takes about one thousand's part of a second.

Nondelay fuses are used with high-explosive bombs to produce an air blast effect and considerable fragmentation because of the high velocity of departure. The same is also true of the multiple purpose bomb, whose fragments however are more massed. Nondelay fuses are used for intensive incendiary bombs as well as for "sedentary" chemical and smoke bombs in order to disperse their contents over the target area.

c. ~~Delayed-Action Fuses~~. Delayed-action is the other type of fuse that is more important for the effect of high-explosive and armor-piercing bombs. The bomb should not penetrate any further into the target than is necessary to obtain optimum effectiveness. With the fuses attached to the various types of bombs it has different effects and is ~~XXXXXXXX~~ mainly determined by the burning of a pressed grain of powder.

The delay of fuse (25) used for high-explosive SC 250 and SC 500 bombs corresponds to the respective drop altitude and the resistance of the target. The average setting is 0.08 of a second. As previously mentioned, the delayed-action can also be reset in special cases for timing in the dead center of the bomb.

Protected land or naval targets require different fuses. The large high-explosive bombs SC 1000, SC 1800, and SC 2000 as well as the SD 1700 are delivered with (28) B fuses, which have fixed delays in the explosion of the powder as well as mechanically acting,"kinetical" delays that strongly break the bomb at the target. This delayed action is adjusted in accordance with the consistency of bomb case to various multiples of the acceleration of gravity, amounting to 800 grams in the case of the SC 1800, 2,000 grams in the case of the SC 1000 and SC 2000, and 6,000 grams for the SD 1700. This device is installed to prevent insofar as possible the bombs from breaking up prematurely upon hitting targets that are too hard.

The (35) fuse used for armor-piercing bombs has only one fixed delay. On the other hand, the armor-penetrating No. (48) bomb has a ground fuse that can be set for short or long delays depending on the various drop levels and target resistance strengths. The detonation is to be initiated directly upon penetration of the main layer of armor and not only below the deck.

The rocket attachment in armor-piercing bombs with propulsion was ignited 2.7 seconds after being dropped by fuse (49) if the timing was set at no delay, whereas if it was set for delayed-action it went off according to the timing.

d. ~~Delay Fuses~~. Delay fuses are needed for low-level attacks to give the aircraft time to depart from the danger area where the high-explosive bombs were dropped. The customary ground fuses switched automatically from delayed-action to delay fuses as soon as the safety ceiling for high-level or dive-bombing attacks had been underpassed. The delay fuse in older models (15) was about 8 seconds, for No. (25) it was about 14 seconds. Fuse (38), used for attacking unprotected vessels with high-explosive bombs, had a delay fuse set for 5 seconds so that the bomb would not drop too low before detonating, whereas the usual delays of 0.05 and 0.2 seconds were available for high and medium altitudes or small and large vessels, respectively.

The importance of properly setting and selecting the fuse cannot be overemphasized, as pointed out in the following. Under certain circumstances entire fuse assemblies should be exchanged for attacks on certain types of targets. For instance, when the previously mentioned large high-explosive bombs were used, fuse (28)B, which was not suitable for low-level attacks, was exchanged against a (25) or (38), if bridge foundations, dams, lock gates or ships were to be attacked at low levels.

In general, the detonation of a bomb at the right time was really more important than the type and size of the bomb proper. If, for instance, an aircraft has been loaded with multiple-purpose bombs of caliber SD 70 and was to attack columns of troops at high level, the crews had to realize that the success of the operation would d pend on setting the fuse switchbox at nondelay. If they were set at delayed action, the bombs would penetrate into the ground and have little fragmentation effect. Even larger caliber bombs would have less effect than small but properly fused bombs.

In another instance, an attack on a major switching station might have been ordered and most of the aircraft were accordingly loaded with high-explosive SC 250 bombs that were to be dropped with delayed action. Upon approaching the target, however, it was established that troops were detraining. In this case it would be more effective to drop the high-explosive bombs without delay fuses. The unit commander immediately issued the corresponding orders by radio.

In a third instance a minor machine tool factory consisted of one-storied workshops that were 16 feet high. The walls were built of bricks and the buildings were subdivided into single parcels of 66 by 99 feet, with the various machines distributed among them. One single 550-pound high-explosive bomb could destroy such an area about 80 percent if it detonated in the center of the hangar floor with a short delay. A SC 500 bomb that penetrated deep into the ground with a long-delay fuse, would have far less effect. Without delay, the bomb would ignite upon hitting the roof. The situation is similar with regard to naval targets, for which numerous examples of insufficient effectiveness because of too little or too much delay in fuse timing can be cited.

e. ~~Time Fuses~~. With these, ignition occurs according to the fuse and its timing either between 5 and 40 or between 4 and 60 seconds after the bomb was dropped. Originally meant for flash and photoflash bombs, these fuses can also be used for certain chemical bombs. Even high-explosive bombs, such as the SHr 500, can be successfully used against flying targets. Simple types of time fuses can be equipped with 2 or 3 charges burning for varying periods so that they can serve for opening drop containers above the target.

f. Long-Delay Fuses. Originally, the special fuse (17) was designed for Army support in attacking prepared positions, with the Luftwaffe supposed to bomb the respective sectors some time in advance. Only a small number of bombs used for that purpose were to detonate immediately, whereas the majority of them were to explode at a definite time, under circumstances 2 or 3 days later. The clockworks in (17)A fuses were therefore set for a certain time up to 100 hours in advance. After the R.A.F. dropped the first bombs with long-delay fuses in April 1940 in order to extend the attack over a longer period, the (17)A fuse was used by the Germans for the same purpose. Similar timing delays, but with less precision, were inherent in the long-delay fuse No. (57).

g. Nuisance Fuses. This included all those fuses that did not detonate immediately, just like the long-delay fuses. On the contrary, they continued and maintained the confusion created by the raid proper, complicated the clearing efforts, and disturbed the resumption of factory and traffic routines. Short data on the subject can be gathered from the fuse statistics contained in Part III. The proper use of these fuses requires very thorough knowledge that can be acquired by studying the technical directives concerning the respective fuses.

4. The Effect of Fire

Passed wartime experience has shown that many targets can be attacked more effectively with incendiary bombs than with explosive bombs. The following differences between industrial targets, residential areas, and commercial districts on the one hand and live targets on the other are to be noted:

a. Industrial Targets. Their vulnerability to fire depends on the type of construction and contents of the buildings or both. If a quarter of the target consists of inflammable material, the use of incendiary bombs will prove to be worth while. Prior target reconnaissance and exact evaluation are indicated. High susceptibility to fire can become the cause of large-scale fires that extend to adjoining districts.

b. Residential Areas and Commercial Districts. The determining factor for the effect of fire is the density of the built-up sections as well as combustibility of the buildings and their interior installations. Large-scale fires are affected by the existence of fire walls, fire gaps, etc., as well as by the accessibility of water to extinguish the fire and the discipline of the fire brigades.

c. Live Targets. Already at the outset of the war, incendiary bombs proved effective in attacks on march columns, troops in hasty positions, and fortifications. Dropped like activated

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incendiaries with nondelay fuses in low-level attacks, they affected the morale of the troops. Occasionally, even targets that cannot be too effectively attacked with explosive bombs, can be temporarily neutralized by fire bombs; among these are observations points, port-openings, and slits in turrets and disappearing gun mounts in fixed fortifications. The most effective way to attack these would be to first drop a few incandiaries blindly: their contents will penetrate slits and gaps, and only then toward the end of the attack one would use a bomb with delayed fuse on that target. In open terrain the difference between incendiary and activated flame bombs is that the former will form a compact XXXX ball of fire which however will be of only short duration, while the latter will create more extensive areas of fire that will burn longer but will be separated individually.

5. To produce ~~underwater explosions~~ is the objective of anti-submarine warfare and of low-level attacks on ships, dams, lock gates, and other port installations situated in the water. Underwater effects are also produced by near misses of XXXXX bombs dropped from high altitudes or in dive-bombing attacks on war ships. However, major damages will not be produced outside a relatively limited radius, around the target.

Experience data are available only from tests which showed that, contrary to high-explosive bombs and torpedoes, the effect of fire bombs is reduced by one third by the air shaft formed behind the bomb. Leakages and engine room breakdowns, however, were often achieved even from considerable distances.

Similar effects to those produced by direct hits can be attained only by bombs dropped near the sidewall of commercial vessels up to 8,000 tons, lightly protected warships such as destroyers and cruisers up to 4,000 tons, and small aircraft carriers. Large transport vessels and cruisers of more than 8,000 tons usually have double bottoms and several watertight compartments extending over three quarters of the vessel's length. The bow and the rear, however, have only one simple hull. For this reason the effect of direct hits would be overwhelming against this type of vessel so long as the bomb penetrates deeply into the ship's body. Underwater damages to the bow and stern correspong to those achieved against unprotected vessels. Modern battleships and large aircraft carriers have well constructed underwater protection at midship: this extends to about half the entire length of the ship in order to reduce the effect of torpedoes. This will also greatly reduce the effectiveness of near misses of high-explosive bombs weighing less than 2,200 pounds in comparison with direct hits by armor- piercing bombs of equal caliber. Near misses can achieve considerable effectiveness, if they drop near the unprotected bow or stern. If the bombs are dropped out of flat dives, they can be brought so close to the ship's wall that its higher explosive contents can produce mare results than aircraft torpedoes of equal weight. Unprotected ships and unportected bows and sterns of major warships suffer the same damages from this type of attack

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as if these parts of the ship had been hit directly. It has proved effective to attach headrings to high-explosive bombs used for this purpose.

Low-level attacks by high-explosive bombs dropped from the level of mast tops will penetrate unprotected walls or bounce off, if the latter are too thick. In that case, and also if the bomb drops short of the target, the damages will be proportionate to the distance between the exploding bomb and the side of the ship. The depth of the water has also a great effect on the effect produced. Shallow bodies of water will reduce~~d~~ the effect of explosions at major distances just as much as detonations at too low or too high a level. The best effect is generally produced if the depth of detonation is about equal to the distance from the ship's wall. The use of impact disks will prevent that the bomb dropped during a low-level attack bounces off the surface of the water and jumps beyond the target. With an impact disk attachment the bomb will ~~XXXX~~ slide along the water up to the vessel and will sink there, detonating after 5 seconds if it is equipped with a (38) fuse.

The fuses attached to armor-piercing bombs are set only for direct hits and the delay for penetrating into the vessel will correspond approximately to the circumstances prevailing in the case of near misses.

Fuses (28)B for high-explosive SC 1000 - SC 2000 bombs and for multiple purpose SD 1700 bombs are set for fixed delays pertaining to underwater effectiveness. As previously mentioned,

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the added acceleration fuse guarantees deep penetration into the vessel. The SD 1700 probably penetrated to the main armored deck, which would reduce the combat capability of the target object quite considerably.

Major explosions below the ship are far more dangerous than detonations next to the vessel. They affect the keel and the frame and bulkhead that are connected with it: moreover, the explosive gases move upward in accordance with the law of gravity. This is also the case with distance pistols introduced in aerial torpedoes.

6. The Effect of Chemical Bombs

The use of chemical agents was anticipated only if the enemy employed them first. Special tactical and technical instructions had been prepared for that purpose, which are beyond the scope of this study.

7. The Relationship of Attack Method to the Effect of Bombs

In general, the effect of a normal explosive bomb dropped in a low-level attack on a ground target will be less than if that bomb is dropped from a high altitude or out of a diving attack. Bombs dropped from a low altitude might bounce off and skip over the target. This action will be greatly reduced if an impact disk is attached to the bomb. The fragment density and figures given in the following parts of this directive are based on the assumption that these bombs will hit their targets almost vertically. A horizontally hitting multiple-purpose bomb will lose about one third of its fragments that will enter the ground and the fragmentation effect will be quite unfavorable because of the unequal distribution of fragments.

To remedy these deficiencies, the Germans developed special explosive bombs for low-level attacks, such as the SD 2 t, SC 250 Stabo (spike bomb), and the SD 500 Br.

The greater durability of the multiple-purpose bombs in low-level attacks is compensated for by lower pressure effect than that of the high-explosive bombs. In diving attacks on ships that are heavily armored, the angle generally did not exceed 60 degrees to the horizontal so that the bomb hit the deck obliquely and therefore had to cover a longer route than if it was dropped from a high altitude. The side walls of the casing of the relatively long armor-piercing bombs suffered greater stress than that exerted on the point of the bomb so that stronger walls had to be used for such casings than if the bomb had been dropped from a hogh altitude.

X

~~Glossary of German Abbreviations~~

SB (Grossladungsbombe)	Major charge bomb
SD (Splitter- oder Mehrzwecke bombe)	Fragmentation or multiple-purpose bomb
SC (Minenbombe)	High-explosive bomb
PC (Panzersprengbombe)	Armor-piercing bomb
PC/RS (Panzerdurchschlagbombe mit Raketenantrieb)	Armor-piercing bomb with rocket attachment
PD (Panzerdurchschlagbombe)	Armor-piercing bomb
--X (Panzerbombe mit Nach-steuerung)	Armor-piercing bomb with rear control
Stabo (Minenbombe mit Stachel)	High-explosive bomb with nose spike
SD 250 Tel (Splitterbombe mit 3m langem Distanzrohr)	Fragmentation bomb with 10-foot distance tube
SD 500 Br (Mehrzweckebombe mit Bremsschirm)	Multiple-purpose bomb with brake parachute
SHr 500 (Schrapnellbombe gegen fliegende Ziele)	Shrapnel bomb (against flying targets)
SHl (Hohlladungsbombe)	Hollow-charge bomb
KC (Kampfstoffbombe)	Chemical bomb
NC (Nebelbombe)	Smoke bomb
LC (Leuchtbombe)	Flare or flash bomb
Bl C (Blitzlichtbombe)	Photo flashbomb
Lux (Seenotzeichen)	Air-sea rescue signal
LM (Flz.Mine mit Fallschirm und mit Fernzuendung)	Aerial mine with parachute and remote control fuse
BM (Bombenmine mit Fernzuendung	High-explosive bomb with remote control fuse

WB (Fl. Wasserbombe)	-	Aerial water bomb
LT (Flz Torpedo -B8 mit Streubrandbombe -SD 1 auch -SD 3)	-	Aerial torpedo with scatter bombs of the SD 1 and SD 3 type
AB (Abwurfbehaelter -EE mit Elektronbrandbomben *SD 10 auch -SD 9 und -SD 15	-	Drop containers with electron incendiary bombs of the SD 10, SD 9, and SD 15 type
Kaliber ("qua libra" Bomben- gewicht in kg)	-	Caliber (Bomb weight in kilo- grams)
El AZ (elektrischer Aufschlag- zuender)	-	Electrical impact fuse
Zt Z (Zeitzuender)	-	Time fuse
Dopp Z (Doppelzuender)	-	Double-action fuse
LZZ (Langzeitzuender) 5-120 min bzw 2 - 100 Std	-	Long-delay fuse (5 to 120 minutes or 2 to 100 hours)
o V (ohne Verzoegerungsein- richtung)	-	Nondelay
m V (mit kurzer Verzoegerung- 0.045 - 0.2 sec)	-	With short delay (0.045 to o.2 seconds)
V Z (Verzugsdr. bzw. Ver- zugszuendung 5-30 sec)	-	Delayed action fuse (5 to 30 seconds)
Tief (Tiefangriff aus 5 - ca. 100 m. Flughoehe)	-	Low-level attack (from 17 to 330 feet flight altitude)
Hoch (Hochangriff aus ueber 2000 m Flughoehe)	-	High altitude attack (from a flight altitude of more than 6,600 feet)
Stz. (Abwurf aus dem Sturz- fluge -- bei Panzerbomben muss die Ausleesehoehe mindestens 1.2 km betragen)	-	Air drop from diving attack (armor-piercing bombs must be released from a minimum altitude of 4,000 feet)
B - E (Elektronbrandbomben von 1 - 2 kg Gewicht; Z - mit Zerlegerldg.)	-	Electron incendiary bombs weighing 2,2 to 4.4 lbs; with self-destroying charge
Brand (Streubrandbomben von 4 - 10 kg Gewicht)	-	Scatter bombs weighing 8.8 - 22 lbs
Sprbrd C 50 (Sprengbrandbombe 50 kg)	-	Combination incendiary- demolition bomb weighing 110 lbs.
Strbrd C 500 (Streubrand- bombe mit 1200 Branddosen) *		Scatter bomb with 1,200 incendiary cans

All bombs with high explosive charges are demolition or high-explosive bombs.

III. Technical Data Concerning Bombs

a. General Description and Composition of Bombs and Fuses. The outer shape of most bombs is cylindric; only in the case of multiple-purpose bombs and armor-piercing bombs does the diameter slightly decrease in order to add to the strength of the casing against lateral tension.

The point of the bomb is ogival to permit higher penetration and has a radius of sphericity varying between 1.0 and 2 times the diameter. The small electron and scatter bombs are flattened at the front, which facilitates stabilization considerably. The tail assemblies are usually twice to three times as long as the diameter. Generally, they consist of 4 guide fins with 1 ball race at the end. The 3.3-lbs electron incendiary bomb and the 22-lbs scatter bomb are equipped with a socalled semimonocoque tail assembly so that they can be packed tighter into the drop containers. The 8.8-lbs "fire box" has no stabilizer and is therefore particularly suited for low-level drops. The 4.4-lbs anti-personnel bomb is equipped with fan brakes that open up when the bomb leaves the drop container so that this weapon can be used for low-level attacks without fuse delay after impact or with a 2 second time fuse after release.

The 550-lbs hig-explosive bomb is used without tail assembly when it is employed a aerial water bomb against submarines; in this manner, the sinking speed in the water is regularized during low-level attacks.

The bomb case around the explosive is usually made of steel or special cast iron in the case of fragmentation bombs. The same type of bomb made of artillery shells is produced of pressed steel. The multiple-purpose bomb SD 50, which serves exclusively as fragmentation weapon, is produced essentially of steel casting. On the other hand, the SD 70 is pressed or rolled in one piece so that it can penetrate 1/8th of an inch of steel, quite apart from its fragmentation effect. Sd 250 and SD 500 A bombs are welded from two molded pieces or made of cast steel. the SD 500 B and SD 1000 A, however, are molded in one piece and rifled. This type of production method in the field of high-explosive bombs is considered as quality No. 1. It guarantees in the case of a vetical impact that for instance a SC 250 would penetrate structural steel of 1/5" thickness or 1.5 feet of concrete. Against unprotected but resistant targets that are of robust construction, such as industrial facilities or ships, one should use only quality No. 1 weapons. High-explosive bombs welded from 2 or 3 pieces are considered quality No. 2 and 3, respectively, and have only about 60 and 40 percent respectively of the resistance to stress found in quality No. 1. They can be employed only against targets that have been identified as less resistant, but never for low-level attacks.

Armor piercing bombs are made of alloy steel so that they can penetrate armor-plated decks.

The bomb cases, also those of high-explosive bombs, are rounded off and reinforced toward the bottom. The thickness of the walls is gradually reduced from the widest diameter downward in order to achieve maximum strength at every point. The fill opening for

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the explosive is closed with a strong screw-on lid.

All bombs weighing 11-lbs or more are suspended on an eye above their center of gravity. Bombs weighing less than 110-lbs are dropped by containers that are shaped like bombs and are suspended on eyelets in the aircraft. The containers open after the release according to a time fuse set at will so that their contents are dispersed over the target. Each little bomb has its own fuse.

With the exception of the small bombs, armor-penetrating bombs, and some special bombs, all other bombs are equipped with side fuses that are activated by electrical impulse. The fuse boxes are vertically installed to the roll axis and contain the fuse proper as well as transmission charges and occasionally also special locking devices against dismantling. This arrangement facilitates nondelay or delayed fuse setting, and the explosive charge is activated from the center. The bomb point can remain massive. which in turn produces considerably greater tensil strength.

The SD 2 had a central fuse: all other small fragmentation bombs had head fuses. The armor-piercing bombs had fuses at the bottom so that their side walls would also remain solid.

The method of attaching the fuse of other bombs is shown on the illustrations.

The bombs are first painted with rust repellant, which is then covered with a grey or light-yellow camouflage paint.

The proper use of explosive and incendiary bombs was facilitated by colored rings or stripes painted on the bomb cases, which had the following significance:

1 red ring	-	flash bombs
2 red rings	-	intensive incendiary bombs
1 red stripe	-	fragmentation and multiple-purpose bombs
1 yellow stripe	-	high-explosive bombs
2 yellow stripes	-	major charge bombs
1 blue stripe	-	armor-piercing bombs

The ~~xxx~~ colored rings were painted around the point and around the center part of the bombs, whereas the stripes were painted on the cone.

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Data Concerning Bombs and Fuses

Tables I and 2: Fragmentation and Multiple-Purpose Bombs

(Fragmentation Effect)

Type of Bomb	Level of Attack	Fragment Density	No. of Fragm.	No. of Bombs in Drop Cont. 70	250	500	1000	Fuses No.	Fuses Type	Typical Targets
SD 1	High	26.4'	130	-	225	392	-	73	nondelay	Troops in open terrain and field positions
SD 3	"	42.9'	560	-	-	84	-	73	"	
SD 9	"	66'	440	4	-	-	-	66	"	
SD 10	"	82.5'	500	-	17	37	-	66	"	Columns of marching troops
SD 15	"	105.6'	660	-	-	24	-	66	"	
SD 2t	Low	39.6'	250	24	114	-	-	41	nondel. time	Aircraft on the ground
SD 4H1	Dive	42.9'	450	-	30	70	-	66	nondelay	Tanks

Type of Bomb	Level of Attack	Fragment Density	No. of Fragm.	Average Fragment Weight*	Fuses No.	Fuses Type	Typical Targets
S Be 50	High	125.4'	1600	11 grams	55	nondel.	March column
SD 50	high &low	105.6'	1300	13 grams	55	non-delay	Aircraft & truck column
SD 70	high &low	148.5'	2000	15 grams			small industr plants, heavy trucks
SD 250	"	198'	6800	40 grams		delayed ignition	Heavy industry
SD 500A	"	264'	3700	explosive charge			
SD 500B	"	231'	4500	77 grams 90 kilos	28A	delayed	heavy cruiser
SD 1000A	"	280.5'	7000	100 grams 200 kilos	25	nondel.	Blast furnaces
					28A	delayed	Power plants & aircraft carriers

* Observation regarding fragmentation bombs: For targets which are to be attacked with SD1 according to Part IV, one can also employ drop containers with SD 3. The same is also true of SD 10 targets, against which one can also use aerial containers with SD 9 or SD 15. For information on fragment density and fragment numbers, see page 44.

Tables 3 and 4: High-Explosive and High-Charge Bombs

(Power of Penetration and Dielectric Strength)

Type of Bomb	Level of Attack	Fragment Weight	Penetration	Fuse No.	Fuse Type	Typical Targets
SC 50	high	52.8 lbs	30 mm structural steel	25	delayed	Small industr. plants
SC 250	"	275 lbs	50 mm structural steel	25	delayed	ordinary buildings (destroyed)
SC 500	"	572 lbs	500 mm concrete	25	delayed	solid structures (damaged)
SC 1000	"	1,166 lbs	650 mm "	28B	"	large airplane and factory hangars
SC 2000	"	2,178 lbs	800 mm "	28B	"	Dams & bridges
SC 1800	"	2,200 lbs	30 mm armor	28B	"	Large warships
SD 1700	"	1,584 lbs	60 mm "	28B	"	Aircraft carriers, older-type battleships

Data on depth of penetration, sizes of craters, and pressure effects are to be found in Part III C.

Type of Bomb	Level of Attack	Fragment Weight	Penetration	Fuse No.	Fuse Type	Typical Targets
LMB w	low	1,540 lbs	For information regarding blast effect, see Part III	34	delayed ignition	Targets susceptible to air pressure
SB 1000	high	1,617 lbs	(as above)	C 24	nondelay	densely inhabited districts
SB 2500	"	3,762 lbs	(as above)	24	"	Dispersed buildings

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Table 5: Armor-Piercing Bombs (Power of Penetration)

Type of Bomb	Level of Attack	Weight of Expl. Charge	Penetration	Fuse No.	Fuse Type	Typical Targets
PC 500	High & Dive	220 lbs	80 mm armor plat.	35	delayed	Heavy cruisers
PC 1000	"	352 lbs	100 mm " "	35	delayed	Aircraft carriers
PC 1400	"	660 lbs	130 mm " "	35	"	older-type battleships
PC 1600	"	506 lbs	180 mm " "	48	"	Modern battleships
PC 500RS	Dive	26.4 lbs	200 mm " "	49	"	Battleships up to 35,000 tons
PC 1000RS	"	143 lbs	180 mm " "	49	"	
PC 1800RS	"	484 lbs	180 mm " "	49	"	
PD 500	High	63.8 lbs	160 mm " "	48	"	Battleships of 39,000 tons
PD 1000	"	132 lbs	180 mm " "	48	"	Battleships of 35,000 tons
PC 1400X	"	660 lbs	130 mm " "	35	"	Battleships of 30,000 tons
PD 2500X	"	319 lbs	230 mm " "	48	"	Battleships of 50,000 tons

Table 6: Special Explosive Bombs

Type of Bomb	Level of Attack	Purpose and/or Performance	Fuse No.	Fuse Type	Typical Targets
Stabo 50	Low	Extremely low-level attacks	55	delayed ignition	Railroad lines
Stabo 250	"	" " " "	17+50	time	" (Nuisance effect)
SD Te1250	High & Dive	Fragment Density - 390 feet Fragments number 5,000	55A	nondelay	live and relatively light
SD Br.500	Low	Low-level attacks at high speed	55A	nondelay	"dead"(fixed)
SHr 500	High	Dropped on flying objects	89	time	Bomber units
SH1 500	Dive	Hollow-charge bomb; penetrates 11.55 feet of cement	66	nondelay	Fixed fortifications
SH1 800	"	Hollow-charge bomb; penetrates cement that is 16.5 feet thick			
SH1 4000		"Mistel" (missile) attached to turret of Junkers 88 aircraft	66	nondelay	Large naval vessels
Hs 293		Glider bomb with rear control mechanism	28A	delayed action	Large commercial vessels

Table 7: Incendiary Bombs Z = with self-destroying device (optional)

Type of Bomb	Level of Attack	Thickness of Cement that Can Be penetrated	No. of Bombs in Drop Container 250	500	1000	Typical Targets
B1E(Z)	High	50 mm	96	-	610	) Normally) roofed) habitations
B1.3E(Z)	"	70 mm	-	184	248	
B 2 EZ	"	100 mm	64	-	+(238	) Buildings) with strong) roofs
B 1 5E (Z)	"	80 mm	-	-	778	
Brand 4	Low	-	-	52	-	Barracks, bivouacs
Brand 10	High & Low	100 - 150 mm	28	-	-	Aircraft hangars, large habitations & administrative buildings

Type of Bomb	Level of Attack	Size of Effective Area	Penetration	Typical Targets
Sprbrd C 50	low	66' x 66'	200 mm cement	Lightly protected industrial facilities
Strbrd C500	high	about 6 sq miles	-	Pine forests & wheat fields
Brand C 50	high & low	33' x 66'	150 - 200 mm)	) Installations) that are not) easily) inflammable
Brand C250	"	132' x 165'	200 - 250 mm)	
Flam C250	"	66' x 66'	-	) Live targets,) easily) inflammable) surfaces
Flam C 500	"	99' x 99'	-	

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Table 8: Chemical, Smoke, and Flash Bombs, Air-Sea Rescue Signals

Type of ~~XXXX~~ Bomb	~~XXXXXXXX~~ Capacity	Contents	Effect through:	Fuse	Color Rings
KC 250 yel.	70 quarts	ordinary mustard gas	skin irritant	(15)	1 yellow
KC 250 I grey	70 quarts	diluted mustard gas	skin and breathing irritant	(26)	1 green & 1 yellow
KC 250 II grey	65 quarts	phosgene gas	respiratory irritant	(26)	1 green
KC 250 II yellow	70 quarts	adherent mustard gas	skin irritant	(9)	2 yellow
KC 250 w	198lbs	Chloracetophenon gas	eye and nose irritant	(9)	1 white
KC 250 III green	70 quarts	Trilone, tabune, sarine	nerve irritant	(55)A	2 green

LC 50 F/C Light strength: 600,000 Hefner candles; duration of flash: 5 - 6 minutes; Fuse (59).

LC 50 F/G Light strength: 1.4 million Hefner candles; duration of flash: 5 - 6 minutes; Fuse (59).

Bl C 50 Light strength about 60 million Hefner candles; area that can be photographed: 2.6 square miles; Fuse (9).

Bl C 50A Light strength about 600 million Hefner candles; altitude from which one can photograph: 23,100 feet; Fuse (89).

NC 50 Smoke of about 20 minutes' duration.

NC 50 W Swims and spreads yellow smoke for 10 minutes.

NC 250S Develop~~e~~s sudden smoke clouds of 165' by 247.5' by 660'

Lux S Inflation gas, weighing 4 lbs: air-sea rescue signal lit up for the duration of 5 - 6 hours.

Lux N Inflation gas, weighing 11 lbs: air-sea rescue signal creating smoke for about 10 hours.

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Table 9: Aerial Mines, Aerial Water Bombs, and Aerial Torpedoes

Type of Bomb	W~~/~~eight	Explosive Charge	Dimensions (Circumference)	(Speed and Distance Covered by Aerial Torpedo)	
LMA	1,276 lbs	660 lbs	600 mm	2100 mm long	(Ground mine
LMB	2,101 lbs	1,540 lbs	"	3040 mm "	(with (Parachute
BMC	1,364 lbs	110 lbs	"	2800 mm "	Moored mine
BM 1000	2,200 lbs	1,892 lbs	650 mm	2600 mm "	Aerial mine
Fl.WB 250	550 lbs	286 lbs	368 mm	1250 mm "	with fuses (9) or (89)
LT 350(it)	770 lbs	264 lbs	500mm 7 m/s	2500 mm " 9.4 miles	Dropped by parachute, runs in circles
LT 5 b	1,650 lbs	440 lbs	450 mm 40 meters per second	5390 mm " 1.2 miles	Shelter torpedo
LT 5 w	2,068 lbs	440 lbs	450 mm 40 meters per second	6070 mm 1.5 miles	Whitehead torpedo

Remote Ignition for LMA and LMB Mines

Fab 1 - magnetic

Fab 3 - ac~~c~~oustic

Fab 10 - ac~~c~~oustic with special safety against mine sweeping

Fab 11 - ac~~c~~oustic and magnetic

Fab 27 - magnetic & ac~~c~~oustic, fuses only during ascent.

Remote Ignition Equipment for BM 1000

M 101 - Magnetic

A 105 - Ac~~c~~oustic

MDA 105 - Magnetic & hydrostatic including ac~~c~~oustic ignition

AD 104 - Ac~~c~~oustically switched, hydrostatically ignited

AA 106 - Ac~~c~~oustically switched, ac~~c~~oustically set for ignition.

DA 102 - Hydrostatically switched, ac~~c~~oustically set for ignition

AE102 - Ac~~c~~oustically turned on, induction ignition.

IDA 105 - Inductively and hydrostatically turned on, ac~~c~~oustically ignited.

Both the LM and the BM mines and bombs can be equipped with computer contacts up to 24 idle travels and contactors for certain times of the day or night as well as with delayed-action devices for as long as one week.

Table 10: Load Capability in Drop Containers (No. of Bombs Contained)

Container	SD 1	SD 2	SD 3	SD 4HL	SD9	SD10	SD15	B 1.3E	B 1.5E	B2EZ	Brand 4/10
AB 50/70	50	23t			4			42			
AB 250	224	114 time fuse		30		17		96		64	
AB 1000	1052		(248 1.3E + 238 B2EZ)					610	778		28
AB 500	392		84	70		37	24	184		116	

The load standards are given in Tables 1 and 7 (normal loads)

Supply containers for ammunition had a capacity of 1,760 lbs each.

Supply containers with parachute had a payload of 1,540 lbs and a drop speed of approximately 220 miles an hour.

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Table II: The Most Important Bomb Fuses (Attached to the Side unless otherwise indicated)

Type of Fuse	Delays, if set for Nondelay	Delayed Action	Delayed Ignition	Mainly Employed with
El AZ 15	0.001	0.05	8	SC 50-SC500;KC250gb
El AZ 25	0.001	0.08	14	SD 500B, SD 1000 A
El AZ 26	0.0005	-	-	Flam C 250/500; KC 250 gr
El AZ 28A	0.001	0.15	-	SC 50-SC 500 against ships
El AZ 28B	-	0.12 + kinetic fuse	-	SC 1000-SC 2000, SD 1700
El AZ 35	0.1	0.1	-	PC 500-PC1400/water
El AZ 38	0.05	0.2	5	All SC bombs against
El AZ 48	0.045	0.075	-	PD 500/1000;PC 1600
El AZ 55	0.001	-	14	SD 50-SD 500 A,SBe5C
El AZ 55A	0.0002	-	14	(All SD bombs up to SD 500 Br KC 250 III XXX large Flam C 250/500
El AZ 24	0.0005 + fraction fuse			SB 1000/2500
El ZtZ 9	long-range remote control of 5 to 40 seconds			KC 250 w and IIgb, Bl. C 50, etc.
El DoppZ 49	ignites rocket delayed action of 0.04 seconds after 2.7 seconds			PC 500/1000 RS
Uhrw.ZtZ 89	can be set from 4 to 60 seconds			Bl C 50A, SHr 500
VZ 34	ignites LM 30 seconds after hitting the ground			
e AZ 66	highly sensitive electro-dynamic head fuse			SD 9/15, all Hl bombs
AZ 3	mechanical head fuse for high or low-level drops of single			SD 10's
AZ 13A	mechanical head fuse with unilateral effect			B 1 E, B 1.3 E
AZ 23A	mechanical ~~XXXXXXXXX~~ base fuse with all-around effect			Brand 4/10

Type of Fuse	Delays, If Set for ~~Nondelay~~ ~~Delayed Action~~ Delayed ~~Ignition~~	Mainly Employed with
a AZ 73	Highly sensitive head fuse with membrane	SD 1/3
DoppZ 41	Central fuse without delay and two lateral time fuses	SD 2 t
ZtZ 59	with a combustion period of 13 and/or 37 seconds	LC 50 F and AB 250/500
ZtZ 79	with a combustion period of 3, 13 or 30 seconds	AB 250/1000
ZtZ 69 D	Small aperture fuse with 1.2 seconds	AB 50/500
Uhrw.LZZ 17A	Can be set between 2 and 72 hours	SC 250/500
Uhrw. LZZ 17B	Can be set between 5 and 120 minutes	SC 250/500
Zus.40	mechanical removal block for LZZ 17	SC 250/500
El.StoerZ 50	responds to the slightest vibration, nose-spiked bomb, etc.	
Chem LZZ 57	effective time 12, 36 and about 100 hours	SC 250/500
El.Stoer Z 60	like (50), but effective duration one year	SC 250/500
LZZ 67	central fuse that ignites after 5 - 30 minutes	SD 2 time
Stoer Z 70 B	central fuse that becomes highly sensitive after impact	SD 2 time fuse
Chem LZZ 77	central fuse with 6 - 48 hours effective duration	SD 2 time fuse

Author's Note: See specifications No. 48 (illustration) for arming time.

Table 12: Code Number and Composition of Explosive Charges

Code Number	Designation	Composition and/or Use	Method of Filling Bomb
13	Fp 60/40	60% Trinitrotoluol 40% Ammonium Nitrate	Poured
13A	Fp 50/50	50% Trinitrotoluol 50% Ammonium Nitrate	"
14	Fp 02	100% Trinitrotoluol	"
52	Amatol	50%Dinitrobenzole 35% Ammonium Nitrate 15 % Tetramethylenetrinitramine	"
101	Fp 02 phlegm.		"
102	Fp 60/40 phlegm.		"
105	~~XXXXX~~ Trialen (Trichlor-ethylene)	70% Trinitrotoluol ~~XX~~ 15% Aluminum 15% Tetramethylene trinitramine	"
106	Trialen (id)	50% Trinitrotoluol 25% Aluminum 25% Tetramethylenetrinitramine	"
"E"	Trialen (id)	60% Tetramethylenetrinitramine (pressed) with 40% Trichlorethylene 106	"
TH 11	Tri/He	60% Trinitrotoluol 40% Tetramethylenetrinitramine	"
SW 18	Schiesswolle (Nitro-cellulose)	Filled for parachute mines	"
SW 36	"	" " torpedoes	"
109	PMF	" " armor-piercing bombs	Pressed
113	Ammonal	Replacement filler for S Be 50	Packed
114	"	" " " SC 250 III	Packed
"A"	Ammonit (Ammonium Nitrate)	Filler for SD 1 and SD 3	Packed

B. Short Description of Bombs, Mines, and Torpedoes Dropped from Aircraft

1. Fragmentation Bombs (Abbreviated Designation: SD)

Small fragmentation bombs are best suited for attacking live targets and light fixed (dead) targets, if they are dropped in sufficient number from high altitudes or in a nose dive. The light fixed targets under consideration are aircraft, light vehicles, and radio and direction-finding stations. Live targets, such as troops, can be on the march or in unprotected positions.

SD 1 and SD 3 as well as SD 9, SD 10, and SD 15 are most suitable for high altitude attacks. SD 4 Hl, the antitank bomb, is most effective when dropped out of a diving flight; its directed gas ~~XXX~~ jet penetrates all armor-plating used for armored vehicles and ignites ammunition and fuel within the tank. In addition, this bomb also has relatively effective fragmentation results on escorting infantry troops.

The SD 2t was at first developed for low-level attacks exclusively, but can also be dropped without its brake vanes and equipped only with arming propeller; its designation then changes to SD 2 Zt and it is dropped from high altitudes, for instance on bomber units with a time fuse or on airports, routes of communication, etc., when equipped with various interference fuses. Its special use consists in hampering clearance procedures or the resumption of traffic and work after major air attacks.

The great number of small bombs packed into containers achieves far greated density of target coverage than by the use of multiple-purpose bombs. This can be decisive for the success of an air attack, if the enemy is well dug in and splinterproof walls protect the parked aircraft.

Fragmentation bombs proper generally do not exceed a weight of 33 lbs. Heavier fragmentation bombs also exert pressure effect on objects near their impact point and are therefore designated multiple-purpose bombs.

All fragmentation bombs have thick walls and contain from 10 - 12 percent explosive charges in relation to their over-all weight. The purpose of these bombs is to produce as many effective fragments as possible. Their fuses must be extremely sensitive, and thei range can be considerable extended by the use of distance tubes and drag struts. Originally, the only existing fragmentation bomb was the SD 10; however, single drops of this bomb are rare; instead they are also dropped in large numbers in containers together with other bombs: for instance AB 250's with 17 of the SD 10 type, which are equipped with eAZ (66) fuses rather than the AZ 5 (5). To an increasing degree, however, have mortar shells of 50 and 80-mm caliber as well as high-explosive shells of 88- and 105-mm calibers -- both of Army origin -- been transformed into SD 1 and SD 3 as well as SD 9 and SD 15, respectively and equipped with membrane fuses AZ (73) or (66). With appropriate targets, the SD 1 and SD 15 have proved especially effective.

Fragmentation bombs are evaluated according to the number of fragments and fragment density produced. The latter is defined as that distance measured in meters from the point of bomb explosion

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at which one fragment can still reach an individual square meter of a vertical target surface and still have sufficient power of penetration that it can penetrate pine wood of one-inch thickness. This would correspond approximately to a performance of 8 meter-kilograms and would be considered as sufficient to put a live target out of combat.

In figuring out the number of fragments, one usually calculates every fragment up to one gram in weight for bombs weighing up to 4,000 grams, because such fragments still carry sufficient energy with them because of the small effective ~~XXXXXXX~~ range of these weapons. The SD 1 has the same effect on aircraft as the 37-mm antiaircraft shell. For larger fragmentation bombs only fragments weighing more than 5 grams are counted. The average weight of frggments indicates whether the respective caliber weapon is suitable for attacking targets with greater resistance. An important factor, however, is the velocity of departure of the fragments, which is for instance lower in the case of armor-piercing bombs because of the~~XX~~ smaller quantity of explosives they contain than for multiple-purpose or high-explosive bombs of equal weight.

A poor substitue for a fragmentation bomb is the cement bomb S Be 50 that was produced in large quantities during the first year of the war. The fragments were poured into the cement case, and the bomb therefore contained insufficient explosives, especially ammonal. Effective fragmentation is achieved by using drag struts.

The previously mentioned SD 2t and SD 4 Hl, the telescope bomb SD 250 Tel, the brake parachute bomb SD 500, and the shrapnel bomb SHr 500 constitute special types of fragmentation bombs which will be discussed briefly in a later part of this study.

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2. Multiple-Purpose Bombs

Although their power of penetration does not exceed that of 50-percent high-explosive bombs, multiple-purpose bombs dropped from low altitudes have far greater consistency than the high-explosive weapons. But because of their lesser content of explosives, their effective pressure is only half as great as that of high-explosive bombs. However, the multiple-purpose bombs produce rough fragments that are suitable for penetrating even heavy material. such as locomotives, heavy presses and machine tools,etc.

The German abbreviation for multiple-purpose bombs is "SD", the same as for fragmentation bombs. Whereas the corresponding British bomb is designated "general purpose bomb," in the United States a "GP bomb" is a high-explosive or demolition bomb that was formerly designated "DEMO." The SD type bombs have relatively thick walls. The caliber SD 70 (154-lbs), SD 250 (550-lbs), and SD 500A (1,100-lbs) have no greater power of penetration than high-explosive bombs of equal weight. All SD bombs are produced of steel without alloys and are filled with normal explosives. The more recent models SD 500B and SD 1000 A are pressed from plain steel and rifled so that they can replace the corresponding armor-piercing bombs. They are also very effective against resilient ground targets or if heavy fragmentation is desired, in low-level attacks with delayed-action fuses and at high altitudes with nondelay fuses.

3. High-Explosive Bombs

High-explosive bombs, particularly those of medium size, are most commonly used for attacks at high altitudes or for dive bombing of land and sea targets. Their abbreviated designation is "SC" in German. Since they contain 50 percent explosives, their cases are relatively thin, but sufficiently solid that they can penetrate into any unprotected object and destroy it from the inside. High-explosive bombs are usually made of ordinary steel and -- as previously mentioned -- are produced in three qualities according to the manufacturing process. Quailities I and II are filled with ordinary explosives, while quality III contains substitute explosives. SC 250 and SC 500 bombs, that were committed against naval targets, were filled with high-powered explosives and were therefore exclusively quality I products. Delayed-action fuses were used in most instances.

The production of SC 50's was discontinued for quite some time in favor of the more modern SD 70, which contained the same amount of explosives. The welded SC 1800 was also discontinued and replaced by the SC 2000 that was produced from one piece of metal and was about twice as strong. The diameter of the SC 2000 measured 660-mm, against 440-mm of the SC 1800, which could be considered as an SC 2000 of third quality. In addition to designating the quality of high-explosive bombs, their method of production was also indicated, which however was of only technical significance.

The SD 1700 was an integrally rifled high-explosive bomb with activated power of penetration and 40 percent explosive content. It could penetrate into any large naval vessel up to the main armored plating, and its high explosive charge was effective even in the case of a near-miss. It penetrated cruisers completely.

Since the supply of these bombs was ample for operations against naval vessels, their production was halted.

The dielectric strength of high-explosive bombs was established by firing at vertical cement walls and steel plates.

4. High-Charge Bombs

High-explosive bombs with an explosive charge of about 75 percent were designated high-charge bombs and abbreviated with the letters "SB." They were used, when blast effect would produce the maximum damage. They were large bombs whose front part had the shape of a demi-globe and whose walls were relatively weak so that only nondelay fuses could be used. The charge consisted of poured high-powered explosives. SB 1000 and SB 2500 had been developed on the basis of wartime experiences, according to which the optimum charge for densely built-up areas was about 1,600 lbs and for dispersed constructions 1.5 to 2 tons. Direct hits would destroy even strong cement structures. The fuses were nondelay, and an additional fracture fuse was useful if the case of the bomb was deformed because the fuse attached to the side was by itself not sufficiently sensitive in view of the great bulk of the bomb. For low-level attacks the parachute high-explosive bomb LMB "weiss" (white) ~~xxx~~ could be considered as a high-charge bomb. In this case, the remote-control fuse was removed so that only the delayed-action fuse (34) became effective after a delay of exactly 30 seconds.

5. Armor-Piercing Bombs

In this field one must distinguish between armor-penetrating bombs, also designated as semi-armor-piercing bombs, and the armor-piercing bombs proper.

a. Armor-Penetrating Bombs

Their abbreviated designation is "PC"; they accomplish the required penetration even if they are produced of cast steel. They were found suitable for high altitude and dive bombing attacks against well protected targets and against warships with tonnages up to 30,000 tons. High altitudes or steep dives are essential in order to obtain favorable angles of impact. The bombs were equipped with medium strength walls and contained 15 - 20 percent phlegmatic normal explosive. Their points were rather slender and the bodies were slightly reduced toward the rear so that they could easily penetrate the armored plate at a 60° angle. The fuses had only two parallel delays of o.1 second each and were attached to the side like those of the high-explosive and multiple-purpose bombs.

The standard armor-penetrating bomb was the PC 1400 which was also produced with a rear control as model "X".

The PC 1600 was really an armor-piercing bomb equipped with a base fuse. It was available only in limited quantities and was reserved for special commitments. The PC 500 and PC 1000 bombs were available in larger quantities and were no longer produced, having been replaced by the SD 500 B and SD 1000 A.

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b. Armor-Piercing Bombs with Propulsion (Symbol "PC/RS")

In order to attack strongly armored ships up to about 35,000 tons in a dive-bombing flight with chances of sinking them, the Germans developed armor-piercing bombs with rocket propulsion at an early time. The combustion period of the rockets was set for a release altitude of 0.75 miles at an about 60° angle drop.

This type of bomb had a charge of only a few percent which consisted of pressed shock-proof high-performance explosives. The bombs were short and cylindric and forged from alloyed steel. The propellant was attached to their rear; shortly after the release of the bomb it was ignited by fuse (49), thus bringing the bomb to an impact speed of about 1,000 feet per second. The impact fuse set at o.o4 second delay was inserted into the plunger of the projectile. The standard size was the PC 1000 RS, the PC 500 RS and PC 1800 RS having been discontinued because the charge in the former was hardly sufficient to ~~XXXXXXXX~~ ignite the ammunition in the attacked vessel. The PC 1800 RS's power of penetration did not correspond to its heavy weight. It was also possible to drop the PC/RS bombs from high altitudes without switching on the rocket attachment, if by any chance no PD bombs were available.

c. Armor-Piercing Bombs (Symbol "PD")

They were suitable only for high altitude attacks so that sufficient impact velocity could be generated to pierce the

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armor-plated decks of warships of approximately 35,000 tons. To obtain a high ballistic coefficient, the bomb cases were forged in unusual length and with very thick walls out of alloyed steel. The points were dull and the charge consisted of 6 percent compressed high-performance explosive. The PD 1000 was the standard caliber weapon for the same reason given in the case of the PC 1000 RS.

d. Remote-Control Armor-Piercing Bombs

In order to increase the accuracy of high altitude bombing, the Germans developed armor-piercing bombs that could be controlled after they had been dropped. The control in the drop parabola could be achieved both by wireless means and by a o.2-mm wire that extended from the aircraft to the bomb until the latter hit the target.

The remote-control bombs have a source of light in the rear so that they could be better directed toward their target. The PC 1400 X had the same power of penetration and explosive performance as the PC 1400 without remote control.

The PD 2500 X, which was being introduced, was developed for attacks on the more recent models of American battleships in the "Iowa" class. It had a very great power of penetration and had a charge of compressed high-performance explosive. Its commitment was worth while only against warships of above class.

6. Other Explosive Bombs Available to the Luftwaffe

Since the so-called standard bombs were not always available in sufficient numbers, the Germans occasionally had to use older type bombs, as previously mentioned. Among these were the high-explosive bombs SC 50 and the multiple-purpose bombs SD 50, which had meanwhile been replaced by SD 70's in the production lines. If no SD 70's were readily available, one had to take the SD 50's, if more fragmentation effect than explosive effect was desired, and the Sc 50's if it was the other way .

The SD 500 A produced a greater number of fragments and had more explosive effect than the SD 500 B, but did not have as much power of penetration. The PC 500 RS was to be used only against fortified land targets against which its explosive effect was considered as sufficient. For the same reason the PC 1000 was also to be employed against corresponding targets on the ground, insofar as it was the type of bomb that had been produced of steel without alloys. Whenever bad visibility would not admit the employment of PC 1400 X, the PC 1400 was to be used in a dive-bombing flight.

There was only a limited number of PC 1600's because these weapons were produced from captured equipment; they were remodelled French mortar shells made of high-alloy steel. In high altitude attacks the SD 1700 was to be preferred to the SC 2000, especially against large warships, if there was any prospect of penetrating deeply. The SC 1800 could be used up without disadvantage in place of the SC 2000, if employed without delayed-action fuse. It was then to be used mainly against industrial targets. The PC 1800 RS was discontinued since the PC 1000 RS sufficed for all possible contingencies.

The cement fragmentation bomb S Be 50 was to be used only in an emergency. Otherwise, all so-called "older-type" bombs were still fully capable of employment. The standard models were introduced mainly to reduce the number of continually produced types of bombs to a minimum.

6b. ~~Special Explosive Bombs and Additive Equipment~~

~~Hollow-Charge Bombs~~

The previously mentioned SD 4 Hl was developed for attacks on tanks and attached infantry teams. The prospect of scoring several hits on a tank with a salvo of 70 SD 4 Hl and to put the vehicle out of operation ~~XX~~ was considerably greater than ~~XXXXXXXX~~ by employing one single SC 500 with nondelay fuse, which had an effective range of about 10 feet away from the Russian T-34, according to German experience factors. The SD 10 HL was a dual-purpose fragmentation and antitank bomb, which however had not been introduced.

Normal high-explosive bombs can be equipped with frontal attachments that produce an advance boring effect on one's own bombs. Normal explosive bombs can also be converted to hollow-charge effect. These as well as the frontal attachments were not introduced in combat because ordinary armor-piercing bombs produced better results. The SHl 500 and the SHl 800 have only a directed explosive effect permitting penetrations of any armored or cement cover when dropped in a dive-bombing attack.

The hollow-charge bombs that were in use were charged with tetramethylenetrinitramine in compressed form or with poured trinitrotoluol that was enriched with tetramethylenetrinitramine. This was also the case with the SH1 4000 that was attached to a pilotless Junkers 88 at the front and directed to the target area by a Messerschmitt 109 attached to its top. After a flat dive toward the target, the fighter pilot would disengage his aircraft, and the flying charge would continue its path to the point of impact. This was called the Mistel process. The penetrative power was so great that a hole of about 16" was torn across the entire width of a battleship.

Fighter Bomber and Nuisance Bomb SD 2

The bomb consisted of a small cast steel body filled with ordinary explosives and covered by 4 tin wings when in folded condition. The wings opened up when the bomb left the drop container, disengaged the fuse (41) by turninga 6" steel cable, and simultaneously acted as brakes for the bomb so that the aircraft from which it was dropped would be able to escape the fragmentation range even if it flew at very low altitude. (SD 2t) Without brake vanes and equipped only with an arming propeller the SD 2 Zt would drop faster and thus enter the ground. In this manner the SD 2 was employed mainly as nuisance bomb, equipped with (67), (70)B, and (77) fuses.

Telescopic Fragmentation Bomb SD 250 Tel

This bomb consisted of a thick-walled multiple-purpose bomb to which an extendable telescope-type device was attached in its roll axis; it had been built of 3 tubes that measured about 3 feet each and were placed inside one another.

At the point of this device a membrane contact was attached, connecting it with the El AZ (55)A fuse. During the descent the tubes were expelled by a cartridge so that the ignition occurred about 8 feet above the ground or surface of the water. The range of the fragments was thus considerably extended so that they would reach even into the sheltered positions.

Shrapnel Bomb SHr 500

This was designed to be a time fuse bomb against flying objects; it contained 3,000 separate fragments ~~XX~~ weighing about 4 ounces each.

Brake Parachute Bomb SD 500 Br

The SD 500 A was used for this purpose, with a distance tube of 5 feet and a membrane contact to a (55)A fuse, both attached to the point of the bomb. Instead of the stearing assembly, it had a brake parachute made of nylon. This parachute was tested for drop speeds up to 400 miles per hour; with its use, the bomb could be dropped from a minimum altitude of 165 feet with a nondelay fuse. In this case the bomb would hit almost vertically and produce a good fragmentation effect. The air resistance encountered by the SD 500 Br, suspended underneath the aircraft, was less than for an ordinary bomb with the usual guidance system. The fragment were capable of sinking even invasion barges (LC 250 tons) at major distances.

Nose-Spiked Bombs

SC 50 and SC 250 nose-spiked bombs had a strong spike attached to their points, which was forged and screwed on at the top. Even from such very low altitudes as 17 - 33 feet, this spike would get a grip under the ties of railroad tracks so that the bomb would be prevented from skipping. On the contrary, they would be stopped immediately and penetrated into the gravel cover. The most effective use of the bomb was with long-delay fuse, combined with interference fuses (50) or (60). The latter would ignite if and when a train would pass the impact point, whereas the former fuse would ignite after the time had expired for which it had been set.

Head Rings

All high-explosive and armor-penetrating bombs that are dropped on ships from hig altitudes should be equipped with head rings so that they keep a fairly straight course below water. The head rings cut across the water current around the bomb, thus keeping it from being diverted.

Bounce Disks and Shock Plates

These disks and plates were used for low-level attacks on naval targets and cement runways or platforms. They were attached to high-explosive bombs and reduced the bounce off the surface. The disks and plates had a smaller diameter than the bombs to his point they were attached.

The bounce disks were made of tin welded to the bomb. The shock plates against ground targets were made of cast steel and their sharp edges braked the bomb so much on a flat impact that, similar to the naval bombs equipped with bounce disks, the weapon moved forward only a few yards and then detonated, being ignited

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by delayed action. The fuses used against naval targets were (38) set at 5 seconds and against ground targets (25) set at 14 seconds.

Drag Struts and Distance Tubes

In an effort to expand the effective range of fragments originating from multiple-purpose bombs, particularly when a high alyer of snow covered the ground, the Germans found it advisable to attach drag struts or distance tubes to bombs suspended on the outside of aircraft. The difference between the two was that drag struts were massive sticks that transmitted the impact shock to the entire bomb, which was necessary unless the bomb was equipped with a (55)A fuse. Whenever that fuse was used, it was combined with distance tubes to the points of which the diaphragm contacts of the (55)A were screwed.

A tin disk attached to the point of the XXXXXXX drag struts produced early ignition when the bomb hit water or snow surfaces.

If the bombs were suspended inside the aircraft, the Germans preferred to use the (55)A fuse if the ground above the target was covered with snow and fragmentation effects with multiple-purpose and high-explosive bombs were wanted. The effect of the smaller fragmentation bombs was greatly reduced by snow. On the other hand, the SD 250 Tel had the effect of a fragmentation bomb with an 8-foot fuse distance tube; it was suitable for being suspended inside the aircraft and had a long range even when the snow was high.

7. Incendiary Bombs

In order to be able to evaluate the possible effect of the various types of incendiary bombs, one must first know their design and the target that is to be attacked. The penetration of the incendiary bomb must correspond to the cover of the target. The distribution of the bombs above the target must be brought in line with the type and size of the fire protection sectors. The speed with which the fire will spread, the ratio of incendiaries equipped with self-destroying devices, and the number of high-explosive bombs with impact and long-delay fuses which will be dropped simultaneously will all ~~XXXXX~~ together have to prove more effective than the enemy's fire prevention measures or else the attack will not be successful. Of special importance is the density of fire so that sufficient destruction will be achieved.

Other details that are of tactical and technical significance in employing incendiaries are the target feasibilities, the use of high- or low-altitude attacks, the penetration, and incendiary qualities.

One must distinguish between the electron incendiary bombs weighing from 2.2 to 4.4 lbs, the so-called scatter bombs Brand 4 and Brand 10, the intensive incendiary bombs Brand C 50 and Brand C 250, the flame bombs Flam C 250 and Flam C 500, the combination incendiary-demolition bomb weighing 118 lbs, and the scatter bomb weighing 1100 lbs.

The use of Brand C 50 and Brand C 250 bombs makes it possible to perform aimed single-bomb drops from high altitudes against

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point targets with large fire protection sectors. These bombs/ can, however, also be dropped from low levels; then they will penetrate roofs of houses and relatively weak circumferential and intermediate walls, if they are equipped with delayed-action fuses.

The small incendiaries weighing 2.2 to 22 lbs are most effective against targets whose fire protection is minutely subdivided; they are dropped from containers whose sizes vary up to 2,200 lbs. Containers filled with electron incendiaries can be used only from high altitudes, since these bombs take more time to get stabilized after they leave the container. Scatter bombs can be dropped from as low an altitude as 330 feet, if the container is set for 1.2 seconds opening time with a (69) time fuse. However, under such conditions the bombs will have no penetrative power beyond piercing glass or cardboard roofs. The combination incendiary-demolition bomb C 50 can be best used for low-level attacks on industrial facilities.

The flame bombs have great effect on the morale of troops marching in columns. Dropped from a dive- or low-level attack, their burning contents will penetrate crack and gaps in fortified positions, and create surface fire in supply installations, light-industry plants, etc. B 1 E to Brand 4 produce only initial fires at one single level, mostly in attics, whereas Brand 10 spreads its contents from the attic to the lower floors. This is even more so in the case of intensive incendiary bombs. The employment of Brand C 250 bombs against city districts may be considered as

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a waste of a heavy caliber weapon and should be considered only for attacks on heavily inflammable targets of the industrial type.

Targets that are easily inflammable should not be attacked with too many fragmentation bombs simultaneously with incendiaries because the former create fire gaps by collapsing entire buildings, thus hampering the spread of the fire.

The dropping of a small number of heavy charge bombs with nondelay fuses is recommended in order to force the air defense service personnel to take cover and to create drafts by smashing doors and windows to fan the fires. Individual high-explosive bombs weighing 550 lbs, equipped with long-delay fuses (17)B set for one half to one hour, should be dropped by the first attack wave, and SD 2 Zt with nuisance fuses ought to be dropped by the last wave; they will serve to inflict losses on the air defense and fire brigade personnel after the attack proper and to prevent them from extinguishing the fires so that the assume catastrophic proportions.

But this use of explosive bombs should not in any way restrict the number of incendiary bombs that are needed to achieve sufficient fire effect. The ratio of explosive bombs will in any incendiary attack depend greatly upon the number of aircraft available.

From the technical point of view the following should be added:
The center piece of the various electron incendiary bombs is the same for all types: it consists of an 8-inch tube of a magnesium alloy, whose outer diameter was 2 inches, wall thickness was .4",

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and whose inside contained a heating bag filled with thermite. The ignition energy is therefore the same for all electron fire bombs, only their penetrative power and nuisance effects vary.

The flat top of the original B 1 E was also made of electron and contained the single-effect impact fuse. The control was made of steel plate. In the cone of the incendiary bombs marked with "Z" was a self-destroying charge, composed of the primer C/34 which was to spread the fire; this was to be achieved by the explosive charge detonating 1 or 2 minutes after the impact of the bomb, thus distributing the glowing heap of ~~XXXXX~~ cinders all over the target area. The more recent B 1.3 E was arranged similarly but had more penetrative power because of its steel top. The B 2 EZ had a larger explosive top whose effect was that of a hand grenade. Shortly after hitting the target, the top would separate from the incendiary bomb proper and detonate only after several minutes, thus complicating the fire extinguishing in the vicinity proportionately. The latest B 1.5 E had a space-saving so-called semimonocoque control similar to the Brand 10 so that more bombs could be packed into the drop containers. The B 1.5 was considered the standard incendiary bomb together with the Brand 10, leaving out of consideration the available supplies of other incendiary bombs. The penetrative power sufficed for all usual types of roofing materials.

The intensive incendiary bombs were so effective that even the Brand C 50 caliber (110-lbs) could not successfully be extinguished

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by auxiliary fire brigades. They were capable of setting fire to even the less inflammable targets. Their resistance to stress made them capable of being dropped with delayed-action fuses both from low levels as well as high altitudes and diving attacks, burrying their charges deep into the target area, which meant the lower floors in multiple-floor buildings or through walls of one-brick thickness. For further details on incendiary bombs, see Table 8. Brand C 50 and Brand C 250 bombs consisted of welded jackets of equal-size high-explosive bombs that were filled with concentrated benzine. The charge was expelled by a small explosive filler that was ignited by an ordinary impact fuse with or without delayed action. The incendiary component was set on fire by several ampoules of a liquid phosphorus-sulphur solution, which were broken by the explosion of the charge, became mixed up with the inflammable component, and ignited upon contact with air.

Among the scatter bombs, the Brand 10 had the same inflammable component as the large-size intensive incendiary bombs, with the difference that the phosphorus combustible composition was firmly attached. The all-purpose impact fuse (23)A was placed at the bottom of the weldless container of liquids to which the semi-monocoque control mechanism was welded. In order to penetrate the roof and at least one or two floors of a building, the bomb was reinforced by a tin top welded to its front part. The burning contents of the bomb were distributed all over the doors and other objects at the time of the explosion, attached themselves

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to the vertical outer surfaces of such objects, and set them on fire. This was the main difference between the effect produced by these bombs and that of electron incendiaries.

The Brand 4 bomb contained incendiary materials such as naphtalene and other carbohydrates, and was ~~ignited~~ primed by thermite. However, this bomb also came with sodium fillers that were not extinguishable ~~with~~ by water or with chlorate fillers that produced one or two long streams of fire and moved around the target area propelled by jet reaction. The fire brigade personnel were to be scared away from their task by the multiplicity of the incendiary phenomena.

The flame bombs were filled with light oils; the tank skin was thin and shaped like high-explosive bombs that were equipped with sensitive impact fuses, either the (26) or more recently the (55)A. Upon impact they produced flash-fire type ball of ~~XY~~ fire with a diameter of 10 to 16 inches, which disintegrated within a few seconds. One of the peculiarities of the bomb was its capability of penetrating between stacks of material and into cracks of mobile turrets and of continuing to burn there; this result was produced by the fluidity of its liquid contents. For this reason the flame bombs were used against such specialized targets in addition to being employed as antipersonnel bombs.

The combination incendiary-demolition bomb C 50 was created to produce blazes during low-level attacks on industrial plants whenever a combination of good fire effect with medium explosive results was to be achieved. These bombs were also used when greater resistance to stress appeared necessary than that inherent in intensive incendiary bombs. Sprbrd C 50 were made of one-piece SC 50 cones, whose front section up to the fuse box was filled with 13.2 lbs of explosives. Behind that in the bomb cone were about 50 electron incendiaries weighing about one pound each, which had booster charges. Upon impact these would be ignited with a very short delay and expelled rearward. The forward section of the bomb would continue its penetration of the target and detonate after three seconds, while the fire would be fanned by air currents so that it could spread.

Scatter bomb Streubrand C 500 was created to produce area fires. For this purpose about 1,200 celluloid boxes enclosing 1.5 ounces of hard inflammables consisting of paraffin and wood shavings were put inside the bomb. Phosphorus tablets that were glued on were used as primers. The boxes were stored in the bomb in a cold-proof mixture of water and gasoline. The bomb was opened by a time fuse at about 3,300 to 6,600 feet altitude, and the inflammable boxes ignited according to temperature and gasoline contents after a delay of several hours.

8. <u>Chemical, Smoke, Flash, and Flare Bombs, Air-Sea Rescue Signals</u>

a. <u>Chemical Bombs</u>. (Total weight varying from 264 to 352 lbs, depending on their contents). These bombs were produced exclusively in 550-lbs explosive-bomb cases made of 1 - 2 mm steel plate. Their tactical employment was indicated by colored rings around the point of the bomb and its center strip as follows:

white --- irritant effect, for instance with chloracetophenon;

green --- immediate poisenous effect, for instance with phosgene or trilone; and

yellow --- lasting effect, for instance with mustard gas.

The example for German designations on chemical bombs would read as follows: KC 250 w, gr or gb (white, green or yellow); Roman numerals after the caliber figures would designate increased effectiveness in comparison to older types, just as two colored circles would. A green and a yellow ring would indicate vapor effect. The word "Typ" meant that the respective bomb was resistant to tropical climates.

To make normal viscous mustard gas effective, it was sufficient to use the ordinary electrical fuses attached to the sides and to set them for nondelay operation. Sensitive impact fuses were employed for immediate effect, usually No. (26) or (55)A. To distribute compressed mustard or other irritants over the terrain, the bombs filled with these gasses were equipped with electrical time fuses (9) that could be set above the target for any given level of explosion, at approximately 1,650 to 3,300 feet.

b. <u>Smoke Bombs</u>. The NC 50 could serve both for camouflaging one's own forces and for obscuring enemy vision in support of the ground forces. The bomb had the same size as a SC 50 and was recognizable by a white point and four stripes along its cone. Upon impact on the ground it produced white fog varying in height from 66 to 132 feet and in width from 33 to 66 feet during a vaporization time of 20 minutes, depending on the weather conditions. To prevent deep penetration, a brake vane was installed behind the control mechanism.

The NC 50 W in the "C" model had one yellow point and four yellow stripes. It was used for rescuing crews that had been shipwrecked, and swam veftically in the water, developing yellow smoke at ten-minute intervals.

The NC 250 S was suitable for operations against ground and water targets; with normal weather conditions, it produced a large smoke cloud upon impact, which would cover a target for several minutes.

c. ~~Flash~~ and Flare Bombs. The parachute flare ~~flash~~ bomb LC 50 F that burned for at least 5 minutes served to light a target during darkness. In the "F" model it had 4 magnesium stcks, whereas the "G" model consisted of only one single charge of very great lighting power, which contained not only magnesium and natrium nitrate but also calcium oxalate in order to prduce monchromatic light, that can more easily penetrate haze. The flare ~~flash~~ bombs consisted of a cylindric tube of the same thickness as a SC 50, which was 3.6 feet long and had 4 narrow guide fins welded on for proper stabilization. In the forward part was the folded parachute, which was expelled by a time fuse at about 4,000 to 5,000 feet from the ground. Upon opening, the parachute automatically released a zipp fuse for the flash charge. The rate of descent was 7 to 10 feet per second.

Flash ~~XXXXX~~ bombs were used for night photo-graphy. The Bl C50 was a remodelled SC 50. Its light sufficed to light up an area of 2½ square miles with a lense opening of F - 2.8 and aerorapid film used. The more recent model "A" had such a strong charge that photographs could be taken at altitudes as high as 23,100 feet. Because of the 0.3 second duration of the flash, however, so-called cameras had to be used, which wound the film at speeds corresponding to the distances covered above the ground. The light source could appear on the side of the picture.

~~Air-Sea Rescue Signals~~

The Lux "S" weighed 14.3 pounds and contained 4 lbs of calcium carbide and calcium phosphate. Lux S was taken aboard ~~ship~~ aircraft and in case of distress at sea, it was uncovered by hand and thrown into the water. The filler lit a flame for about 5 to 6 hours. The major air-sea rescue signal "Lux N" was a swimming bomb that was released by drop mechanisms. The chemical contents of the bomb weighed 11 pounds and created a dense smoke for 10 hours.

9. Aerial ~~Mines and~~ ~~Aerial Torpe~~does

Aircraft plant naval mines in enemy waters which are not accessible to one's own naval forces. This action will directly affect enemy sea traffic by sinking ships and indirectly by forcing the diversion of sea traffic because gateways are blocked. But a tactical success is achieved even if only war ships are confined to a certain place so that they cannot assume the offensive or that they can subsequently be destroyed by one's own air and naval forces.

The execution of proper mining operations from the air will depend greatly on the local conditions in the enemy area and on one's own strategic plans, and can therefore be planned only in conjunction with the naval operations staff. The hours of darkness are particularly suited for mining operations, but precise navigation will then be a prerequisite. One's own ships should not be endangered under any circumstances.

With the importance that aerial mining operations have assumed it is necessary that the air force staffs be well oriented on the strategic and tactical effectiveness of the different types of mines and their multiple-purpose remote-control fuse mechanisms. Among the essential data needed concerning the target that is to be mined are its military significance, the density of traffic, local conditions such as the depth of the water and currents, as well as the status of enemy mine clearing organizations. There was a basic difference between the German parachute mine "LM" and the bomb mine "BM." The latter was dropped and aimed like an ordinary explosive bomb. The minimum depth of water was 33 feet, within which the mine bomb turned because of its head shape and rested at the bottom of the water, like the LM. The explosive charge of the LM consited of nitrocellulose 18 and that of the BM of trichlorethylene 105, both of them effective underwater explosive media. The built-in remote-control fuses were effective against larger ships up to 200 feet depth of water, in which the 1,540-lbs explosive charge fully sufficed to sink commercial vessels of about 8,000 tons.

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Modern warships with several watertight compartments can be sunk by one single floating mine only if the fuse is properly timed for exploding when the ship passes over the mine.

The various ignition systems listed in Table 9 were to be used: those designated "Fab" for the parachute mines and those identified by numbers above 100 for the mine bombs.

The BMC was a moored mine for depth up to 1,000 feet; it was equipped with a contact fuse, but its explosive charge did not exceed 110 lbs.

Ordinary aerial mine bombs such as the SC 250 were also equipped with the remote ignition equipment AD 104 and were dropped by fighter aircraft during enemy landing operations. In waters down to about 50 feet depth they acted like explosive bombs provided they were overrun by ships whose tonnage exceeded about 500 tons.

The aerial water bomb 250 was also another version of the SC 250, without control mechanism, and was used to combat submarines with time fuse equipment. The BM 1000 had both remote control ignition equipment and an acceleration fuse, just like the aerial mine bombs. If the mine bomb hit the ground, for instance in the case of narrow harbor entrances, it would explode immediately.

<u>Aerial Torpedoes</u>

These were essentially E-boat torpedoes with an 18-inch diameter and a 16.5 foot length. They were subsequently refurnished for use by aircraft drops from altitudes up to 330 feet by the addition of special stabilizing fins and air vanes. They were however governed by certain speed limits.

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Aerial torpedoes have proved particularly effective in combination with bombing attacks on major warships since they were capable of producing quick sinkings. For attacks on smaller warships and commercial vessels it proved sufficient to commit either torpedo or bombing aircraft.

The explosive charge of the LT 5 weighed 440 lbs and consisted of nitrocellulose 36; at first ignition occurred upon impact on the side of the vessel. Remote-control fuses of the the magnetic type -- distance pistols -- were being developed.

The LT 350 was an Italian cyclic torpedo ("Motobomba") which was dropped by parachute upon assemblies of commercial vessels located at docksides or anchoring in a bay. Upon hitting the water the parachute would separate from the torpedo and the latter would start its course, describing ever large circles or following a previously set curve pattern directly below the water surface until it exploded either upon impact or after covering almost 10 miles.

10. ~~Aerial Delivery Containers~~. These served to drop small-caliber ammunition, including fragmentation and incendiary bombs weighing 2.2 to 22 lbs (also SD 15's), because such small bombs could not be individually suspended in aircrafts. By being ignited simultaneously, these bombs could be distributed over a certain target area.

The filled aerial delivery containers were issued to the field forces ready for use and could thus be suspended on loops on drop

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mechanisms, just like large-size bombs. They had a contact similar to the electrical fuses attached to the sides of bombs, which was connected with a loading plug.

The AB 70, AB 250, and AB 500 aerial delivery containers for small bombs consisted of two tin cups that were attached to one another by a hinge at the control end so that they could be closed into a shape corresponding to that of a high-explosive bomb. During the preparatory stage at the loading installation the small bombs were packed in layers in the lower cup, wherupon the top cup was closed and bolted. After crossing the drop distance, which depended on the type of attack launched, the bolt was removed, the cups came apart, and the contents of the container could drop freely on the target.

The AB 1000 could be opened in four distinct phases if the bombs were to be distributed over a relatively long distance.

More recent delivery containers had cloth directional devices insead of control mechanisms in order to use up less space or offer less resistance to air.

Although delivery containers could be used for any type of ammunition, a standardization of fillers was introduced for logistical reasons. The composition of these fillers could be seen on Tables 1 and 7. Even so every aircraft, whether it was equipped to drop small or large bombs, was capable of XXXXXXXX attacking any given target with electron, scatter, or fragmentation bombs that produced various sizes of fragments.

Whereas the delivery containers were really improvisations that consisted of the case and the parachute of an explosive bomb, the mixed load container for 2,200 lbs was the standard supply container used to provide far advanced or cut-off troop elements that had run out of supplies with the urgently needed ammunition, gasoline, rations, etc., by airlift. This container was made of sheet steel, and was equipped witha shock absorber in front and a brak parachute in back. When dropped from high altitudes, this supply container could be released with closed parachute so that it would drop closer to the target. A timing device that had been pre-set would open the parachute at the desired altitude above the ground.

11. ~~General Observations Concerning Bomb Fuses~~

Fuses serve the purpose of exploding bombs at the proper time or to ignit incendiary and flare bombs or to open delivery containers or other functions.

The basic categories of fuses are distinguished by the way in which they are mounted at the top, on the side or at the bottom of the bomb. Another basic distinction is according to their functioning as impact, nuisance or time fuses and according to their composition as electrical, mechanical or chemical fuses.

Double fuses have both impcat and timing functions

Among the impcat fuses, a distinction was made between highly sensitive fuses, those with or without delaying mechanisms, and delayed-action fuses that can be used also for long delays. In time fuses one counted the time from the release point. Long-

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delay and other nuisance fuses are however ~~ignited~~ initiated upon impact.

Chemical ignitions ~~fuses~~ were used only for long-delay fuses; ignition occurred upon disintegration of a locking disk made of celluloid that had been inserted between the forward ignition pin and the primer. The solution used for this purpose was acetone. Electrical igniters usually are activated according to the static condensator discharge principle, whereas (66) fuses operate according to the dynamic shock generator system, and (60) fuses are activated by batteries.

The delay in impact fuses was caused by a grain of powder. The (28)B fuse had an additional mechanical delay mechanism and the (24) fuse had an additional fracture fuse for the case that ~~if~~ the point of thebomb was deformed. Every fuse was designated by a figure within a circle, which was stamped into the head of fuses attached on the side of bombs.

The overwhelming majority of bombs were equipped with electrical fuses on the side, whose top pointed toward the front of the bomb. The small fragmentation and incendiary bombs mostly had head fuses, except for Brand 4 and Brand 10 which had (23) fuses attached to their bottoms. Armor-piercing bombs also had fuses at the bottom.

Table 11 shows the most important fuses, delay mechanisms, and their uses. The enclosed illustrations show the various arming times and their relationships to drop altitudes and types of attack. Non-delay and delayed-action fuses with the corresponding fuse switch boxes were selected in advance in the aircraft. When fuses were set for non-delay, delayed-action was always set simultaneously. This made it possible to drop some of the bombs with non-delay and others with delayed-action fuses from the same aircraft. For safety reasons, however, aircraft should be carry out low-level attacks with separate explosive and incendiary bomb cargos, not with mixed payloads.

As a rule, all bombs were delivered through supply channels fully ~~with~~ equipped with fuses. Fuses for high-explosive bombs that were to be used against naval targets -- such as the (28)A or (38) -- had to be especially requisitioned, which was also true in the case of long-delay or other nuisance fuses. Bomb fuses were almost exclusively taken off safety within a certain time after being dropped. The fuse (66), however, was activated by katabatic wind, that is to say during its drop, and so was the (23)A. The fuses of ~~for~~ electron incendiary bombs and for SD 1 and SD 3 were activated immediately after the bombs left their containers.

When the fuse switchbox was set for "drop", the activating time for vertical flight was about halved. For low-level attacks with flame, incendiary, and combined incendiary-high-explosive bombs the fuse switchbox was set for "drop" so that the fuses of these bombs were primed at the time the side walls of buildings were hit.

The high-explosive bombs weighing 550 and 1,100 lbs of quality I were exclusively equipped with two fuse boxes; for attacks on naval targets, two (28)A or (38) fuses were to be employed. Long-delay fuses were to be used incombination with nuisance fuses, for instance (17) with (50) or (57) with (60) fuses.

12. Explosive Charges

The various types of bombs were filled with explosive charges mixed in accordance with the aim of maximum effectiveness in destroying the target.

a. ~~Normal explosives~~ such as Trinitrotoluol were used for filling all Sc and SD bombs before the war. Trinitrotoluol - Ammonium Nitrate was used mainly in a 60:40 ratio to fill the above bombs as well as PC's during the war. The PC's were given mining wax as additives to the fillers so that the bombs would be more shock-proof.

b. ~~High-Performance Explosive~~ such as trichlorethylene and nitrocellulose (code symbols "TH" and "E"), were mixtures of tetramethylenetrinitramine or other synthetic explosives with triniytotoluol and partly also with trinitrotoluol and aluminum additives Aluminum-holding mixtures were preferrably used, if underwater effects were to be produced, that is to say for naval target and water bombs, demolition mines and torpedoes. Since such fillers could be poured, they were also employed in SB bombs. Compressed high-performance explosive charges were used for armor-piercing bombs without aluminum additive. However, certain categories of all calibers of mine bombs were filled with trichlorethylene for special purposes. Because of the danger of an explosion upon shock, such bombs could not be dropped from low levels against ground targets, and specially painted designations indicated that fact.

c. ~~Substitute Explosives~~

Ammonium Nitrate DJ and DJ 1 were dry mixtures of 60 - 80 percent of ammonium nitrate, 10 - 20 percent trinitrotoluol, and 5 - 15 percent Aluminum, which were packed into the bomb cases in powder form. The former had been filled into cement fragmentation bombs of the S Be 50 type during the first year of the war, while the latter had been used for the SC 250 of quality III, while this type of bomb was still being produced. Another high-grade ammonium nitrate mixture is the "A" Ammonium Nitrate bomb, which did not in any way reduce the results produced by the small fragmentation bombs SD 1 and SD 3 as well as the SD 10B made by using special grey cast iron casings.

The explosive mixtures employed for Group b had about 30 percent more and those in Group c about 30 percent less blast effect than the normal explosives in Group a.

In the longitudinal direction of bombs and mines the poured and compressed explosive charges were usually reinforced by transmission charges of trinitrotoluol or of tetramethylenetrinitramine (the latter in trichlorethylene bombs). These supercharges served to transmit the explosion from the fuses boxes, equipped with pressed trinitrophenole, to the main charge and to thus guarantee a full detonation of the entire explosive charge.

C. ~~Survey of the Effects Produced by Explosive Bombs~~

Tables 13 and 14: Depth of Penetration and Crater Measurements

The depth to which a bomb penetrated into a target depended on its impact speed, the ballistic coefficient, and the shape of the point of the bomb as well as on the resistance offered by the target.

The impact velocity was dependent on the flight speed, the attack method -- horizontal or dive flight -- the drop altitude, and the ballistic peculiarities of the bomb.

The ballistic coefficient resulted from dividing the weight of the bomb by its largest corpss-sectional area. The ballistic peculiarities of the bomb were expressed by its drop time and trail correction, which are shown in Tables 19 and 20 as related to flight speed and drop altitude; these tables indicate how bomb sights are to be set. In the case of some bombs only a little or no penetration whatsoever was desired, such as for instance incendiary, fragmentation, flame, chemical, smoke, and high-charge bombs.

The shape of the point of the bomb was indicated by the radius of sphericity, which was as follows in the case of bombs capable of penetration: 1D for PD bombs, 1.2 D for PC/RS bombs, 1.5 D for SC bombs, 1.75 for SD bombs, and 2.0 D for PC bombs (D was equivalent to the largest diameter).

For penetrating into covered ground or unprotected targets the shape of the point of the bomb played a relatively small part.

Since the ballistic coefficient rises in relation to the caliber, heavier bombs penetrate deeper than small ones. The ballistic coefficient for thick-walled bombs is generally also higher than in the case of thinly cased ones; for this reason, the SD and PC bombs penetrate deeper than SC bombs of the same caliber.

One can assume that all bombs listed reach their greatest depth of penetration already within 0.1 second after impact upon covered ground; this is called stagnation point. But this depth does not correspond to the one at which explosive bombs are supposed to explode in orde to be most effective. Armor-piercing bombs are excepted, and in special instances one can initiate the ignition of high-explosive bombs at the stagnation point, if the target offers little resistance. This is achieved by setting the (25) fuse at the second delay-point before suspending the bombs in the drop mechanisms; the delay would then amount to 14 seconds, which is otherwise used as delay fuse for low-level attacks.

To produce the "mine effect" with bombs, one needed a tamping by consistency of the target, such as for instance the sea mine that exploded deep in the water. If, however, a LMB w with parachute was dropped obve land so that it would explode on the surfade of the ground, one could not speak of mine effect but rather of air pressure effect, the range of which is indicated on Table 15.

The mine effect of explosive bombs is usually expressed in crater measurements; that is the crater created after the bomb had penetrated into material suitable for comparisons, such as sand which was ~~the~~ best suited for this purpose, and in which the bombs detonated after normal delays. To compare the mine effects of the various bombs one had to select those craters with the largest cubic capacity, which had been created by bombs dropped from different altitudes. Small bombs dropped from low altitudes create relatively large craters, whereas large bombs have to be dropped from high altitudes to produce maximum volume craters. Bombs dropped from higher altitudes penetrate deeper; this is equally true of bombs falling into soft soil such as mud or swamps. In these cases, however, the craters have smaller diameters and refill quickly with dirt, which has been thrown up into the air by the explosion and which resettles often in such a manner that mounds are created instead of craters.

Bombs that have deeply penetrated, such as for instance armor penetrating bombs, densify the surrounding dirt if they explode after 0.1 seconds, so that major hollow spaces below the surface are created. Their only access to the surface is the channel of penetration, which however may be also filled by loose dirt. In such a case the resulting pressure effect expands in all directions equally below the ground -- a so-called dirt blast -- so that subterranean installations, garrison facilities and vital manufacturing plants can be destroyed at level two or three times below the depth of penetration.

The depths of penetration shown in Table 13 indicate the stagnation point of the bomb in sand that has a compressive strength of about 440 pounds per .4 ~~xxxxxx~~ square inches. (200 kilos per square centimete in pure loamy soil of 330 pounds per .4 square inches (150 kilos per square centimeter), the figures indicated on the table should be increased by 50 percent and in chalky soil of 880 lbs per .4 sq in the figuers should be divided by 2. The depth of penetration is particularly important in the case of bombs that are equipped with long-delay fuses or if subterranean facilities are to be destroyed with delay fuses II. In Table 14 one can easily notice the influence of drop altitudes since the delays are the same or very similar for all bombs shown. The figures shown refer to normal-type explosives and ~~for~~ to sandy soil. Mine bombs filled with ammonium nitrate, that is to say substitute explosives, produce craters whose volume is about 30 percent smaller. Mine bombs filled with trichlorethylene, especially the larger caliber bombs, could explode already upon impact upon sandy soil because of spontaneous ignition of the explosives, the so-called shock explosion. For this reason, such bombs could be used only with delayed fuses against targets in water.

Tables 15 and 16: The Pressure Effect of Explosive Bombs on Ground Tagets

The term pressure effect is used for the effect of air pressure in the case of explosive bombs equipped with nondelay fuses or the effect of dirt pressure if the same bombs are equipped with delayed fuses. Fragmentation bombs have practically no pressure effect and multiple-purpose bombs have only half the pressure effect of mine bombs. Whereas mine bombs detonated with nondelay fuses have a certain fragmentation pressure in addition to air pressure effect, high-charge bombs have only air pressure effect.

The pri cipal damages inflicted upon less resistant targets by the explosion of mine- and high-charge bombs bursting at the ground or water level were caused by the pressure of explosive gasses which compressed the surrounding athmosphere and speeded up the circulation of air. Such a pressure wave consisted of a sudden increase of pressure -- the so-called air blast -- which dropped immediately afterward and was replaced by low pressure until the normal pressure of the atmosphere was restored.

The characteristic effect of a pressure wave was to crush walls near the explosion point and to push them outward at longer distances. If a bu lding was very close, it would collapse completely; an isolated two-story family house of normal construction, which was situated at 66 feet from the explosion point of a high-charge bomb weighing 2,200 lbs, would disintegrate. Houses standing behind others would collapse except for the circumference walls which would remain standing, even if they were of light construction, on the side toward the bomb, whereas the XXXXXXX rear wall opposite would fall outward. Over long distances, houses exposed freely to air pressure would have damaged roofs and walls at the higher floor levels. The lower walls would show tears and cracks reaching upward from the ground level.

Man-made constructions with small surfaces would suffer the least damages from air pressure; among these are trellis bridges, separate cement air raid shelters, chimneys, telephone poles, etc.

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On the other hand, trees are often uprooted because of their great resistance to air. Box girder bridges are greatly exposed to damage by air blast, since they are liable to be lifted from abutments and often cave in or break right through the middle.

Light buildings and furnishings such as attics, partition walls, doors, windows, etc., suffer extensively from pressure damages. The cover of attics would be destroyed over long distances by the under-pressure caused by the air blast since the normal pressure prevailing in the house would then have the effect of interior over-pressure. In the case of tile roofs, the tiles would usually be raised while the structure of the attic would remain intact, whereas the entire attic would be destroyed in the case of a tin roof. In the vicinity of the impact point, however, both tile and tin roofs would be completely smashed.

In subparagraph a on Table 15 are shown the distances for three types of damages that would be inflicted upon a modern family house and its interior furnishings. The house was assumed to be built of bricks with 15-inch walls, the skeleton consisting of 1-percent reinforced concrete with 5-inch panels of brick. The damage would be inflicted by air pressure from high-explosive and high-charge bombs. the three types of damages would be:

Complete ~~damage~~ destruction --- 100% damage;
irreperable damage --- 65% damage; and
house temporarily not inhabitable --- 35% damage.

The figures shown at subparagraphs b - d indicate the maximum distances at which at the utmost 20% damages -- that is to say light damages -- could be inflicted.

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b. Partition walls made of light cement, roofs, doors, etc.

Window panes.

c. Detached brick walls which are 5 inches thick;

detached brick walls that are 10 inches thick; and

detached brick walls that are 15 inches thick.

d. Detached cement walls that are 6 inches thick; and

detached ~~brick~~ cement walls that are 12 inches thick.

~~Table 16~~ shows the range of dirt blast effects. Subparagraph a indicates the same degrees of damage as Table 15. The maximum distances for achieving at least 20% damage to the foundations are also the same.

b. Brick foundations of 10-inch strength;

brick foundation of 20-inch strength; and

brick foundation of 30-inch strength.

c. Foundation of reinforced concrete of 6-inch strength;

foundation of reinforced concrete of 12-inch strength;

foundation of reinforced concrete of 18-inch strength; and

foundation of reinforced concrete of 24-inch strength.

c. Lines burried in the ground;

drainage pipes of clay, earthenware, etc.

Iron gas and water pipe lines.

At half distance the lines enumerated in c would be assumed as destroyed.

The delays at which the fuses of the listed bombs would have to be set are the same as those shown in Tables 14 and 16.

Because of the ~~xxxxx~~ compression and shifting of the ground, pipe lines would be subjected to flexural and tensile stress. If the construction material was brittle, breaks would appear at branch lines even at major distances that would be greater than shown on the respective table. Steel pipes and electrical cables are, however, far more capable of resistance than the above-mentioned lines and suffer less from ground blasts if they are in protective covers made of ceramic materials. Only the outer covers would break.

The distances stated in Table 16 pertain to sandy soil. They should be multiplied by 1.1 in case of chalky, by 1.3 for loamy, by 1.6 for loose and filled-in soil, and by 2.0 for swampy ground. In taking those factors into consideration, one must also calculate the drop altitude factors that correspond to the ground conditions mentioned in the footnote to Table 13.

In comparing the figures shown on Tables 15 and 16 one arrives at the conclusion that the ground blast effect can be greater than the air blast effect in the case of types of soil that can be easily moved. If bombs are filled with substitute explosives, such as ammonium nitrate, the effective range of ground blasts also is about 30 percent less than for normal explosives. High-performance explosives used as fillers are not suitable for producing ground blast effects because of the previously mentioned reasons.

Table 17. The diffusion of underwater pressure differs from propagation in the air or in porous ground, because water is practically impervious to compression. The effect of underwater bombs on ships is being examined in the section pertaining to the effect of bombs on naval vessels.

In this table the extreme ranges for explosive bombs exploding under water are given with the aim of inflicting light damages on various targets. These damages are cracks in cement, gaps in walls, twists in lock gates and steel pipes, leaks in other pipe lines, lossening of bolts, and damages to bearings of ship engines.

Table 18. To be effective, fragments need a certain penetrative power. The fragments of the SD 10 are required to perform the work of 8 meterkilos, for instance, that is to say that a 5-gram fragment would have to have an impact velocity of 180 meters per second to be considered an "effective" fragment. In Table 18, the multiple-purpose bombs SD 50 to SD 1000A are shown in addition to the SD 10, together with their penetrative power as related to the fragmentation density. The target surfaces are vertically placed and their significance is as follows:

A: live targets;

B: aircraft, passenger cars, light chemical facilities, etc.

C: Trucks, light tools, transformers without protective walls, gas tanks, railroad cars, tank cars, barracks, 5-ton bridges, heavy chemical installations, power lines, etc.

D: locomotives, heavy machine tools, hydraulic presses, blast furnaces, loading cranes, railroad switches, 10-ton bridges, cross-country lines, brick walls measuring 10 in ches, etc.

Individual fragments of SD 500A and SD 1000A bombs had pierced

20 to 30-mm armor plates. Tanks could therefore be put out of commission by large multiple-purpose bombs under certain circumstances. The gas pressure exerted by a high-explosive bomb detonating near an armored vehicle had proved more effective in igniting the amuunition, oil, and gasoline inside the vehicle. Inthe case of the Russian T-34, this was achieved by SC 500 bombs, ignited by nondelay fuses, hitting at 10-foot distances.

~~Illustration 21a: Stress Reis~~tance of Bombs (21b: Categories of Quality)

This illustration conveys a general idea of the the ~~impact stress~~ resistance of various explosive bombs dropped from high altitudes. Since the target consistency is of practically indefinite thickness, the impact stress resistance of bombs is different from the penetrative power through a limited cover given in Tables 3 and 5 for the respective categories of bombs. First one has to distinguish between the stress placed on bombs dropped from low levels or high altitudes upon their impact on hard ground. If the explosive charges are to be fully effective, bombs with fuses set for delayed-action or time delays must be produced ~~fxxx~~ with casings and fuse boxes that will remain intact.

The bombs are essentially constructed for stress in the longitudinal axis, and the massive point gives them a relatively great stress resistance when they are dropped from high altitudes. When dropped in low-level attacks, the bombs are exposed to strong lateral stress and strain, if they bounce off and in the process hit vertical objects such as concrete walls, construction works made of steel, supports or heavy machine parts. For this reason it is preferrable to use thick-walled multiple-purpose bombs rather than thin high-explosive bombs against this type of target.

The high-explosive bombs weighing from 110 to 1,100 lbs are sufficiently solid for being dropped from high altitudes on ordinary unprotected ground targets and naval vessels, if delayed-action fuses are used. The limit for stress resistance for the SC 250, for instance, is 50-mm structural steel or 400-mm reinforced concrete for quality I bombs, 30-mm structural steel or 250-mm reinforced concrete for quality II bombs, and 20-mm steel or 150-mm concrete for quality III. These figures were obtained during tests with sample bombs against steel and concrete plates by special testing procedures. In attacks on ships one must always use only quality I high-explosive bombs.

The impact stress resistance of the various bombs was currently tested upon each delivery when sample bombs were dropped on rocky ground. High-explosive and multiple-purpose bombs were dropped on chalky ground (at Muensingen with about 880 lbs per square .4" and at Foggia with about 1,980 lbs per square .4" pressure resistance) and with armor-piercing bombs on granite (at Mandal with about 6,600 lbs per square .4"). During these tests it was observed at which drop altitude the respective bomb cases that were without fuses remained intact. The tests also served to check the explosive filler as to its shock resistance. Illustration 24a therefore also shows the limitations of using bombs in mountainous terrain, if penetration into covered ground is required for their effectiveness. As the illustration indicates, the case of the SC 250 I (Manufactirers' sign JA) remained intact up to a drop altitude of 9,900 feet ~~xxxxxxx~~ onto hard chalky soil and up to 16,500 feet on weathered chalky soil. From higher altitudes, even trinitrotoluol (digit 14), that is to say normal explosive matter, becomes spontaneously inflammable. SC 250 I bombs filled with trichlorethylene 105 disintegrate even if dropped from altitudes of only 3,300 - 6,600 feet onto hard chalk and from 6,600 - 9,900 feet onto softer chalk. The SC 250 III (K) disintegrates already from altitudes of only 3,300 feet onto hard chalk and from 8,250 feet onto weathered chalky rocks. The large explosive bombs SC 1000 and SC 2000 have less stress resistance than the SC 250 and SC 500, and are therefore equipped with acceleration fuses (28)B.

The SD 500A, which is made of ~~xxxxx~~ cast steel, is less firm than the SC 250 I, which is stamped out of one piece of steel. High-explosive and multiple-purpose bombs must therefore be dropped from high altitudes onto hard ground with nondelay fuses.

The SB 2500 (designated SC 2500 St in the illustration) explodes its trichlorethylene filler from minimum altitudes. For this reason, a minimum altitude must be observed onto hard targets, if large bombs and mine bombs are dropped with non-cushioned high-performance explosive~~s~~ charges. This altitude should vary from 1,000 to ,600 feet. The PC 1400 can be dropped from up to 16,500 feet onto granite, but will explode if dropped from higher altitudes. PD bombs remained intact from any altitude.

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~~Table 13: Depth of Penetration of Various Bombs in Sandy Soil~~

(measured in feet and related to the point of the bomb)

Drop Altitude	SD 70	SC 250	SC 500	SC 1000	SC 2000	SD 1000	SD 1700	PC 1400
3,300	5.9	8.5	11.1	11.8	19.8	18.4	18.1	19.8
6,600	9.6	11.1	13.7	14.7	25.7	23.8	23.1	27.1
9,900	11.8	13.3	16.0	18.4	31.0	28.1	27.4.	34.0
13,200	13.7	15.3	18.1	21.0	35.6	31.7	31.0	39.6
16,500	15.3	17.1	19.4	22.8	39.6	35.0	34.3	44.9
19,800	17.1	17.8	20.6	24.4	42.9	38.0	37.0	49.5

Footnote: This table is based on sand that has a compressive strength of about 440 lbs per .4 square inch (200 kilos per square centimeter); in loamy soil of about 330 lbs per .4 square inch (150 kilos per square centimeter) the figures indicated in the above table should be multiplied by 1.5. If the soil is chalky and has a compressive strength of about 880 lbs per .4 square inch (400 kilos per square centimeter), the figures should be multiplied by 0.5.

Table 14: Crater Measurements Produced by High-Explosive Bombs with Delayed-Action Fuses (The figures pertain to normal-type explosives and to sandy soil).

(Measurements are in Meters or Cubic Meters)

Drop	SC 50			SC 250			SC 500			SC 1000			SC 2000		
Altitude	De*	Di**	C***	Se*	Di**	C***	De*	Di**	C***	De	Di	C**	De*	Di**	C***
1,000	1.2	5.6		2.8	7.8		3.6	10.5		4.4	13.2		5.4	15.0	
2,000	1.6	6.2	16	3.0	8.4		3.8	10.8		4.6	14.		6.0	15.4	
3,000	1.3	6.0		3.1	8.6	64	3.8	11.4		4.8	14.2		6.2	16.0	
4,000	1.0	5.2		2.6	8.2		3.9	11.6	138	4.8	14.2		6.4	16.6	
5,000	0.7	5.0		2.4	7.8		3.6	11.2		5.0	14.4	274	6.4	17.2	
6,000	0.5	4.8		2.2	7.2		3.4	10.8		4.8	13.0		6.6	18	560

Footnote: De* - Depth of crater (in meters)
Di** - Diameter of crater (in meters)
C*** - Capacity of crater (in cubic meters)

The largest crater capacity in each case is doubly underscored -- like this ___ -- and pertains to normal-type explosives and to sandy soil.

The delays assumed for SC 50, SC 250, and SC 500 bombs were 0.08 second; for SC 1000 and SC 2000 bombs these delays were 0.12 of a second. However, the acceleration fuse inserted in the bomb ignited sooner upon impact on covered ground. The crater measurements of the two large bombs -- SC 1000 and SC 2000 - could therefore be compared with those produced by smaller caliber bombs that were ignited with less delay.

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Table 15: Distances for Damages Caused by Air Pressure Produced

By Bombs Exploded with Nondelay Fuses (In Meters)

Degree of Damage to Brick Struct.	SC50	SC 250	SC 500	SC 1000	SC 2000	LMBW	SB 1000	SC 2500
a.								
Complete destruction	7.5	12.0	15.0	18.5	23.5	22.0	23.0	28.0
Irreperable Damage	9.5	16.0	20.0	25.0	30.0	28.0	29.0	35.0
Temporarily Uninhabitable	13.0	23.0	28.0	36.0	44.0	42.0	43.0	52.0
Maximum Distances of Damages								
b.								
Partitions	40	137	198	305	442	549	560	690
Windowpanes	76	183	274	335	457	609	620	760
c.								
Brick walls								
5 inch.	14	42	66	99	144	167	171	206
10 inch.	7	22	33	49	71	82	85	101
15 inch.	5	14	22	33	47	55	59	76
d.								
Concrete walls 6 inch.	1.5	6	9	15	21	24	25	30
12 inch	o.8	3	4.5	7.5	10.5	12	13	15

Footnote: For the high-explosive bombs it was assumed that they would be filled with normal explosive matter, whereas the high-charge bombs would have high-performance explosive fillers. The "maximum distances" indicated in Tables 15, 16, and 17 are the extreme distances at which slight damages were still caused, i.e. the maximum distances of the respective bombs obtained in attacking the indicated targets.

Table 15: Range of Dirt Blast Effects with Delayed-Action Bombs

(For normal explosives and sandy soil; distances measured in meters).

Minimum Drop Altitude	SD 70 2,000 meters	SC 250 3,000 meters	SC 500 3,000 meters	SC 1000 3,500 meters	SC 2000 2,500 meters	SD 1000 1,500 meters	SD1700 2,000 meters	PC 1400 1,000 meters
a. Degree of Damage to								
Brick Str.								
Complete destruction	2.9	5.3	8.3	14.6	17.0	7.0	16.0	9.0
Irreperable Damage	5.6	10.7	16.5	28.2	34.0	14.0	32.0	18.0
Temporarily Uninhabitable	12.2	17.0	24.4	48.8	60.7	20.0	54.0	26.0
Maximum Range for Damages								
b. Foundations								
Brick								
10-inch	4.3	8.6	11.0	13.8	16.0	9.5	14.5	11.5
20-inch	3.6	7.2	9.4	12.2	14.0	8.5	13.0	10.0
30-inch	3.1	6.6	8.6	10.4	12.0	7.5	11.0	9.0
Concrete								
6-inch	4.2	8.8	11.4	14.4	17.0	10.0	16.0	12.0
12-inch	3.4	7.5	9.5	12.2	14.0	8.5	13.0	10.0
18-inch	2.9	6.6	8.6	11.0	13.0	7.5	12.0	9.0
24-inch	2.6	5.8	7.8	10.2	12.0	7.0	11.0	8.5
c. Lines under Ground								
clay pipes	4.9	9.7	12.2	14.7	19.5	11.5	17.5	12.5
iron pipes	3.7	6.1	7.3	9.7	11.0	7.0	10.5	7.5

Footnote: The delays used for SC 250 and SC 500, SD 70 and SD 1000 were 0.08 of a second; For PC 1400 -- 0.1 of a second and for SC 1000, SC 2000, and SD 1700 -- 0.12 of a second. The latter, however, had an acceleration fuse that ignited a little sooner upon impact on firm ground.

Table 17: Range for Light Damages Inflicted by Underwater Explosions of High-Explosive, Multiple-Purpose, and Armor-Piercing Bombs ~~(Distances measured in meters)~~

Targets	SC 50	SC 250	SC 500	SC 1000	SC 2000	SD 1700	PC 1000	PC 1400
a. Bridge Foundations	1.5	3.0	4.0	5.0	6.0	5.5	3.5	4.5
b. Concrete Dams	2.0	4.5	5.5	6.5	7.5	7.0	5.0	6.0
c. Walled Dams	2.5	4.5	7.0	9.0	11.0	10.0	6.0	7.5
d. Lock Gates	3.5	8.0	10.5	13.5	17.0	15.0	9.0	11.0
e. Pipe Lines	5.0	12.0	16.5	22.0	28.0	25.0	13.0	17.5
f. Unprotected Vessels	8.0	20.0	26.0	36.0	45.0	40.0	22.0	28.0

~~Footnote:~~ The above figures are valid for normal explosive charges. If high-performance explosive were used, these figures would have to be multiplied by 1.3. The depth of the explosion has been assumed to be twice as great up to 5 meters distance, equally great at 12 meters distance, and at least half as great as the explosion ranges for distances beyond 12 meters.

~~Table 10: Range of "Effective" Fragments of Multiple-Purpose Bombs Aimed at Targets of Varying Resistance in Comparison with SD 10's (Measured in meters~~).

Number of Penetrations per Square Meter of Target Area		SD 10	SD 50	SD 70	SD 250	SD 500A	SD 1000A
No. of ~~Fragments~~							
100	D*	0	2.9	3.9	5.0	5.5	5.8
50	D*	0	3.6	4.6	7.0	8.2	9.0
1	D*	0	9.0	11.0	19.2	22.0	25.0
1	C*	5	17.0	18.2	29.0	35.0	40.0
1	B*	18	20	22	33	44	56
1	A*	25	32	45	60	80	85

Footnote: The signigificance of the letters with asterisks in the second column is as follows:

Target A* -- live targets;
" B* -- light, inanimate targets;
" C* -- medium-resistance offering , inanimate targets; and
" D* -- Resistant, inanimate targets.

For examples, see text on pp. 84 -5.

The most effective caliber bombs are ~~underscored~~ in the above table.

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Table 19: Times of Fall in Seconds at a Flight Speed of 250 Miles per Hour

Drop Altitude	Types of Bombs				
Meters	AB, KC, NC, etc.	BM, SB	SC, SD 50-500	SC, SD 1000-2000	PC, PD
1,000	15.5	15.0	14.7	14.6	14.5
2,000	21.9	21.4	20.9	20.8	20.7
3,000	27.0	26.5	25.9	25.7	25.5
4,000	31.2	30.6	30.1	29.9	29.7
5,000	34.9	34.3	33.8	33.6	33.3
6,000	38.0	37.4	37.2	37.0	36.8
7,000	41.4	40.7	40.3	40.1	39.9

Table 20: Drift Readings in Percentage of Altitudes of Fall for Different Types of Bombs

Altitude of Drop (in feet)							
19,800			AB, KC NC, etc.	BM, SB	SC, SD 50-500	SC, SD 1000 - 2000	PC, PD
13,200		AB, KC	BM, SB	SC, SD 50-500	SC, SD 1000 - 2000	PC, PD	
6,600	AB, KC NC, etc.	BM, SB	SC, SD 50-500	SC, SD 1000-2000	PC, PD		
Flight Speeds (in miles)							
190	5.7	5.6	5.5	5.5	5.4	5.4	5.3
250	9.0	8.8	8.5	8.1	7.6	7.0	6.3
310	13.8	13.3	12.8	12.2	11.6	10.9	10.1

D. ~~The Effect of Bombs on Naval Vessels~~

~~Illustration 22~~: ~~Comparison of the Various Types of Bombs~~

The differences in the results obtained by high-explosive, armor-penetrating, and armor-piercing bombs of the same caliber can best be illustrated by taking the example of three different types of naval vessels. Illustration 22 shows three British war ships which were being attacked with SC 1000, PC 1000, and PC 1000RS bombs. The disruptive strength of these bombs has been established after test drops as capability to penetrate 40-mm, 100-mm, and 180-mm armored plate, respectively; the quality of the armor was "Wh" with a tensile strength of about 220 lbs per square milimeter.The distances for the effectiveness of underwater explosions of near misses were taken from reports on German Navy tests.

Type of Ship Name of Ship	Battleship "Nelson"	Old Battleship "Queen Elizabeth"	Heavy Cruiser "Dorsetshire"
Launched in	1925	1913	1929
Weight (in reg. tons)	33,900	30.600	9,975
Crew (No. of personnel)	1,320	1,180	680
Max. Speed (in knots)	23.5	24	32.2
Length (in meters)	216	195	180
Width (in meters)	32.3	31.7	20
Draught (in meters)	9.1	9.3	5.2
Surface of Deck (in squ. m)	5,200	4,500	2,800
Horizontal Protection	30+10+159 mm	25+37+51 mm	20+10+30 (76?)
Equivalent Deck*	170 (9x40.6cm L45 12x15cm L50 (6x 12cm L40	85 (8x38.1cm L42 12x11.4cm L40	40 (80?) 8x10.2cm L45

~~Footnote:~~ The "Equivalent Deck*" has been calculated according to the ~~the~~ formula of de Marre from resistance~~s~~ factors of the various decks.

In illustration 22 the "effective target surface" offered by any ship to a specific bomb is indicated in percentages of the surface of the deck. The effective target surface is a composite figure of deck and target surface, the latter extending all around the ship like a belt. One single hit of the proper bomb can produce the sinking of the attacked vessel.

The "effective target surface" is simultaneously a means of measuring the vulnerability of a ship to a specific bomb. The objective plane around the ship is also designated "enlarged target." The "effective target areas" of the ships in Illustration 22 ~~is~~ are shown in red color and designate~~s~~ therefore the points where the bomb would have to hit in order to sink the ship with a direct hit or near miss. Areas colored in green indicate serious damages, and yellow areas show light damages.

Several hits in the " enlarged, green target area" can also produce a sinking, but this result will depend largely on the subdivisions of the ship into watertight parts separated by transverse bulkheads and longitudinal bulkheads. This is the main reason why warships from cruisers on up should also be attacked with high-explosive bombs, even though the sinking of such vessels by a single high-explosive bombs, however large it may be, seems improbable. A bomb capable of penetration into a vessel will always be selected on the basis of its capability to pierce the strongest armored plate on deck of the vessel. Since however the horizontal protection of major warships is formed by several

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decks, the drop altitude would have to be so high that the bomb could reach below the lowest armored deck before it exploded. For this purpose the resistance offered by each individual deck is calculated according to de Marre's formula for penetrating armor and these figures are added up so that a so-called "equivalent deck" value is established for every armor-protected vessel, which is indicated separately.

According to Illustration 22 the "effective target areas" amount for

a. SC 1000 to 63 percent for the "Dorsetshire",
0 percent for the "Queen Elizabeth", and
0 percent for the "Nelson".

b. PC 1000 to 60 percent for the "Dorsetshire",
16 percent for the "Queen Elizabeth", and
0 percent for the "Nelson".

c. PC 1000RS to 27 percent for the "Dorsetshire",
26 percent for the "Queen Elizabeth", and
13 percent for the "nelson".

Evaluation

a. SC 1000 -- only the "Dorsetshire" will be sunk, and that mainly through the effect of near misses.

b. PC 1000 -- The over-all effect on the "Dorsetshire" is smaller than by using SC 1000, although the PC 1000 would pierce the superstructure ("Citadelle" ?) at the extreme third of its width and open a gap in the

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outer wall of the ship.

The "Queen Elizabeth" could be destroyed by a direct hit in its ammunition ~~sk~~ rooms. However, the turrets proper, with their heavy guns and their rockers and gun mounts, offer insurmountable resistance to a bomb. Although they would be completely neutralized, they would protect the transfer rooms and the ammunition at the gun.

The PC 1000 would also penetrate the turret covers of the "Nelson", but not the armor-plated deck; the effect of near misses would be minor. On the other hand, the high-explosive bomb would at least cause light damages under water.

c. PC 1000. The effective target area of the armor-piercing bomb is far smaller than that of the SC 1000 and PC1000. On the other hand, the "Nelson" could be destroyed by hits in the forward or rear ammunition rooms, and the "Queen Elizabeth" also by hits in the turret. The effective target area would be greater than for the PC 1000.

Summary

On the assumption that only bombs weighing 2,200 pounds are taken into consideration, the most effective method to attack the "Dorsetshire" would be by using high-explosive SC 1000 bombs, whereas the destruction of the "Nelson" could be achieved

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only by employing the armor-piercing PC 1000RS bomb.

The PC 1000RS also has the greatest chances of sinking the "Queen Elizabeth", but its high penetrative ~~xxxxx~~ capability of 180-mm armor-plate steel is not actually needed to deal a deathly blow to the ~~xxxxxxxxxxxxxxx~~ old vessel that is so badly protected against bombs. The penetrative power of the PC 1000, which is 100-mm, is fully satisfactory for the "Queen Elizabeth", except that the explosive charge of 352 lbs does not suffice to tear the ship apart.

To destroy the innate strength of a warship, the bomb that penetrates below deck would have to contain a quantity of explosives equivalent to o.ol per thousand of the water displacement. In the case of the "Queen Elizabeth" this would amount to 660 pounds, and for the "Dorsetshire" some 220 lbs of explosives would be needed. The armor-piercing PC 1400 and PC 500 contain that much explosive matter. The latter bomb would suffice, if it was made of ordinary nonalloy steel, in which case it would be designated SD 500B. (It is not to be confused with the SD 500A, which is a multiple-purpose bomb for achieving high fragmentation effect.)

To ~~xxxxxxxxx~~ explode the ammunition rooms of a ship it is sufficient to use an explosive charge of 110 - 220 lbs, according to experience factors. The PC 500RS and PD 500 can therefore not be considered as standard bombs for this purpose since they contain only 27.5 and 63.8 lbs of explosives, respectively. The PC 1800RS, with its 484 lbs of compressed high-performance explosives, corresponds to the PC 1400 with its 660 lbs of normal explosives, but when its impact resistance strength was tested on a granite surface, doubts

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in the penetrative capability of the PC 1800 RS (then designated PC 1600 because it was without a rocket attachment) arose; these deficiencies led to the withdrawal from production of this bomb (See Illustration 21a).

Table 23: Explosive Effect of Bombs (See also Illustration 52)

The table contains figures concerning the "eefective target areas" and the distances of near misses for all categories of bombs that can possibly be employed for attacks on floating targets. In addition to the previously mentioned British ships, the following Russian vessels were taken into consideration:

Type of Ship Name of Ship	Destroyer "Strèmitelnij"	Fast Cruiser "Kirow"	Old Battleship "Gangut"
Launched in	1936	1936	1911
Weight (in reg. tons)	1,800	8,800	23,300
Max. Speed (in knots)	37	33	23
Length (in meters)	120	183	181
Width (in meters)	12	18	26.5
Draught (in meters)	--	6.4	--
Surface of Decks(in sq met)	1,200	2,700	3,800
Horizontal Protection	10 + 10 mm	10 + 10+50 mm	20+5+76 mm
Equivalent Deck*	16 mm	55 mm	85 mm
Guns (calibers in mm)	4 @ 130	9 @ 180	12 @ 305 L 52 16 @ 11.4

* According to the armor-piercing formula of De Marre.

Evaluation. According to this table the following caliber bombs, scoring individual hits have the greatest chances of sinking ships:

"Nelson" (?) with PC 1000 RS -- 13 percent;
"Queen Eliz."(?) PC 1400 -- 48 percent; and
"Dorsetshire"(?) SD 1700 -- 152 percent.

The comparison with smaller bombs weighing less than 2,200 lbs shows, however, in the case of the "Kirow" that the effective target area of 25 percent for SC 500 bombs consists only of "enlarged target" because the penetrative strength of the bomb does not suffice to crack the horizontal protection. In addition, the SC 50 - SC 500 bombs employed against naval targets are filled with trichlorethylene which has particularly strong pressure effect under water but is not shockproof.

The SD 500B, which is filled with normal explosives, contains far less explosives that the SC 500 and can therefore sink cruisers only by direct hit, for which purpose however the bomb has an effective target surface of 50 percent at its disposal.

The SD 500B can therefore be considered as the proper type of bomb and the proper caliber for attacks on cruisers displacing from 8,000 to 10,000 tons, and also for an attack on the "Dorsetshire", mainly because the thickness of the armor-plating protecting the ammunition rooms on this ship is not reliable, measuring only 76 mm.

The circumstances are reversed in the case of ~~destroyers~~. The SD 70 would have an effective target area of 80 percent if it scored a direct hit, so that every hit scored anywhere on board ship except the forward and extreme rear would lead to a sinking. However, wartime experience has shown that destroyers are very maneuverable. For this reason it is best to attack them with SC 250's whose effective range under water is considerable because of the relatively weak hull protecting the delicate engine mechanism of destroyers. From a tactical viewpoint one must also consider that bombers operate most effectively when loaded with bombs weighing from 550 to 1,100 lbs. For space reasons it is not possible to fully load aircraft with smaller caliber bombs, and loading them with very heavy bombs usually reduces their range. If the SC 2000 exploded near the side of the "Queen Elizabeth" -- by accident -- it would have the same effective target area as the PC 1000 hitting the deck of that ship. The SD 1700, however, would probably succeed in penetrating this same ship down to the lower armor-plated deck.

As explained in the first part of this study in the section dealing with general principles governing attacks on naval targets, large warships should always be attacked simultaneously with high-explosive and armor-piercing bombs in order to produce damages below the water line with the high explosives.

In attacks on modern battleships and large aircraft carriers it was usually most appropriate to employ SC 2000 bombs and drop them either from high altitudes or, if circumstances permitted, in low-level attacks or surprise glides out of low clouds. The SC 1000 is of sufficient effect against cruisers. The SD 1700 was used when the possibility existed that one could penetrate deeper into the ship as with an SC 2000, that is to say especially in the case of the older type battleships and aircraft carriers up to 25,000-ton displacement. However, armor-piercing bombs ~~xxxx~~ would be preferrable for attacks on armor-plated ships; they would have to form two-thirds of the ammunition employed, while the rest would be aircraft torpedoes and high-explosive bombs. Wartime experience has shown that the small and medium high-explosive bombs had little effect on battleships. The old Russian battleship "Gangut" had survived numerous hits by SC 250 and SC500 bombs filled with normal explosives without having suffered any apparent major damages. After a PC 1000 hit its ~~xxxx~~ quarter deck, however, the ship sank. ~~It~~ She would have been completely destroyed, had ~~it~~ she been hit by a PC 1400. Even though the PC 1800RS would have more chances to sink the "Queen Elizabeth" than the PC 1400 bomb, its penetrative power would not be fully used because of its greater weight. The modern Italian battleship "Roma", whose ~~xxxxxxplated~~ main deck was protected by 125-mm of armor plating was sunk by a direct hit. It should be specially mentioned that all SC, SD, and PC bombs should be equipped with head rings for high-altitude attacks on ships; their method of operation can be seen in illustration 47. High-explosive bombs used for low-level attacks should be equipped with bounce disks.

Table 24: Penetration Performances

The statistics on this table show ~~that~~ the horizontal protection of major warships and the most effective types of bombs for attacks of specific ships. The armor-piercing PD 1000 and PD 2500 X bombs, the latter controlled from the rear, were used against new ships introduced during the war. In addition to the bombs that were withdrawn from production and that have already been mentioned, the PC 1000 was replaced by the SD 1000A bomb which could be used for more general purposes and which was manufactured from nonalloy

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steel and contained more explosives than the former. The maximum penetrative power indicated in the column headed "S" in that table, the bomb proper would remain intact under all circumstances. As to the number of hits that were actually needed for sinking a certain warship, the data collected in all theaters of war provide a certain amount of information.

The factor of how many tons of warship displacement (weight and water displacement) could be sunk in an average with one ton of ammunition that hit the target was to be established.

For this purpose the ammunition was calculated according to the following weight categories:

Grenades: 200-mm -- 220 lbs; 280-mm -- 660 lbs, 400-mm -- 2,200 lbs.

Bombs: according to their calibers which indicated their weights, without differentiating between their charges.

Torpedoes: 450-mm -- 2,200 lbs; 540-mm -- ~~XXX~~ 3,520 lbs; 610-mm -- 4,400 lbs; 25 percent more for torpedoes with distance pistols.

Floating Mines: 2,200 lbs.

~~Results~~

~~Battleships:~~ altogether 15 ships with an average age of 17 years were incorporated in the table.

With 1 ton of bombs or grenades 9,000 tons (6 ships) were sunk; with 1 ton of torpedoes 9,750 tons (9 ships) were sunk.

Accordingly, the modern battleship "King George V", displacing 35,000 tons, could not be sunk unless hit directly by 4 PD 1000 bombs or 4 hits scored by aircraft torpedoes.

Aircraft Carriers: Altogether 16 aircraft carriers, averaging 6 years of age, were included in the statistics.

One ton of bombs could sink 13,000 tons (5 ships), while 1 ton of torpedoes sank 7,100 tons (11 ships).

An aircraft carrier of the British "indomitable" size would therefore have to receive two direct hits of SD 1000A or 3 aircraft torpedo hits before it would sink. This shows the vulnerability of this type of vessel to bombs, even if the ships are modern.

Cruisers: Included in the statistics were 32 ships, mainly heavy cruisers, whose average age was 11 years.

With 1 ton of bombs or grenades 5,600 tons (10 ships) were sunk, while 1 ton of torpedoes sank 2,550 tons (22 Ships).

The "Dorsetshire" would therefore have needed to receive 4 direct hits of SD 500 B or 4 torpedoes of 450-mm each before it would sink.

The greater capability of cruisers to resist hits above and particularly below the waterline was probably to be attributed to the far lesser average age of the cruisers than that of the battleships.

The over-all average figures for all 63 ships together are:

With 1 ton of bombs or grenades 8,470 tons (21 ships) were sunk, and with 1 ton of torpedoes 5,300 tons (42 ships).

No data on results achieved by combined torpedo and bombing attacks are available.

Table 23: "Effective Target Area" in Percentages of the Deck of Various Warships for All Types of Bombs (Distances in Meters)

Types of Bombs	"Stremitelnij" a.	b.	c.	d.	"Kirow" a.	b.	c.	d.	"Gangut" a.	b.	c.	d.
SD 70	8	3	-	80	5	-	-	-	3	-	-	-
SC 250	15	5	3	120	8	3	-	-	5	-	-	-
SC 500+)	26	10	5	165	12	5	3	25	10	3	-	-
SD 500B	12	4	2	90	6	2	-	50	6	2	-	-

Types of Bombs	"Dorsetshire" a.	b.	c.	d.	"Queen Elizabeth" a.	b.	c.	d.	"Nelson" a.	b.	c.	d.
SC 1000	18	7.5	4.5	63	12.5	5.5	-	-	11.0	4.5	-	-
PC 1000	12	4.0	2.5	60	8.0	-	-	16	8.0	-	-	-
PC 1000RS	9	-	-	27	-	-	-	26	-	-	-	13
PC 1400	15	5	3	125	11.5	5	-	48	10	4	-	-
SD 1700	20	8	5	152	16.5	6.5	-	31	15	5	-	-
SC 2000	24	10	6	100	20	8	3	16	17	6	-	-
PC 1800RS	15	5	3	125	12	6	-	57	12	5	-	13

Footnote: a. designates distance for light damages;

b. designates distance for heavy damages;

c. designates distances for sinking; and

d. is the "effective target area" for sinking and is ~~in~~ expressed in oercentages of the deck surface of the corresponding ship. The effective target area is a composite figure derived from the surface of the deck

+) For the effect produced by the SC 500I on Russian ships, see the illustration No. 52. The data given with regard to the "Queen Elizabeth" are also valid for the "Gangut." The most effective bomb is the PC 1400.

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plus the strip along the central part of the ship where a near-miss produced a sinking, if it occurs immediately on the side of the ship.

The "effective target area" is underscored in the case of the most effective bombs shown in the table. The distances and effective target area figures are practically the same for the "Dorsetshire" and the "Kirow", and the the most suitable bomb for this type of ship is the SD 500B.

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Table 24: Horizontal Protection of Large Warships, Bombs

Capable of Penetrating, and Minimum Drop Levels

Ships	Thickness of Armor-Plate of Deck(mm)	Bomb	"S"	Drop Level in 1,000 Meters	Observations
"Dorsetshire" 10,000 tons	20+10+30(76)* equiv. 45(80)	SD 500 B (SD 1000A	60 80	2.0 1.5)	High-level or dive
"Furious" 22,450 tons	20+5+5+70 equiv. 80	SD 1000A	80	1.5	" "
"Queen Eliz." 30,600 tons	25+37+51 equiv. 85	PC 1400	130	1.6	" "
"Dunkerque" 26.500 tons	20+10+125+50 equiv. 160	(PC 1000RS (PC 1400	180 130	1.2 4.2	Diving attack
"Nelson" 33,900 tons	30+10+159 equiv. 170	(PC 1000RS (PD 1000	180 180	1.2 4.5	Diving attack
Modern Heavy Cruiser 10,000 tons	30+10+40 equiv. 65	SD 500B	60	2.5	High-level or dive
Modern British Battleship 35,000 tons	10+30+10+160 equiv. 175	(PC 1000RS (PD 1000	180 180	1.2 4.7	Diving attack
Modern British Aircraft Carrier 23,000 tons	10+10+25+10+10 +50 -- equiv. to 90	SD 1000A	80	1.7	High-level or dive
Modern American Battleship 35,000	10+160+50 equiv. 186	(PD 1000 (PC 1600	180 180	5.2 4.0	
"Vanguard" 42,500 tons	10+152+125 equiv. 230	PD 2500X	230	3.9)	Armor-piercing bomb with rear control
"Iowa" 52,000 tons	10+190+114 equiv. 251	PD 2500X	230	4.3)	

* The "Dorsetshire" apparently had 76-mm armor plates above the ammunition rooms, while the rest of the armor-plating of its deck was only 30-mm thick.

Footnote: The data on armor-plate thickness of decks were given by the Navy.

The equivalent deck thickness was calculated according to the formula by de Marre.

The maximum thickness of the deck is established according to the caliber of bombs used and the types of bombs.

The equivalent deck thickness determines the drop level of the respective bomb.

"S" is the maximum penetrative performance expressed in milimeters of armor-plate steel for each respective bomb.

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IV. Target Records for Bombing Operations

In the following target records only data concerning the use of explosive and incendiary bombs as well as aircraft torpedoes are included. The use of aerial mines and chemical bombs is governed by special plans or executed upon special orders. Unless their employment is specially ordered for a major operation, the use of smoke bombs, flare bombs, supply bombs, and air-sea rescue bombs, etc., is controlled by the field forces.

On the other hand, the use of nose rods (distance rods and tubes) for nondelay fuses of multiple-purpose bombs is once again mentioned; they were used to improve the fragmentation effect of bombs dropped into high snow layers on the ground. Insofar as the bomb suspension would permit, fuse (55)A with membrane contact was used for horizontally suspended bombs. The fragmentation effect of SD 1 to SD 15 bombs would be greatly reduced by high snow. If absolutely necessary, one could use the smallest caliber SD 1 with large drop containers in order to score direct hits for effect. Whenever available, one should use the SD 250 Tel bomb.

The target records are subdivided according to ground and naval targets. They consist of tables for various targets, in which the most effective bombs and fuses are indicated according to the type of attack launched. The bombs, fuses, and type of ignition are indicated by abbreviated symbols.

The drop levels for the different types of release are as follows:

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Low-level: depending on the terrain, but no higher than 330 feet; above open railroad tracks and against point targets at least 33 feet above ground; against ships at mast level.

High Altitude: average drop level 6,600 to 13,200 feet; higher drop levels above 16,500 feet.

Dive: fixed at 4,000 feet release altitude for rocket-propelled armor-piercing bombs, with a minimum angle of 60° toward the trajectory line.

Against unprotected targets or if underwater explosion by mine bombs is intended, the release altitude should be 1,650 feet with an approximate angle of 30°.

The last column of the target records shows the most favorable ratio of explosive to incendiary bombs with the respective quantities of each to be used against ground targets that are to be attacked.

A. Ground Targets. General

There is a great difference in the effect produced by bombs dropped on point targets that are mostly protected or massively constructed and area targets that offer relatively little resistance.

The following data must be available for the preparation of a bombing operation:

1. Type of construction, measurements, and stress resistance of the target, and particularly important facilities located in the target area.

2. Size of the target and distribution of facilities in the target area.

3. Exact knowledge of the effect of explosive and incendiary bombs of various types and different fuses on the individual parts of the target, as related to effective distances.

4. Estimate of the success that could be achieved in dropping many small bombs or fewer large ones over the entire target surface in contrast to concentrating one very large bomb on the most significant parts of the target.

The employment of bombs will also depend on the number of aircraft available and their loading capacity, the availability of the most effective bombs and fuses, the training status of the crews, the enemy defenses, and the weather conditions (cloud level).

In indicating the most suitable bombs, the point of departure was the previously mentioned principle to first name the type of bomb that would most likely destroy the respective target. The other bombs are listed in accordance with their effectiveness to produce fires or damages by pressure or fragmentation, and finally the nuisance-fuse bombs are mentioned.

The drop level, however, determines the impact velocity and the scatter area of bombs and aerial delivery containers, and must therefore be considered in connection with the bomb and the fuse. For low altitudes one cannot always use the smallest effective bomb. Because of the greater accuracy and the anyhow small impact

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velocity inherent in low-level attacks, it is advisable to use the next largest caliber bomb.

Compromises must be made in the majority of average targets.

The delay at which the fue is set will depend on impact velocity, target resistance, and the desired depth of explosion within the target.

Naval bases are particularly important targets. They offer a variety of points of main effort within a limited area, some of which are important targets by themselves and most of which complement one another. It is therefore of great importance to identify those individual targets among them, the destruction of which will affect the over-all functions of the naval base to a maximum.

A naval base generally consists of the dock area for ships, repair shops, piers, dry docks, floating docks, cranes, shop areas, power installations, transformers, terminals, railway shunting yards, gasoline dumps, warehouses, and billets for personnel.

In general, bases would also include installations for equipping ships with engines, artillery, instruments, etc.

In their priority of importance the individual targets should be ranked as follows:

a. One ship sunk at a dock, in the wharf, or at a pier or even at the entrance to the port will immobilize not only that particular installation but will also form an obstacle to other shipping.

b. Power stations are among the most vital targets on land. No other bomb hit disrupts the entire operation of an installation as much as the neutralization of a power station.

c. Lock gates and pumps are the most vulnerable parts of a dock. Especially when the lock is empty, a hit scored on these parts is more important than on the ship proper. Pumping stations are usually protected by concrete. Dock installations above ground should be attacked like power stations.

d. Floating drydocks that have been wrecked cannot be used for repairing ships that have been damaged below the water line.

Targets of secondary importance within a naval base are workshops near docks, gasoline dumps, cranes, railroad installations, warehouses, and quarters for personnel.

Fuses and bombs for air attacks on the above-mentioned targets should be selected according to the importance of the respective target. Burning gasoline facilities might form a protective smoke cover above the main target points.

B. Naval Targets

The basic information has been given in the preceding text. In selecting bombs and fuses for operations directed against ships the following points must be taken into serious consideration:

1. The flight altitude and drop level;
2. The type of ship to be attacked;

3. The armor-plating;
4. The possibility of sinking the vessel with one hit or more as well as the amount of damage caused;
5. The chances of scoring hits;
6. The bomb payload capability of the aircraft;
7. The need to neutralize the ~~xxxxxxxxxxxxxxxx~~ flak on board ship by small-caliber bombs or aircraft weapons before the principal attack which is supposed to be carried out with large bombs and torpedoes.
8. If the available forces are insufficient to score a sinking, a reduction in the speed of the enemy vessel may be considered as a success because it can thus be made an easy prey of friendly ~~xxx~~ naval units or other friendly air forces.
9. All other circumstances and conditions, such as the range of the aircraft, the weather, the time of the day, the defensive situation, etc.

According to earlier points made in this study, all warships larger than and including heavy cruisers should be attacked simultaneously with armor-piercing and high-explosive bombs. But the use of torpedo-launching aircraft should also be combined with the dropping of bombs in order to achieve quick sinkings, particularly among the large ships.

The minimum altitudes for armor-piercing bombs for high-level attacks must be observed in order to produce the essential penetrative power. If the low level of the cloud ceiling will not permit such action, one can attack only in a dive flight in order to penetrate the armor-protected deck with rocket-propelled bombs. To increase the drop level of PC 1000 RS will not result in any increase in the penetrative power. If high-explosive bombs are dropped on ships, only the best quality (I) should be taken into consideration for low-level or gliding flight attacks; these bombs should be filled with trichlorethylene.

Before operations against other types of targets than those indicated in the tables of Part IV one must select the bombs and fuses on the basis of previously obtained accurate information concerning the target.

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Land Target Charts

Target and Target Conditions	Type of Attack	Bombs	Fuses	Type of Fuse	Observations
1. Light Industry					
(Aircraft, trucks, chemical, and accessory plants)	Low-level	(SD 250	55	del.	Fragmentation to incendiary bombs at a ratio of 80 : 20
		(Sprbrd C 50	55	nondel.	
		(LMB w	34	delayed	
		(SD 70	55	delayed	
		(Brand C 50	25	delay-act.	
		(Flam C 250	26	nondelay	
Small or large installations, mostly above ~~grxx~~ ground; light steel construction with brick reinforcements, up to 20 feet high.	High altitude and dive bombing	(SC 250	25	delayed	Scatter bombs
		(AB 500-BS	59	time	
		(SC 500	25	nondelay	
		(Brand C 50	25	delayed	
		(SD 500A	55	nondelay	
		(SC 250	57	long-delay	

Footnote: All explosive bombs used in low-level attacks on industrial facilities and similar installations should be equipped with bounce plates.

Target and Target Conditions	Type of Attack	Bombs	Fuses	Type of Fuse	Observations
2. Heavy Industry					
(Tanks, guns, shells, railroad material, machine tool factories)	Low-level	(SD 500 A	55	delayed	
		(LMB w	34	delayed	
Extensive facilities above ground: strong steel structures with concrete, long spans and heights up to about 33 feet	High altitude and dive bombing	(SC 500	25	delay-act.	
		(SB 1000	24	nondelay	
		(SD 1000	25	nondelay	
		(SC 250	57	long delay	

Footnote: The sequence in which the bombs are listed indicates the effectiveness of the individual types of bombs for the specific purposes.

Target and Target Conditions	Type of Attack	Bombs	Fuses	Type of Fuse	Observations
3. Multiple Story Factory Facilities		(SD 500A	55	delayed	Ratio of Fragmentation to Incendiary Bombs:
		(Brand C 250	25	delay.act.	80 : 20
in one single or several buildings situated close together; steel structure with brick walls or reinforced cement	low level	(LMB w	34	delayed	
		~~(XXXXXXXXXXX~~			
		(Sprbrd C 50	35	nondelay	
	high altitude and dive bombing	(SC 500	25	del. act.	
		(Brand C 250	25	del. act.	
		(SB 1000	24	nondelay	
		(SD 500 A	55	nondelay	
		SC 250	57	long-delay	
(Electrical industry, optical, fine mechanics)					

4. Special Plants

Target and Target Conditions	Type of Attack	Bombs	Fuses	Type of Fuse	Observations
a. Gas works with benzol extraction plant	low level	(SD 250	55	delayed	Ratio of fragmentation to incendiary bombs -- 90 : 10
		(Sprbrd C 50	55	nondelay	
	high altitude and dive bombing	(SC 250	25	del. act.	
		(SD 70	25	nondelay	
		(AB 500-BS	59	time	
		(SC 250	57	long-delay	

Footnote: For low-level attacks with incendiary bombs ZSK, set for "dive."

Target and Target Conditions	Type of Attack	Bombs	Fuses	Type of Fuse	Observations
b. Blast Furnaces	low level	SD 500 A	55	delayed	
	high altitude and dive bombing	(SC 500	25	delay.act.	
		(SD 1000	25	nondelay	
		(SC 250	57	long-delay	
c. Steel plants	low level	SD 250	55	delayed	
	high altitude and dive bombing	(SC 250	25	delay.act.	
		(SD 500 A	55	nondelay	
		(SC 250	57	long-delay	
d. Fuel production plants	low level	(SD 250	55	delayed	Ratio~~s~~ of scatter to incendiary bombs -- 90 : 10
		(Sprbrd C 50	55	nondelay	Electron-incendiary bombs
		(AB 500-BS	69	time	
	high altitude and dive bombing	(SD 70	55	delayed	
		(SC 250	25	delay.act.	
		(AB 500-BE	59	time	
		(SC 250	57	long-delay	

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Target and Target Conditions	Type of Attack	Bombs	Fuses	Type of Fuse	Observations
e. Steam power plants	Low level	SD 500A	55	delayed	
	high altitude and dive bombing	(SC 500	25	delay.act.	
		(SC 1000	28B	delay.act.	
		(SD 1000A	25	nondelay	
		(SC 250	57	long-delay	
f. Hydraulic plant	low level	(SD 1000A	25	delayed	inland
		(SC 1000	38	delayed	toward water
	high altitude and dive bombing	(SC 1000	28B	delay. act.	inland
		(SB 2500	24	nondelay	
		(SC 2000	28B	delay.act.	toward water
		(SC 500	57	long-delay	
g. Step-down Transformers in Buildings	low level	SD 500A	55	delayed	
	high altitude and dive bombing	(SC 250	25	delay-act	
		(SD 250	55	nondelay	
h. Isolated Tranformers	low level	SD 70	55	delay. act.	
	high altitude and dive bombing	(SD 70	55	nondelay	
		(AB 500 -SD 10	59	time	
		SD 250	55	nondelay	
5. <u>Fuel Storage Installations</u> Supply Dumps					
a. Above ground	low level	(SD 70	55	delayed act.	
		(Sprbrd C 50	55	nondelay	
		(AB 500-BS	69	nondelay	scatter
		(Flam C 500	55A	nondelay	Ratio of fragmentation to incendiary bombs -- 90:10
	high altitude and dive bombing	(SD 70	55	nondelay	
		(Brand C 50	25	nondelay	
		(SD 250	55	nondelay	
		(AB 500BE	59	time	electron incend.
b. Under ground	low level	(AB 500-SD 2	69	nondelay	Ratio of fragmentation to incendiary 90 : 10
		(Flam C 500	55A	nondelay	
	high altitude and dive bomb.	(SC 250	25	delay.act.	
		(AB 500 Be	59	time	electron incend.
c. Supply dump	low level	(SD 70	55	delayed	
		(Brand C 50	25	delay. act.	Ratio of fragm. to incend. 60:40
		(Flam C 250	26	nondelay	
	high altitude and dive bomb.	(SD 250	55	nondelay	
		(Brand C 250	25	nondelay.	

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Target and Earget Conditions	Type of Attack	Bombs	Fuses	Type of Fuse	Observations
d. Field Ammunition Dump for Air Force	Low level	(SD 70	55	delay	
		(Sprbrd C 50	55	nondelay	
		(AB 500-BS	69	nondelay	scatter
(With Blast Protection Walls)	High altit. & dive bombing	(SD 70	55	nondelay	ratio of fragmentation to incendiary--80:20
		(AB 500-SD 10	59	time	
		(AB 500-Be	59	time	
		(SC 250	57	long-delay	electron incend.
6. <u>City Districts</u>					
a. Administartive Buildings in Business Districts Skyscrapers	Low level	(SD 500 A	55	delay	
		(Brand C 50	25	dela. act.	
		(LMB w	34	delay	ratio of fragm. to incendiary -- 60 : 40
	High altit. & dive bomb.	(SC 500	25	del.act.	
		(Brand C 50	25	del.act.	
		(SB 1000	24	nondelay	
		(AB 500-Be	59	time	scatter
		(SC 1000	28B	dela.act.	
		(SC 500	57	long-delay	
b. Closely bult-up areas, 50 % covered with habitations	Low level	(SD 250	55	delay	
		(Brand C 50	25	del. act.	ratio of fragm. to incendiary 60 : 40
		(LMB w	34	delay	
	high altitu. and dive bomb.	(SC 250	25	delay	
		(SB 1000	24	nondelay	
		(Brand C 50	55	del. act.	
		(SC 500	25	del.act II	
		(AB 1000-BE	59	time	electron incend.
		(SC 250	57	long-delay	
		(AB 500-Sd 2Z	59	time	
c. Scarcely Inhabited Areas (only 10 - 20% built-up)	low level	(SD 70	55	delay	
		(LMB w	34	delay	
	high altit. and dive bombing	(SB 2500	24	nondelay	
		(AB 1000-BE	59	time	electron incend.
		(AB 500-SD 10	59	time	
		(AB 500-SD 2Z	59	time	ratio of fragmentation to incendiary bombs -- 60 : 40
		(SC 250	57	long-delay	

Target and Target Conditions	Type of Attack	Bombs	Fuses	Type of Fuse	Observations
7. Railroads	Low	(SC 50 nose-spi.	55	delay	39 feet altit.
a. Open tracks,	along	(SC 250 " "	17 + 50	nuisance	
embankments	across	(SC 1000	25	delay	66 " "
b. Stations w/ rolling stock	low	(SD 250	55	delay	
		(LMB w	34	delay	
		(Brand C 250	25	nondelay	fragm.
	high & dive bomb.	(SC 250	25	del. act.	~~xxxxxxx~~ for fire
		(SD 250	55	nondelay	
		(SB 1000	24	nondelay	
		(AB 500-BS	59	time	scatter
		(SC 500	57	long-delay	
c. Workshops, depots, round-houses, switch stations	low	(SD 500 A	55	delay	
		(LMB w	34	delay	
	high & dive	(SC 500	25	del.act.	
		(SB 1000	24	nondelay	
		(SD 1000A	25	nondelay	
		(AB 500-SD 2Z	59	time	
		(SC 250	57	long-delay	
8. Bridges					
best method	low	(SC 250	25	delay	ratio of
		(Flam C 500	55A	nondelay	fragm. to incendiaries
a. Wood beams spanning 10 - 27 ft.	high & dive	(SC 250	25	del. act.	90 : 10
		(SD 70	55	nondelay	
		(Flam C 250	26	nondelay	
b. Ponton bridg.	low	(AB 250-SD 2 t	69	nondelay	
		(SD 500 Br	55A	nondelay	
	high & dive	(AB 500-SD 10	59	time	
		(SD 70	55	nondelay	
		(SD 250 Tel	55A	nondelay	
c. Brick or light concrete construction, spanning 17 - 66 ft.	low	SV 250	25	delay	aim at pillars
	high & dive	SC 250	25	del.act.	central span
d. Reinforced concrete or steel structure, spanning 83 - 660 ft.	low	SC 2000	25	delay	pillars
	high & dive	(SC 1000	28b	delay	center span
		(SC 2000	28b	delay	pillar

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Target and Target Con-~~ditions~~	Type of ~~Attack~~	Bombs	Fuses	Type of ~~Fuse~~	Observations
e. Box Girders spanning 40 - 100 ft.	low	LMB w	34	delay	~~Point Target~~ center span
	high & dive	(SB 1000 (SC 1000	24 28B	nondelay del. act.	" " pillars
f. Lattice Work 83 - 660 ft.	low	SD 500 Br	55A	nondelay	center span
	high & dive	(SD 1000A (SC 2000	25 25	nondelay del.act.	" " pillars
g. Box girders on high pillars, spanning 40 - 100 ft at an elevation of about 165 ft.	low	SC 1000	25	delayed	pillars
	high & dive	(SV 2500 (SC 1000	24 25	nondelay del.act.	center span pillars
h. Suspension bridges measuring 330 - 3,300 ft. in length	low	SC 2000	25	delay	)towers and)~~xxxx~~ cable
	high & dive	(SC 2000 (SD 1000A	28b 25	del.act. nondelay	)anchoring points. Also, center span
i. Swing and draw bridges	low	(SC 500 (SD 500 Br	25 55A	delay nondelay	Control room bridge
	high & dive	(SC 250 (SD 250 (SC 250	25 55 57	del.act. nondelay long-delay	abutment bridge

Fragmentation Bombs Dropped from Low Levels
with shock impact plates

9. ~~Airfields~~

Target and Target Conditions	Type of Attack	Bombs	Fuses	Type of Fuse	Observations
a. Large hangars made of steel and cement	low	SC 500	25	delay	
	high & dive	(SC 250 (SB 1000 (SC 250	25 24 57	del.act. nondelay long-delay	
b. Aircraft shelters, workshops	low	(SD 70 (Flam C 250	55 26	delay nondelay	ratio of fragment. to incend.
	high & dive	(SC 250 (SD 70 (AB 500-BS	25 55 59	del.act. nondelay time	

Target and Target Conditions	Type of Attack	Bombs	Fuses	Type of Fuse	Observations
c. Isolated Aircraft or aircraft in blast bays without roofs or in tents	low	AB 500-SD 2t	69	nondelay	Point Targets
	high & dive	(AB 500-SD 10 +)	59	time	
		(AB 500-SD 1 +)	59	time	in blast bays
d. Runways and air-strips	low	SC 250	25	delayed	concrete runway
	high & dive	(SC 250	25	del. act.	airstrips
		(AB 500-SD 2 Zt	59	time	" "

Footnote: Craters of SC 50 and SD 70 bombs can easily be filled on runways.

+) The SD 1 affect aircraft like a 37-mm flak shell.

10. Troop Targets

Target and Target Conditions	Type of Attack	Bombs	Fuses	Type of Fuse	Observations
a. Landing operations, troop assemblies	low	(AB 500 SD 2t	69	nondelay	
		(Flam C 250	26	nondelay	
		(SD 500 Br	55A	nondelay	
	high & dive	(AB 500-SD 1	59	time	
		(SD 250 Tel	55A	nondelay	
b. Truck columns, radio and radio direction facilities, troop billets	low	(SD 70	55	delayed	
		(SD 500 Br	55A	nondelay	Ratio of fragm. to incendiary bombs -- 90:10 (only for low level attacks)
		(Flam C 500	55A	nondelay	
		(Brand C 50	25	nondelay	
	high & dive	(AB 500-SD 10	59	time	
		(SD 70	55	nondelay	
		(SD 250 Tel	55A	nondelay	
c. Armored cars, landing barges	low	(SD 500 Br	55A	nondelay	
		(Flam C 500	55A	nondelay	
	dive	(AB 500-SD 4 Hl	59	time	
		(SC 500	25	nondelay	

11. Field Positions

Target and Target Conditions	Type of Attack	Bombs	Fuses	Type of Fuse	Observations
a. Front lines, open trenches w/ fortified positions defended by small arms	low	(AB 500-SD 2t	69	nondelay	
		(Flam C 250	26	nondelay	
	high & dive	(AB 500-SD 1	59	time	Ration of fragmentation to incendiaries 80 : 20
		(SD 70	55	nondelay	
		(SD 250 Tel	55A	nondelay	

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Target and Target Conditions	Type of Attack	Bombs	Fuses	Type of Fuse	Observations
b. Antiair-craft and field artillery	low	(AB 500-SD 2t	69	nondelay	
		(Flam C 500	55A	nondelay	(only low level)
		(SD 70	55	delayed	
up to 105-mm in open field positions	high & dive	(AB 500-SD 10	59	time	
		(SD 250 Tel	55A	nondelay	
c. Medium artillery	low	SD 250	55	delayed	
in firing positions; 150 - 240-mm motorized guns; 210 - 350-mm railroad guns	high & dive	(SD 70	55	nondelay	
		(AB 500-SD 10	59	time	
		(SC 250	25	del.act.	
12. <u>Fortified Lines</u>	low	(SD 500 B	25	delayed	<u>Point Target</u> Entrances
a. Coast artillery in concrete firing positions protected by armor		(Flam C 500	55A	nondelay	slits
	high & dive	PC 1000	35	del.act.	
		SHL 800	66	nondelay	cupolas
b. Concrete bunkers with 10-foot cover	low	(SC 250	25	delayed	raised ground
		(Flam C 250	26	nondelay	slits & entrances
	dive	SHl 500	66	nondelay	cover
13. <u>Naval Bases, Port Installations</u>					
a. Warves and berths for ships	low	SC 500	38	delayed	below vessel
	high & dive	(SC 250	25	delayed	
		(SD 250	25	nondelay	
b. Unloading installations, piers, docks, etc.		(SC 250	57	long-delay	
	low	(SD 500 Br	55A	nondelay	
		(Flam C 500	55A	nondelay	
	high & dive	(SC 250	25	del. act.	
		(AB 500-BE	59	time	electron incendiary
		(SD 250	55	nondelay	

Target and Target ~~Conditions~~	Type of ~~Attack~~	Bombs	Fuses	Type of ~~Fuse~~	Observations ~~Point Target~~
c. Lock gates, dock entrances	low	SC 1000	38	delayed	high-water side
	high & dive	(SC 500 (SD 500A	25 55	del.act. nondelay	dock side
d. Floating docks	low	SC 2000	38	delayed	waterline
	high & dive	(SC 1000 (SD 500A	28B 55	del.act. nondelay	
e. Power stations(see 4e) gasoline dumps, etc. (see 5a)					

14. Other Targets

a. Mine fields, wire barrages	low	LMB w	34	delayed	
	high & dive	(SD 70 (SB 1000	55 24	nondelay nondelay	
b. Dams & barrages w/ strong walls	low	SC 1000	38	delayed	water side
	high & dive	SC 2000	28B	del.act.	
c. Soft (dirt) dams & barrages	high & dive	SC 2000	28A	del. act.	

Target Records for Naval Vessels

Type of Vessel, Tonnage, Maximum Armor-Plating	Type of Attack	Bombs	Fuses	Type of Fuse	Minimum Drop altitude To Achieve Penetration
1. Modern battleship 52,000 tons, 190-mm	low	(SC 2000 (LT 5	38	delayed (del.act.	4,200 meters
	high	(PD 2500 X (SC 2000	48 28B	0.045 sec. del.act.	
2. Modern battleship 35,000 tons, 160-mm	low	(SC 2000 (LT 5	38	delayed	
	high	(PD 1000,PC1600 ((SC 2000	48 28B	(delayed act (0.075 seconds. del.act.	4,700 meters
3. Aircraft carrier, 25,000 tons, 51-mm	low	(SC 2000 (LT 5	38	delayed	
	high & ~~XXXX~~	(SD 1000A (SD 1700	28A 28B	del. act. del. act.	1,700 meters 1,500 meters
	dive	SD 1000A	28A	del.act.	1,200 meters
4. Older-type battelship 30,000 tons, 76-mm	low	(SC 2000 (LT 5	38	delayed	
	high	(PC 1400 (SD 1700	35 28B	delayed act. del. act.	1,600 meters 1,500 meters
	dive	PC 1400	35	del.act.	1,200 meters
5. Heavy cruiser, 10,000 tons, 51-mm	low	(SC 1000 or LT 5	38	delayed	
	dive & high	(SD 500 B (SC 1000	28A 28B	del. act. del. act.	3,000 meters 1,200 meters
6. Light cruiser, 4,000 tons 30-mm	low	SC 1000	38	delayed	
	high & dive	SC 500	28A	del. act.	1,500 to 1,200 meters

Type of Vessel, Tonnage, Maximum Armor-Plating	Type of Attack	Bombs	Fuses	Type of Fuse	Minimum Drop Altitude To Achieve Penetration
7. Modern destroyed, 2,000 tons, 20-mm	low	SC 500	38	delayed	
	high & dive	SC 250	28A	del. act.	

Footnote: Ratio of armor-piercing to high-explosive bombs -- 65:35

Type of Vessel, Tonnage, Maximum Armor-Plating	Type of Attack	Bombs	Fuses	Type of Fuse	Minimum Drop Altitude To Achieve Penetration
8. Torpedo boat, other auxiliary vessels, 800 tons	low	SC 250	38	delayed	
	high & dive	SD 70	28A	del. act.	
9. Submarines, proceeding to submerge, 500 tons	low	Fl.WB 250	9	time	
	high & dive	SC 250	28A	del. act.	
10. Transport vessel, 12,000	low	(SC 1000 (LT 5	38	delayed	
	high	(SC 500	38	del.act, for o.o5 seconds	
		(Hs 293	28A	del.act(corresponding to (10,000 feet	
	dive	SC 500	38	(del.act. (for 0.2 seconds corresp. (to 4,000 feet	
11. Freighter, 4 - 8,000 tons	low	SC 500	38	delayed	
	high	LT 350			ship in roads
	high&dive	SC 250	38	del. act.	
12. Small freighter, 2 - 4,000 tons	low	SC 250	38	delayed	
	high	LT 350			ship in roads
	high&Dive	SC 250	38	del.act.	
13. Speedboats, outpost patrol boats, etc.	low	(SC 250	38	delayed	
		(SD 500 Br	55A	nondelay	
	high& dive	SD 70	28A	nondelay	

~~Footnote:~~ All SC bombs dropped in low-level attacks must be equipped with bounce disks.

SC, SD, and PC bombs dropped from high altitudes or in dive bombing attacks must be equipped with head rings.

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If a direct hit is scored on an unprotected vessel, large fires usually break out on deck.

The calibers of bombs indicated in the above table are suited for sinking the respective type of vessel by one single direct hit or near miss.

If torpedoes are launched, several hits must be scored to produce a sinking, and the same is also true of high-explosive bombs of the caliber next-smaller in size.

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List of Bomb Targets

B. Naval Targets (Figures represent tonnage and armor-plating)

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List of Illustrations

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APPENDIX I

Explanation of the Designation of Various Types of Bombs Used by the Luftwaffe

The Germans distinguished bombs according to their utilization as follows:

Fragmentation or shrapnel bombs, and

High-explosive or gas pressure bombs.

They were designated on the basis of the percentage of explosives they contained as follows:

S.A. bombs had the highest percentage of explosives;

S.B. bombs contained 75 percent explosives;

S.C. bombs had 50 percent explosives;

S.D. bombs contained 30 percent explosives; and

S.E. bombs had a percentage of 15 - 20 explosive contents.

High-Explosive Bombs:

L.M.

Wasserballon (water balloon) -- a code designation.

Armor-Piercing Bombs:

P.C. Armor-piercing bomb; and

P.D. armor-penetrating bomb.

Incendiary Bomb:

B 1, E

B 1, 3 E with steel top

Flambo:

Flam C

Gas Bomb : These bombs were produced as retaliation weapons in order to prevent the enemy from using gas.

K.C.

Spraying apparatus and a spray bomb.

Moreover, there were some other bombs that were not used for bombing raids but only as auxiliary weapons of various types in different kinds of operations, such as:

Smoke bombs to camouflage friendly troop movements or fixed installations.

Flare bombs to light up targets during the hours of darkness.

Flash bombs to produce aerial photographs during the night.

APPENDIX II

Luftwaffe Regulation 8/4 g of 8 June 1941
(L Dv 8/4 g.)

Selection of Bombs and Fuses for Aerial Attacks

is temporarily not available.

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APPENDIX III

The Development of Incendiary and Explosive Bombs

for the Luftwaffe

and Their Status of Readiness for Procurement

(Extracted from a study entitled: "Short survey of the Research and Development of Bombs before 1933 and Establishment of their Technical Status as Point of Departure for Rearmament" by General Marquard (Ret.)

During World War II and until 1945 General Marquard was responsible for reserach and development of all bombs for the Luftwaffe.

Not included in the following statistics are all the plans and developemtns that could not be completed before the end of the war.

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Time at Which Incendiary and Explosive Bombs Were Ready for

Procurement Contracting

			Manufacturer Responsible for Development
1933:	B 1 E	-- Electron incendiary bomb, wieghing 2.2 lbs	I.G. Farben
	S D 10	- Fragmentation bomb, 22 lbs	W. Wurl, Weissensee
	S C 50	- High-explosive bomb, 110 lbs	Rheinmetall, Duesseldorf
	SC 250	- High-explosive bomb, 550 lbs	" "
1935:	S C 500	- High-explosive bomb, 1,100 lbs	" "
1936:	L M A	-- Ground mine, 1,100 lbs	Experimental Barrage Com., Kie
	L M B	-- " " , 2,200 lbs	" " Command, Kiel
1938:	L T 5	-- Aircraft torpedo, 1,760 lbs	Torpedo Experim. Station
	S D 50	-- Multiple-purpose bomb, 110 lbs	Vereinigte Oberschlesische Huetten Werke
1939:	B L3E	-- Electron incendiary bomb, 3 lbs	I. G. Farben
	S D 500	- Multiple-purpose bomb, 1,100 lbs	Ver. Oberschl. Huett. W.
	P C 500	- Armor-piercing bomb, 1,100 lbs	Rheinmetall, Duesseldorf
1940:	S D 2t	- Fighter-bomber bomb, 4.4 lbs	Ver. Oberschl. Huetten W.
	S Be 50	- Concrete-Fragmentation bomb, 110 lbs	Cologne
	P C 500 RS	--Armor-piercing bomb, 1,100 lbs, with rocket attachment	Pheinmetall, Duesseldorf
	SC 1000	- High-explos. bomb, 2,200 lbs	" "
	SC 1800	- " " " , 4,000 lbs	" "
	SD 1700	- Multiple-purpose bomb, 3,740 lbs	" "
	PC 1400	- Armor-piercing bomb, 3,080 lbs	" "
	Flam C 250	- Flam bomb, 550 lbs	Ver. Oberschl. Huetten W.
	Flam C 500	- Flame bomb, 1,100 lbs	" " "

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Year	Designation	Description	Manufacturer Responsible for Development
1941:	B 2 E (Z) --	Electron incendiary bomb, weighing 4.4 lbs	Hagenuk, Kiel
	Sprbrd C 50-	Combination incendiary-demolition bomb, 110 lbs	Dr. Buck, Goeppingen
	Strbrd C 500-	Scatter bomb, 1,100 lbs	Ambi Budd, Johannistal
	SD 250 --	Multiple-purpose bomb, 550 lbs	Bochumer Verein, Bochum
	PC 1000RS --	Armor-piercing bomb, 2,200 lbs with rocket att.	Rheinmetall, Duesseldorf
	SB 2500 --	High-charge bomb, 5,500 lbs	" "
	BM 1000 --	Bomb mine, 2,200 lbs	A.E.G., Berlin
1942:	SD 1 --	Fragmentation bomb, 2.2 lbs	Ver. Oberschl. Huett. W.
	SD 4 Hl --	Hollow-charge bomb, 8.8 "	Wilhelm Wurl, Weissensee
	SD 70 --	Multiple-purpose bomb, 154 lbs	Rheinmetall, Duesseldorf
	SD 1000 --	Multiple-purpose bomb, 220 lbs	" "
	PC 1400 X --	Armor-piercing bomb with rear-control mechanism	Vereinigte Stahlwerke
1943:	Brand C 50 -	Intensive incendiary bomb, 110 lbs	Ver. Oberschl. Huettens.
	Brand C 250-	Intensive incendiary bomb, 550 lbs	" " "
	SD 9: SD 15-	Fragmentation bomb produced from 88 and 105-mm shells	" " "
	Brand 10 --	Incendiary bomb with liquid filler	Wilhelm Wurl, Weissensee
	SB 1000 --	High-charge bomb, 2,200 lbs	Ver. Oberschl. Huettenw.
	SC 2000 --	High-explosive bomb, 4,400 lbs	Rheinmetall, Duesseldorf
	PD 500 --	Armor-penetrating bomb, 1,100 lbs	" "
	PD 1000 --	Armor-penetrating bomb, 2,200 lbs	" "

APPENDIX IV

Sketch of taxiways and one runway

RUNWAY

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APPENDIX V

PHOTOGRAPH

Attempt to neutralize a French runway by dropping bombs. Despite a high expenditure of bombs, the taxiways remained intact or could be repaired by levelling some of the craters.

APPENDIX VI

PHOTOGRAPH

(no text)

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APPENDIX VII

PHOTOGRAPH

Attack by German dive bombers type Junkers 87

in September 1941

on the Russian battleship "Oktoberrevolution"

(October Revolution) near Khronshtadt.

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PHOTOGRAPH

Dive-bomber scored direct hit on the Russian battleship "Marat" outside Khronshtadt.

Smoke from explosion rose 1,320 feet; the battleship was split in two.

The photograph was taken during an antiaircraft barrage; for this reason, only the numerous muzzle flashes and the muzzle-blast smoke are visible on the photograph.

APPENDIX IX

OKL 2382/452

Luftwaffe Operations Staff

SECRET

A-3 Division

Study of the

Operational Potentialities of the Composite Aircraft

1. The commitment of "Mistel" (composite aircraft) is planned against enemy naval forces. Tests carried out to this date lead to the expectation that battleships and aircraft carriers could be sunk if direct hits are scored.

The technical data concerning the commitment of composite aircraft are enclosed as Appendix I, which consists of a verbal report transcript by a technical staff officer of the A-3 Division.

2. After all preparations have been brought to their conclusion and the pilots have been retrained, immediate employment of the weapon is suggested. In the event of enemy large-scale landings the composite aircraft would not benefit from any more favorable operational conditions because the enemy capital ships would remain beyond the range of German aircraft weapons and would probably not intervene in the landings proper. For this reason the idea of postponing the commitment of the weapon in order to preserve the element of surprise for such an event would appear to be

inexpedient. ~~xxxxxxxxxxxx~~ The longer the employment of the weapon is delayed, the more oppoertunities will the enemy have to take defensive measures, especially since absolute secrecy cannot be guaranteed.

3. Among thevarious ~~possibilities of employment~~ -- see Appendices 2 and 3 -- the following deserve to be mentioned as the most promising:

Gibraltar and

Scapa Flow; in addition

Leneingrad (The Russian Fleet).

The advantage of the first two targets is that they can be reached from the continent of Europe and that therefore the displacement of the weapon by sea transport need not be effected.

The commitment against Gibraltar can be envisaged from such locations as Rennes (western France), Toulouse (southwestern France), or Istres (southeastern France). The distances to be covered would vary from 650 - 790 miles. This can be bridged, if modifications for penetrating 820 miles are carried out. Spanish territory would have to be crossed over.(This has hitherto been refused by the Fuehrer.)

At the target interference by strong antiaircraft fire and fighters stationed at the local airfield would have to be expected. Because of the significance of the base one must also expect a fully operational radar network. Even so, however, one can count on a certain degree of surprise at Gibraltar, more than anywhere else. (This would be the first attack.)

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The naval base at Scapa Flow is at 485 miles' distance from the Grove airfield; it could be reached by attaching an additional fuel tank to the Bayrische Flugmotorenwerke 109 model.

The maximum defensive measures are to be expected in the target area. No exact data on this matter are available because the German radio intercept range does not go beyond The Wash. The intelligence officer considers it likely, however, that the fields from the Firth of Forth to the northern coast of Scotland would be held by about 160 - 200 aircraft of the Spitfire, Hurricane, Mosquito, and Beaufighter models.

One also would have to take into account a belt of radio direction finding sets that would cover the air above the ocean completely.

At Leningrad the situation would be similar: maximum defense and little, if any, element of surprise possible.

4. Execution

a. In carrying out the operation one must ~~attempt~~ make every effort to disgusie the composite aircraft from enemy radar screens for as long a period as possible so that the fighters will no longer become effective.

No escort by German fighters will be feasible because the mission goes beyond their range (Stavanger - Scapa Flow is a distance of 320 miles). Flights in bad weather and hours of darkness are not feasible. For this reason, combined attacks of bomber and aerial torpedo units or high-altitude flights are out of question.

The only possible way of approaching the target is therefore at the lowest level with maximum delay in pulling up before reaching the target and then attacking in a glide.

The number of composite aircraft to be employed will depend on intelligence reports of the ships present in the target area.

b. To find the target one must combine the systems suggested in Appendix 1, Number 2. and b. One must make use of the position of the sun, and at the same time pass with the composite aircraft outside the radar range of the radio buoy "Swan" (Since the range of the "Swan" is 50 miles, this could occur only if compound navigation was used at heavy storm drifts.)

c. A reconnaissance must precede the operation that is to say the position of the targets must be established by some other means of navigation. The crews must be able to approach their targets directly on the basis of aerial photographs on which the position of the ships is marked. It is not possible to search for targets upon reaching the naval base only.

d. It is suggested that the IX Air Corps be given the mission of carrying out the attacks.

(signed) von Greiff

Since Gibraltar could be reached only by flying over Spanish territory -- up to now the Fuehrer has always refused to give his permission for any such action -- and the prerequisite for achieving surprise for an attack on Lenigrad did not exist, ~~Scapa Flow was the only remaining possibility~~.

~~Suggestion~~
Recommendation: That preparations be made for an attack on Scapa Flow.

(signed) Christian
certified by
(signature illegible)

* * * * * * * * * * * * * * * * *

Luftwaffe Operations Staff
Operations Branch
Technical Staff Officer

Appendix 1
dated 16 April 1944

~~Verbal Report Transcript~~

~~Subject~~: Technical Data for Composite Aircraft Operations

1. ~~Depth of Penetration~~ or ~~Radius of Action~~: 250 - 310 miles, normally;

470 - 500 miles, if an additional 75-gallon fuel tank is attached to the Bayrische Flugmotorenwerke model 109. The addition of of a fuel tank requires few changes in the fuel lines.

There is apparently a requirement for a range of almost 900 miles, for which purpose the fighter aircraft need not return to the point of origin. (Gibraltar ?) The technical aspects of thus extending the range cannot be clarified without major tests because the carrying of additional fuel will result in a major shifting of the center of gravity.

Take-off Distance: 4,000 feet, required length of runway about 4,600 feet by a widthe of 200 feet.

Average speed en route: about 240 - 250 miles per hour.

~~Maximum speed~~: about 280 - 300 miles per hour.

Decisions have to be made whether

a. A modification for an additional fuel tank should be carried out;

b. Calculations regarding a radius of action of 900 miles should be undertaken.

If a decision regarding point a. is made immediately, there will probably be no delay in flying the mission.

2. ~~Navigational Matters (geared to low-level flight)~~

a. Built in: Three-dimensional control in the Junkers 88 and radio set 16 Z in the Bayrische Flugzeugwerke 109.

~~Resulting Capability:~~ on Very precise course-flying and approach with radio set 16 Z toward radio buoy "Swan" (Range 50 - 60 miles at a flight altitude of 660 feet).

b. Addition of long-wave receiver set Radione so that the sun's position can be fully utilized, for instance at Stavanger and Marseille.

c. The most advantageous solution seems a combination of both systems. For the return flight one can either use emergency DF ~~xxxx~~ for approach flight toward the sun or radio set 16 Z for communication with a ground station transmitter 16.

d. If these means of navigation should malfunction , guidance by a rapid pilot aircraft remains as an emergency solution (Junkers 188 with a radio set 16).

e. The decision has to be made which system is to be added to the aircraft.

3. ~~Attack Methods~~:

The technical minimum release altitude is 165 feet, the most favorable glide angle for the Junkers 88 is 20 degrees so that an approach flight to the immediate vicinity of the ship is essential.

According to existing experience the following operation is considered as the most effective:

Release altitude of 2,310 feet at 1.2 miles distance from the target. The glide angle for the Junkers 88 should be 20 degrees and the speed 345 - 375 miles per hour.

The deviation caused by the Junkers 88 in this process amounts to 60 by 60 feet.

An attack on battleship would therefore be carried out best by approaching diaganally from the rear.

As sighting devise it would be best to use a gyroscopically supported sight (wind elements of the TSA (???)).

4. ~~Time Schedule~~:

a. On 18 April drop at Moenglind, after that retraining of pilots to accustom them to the V-1 and V-2 models.

b. On 15 June the remaining 13 aircraft would probably be completed.

A prerequisite for adhering to the schedule would be that the 45 persons presently available for carrying out the project -- 21 military and the rest civilian technicians -- would continue to be available. General T.T. intends to reassign the 21 men for the purpose of activating a field repair shop detachment, with replacements being made available apparently. The exact data will not be furnished until after the Easter holidays.

Meanwhile 35 men will be transferred to the 2d Squadron of the 101st Bomber Wing, from there they will be attached to Nordhausen.

5. For every aircraft there is one transfer cupola for the transfer flight by ground vision and without radio set; two hollow-charge objects are also available.

To detach the transfer cupola and mount the hollow-charge objects, 6 aircraft mechanics and 2 bomb experts will be needed for one day's work; 3 of these men can be taken along when the Junkers 88 is transferred.

Few tools are needed, and those can be taken along by each man. Essential is only one crane with a hook elevation capacity of 25 feet and a lifting capacity of about 4 tons.

6. <u>Training of Pilots</u>

Target flight training will be carried out with one pilot each for the Bayrische Flugzeugwerke 109 and the Junkers 88. Until now the approach flight was carried out with the help of one anti-aircraft search light which was simultaneously utilized to obtain precise data on the glide angle and the distances involved. It is considered necessary that the following practice flights be executed:

10 approach flights without separating the control airplane from the missile; and

3 approach flights with such a separation.

7. The tests will be carried out by the 2d Squadron of the 101st Bomber Wing, commanded by Capt. Rudat. It is recommended that the operation be put under the control of the IX Air Corps headuqarters, particularly since General Peltz has personally been instrumental in suggesting the composite aircraft concept.

(signed) zur Muehlen

certified correct by

(signature illegible)

APPENDIX X

PHOTOGRAPH OF A COMPOSITE AIRCRAFT

Text: "Mistel" (composite aircraft)

"Huckepack" (pickaback aircraft)

"Vater und Sohn" (parent-child or duplex arrangement)

~~APPENDIX XI~~

PHOTOGRAPH

(Showing City of London with St. Paul's Cathedral)

Text: Effect of the German retaliation attack of 28 - 29 December 1940 on the City of London.

(The attack was ordered by Hitler because the Royal Air Force had attacked Berlin during the Christmas holidays.)

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APPENDIX XII

PHOTOGRAPH

Text: Effect of a V-I Bomb on London

A block of small houses in Poplar, a suburb of London, was practically wiped out by a flying bomb, which caused a flat crater.

(Extracted from the American official magazine *Impact*, No. 8, August 1944.)

APPENDIX XIII

PHOTOGRAPH

Text: Dive bombing attack on ships of a Russian convoy.

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APPENDIX XIV

~~Selection of the Proper Types of Bombs for Operations~~

(Letter Directive of Reich Marshal Goering No. 5663/41, class. Secret, dated 16 February 1942)

~~Teletype Message~~
Sent by Reich Marshal, Secret

16 February 1941
0215

From Robinson:

To be disseminated to subordinate agencies down to wing headquarters inclusive:

Despite many instructions and the issuance of directives and regulations pertaining to the use of various types of bombs for operations, I must discover again and again that ~~the~~ many responsible headquarters do not follow my orders.

I therefore order that in future my directives be obeyed in the strictest manner. The knowledge of the effect of weapons, that is to say the acquaintance with the effect of each individual type of bomb and fuse is absolutely essential and is an important pre-requisite for achieving success. Every unit commander down to the level of group commander must be thoroughly acquainted with every detail and he in turn must see to it that maximum effect is obtained by the proper utilization of bombs and fuses. It is

NECESSARY THAT one considers before every operation which bombs and what tyming of the fuse is the most suitable for the various targets that are to be hit. Of particular importance, however, is the question that has to be answered before each operation, which is whether the target should be attacked with 1,100 or 2,200 lbs bombs or with even heavier ones.

I have had the displeasure to observe that lately these highly valued, very heavy bombs were dropped on secondary targets, even when these were not alternate points.

It is completely wrond to use 1,100-lbs bombs and heavier calibers for attacks on enemy airfields. Enemy airfields should be attacked primarily with 110 lbs SD and ~~XXX~~ SC bombs or with 2.2 and 4.4 lbs incendiaries.

The 550-lbs bomb should be used as additional ~~wep~~ weapon only if strongly constructed objectives are also to be attacked, such as strong hangars or warfts. For low-level attacks on such targets I would like to draw special attention to the newly produced 550-lbs bombs.

For low-level attacks on manufacturing plants and similar installations one should also use the 550-lbs bomb that was especially produced for low-level attacks on such objectives. In special cases heavier bombs might be considered as more appropriate.

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One must always take into consideration that the chances of creating damage are greater if six 550-lbs bombs are used that if that attack is made with two or just one heavier bomb. The very heavy bombs of 2,200 lbs and more are to be used mainly for concentrated attacks on large targets, such as important plants. The number of very heavy bombs to be dropped will depend on the over-all total ratio of aircraft and bombs that can be committed; even so they will have to be dropped only by the very best available crews. The very heavy bombs otherwise will be dropped only on special targets, above all warships, fortifications, etc. It is therefore essential that the equipped condition of the wings be examined particularly in view of readjusting all planes that are especially equipped to carry only individual very heavy bombs.

The units of the IX Air Corps are available for dropping very heavy bombs, its aircraft ~~xxx~~ having been specially equipped for this purpose for their mine laying activities. The other units are to be reorganized for carrying bombs of lower caliber, mainly 110 and 550-lbs. One must furthermore see to ~~xx~~ it that the equipped condition of the other units be such that they can carry the maximum payload of 550- and 110-lbs bombs and above all incendiary bombs. Every care must be taken to adjust the equipped condition of these aircraft in such a manner that no space or weight capacity for carrying bombs is wasted.

When preparations for important attacks are under way and special bomb loads are required, it might occasionally be necessary to take upon oneslef the additional work and inconvenience of switching bomb loads rather than flying the mission with loads that do not guarantee maximum exploitation of the successful operation.

The commanders-in-chif of air fleets and air corps will be personally responsible to me for pre-planning the most promising bomb loads of units prior to large-scale attacks. They have to issue the orders for proper bomb load combinations.

The directives issued to this effect must be discussed over and over again with the crews. I ask all commanders to check on that matter during their staff visits and inspections.

The proper setting of fuses can be of decisive importance for attacks on naval targets and low-level attacks. Frequently heard reports such as "The effect was not observed" are attributed by me to the failure of bombs because of wrong setting of fuses or bad servicing before release.

I reiterate my previous requests to air fleets and corps headquarters to give me detailed reports on all their experiences made during the dropping of bombs and to send directly to me any valuable hint they have uncovered. Individual units cannot keep such information to themselves as if they took patents on their ideas. Instead, every new idea must become the common knowledge of the entire Luftwaffe at the earliest possible moment.

In future also I intend to reexamine continually the bombing operations and I hope that there will be no further reason for finding deficiencies. The units must be told again and again that proper knowledge of the effect of their weapons is a basic prerequisite for success.

(signed) GOERING, Reich Marshal

No. 5663/41

classified secret
military document

APPENDIX XV

~~Training of Flying Units in Wartime~~ (Unit Training)

(Extracted from conference notes No. 16 of a speech made by Reich Marshal Goering in Paris on 14 March 1941.)

"The generals commanding air corps must be constantly on the move. It is their duty to keep a continual check on the operational readiness, target preparations, general awareness of the effect of weapons, implementation of security regulations, and the care and welfare of personnel. They must keep in mind that they are not infantry corps commanders: they have much fewer people under their command. Our combat means are very high-grade. The commitment of a squadron or even one airplane can have far greater results than the employment of a company or a battalion. They must also be aware of the fact that they are responsible for the use of very valuable, highly technical arms. For this reason continual indoctrination and review are essential. Staff visits should not be used to inspect but to attend routine duty performance, to indoctrinate, and to improve the training status steadily. At least four days a week should be devoted to this purpose.

In addition to the corps commanders, the wing commanders should make every possible effort to improve training and

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raise the general level of ability.

The decisive elements in exercising proper leadership are:

1. Operational strength;

2. Target preparations;

3. Acquaintance with weapons and their effect; and

4. Security implementation.

I regret that I have to check on staff visits in the field."

* * * * * *

"During the bad-weather periods that recur constantly, the unit commanders should be called together for detailed refresher courses for which all air corps commanding generals should use every instructional means at their disposal."

* * * * * *

On 18 March 1941 the Reich Marshal stated as follows at The Hague:

"The proper knowledge of weapons, their possibilities of employment, and their effect are my special hobby horses. In an effort to achieve optimum effect on every occasion, special bombs and fuses had to be developed for specific purposes. Only their detailed knowledge will bring about their proper use. Acting upon my orders, the inspector of bombardment of aviation has issued orders that map exercises are to be held with regard to the utilization of weapons, effective immediately. These exercises have the purpose of demonstrating to the field forces all possible methods of utilization of their weapons with the help of practical examples. I attach the greatest importance to these map exercises and I shall check on their progress whenever I make staff visits in the field. The new directive on bombing must become common knowledge of every unit commander and all crew members."

* * * * * * * *

TABLE I

Mission:

To Combat the Enemy Aviation	Weapons Available at the Outbreak of War	Newly Developed Weapons during Wartime
a. Tagets in the Air (Only weapons for combat in the air and not for defense from the ground are taken into account)		
Individual Aircraft of All Types	Aircraft Armament	Aircraft Armament
Reconnaissance planes	Machinegun 15 (7.9-mm)	Automatic Cannon 108 (30-mm)
Fighter aircraft	Machinegun 17 (7.9-mm), fixed position	Automatic cannon 213 (20-mm) Automatic cannon 214/a (50-mm)
Bomber aircraft	20-mm machine gun Oerlikon	Automatic cannon 112 Automatic cannon 114
Close Bomber Formations		Aircraft Armament see above Rockets 210-mm aircraft demolition rocket round billet Fighter bazooka Bombs S.D.2 with time fuse Controlled Bombs Hs 293 (A) Hs 298 X 4 Special Combat Means Towing rope towing rope with attached bomb.

TABLE II

Mission:

To Combat the Enemy Aviation		Weapons Available at the Outbreak of War	Newly Developed Weapons during Wartime	
b. Targets on the Ground				
Aircraft	On the Edge of the runway distributed in the terrain	S.D. 10 (1933) S.D. 50 (1938) B.1 E (1933)	S.D.2 (1940) S.D.1 (1942) B.2 E (1941) see above	) In aerial containers with 154, 550, and 1,100 lbs capacity
	in blast bays	S.D.10 (1933) B 1 E (1933)		
	in blast bays with protective roof	S.C. 50 (1933)		)
Aircraft hangars	above ground	S.C. 50 (1933) S.C. 250(1933)		
	underground		P.C.1000 R.S. (1941)	
Repair shops		S.C. 50 (1933) S.C.250 (1933)		
Supply Dumps				
	POL dumps	B 1 E (1933))mi- S.C. 50 (1933))xed	Flambo C 250 (1940) Flambo C 500 (1940) Brand 10 (1943) Brand C 50 (1943) Brand C 250 (1943)	
Ammunition Dumps				
	Spare parts depots	S.C. 50 (1933) S.C. 250 (1933)		
Aircraft Plants	all types -- See Table V			
Communications Facilities				
	Signal centers, in the open	S.C. 50 (1933)		
	in the open	S.C. 250 (1933)		
	in shelters	S.C. 250 (1933)		
	radar stations	S.D. 250 A (1939)		
Airfields	Runways	S.C. 50 (1933) S.C. 250 (1933)	) Only for contamination) S.D.2 (1933) with delayed action fuses	

TABLE III

Mission:

To Support the Ground-Forces	Weapons Available at the Outbreak of War	Newly Developed Weapons during Wartime
a. Targets in Motion		
Advancing infantry in loose formation	S.D. 10 (1933) S.C. 50 (1933)	S.D. 2 (1940) S.D. 1 (1940)
Vehicles of all types	S.D. 50 (1938)	S.D. 9 (88-mm explosive shell (1943) S.D. 15 (105-mm explosive shell (1943)
Tanks		Improvised Measures S.B.E.50 (1940) Aircraft Armament Aut. cannon 101 (30-mm) Aut. cannon 103 (30-mm) 37-mm aircraft cannon 50-mm aircraft cannon 75-mm gun (for testing purposes) Rockets Panzerschreck (portable antitank rocket) Panzerblitz I (antitank rocket) Panzerblitz II (id.) Panzerblitz III (id.) Bombs S.D.4 H.L. (1942)
Columns of all types	S.D. 10 (1933) L.D. 50 (1938) S.C. 50 (1933)	S.D. 2 (1940) S.D. 1 (1940) S.D. 9 (1943) S.D.15 (1944)

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TABLE III (Cont'd)

b. Immobile Targets	Weapons Available at the Outbreak of the War	Weapons Developed during the War
Troops, Entrenched		
Infantry in foxholes and trenches	S.D.10 (1933) S.C.50 (1933)	S.D.2 (1940) S.D.1 (1942)
Machine gun, mortar, and trench mortar positions		
Artillery gun positions		
Lightly built bunkers	S.D.250 (1933)	
Fortifications of all Types		
Concrete bunkers	S.C.250 (1933)	S.H.250 with rocket propulsion (hollow-charge bomb)
Fortifications	S.C.500 (1933)	
Command Posts		
Buildings	S.C.250 (1933)	
Underground installations		
Communications centers of all types	S.C.250 (1933)	
Depots and dumps		
POL dumps		
Ammunition dumps		
To Affect the Morale of Live Targets		Flam C 250 (1940) Flam C 500 (1940)

TABLE IV

Cooperation with the Navy or Aerial Combat above Sea	Weapons Available at the Outbreak of War	Weapons Developed during Wartime	
Mobile Targets:			
Warships			
Older-type battleships (130-mm armor-plates)		P.C.1400 (1940)	High-level and dive-bombing attack
Modern battleships (180-mm armor-plates)		P.C.1600 Mistel S.H.1 (1944)	High alt. & dive bomb att.
Battleships 30,000 tons		P.D.500(1943)	high alt.
		P.C.1400(1942)*	high alt.
		Mistel S.H.1(1944)	
Battleships up to 35,000 tons		P.C.500 R.S. (1940)	dive-bomb attack
		P.C.1000 R.S. (1941)	dive-bomb attack
		P.C.1800 R.S.	dive att.
		P.D.1000 (1943)	high alt
		MistelS.H.1 (1944)	
Battleship 50,000 tons		P.D.2500*	high-alt.
		Mistel S.H.1 (1944)	
Aircraft carrier (100-mm armor-plates)		P.C.1000 R.S. (1941)	high alt. &dive b.
Auxiliary Aircraft carrier		Mistel S.H.1 (1944)	dive-b. attack
Heavy cruiser	S.C.250* (1933) S.C.500 (1935)		
Destroyers and torpedo boats	S.C. 250* (1933) S.C. 500 (1935)	P.C.500 (1940)	high alt. & dive b.
Speed boats	S.C. 250* (1933) S.C.500 (1935) S.C. 250* (1933)		

* Filled with trichlorethylene

	Weapons Available at the Outbreak of War	Weapons Developed during the War
Commercial Ships		
Ships Tankers	S.C.250 (1933) with trichlorethylene S.C.500 (1935)	
Moreover, all targets on the seas could be attacked with aerial tordepodoes	L.T.5 (1939) which were available for this purpose	
Immobile Targets		
Naval Bases		
Docks Locks ~~XXXXX~~ Wharves Depots Loading and unloading points	S.C.250 (1933) S.C.500 (1935)	S.C.1000 (1940) S.C.1800 (1940)
Commercial Ports		
Locks Warehouses Cranes Landing points	S.C.250 (1935)	
Prevention of movements by mining of port entrances	L.M.A.500 (1936) L.M.B.1000 (1936) with magnetic remote control fuses	The same weapons as those listed in the column on the left were developed with accoustic and mine- remote control fuses.

TABLE V

Mission: Disruption of Lines of Communication to Cut the Flow of Support to the Front or to Cut the Supplies of Essential Military Installtions and Facilities	Weapons Available at the Outbreak of War	Weapons Developed during the War
a. Railroads		
Rolling Stack		
Locomotives		
Railcars		
Trains		
Fixed Installations		
Tracks		(S.C. 55 nose-spike bomb (S.C.255 nose-spike bomb
Manmade structures		
Stations		
Locomotive hangars		
Repairshops		
Power and transformer installations for supply of electrified railroads		
Water supply facilities		
b. Waterways		
Ships of all kinds		
Canal beds		
Manmade Structures		
Bridges		
Locks		
Ship-lifting devices		
Port Installations		
Warehouses		
Wharves		
Relings		
Docks		

	Weapons Available at the outbreak of War	Weapons Developed during the War
c. Roads		
Roads particularly		
Embankments		
Defiles		
Crossings		
Entrances and exits to and from localities		
Manmade Structures		
Bridges		

TABLE VI

Mission:

Attacks on Natural Resources and Industrial Potential of the Enemy Armed Forces	Weapons Available at the Outbreak of War	Weapons Developed during the War
a. Against the Productive Capacity:		
Centers of Production of Raw Materials		
Mines of all types) Oil wells)	S.C.250	
Transformation of Raw Materials		
Blast furnaces Smelting works Steel and rolling mills	S.C. 50 (1933) S.C.250 (1933) B 1 E (	Flambo C 250 (1940) Flambo C 500 (1940) Brand 10 (1943) Brand C 50 (1943) Brand C 250 (1943) C 50 (Combined explosive and incendiary bomb (1941)
Manufacturing Facilities		
Machine tool factories of all types		
Plants Producing Weapons and Carriers of Same		
Rifle and gun factories Plants producing armored weapons Aircraft factories Engine producing plants Torpedo factories Motor vehicle production plants		
b. PowerSupply		
Electricity Supply		
Electricty works) Power plants using water) to produce energy)		Aerial Mines
Dams) Transformers) Power Transmission lines) Trellis masts)	S.D.250 (1933) S.D.500 A (1939) S.D. 50 (1933) S.D.500 A (1939)	Winter balloons Summer balloons Rope bombs

	Weapons Available at the Outbreak of War	Weapons Developed during the War
Gas Supply		
Gas works)		
Gas container)	S.D.250 (1933)	
Gas pipe lines)		
Water Supply		
Pumping stations)		
Water reservoirs)	S.D.250 (1933)	
Dams)		
c. Preventing the Importation of War Essential Supplies, Particularly Food Items		
Ships		
Port Installations		
Granaries	S.C.250 (1933)	S.C.1000 (1941)
Warehouses	S.C.50 (1933))mix-	Flam C 250 (1940)
	B.1.E. (1933))ed	
		Flam C 500 (1940)
		C 50 (1941) Combined explosive and incendiary bomb
Cold storage facilities		
Major Transformation Plants		
	S.C.250 (1933)	S.C.500 (1935)
Large flour mills	S.C.250 (1933)	S.C.500 (1935)
	S.C.250 (1933)	S.C.500 (1935)
Suggar refineries	S.C.250 (1933)	Flam C 250 (1940)
	B.1.E. (1933)	Flam C 500 (1940)
	S.C.250 (1933)	
	S.C.250 (1933)	
Accessory Plants such as		
Crank shaft factories	See Table III	See Table III
Ballbearing plants		
Optical Instruments		
Major Supply Installations		
Oil and gasoline dumps	S.D. 250 (1933)	
Plants Displaced Underground		
	S.D.250 (1933)	

TABLE VII

Mission:

To Attack Military Installations and Facilities in Cities and to Launch Retaliation Attacks	Weapons Available at the Outbreak of War	Weapons Developed during the War
Government and Administrative Centers		
Government buildings	S.C.50 (1933)	
Postal and Telegraph buildings	S.C.250 (1933)	
Radio transmitter stations		S.D.500 A (1939)
Radio stations		
Radio towers		S.D.500 A (1939)
Military Replacement Centers, etc.		
Staff headquarters Garrison and barracks facil. Military schools Military research and testing facilties	S.C. 50 (1933) S.C.250 (1933)	
Retaliation Attacks on Cities		
Inhabited Districts	Bombs	Bombs
(Supply installations, see Appendix V)		
	S.C. 50 (1933) S.C.250 (1933)	S.C.1000 (1940) B.M.1000 (1941) S.C.2000 (1943) S.C.1800 (1940)
		High-Charge Bombs
		S.B.2500 (1941) S.B.1000 (1941)
	Aerial Mines	Aerial Mines
	L.M.A.500 (1936) L.M.B.1000 (1936)	Employed for the first time in 1940 for this purpose with emergency fuses
	Incendiary Bombs	Incendiary Bombs
	B.1.E. (1933) B.1.3.E (1933)	B.2.E.Z. (1941) Brand 10 (1943) Brand C 50 (1943) Brand C 250 (1943) Scatter bomb C 500 (1941)
Subterranean large air raid shelter using subways and tunnels as shelter areas		P.C.500 Rs (1940) P.C.1400 (1940)

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