OP 1666

GERMAN EXPLOSIVE ORDNANCE

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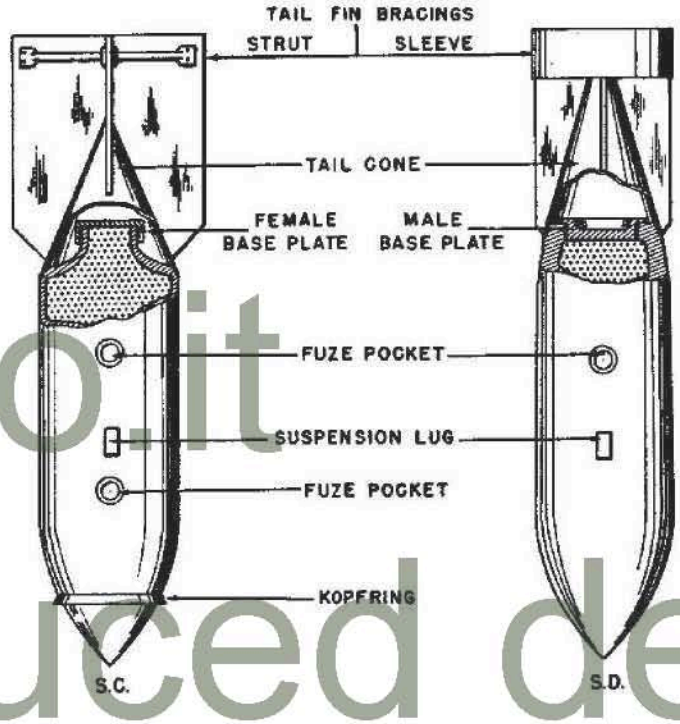

Figure 1—Bomb Component Positions

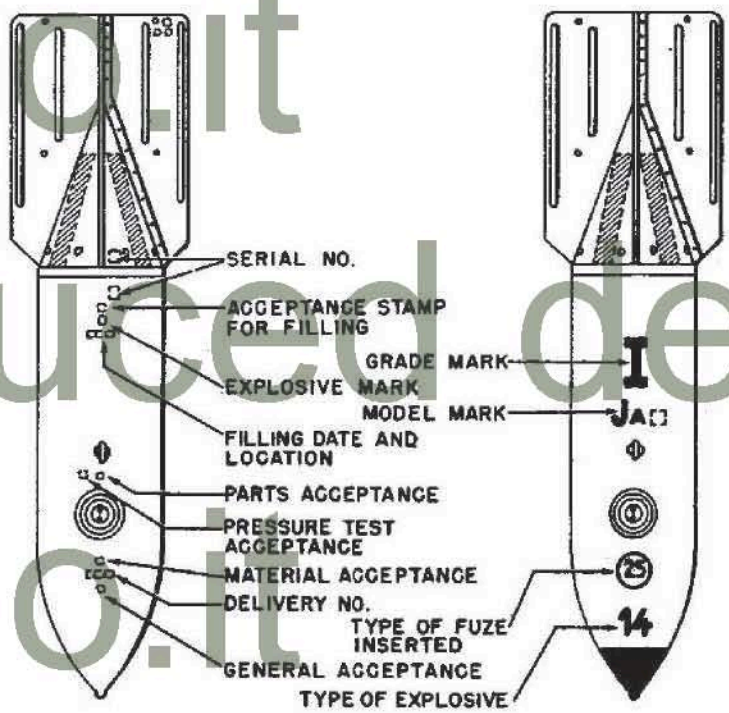

Figure 2—Paint Markings and Stampings

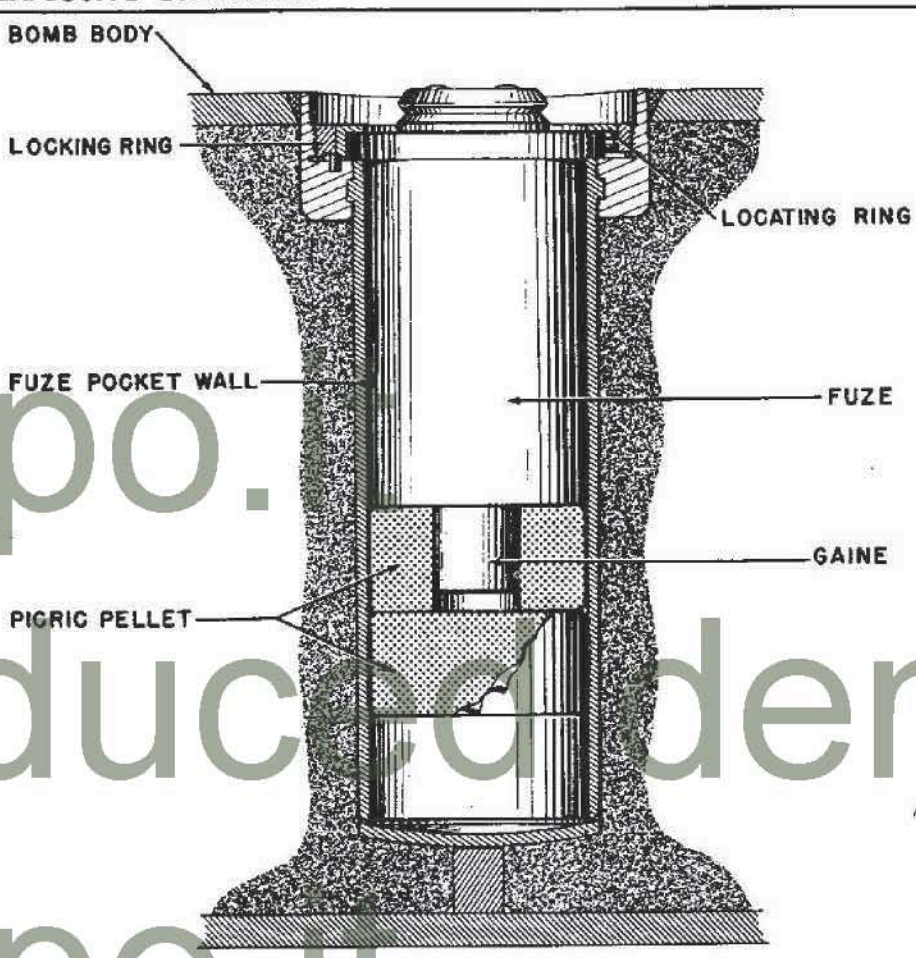

Figure 3—Fuze Pocket In Bomb

The PC or armor-piercing bombs are used primarily against ships and fortifications. They are fuzed with a short delay for penetration. PC bombs are slightly streamlined with a heavy hose and thick walls. The thickness of the walls decreases toward the base of the bomb. They are made of cast steel and the nose is specially hardened. PC bombs have a loading factor of approximately 20 percent and are filled with a TNT wax mixture. PC bombs may be identified by the presence of dark blue paint on the tail cone. PC bombs have been used as SD's for fragmentation and fuzed instantaneously; if so, the dark blue may be over-painted with red.

The PD is even more exclusively armor piercing. Bombs are thinner, longer, have thicker case and a lower loading factor.

BT. The BT (bomben torpedo) was put into production during the last 2 months of the war, but was never used operationally. It is designed along the lines similar to a torpedo except for the after section where there are three large tail fins. The missile has no propulsion except that induced by gravity and the forward motion of the mother aircraft.

SA 4000 (Experimental) is a very large high capacity bomb. The loading factor is about 80 percent. It was never used operationally against the allies.

Misc. Plane Destroying Bombs. The aircraft towed paravane bomb is a small 2-kg bomb towed by a plane. The plane destroying bomb is a small charge with a pull type igniter and safety fuze.

Coloring

Bombs which are carried in internal bomb racks (up through 500 kg) are usually colored dark green. Bombs which are carried in external bomb

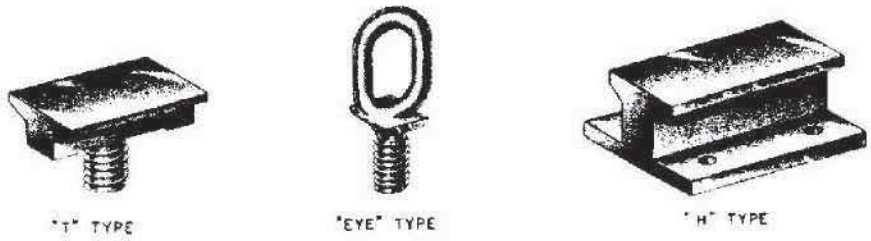

Figure 4—Suspension

racks (1,000 kg and over) are usually colored sky blue. Color may also be controlled by the conditions of the bomb stowage. Aluminum, tan, buff, etc., are colors that may be used.

Typical Bomb Explosive Train

The fuze is located in an athwartship fuze pocket extending the full internal diameter of the bomb. (See fig. 3.) The fuze is usually held in the top of the fuze pocket by a locking ring and a locating ring. Threading into the bottom of the fuze is a steel case called the gaine. The gaine is filled with a P. E. T. N.-wax mixture. A small pellet of lead azide and lead styphnate mixture is positioned in the top of this gaine. These pellets may be of granular TNT. In bombs with powdered fillings, a column of granular TNT pellets is placed longitudinally in the bomb adjacent to the fuze pocket.

Tail Construction

Two tail types are used. The first type, a sheet steel tail, is usually made in four pieces to form a cone with four fins. The fins may be unbraced, braced with tubular struts, or braced with a cylindrical strut (ring). The second type is of magnesium alloy. The cone and four fins are cast in one piece. The fins may be braced with a cylindrical strut of the same material.

Suspension

Bombs up to and including some of the 500 kg types can be suspended either horizontally or vertically. (See fig. 4.) The remaining 500's and all larger types are suspended horizontally. All vertical suspension is by an eyebolt threaded into the nose of the bomb. Horizontal suspension is by an eyebolt for the 50 kg series, either an eyebolt or a threaded T-type lug for the 250 kg and 500 kg series, and by means of an H-type lug for the larger series bombs. The H lug is secured either to a carrying band or directly to the bomb body. The SC 1000 and SC 1200 type bombs have been using a U bolt secured to the carrying band on the latest models.

Kopfring

Kopfrings (nose rings) are sometimes fitted to the nose of SC bombs to prevent excessive penetration against land targets and to prevent ricochet against sea targets. (See figures 5A and 5B.) Kopfrings may also be found on the SD 70 and SD 1700 bombs when they are used against above-mentioned targets.

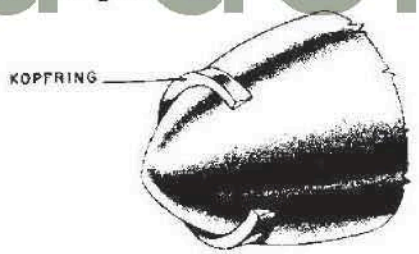

Figure 5A—Kopfring

Figure 5B—Kopfrings

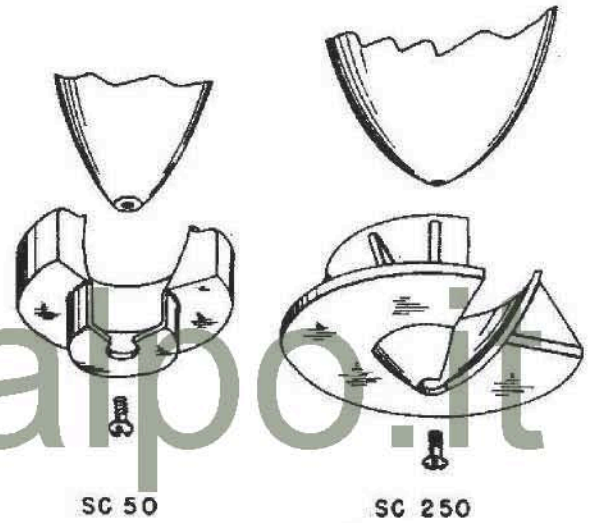

Figure 6—Antiricochet Plates

Antiricochet Plates

The antiricochet plates are used for the same general purpose as the kopfring but are entirely different in construction. Type I, which is used only on the SC 250 kg bombs, is constructed of a conical cup and a dished plate welded to it. (See fig. 6.) The conical cup is of $\frac{3}{16}$ inch steel and designed to fit as a sheath over the nose of the bomb. A dished plate, 10 inches in diameter, fits over the cup and is welded to it. Eight stiffening ribs, also of $\frac{3}{16}$ inch steel, are welded between the plate and the cup. The entire assembly is attached to the nose of the bomb by means of a threaded bolt which passes through a hole in the apex of the cone.

Type II is used on the SC 50 kg bombs. A circular plate, $5\frac{3}{4}$ inches in diameter and $\frac{15}{16}$ inch thick, is machined conically to fit over the nose of the bomb. Welded to this plate is a circular cup, $2\frac{11}{16}$ inches in diameter and drilled centrally to take a bolt for securing the entire assembly to the bomb.

Dinort Rods

Dinort rods are secured to the nose of the SD type bomb and used to obtain a "daisy cutter" effect on impact. There are two types: steel rods and wood rods. (See fig. 7.)

STEEL ROD. The rod consists of a drawn steel tube with a circular steel plate welded to the base and a steel cup welded to the top. A threaded lug is welded to the upper end of the tube and passes through a hole in the cup. This lug screws into the suspension lug socket at the nose of the bomb.

STEEL RODS

	SD 50	SD 70	SD 250	SD 500
Length of Rod	23.6"	23.6"	14.8"	14.8".
Diameter of Rod	1.75"	1.75"	2.75"	2.75".
Diameter of Plate (base)	4.7"	4.7"	9.45"	12.6".
Diameter of Cup (top)		3.6"	5.5"	

WOODEN ROD. The rod consists of the square, center stick with two square pieces of wood nailed to the base. Two U-shaped steel plates welded together, are secured to the upper end of the main member by light woodscrews. A bolt, welded to the plates, is threaded to screw into the nose suspension lug socket at the nose of the bomb.

WOODEN ROD

Over-all length	22.6"
Width of center section	2.25" (square)
Width of base	Smaller piece 4" (square); Larger piece 4.25" (square)

Figure 7—Dinort Rods

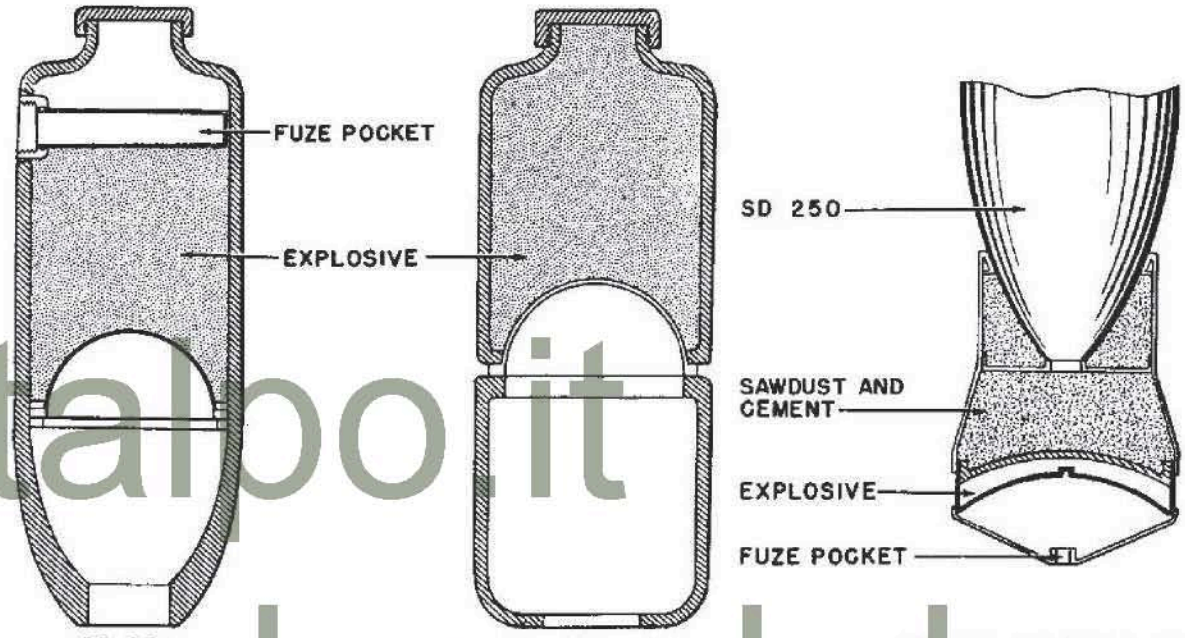

Figure 8—SD and H.L. Hollow Charge Bombs

SD AND HL HOLLOW CHARGE BOMBS HOLLOW CHARGE NOSE DEVICE

CONSTRUCTION. In SD 250 bombs having a hollow charge, the cavity is semicircular in section. The cavity in the SD 500 is a truncated cone, the larger diameter being 30 cms and the smaller diameter, 11 cms. (See fig. 8.)

The H. E. charge has a metal lining for the cavity which is supported on a flange and in order to permit the formation of the jet, the flange is located at a distance from the nose of the bomb of approximately 1.5 times the diameter of the cavity. The opening at the nose of the bomb is approximately 5¼ inches.

The 250 H. L. will penetrate 35 cms of armor plate. The 500 H. L. will penetrate 62.5 cms of armor plate or 350 cms of concrete. The performance figures for the 800 H. L. are not available but it appears that with an H. E. charge of 110 kg it was hoped to penetrate 100 cms of armor or 6 meters of reinforced concrete. They are generally filled with amatol 50/50 or 60/40.

The special nose device for use with SD 250 bombs consists of a hollow charge which is to be attached to a bomb of standard type. This charge which weighs about 4 kg is detonated by its own fuze located in the nose of the device. In order that detonation of hollow charge shall not damage the bomb, the space between the charge and the bomb is filled with a mixture of sawdust and cement.

REMARKS. Details of these types were obtained from documentary evidence only.

The SD hollow charge bomb proved disappointing in performance and modifications were made which resulted in the production of the H. L. type of bomb.

The special nose device for the SD 250 obtains greater penetrating power from low altitudes. It produces a hole in the armor through which bomb can pass. Bomb has a short delay fuze so that detonation of bomb will occur inside the target. Documents state that such a bomb will penetrate 7 cms of armor plate.

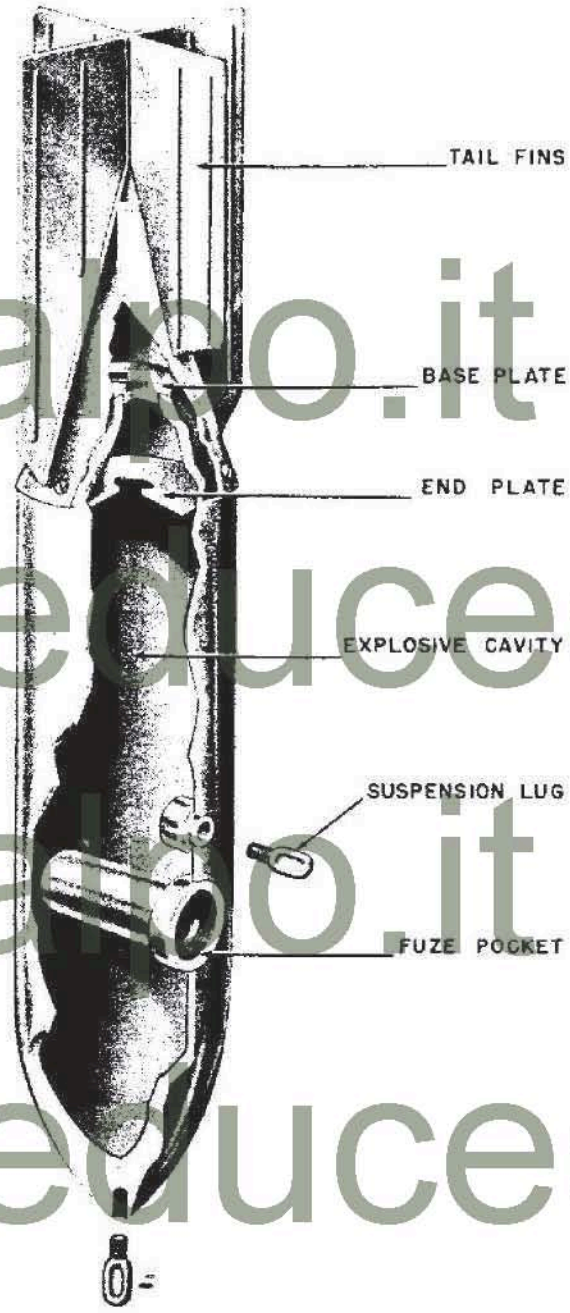

Figure 9—SC 50 Bi Bomb

SC 50-kg Bi

DATA:
Over-all Length: 46.1 in.
Body Length: 30.0 in.
Body Diameter: 7.9 in.
Wall Thickness: 2.0 to 2.6 in.
Tail Width: 11.0 in.
Tail Length: 16.1 in.
Filling: Cast TNT, Amatol or Trialen.
Weight of Filling: 24.4 kg.
Total Weight: 55.5 kg.
Charge/Weight Ratio: 45.75%.
Fuzing: Series 5 or 8.
Color: Dark gray or green over-all.

CONSTRUCTION. The Bi is a one piece cast steel body machined down. All the fittings are welded in place. It is very similar to the Ja and L Series.

The bomb is threaded at the base to take a male base plate. A steel diaphragm with a central hole is located 3¾ inches forward from the base plate. When the bomb is loaded, the filling charge comes only to this diaphragm. (See fig. 9.)

The tail cone is sheet steel constructed in four pieces, and welded together. The assembled cone is secured to the bomb by means of eight screws.

There is one transverse fuze pocket located just forward of the horizontal suspension lug. The bottom end of the pocket is secured to the opposite wall by a weld. It is long enough to accommodate the normal sized electric fuze and two picric pellets.

In the nose female threads take an eye bolt for vertical suspension. The bomb may include a shock plate welded to the nose to help prevent ricochet when used against water targets.

SC 50 GRADE I—Ja, L, and Stabo

DATA:
Over-all Length: Ja and L: 43.3 in. Stabo: 61.8 in.
Body Length: 30.0 in.
Body Diameter: 8.0 in.
Wall Thickness: 0.16 to 0.24 in.
Tail Length: 16.1 in.
Tail Width: 11.0 in.
Filling: Cast TNT: powdered amatol; or cast trialen.
Weight of Filling: 21 to 25 kg.
Total Weight: 48 to 55 kg.
Charge/Weight Ratio: 46%.
Fuzing: 5; 8; or 25B; ElAZ (38) for water targets. Stabo may also take 17 or 57.

CONSTRUCTION. The Ja has a one-piece drawn steel body. The L is the same as Ja except the body is of seamless tubular steel. The Stabo

Fuzing: Charging head—(49) A1, (49) B1, (49) B1. Ex.; Pyrotechnic—(49) A11, (49) B11; Impact—(49) A, (49) A111, (49) B111.

CONSTRUCTION. The rocket container is attached to the base of the bomb by a cylindrical steel distance piece which is threaded internally on both ends—one end threading over the bomb base and the rocket container threading into the other end. (See fig. 33.)

In the side of the distance piece is filled an electric fuze head marked (49) B1 with charging plungers connecting to (49) B11 and (49) B111 fuzes. Fuze (49) B11, a pyrotechnic fuze with a delay of 3 seconds is used for igniting the rockets. Fuze (49) B111 is an electrical impact fuze fitted into the base plate of the bomb, giving a fractional delay action to the bomb after striking the target.

Nineteen rockets are placed in the rocket container. Twelve are 25⅝ inches long by 2 1/16 inches diameter and seven are 27⅝ inches long by 2 1/16 inches diameter. Weight of rocket section is 146 kg.

The tail is 2 feet 4 inches (large diameter): 1 foot 10 inches (small diameter).

SUSPENSION. Horizontal.

COLOR AND MARKINGS: NL 6 40.

PC 500 RS is stenciled in black on the side of the bomb.

PC 1000 RS

DATA:

Over-all Length: 86¾ in.
Body Length: 45 in.
Body Diameter: 14½ in.
Filling: Very pure cast TNT in an aluminum container in the nose. Rest of filling is alternate layers of good and poor quality TNT.
Weight of Filling: 54 kg.
Total Weight: 987 kg.
Chg./Wt. Ratio: 55%.
Fuzing: Charging head—(49) B1; (49) BA1; Pyrotechnic—49 B11; Impact—49 B111, 49 BA111, 49 C111.

CONSTRUCTION. The rocket container is attached to the base of the bomb by a cylindrical steel distance piece which is threaded internally on both ends; one end threading over bomb base and rocket container threading into other end. The tail is 2 feet 4 inches, large diameter; and 1 foot 10 inches, small diameter.

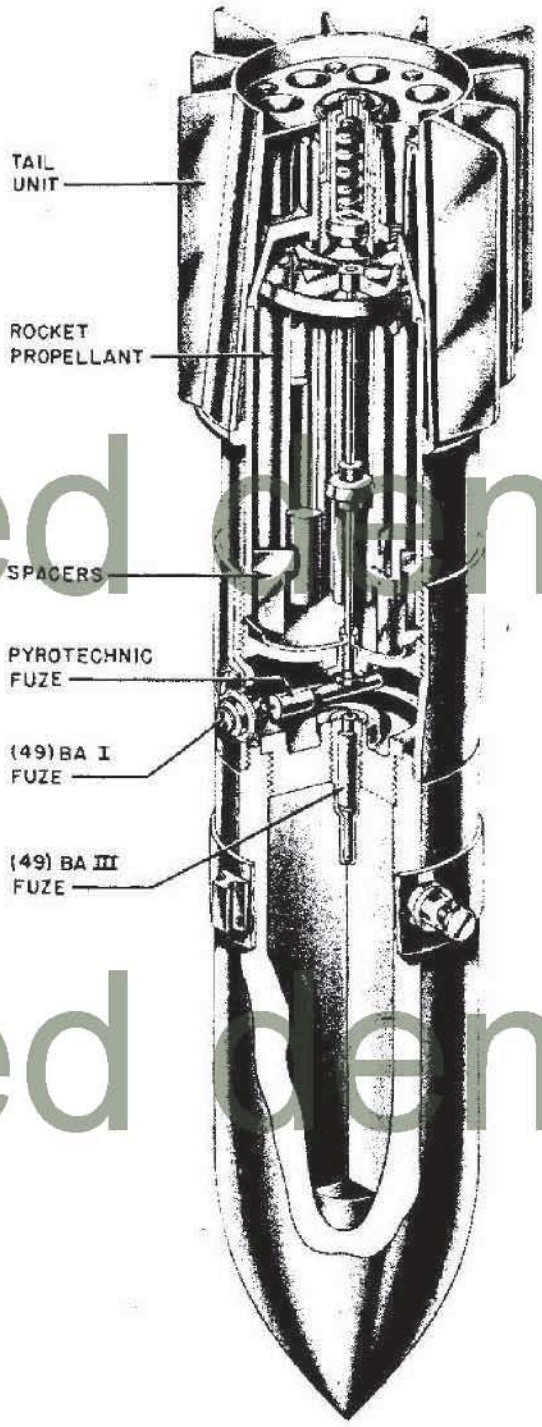

Figure 34—PC 1000 RS Bomb

The rockets consist of candles contained in a separate compartment at the base of the bomb and are held in position by spacers. This compartment forms a pressure chamber from which the gases, generated by the candles, escape through six propulsion venturi tubes. The tubes are sealed with pitch until combustion is effected. The pressure chamber is provided with a spring-loaded pressure release valve at the base. (See fig. 34.)

It is stated that the rockets burn for approximately 3 seconds after ignition and leave a trail of flame 150 feet long behind the bomb.

The bomb is usually of A. P. design, but instead of the exploder pocket lying transversly with the fuze head at one side, it is fuzed through the base plate which lies ahead of the rocket compartment.

The pyrotechnic fuze ignites the rocket about 2½ seconds after the bomb is released. Actually, bomb can be dropped without the rocket being ignited.

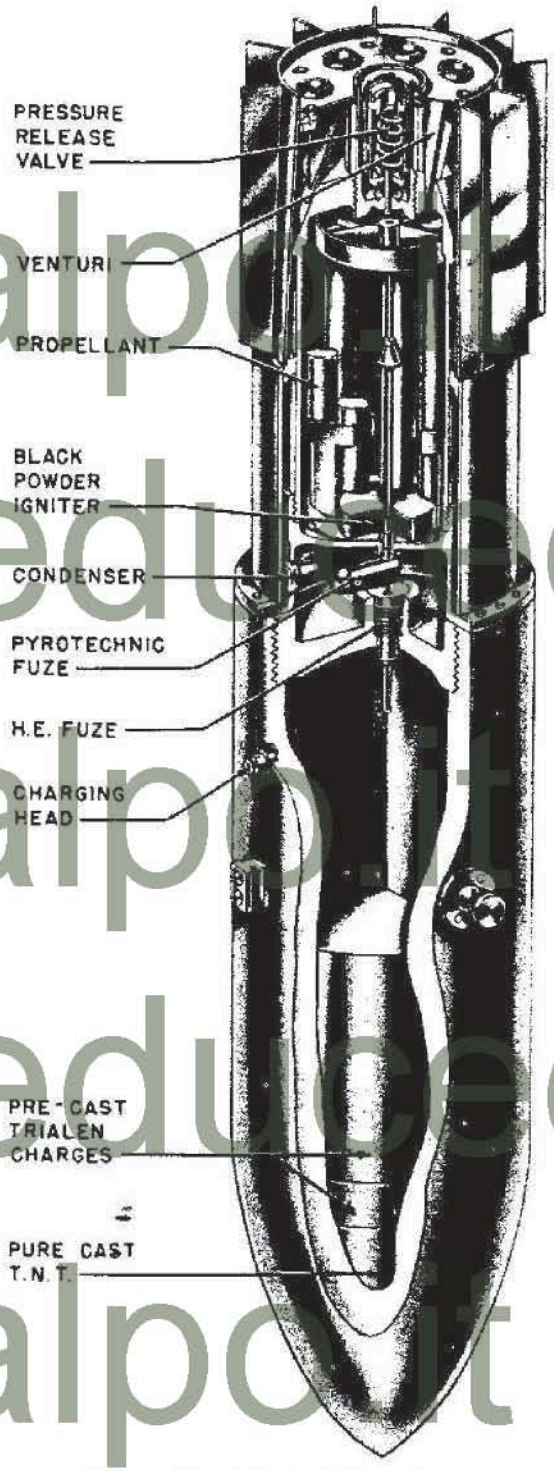

Figure 35—PC 1800 RS Bomb

SUSPENSION. Horizontal.

COLOR AND MARKINGS. Sky-blue. Blue stripes between tail fins. Stenciled:

Achtung vor Beladung

ZSK Ausschalten

Abwerf Z. S. K. O. V. Schalten

unt 28, 5, 41

PC 1000 RS

PC 1800 RS

DATA:

Over-all Length: 107 in.

Body Length: 66½ in.

Body Diameter: 21 in.

Wall Thickness: 1½ to 12 in. tapering.

Filling: Very pure cast TNT in an aluminum container in the nose. Two pre-cast Trialen charges in thick cardboard cylindrical cartons which are waxed into the bomb casing, completes the filling. One specimen had 3 blocks of nitroguanidine in nose and 10 blocks of RDX/Wax/A1 in two cardboard cylinders in the body.

Weight of Filling: 360 kg.

Total Weight: 2,057 kg.

Chg/Wt Ratio: 17.5%.

Fuzing: Charging head (49) C1; Pyrotechnic (49) C2; Impact (49) C3.

CONSTRUCTION. Typical rocket bomb construction with single fuze pocket in distance piece.

Nineteen rockets are used—ten 22½ inches long, eight 20⅞ inches long and one 11¼ inches long. All have a diameter of 2 15/16 inches. Rocket unit weighs 422 kg. (See fig. 35.)

SUSPENSION. Horizontal.

COLOR AND MARKINGS. Bomb body and tail are sky blue in color. Rocket unit and distance piece are olive drab. Stenciled on body:

Konus vor Velastungen
Schutzen
unt 13, 10, 42
Achtung vor beladung
Zsk Aussenalten
PC 1800 RS

PD 500-kg

DATA:

Over-all Length: 6 ft. 11 in.
Body Length: 4 ft. 6½ in.
Body Diameter: 11 in.
Tail Length: 2 ft. 6½ in.
Tail Width: 1 ft. 11 in.
Filling: (109) RDX/Wax/A1. The filling, designation 109, has previously been found in PC 1800 RS, associated with a nose filling block of nitroguanidine.
Weight of Filling: 32 kg.
Total Weight: 500 kg (approx.).
Charge Weight Ratio: 6.4%.
Fuzing: AZ (49) P5.

CONSTRUCTION. The body of the PD 500 is constructed of drawn steel. Compared to the weight of the bomb, it has a very small explosive cavity. In place of the normal transverse fuze pocket, there is a charging head. Electrical leads pass from the charging head to the fuze which is found in the base plate. (See fig. 36.)

The magnesium alloy tail unit is screwed to the base of the bomb with 24 screws.

SUSPENSION. Horizontally by means of an H-type lug.

COLOR. Sky blue over-all with a red stripe on tail cone.

REMARKS. The bomb is stated to be intended for attacking armored targets, especially warships. It is dropped in horizontal flight from a height of at least 11,500 feet.

The penetration of armor is stated to be 5½ inches, increased in later models to 6¼ inches. It is of two-piece construction. The leads from the charging head traverse through a machined hole in the drawn steel bomb body. This bomb employs an H-type carrying lug.

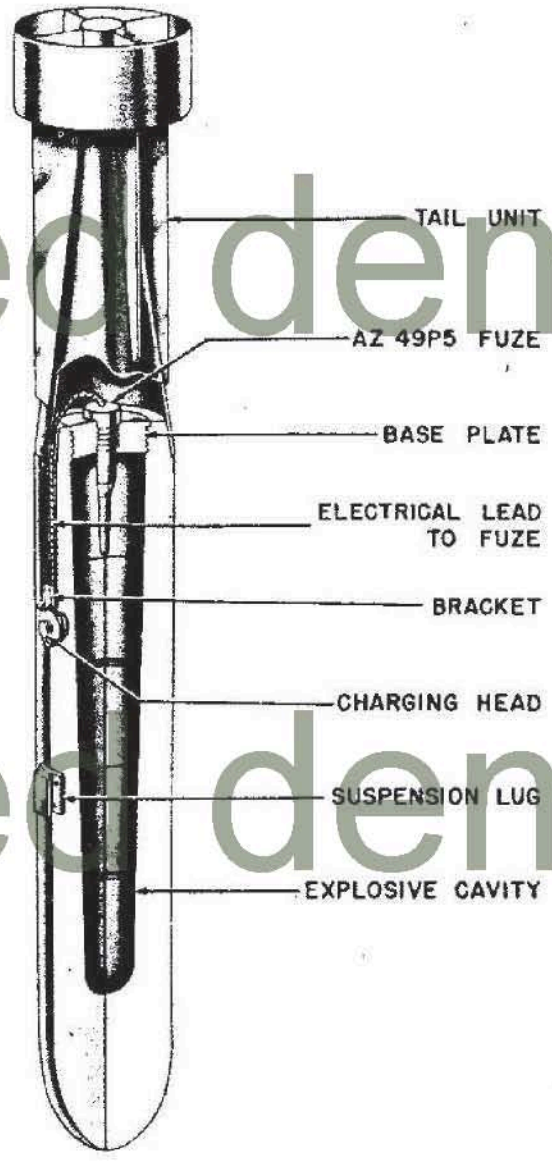

Figure 36—PD 500-Kg Bomb

½-kg ANTIPERSONNEL PARACHUTE BOMB

DATA:

Over-all Length: 4¼ in.
Body Length: 2¼ in.
Body Diameter: 1 7/16 in.
Wall Thickness: 3/16 in.
Weight of Filling: 1 oz.
Total Weight: 16 oz.
CHG/WT Ratio: 6⅔%.
Fuzing: Pull percussion igniter.

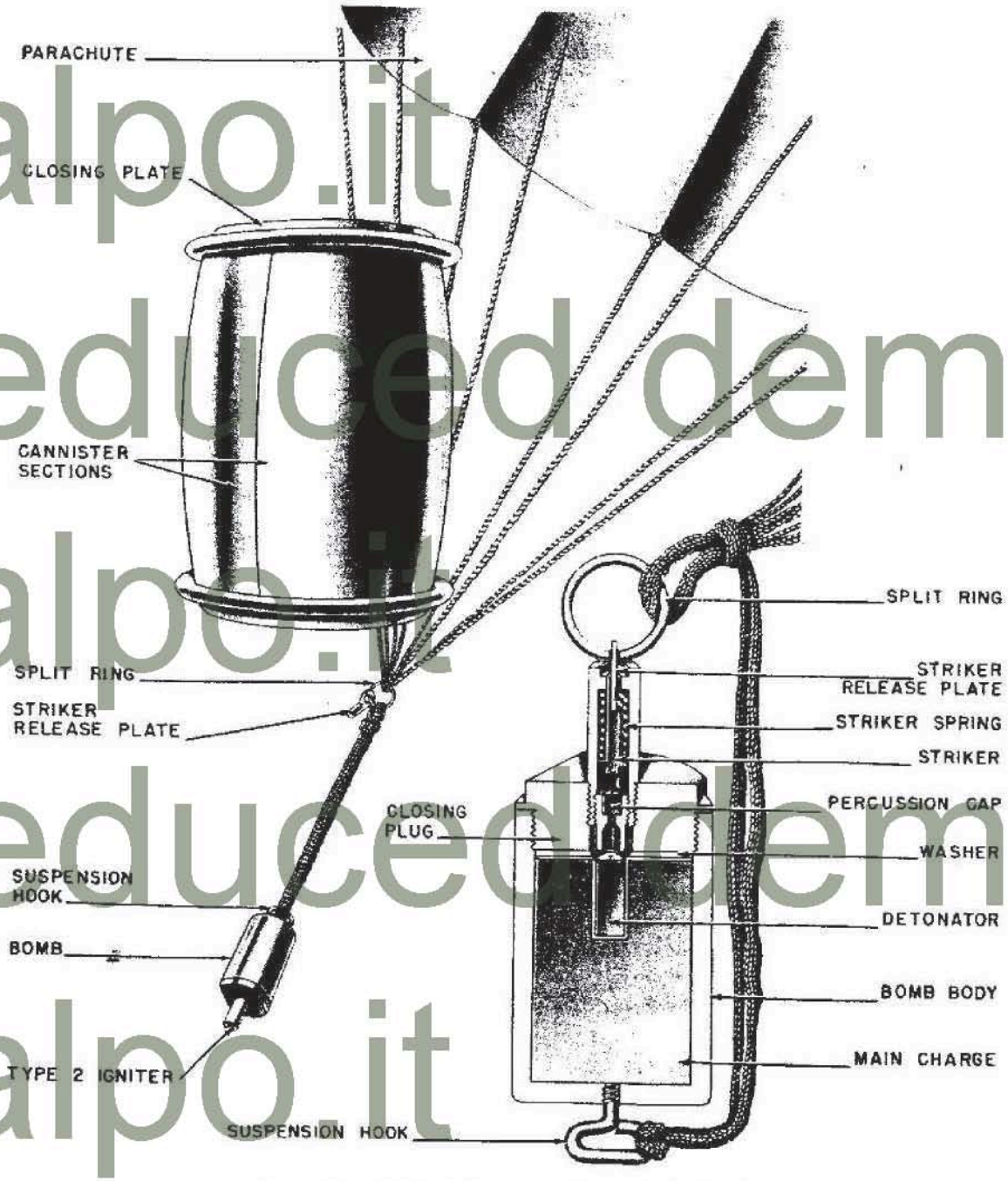

Figure 37—½ Kg Antipersonnel Parachute Bomb

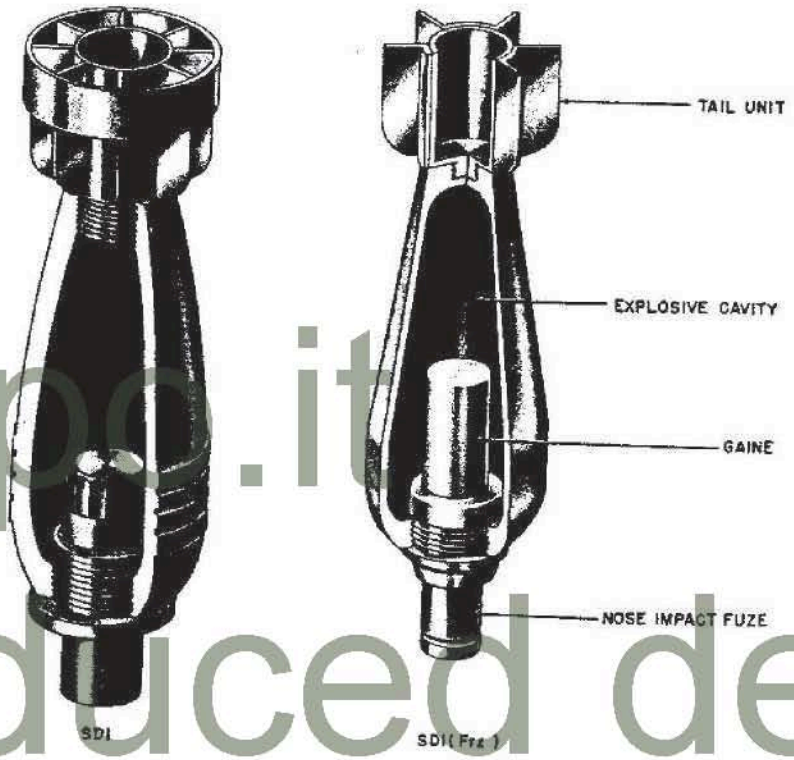

Figure 38—SD 1-Kg Mortar Bomb

CONSTRUCTION. The assembly is composed of two parts—the bomb and the canister. The body is cylindrical and made of cast steel. The base and head are internally threaded, the base to accept a suspension hook and the nose for a steel closing plug. Attached to the suspension hook is a cord which is also tied to a split ring. The parachute is attached to the split ring by eight cords. The split ring is also attached to the pull friction igniter which is threaded into the steel closing plug.

The bomb assembly is housed in a barrel-shaped aluminum canister, the body of which is formed in two separate sections and closed at the ends by twin closing plates. (See fig. 37.)

OPERATION. On release of bomb, canister comes apart and bomb falls clear. When the parachute opens, the shrouds pull the striker release plate out. The striker is then forced into the percussion cap. This action explodes the bomb.

SUSPENSION. Thought to be carried in large containers.

COLOR AND MARKINGS. Canister — unpainted aluminum. One red bar on closing plate indicates 2 seconds delay. Two red bars on closing plate indicate 4 seconds delay for the pull percussion igniter.

1–kg SD MORTAR BOMB, SD 1, SD 1 FRZ

DATA:	SD 1	FRZ
Over-all Length	6.7 in.	6.06 in.
Body Length	4.25 in.	3.75 in.
Body Diameter	2.0 in.	2.0 in.
Wall Thickness	0.4 in. nose. 0.2 in. tail.	0.12 in.
Tail Length	1.25 in.	1.22 in.
Tail Width	2.0 in.	2.0 in.
Filling	Cast TNT.	Amatol 30/70; Granular TNT.
Total Weight	2 lbs.	1.1 lb.
Fuzing	(73), (73) A, (73) A2. Nose impact mechanical.	(73) B2.

CONSTRUCTION: Both bombs have a steel body. The SD 1 tail assembly is of light metal. A tubular frame supports eight light metal fins and a drum. Tail assembly screws into bomb.

The FRZ tail assembly also screws into base of bomb. It is in the form of a cup with three sheet metal pieces spot welded on to it to form six fins. Both sheet steel and aluminum tails were used. (See fig. 38.)

SUSPENSION. SD 1: 392 bombs in AB 500–1 container; 224 bombs in AB 250–2 container; 50 bombs in AB 70–D1 container.

Packing is nose to tail with tail cup of each forming a safety device for fuze behind it.

FRZ bombs are carried in AB 70–D1 container and packed in the same manner as the SD1 bombs.

COLOR AND MARKINGS. SD1 yellow, FRZ—Body is mustard color. Tail (sheet steel) black, (cast aluminum) natural color. Ogive is painted red on Amatol-filled bombs. Markings on FRZ:

NX
AEM–5–38
NX–E–6–37 } Stenciled in black
109

AK 1927–12–38—Stamped

REMARKS. The FRZ is a French bomb used by the Germans.

2-kg "BUTTERFLY" SD 2A AND SD 2B

DATA:

Over-all Length: 3.5 in.
Body Length: 3.1 in.
Body Diameter: 3.0 in.
Wall Thickness: 3/8 in.
Filling: Cast TNT surrounded by a layer of bitumen composition.
Weight of Filling: 7.5 oz.
Total Weight: 4.4 lbs.
CHG/WT Ratio: 11.4%.
Fuzing: SD 2A; (41) (airburst or impact). SD 2B: (41) A (Airburst or impact) (67) (Delay 5–30 min.) (70) B (Antidisturbance).

CONSTRUCTION. The body of the bomb is a cylindrical cast iron casing. A fuze pocket is situated transversely in the side of the body. The SD 2A and SD 2B differ only in the method in

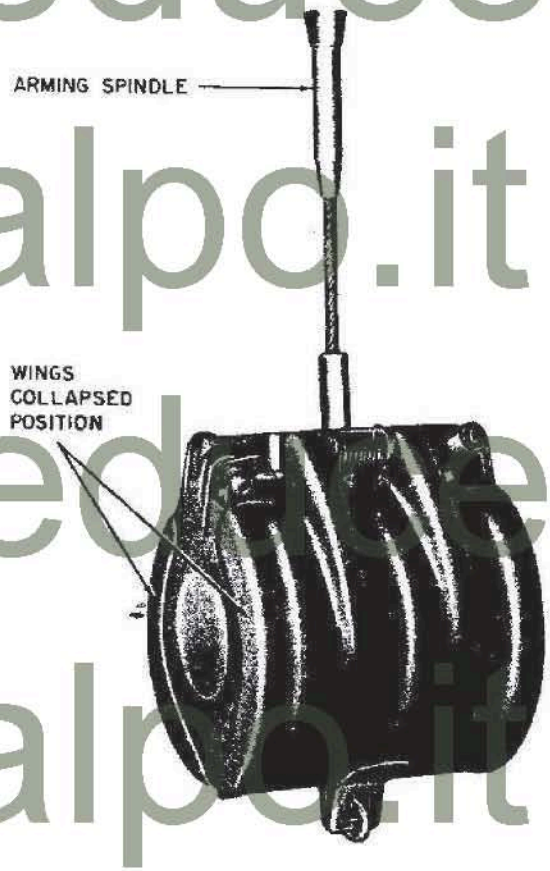

Figure 39A—SD 2-Kg "Butterfly" Bomb

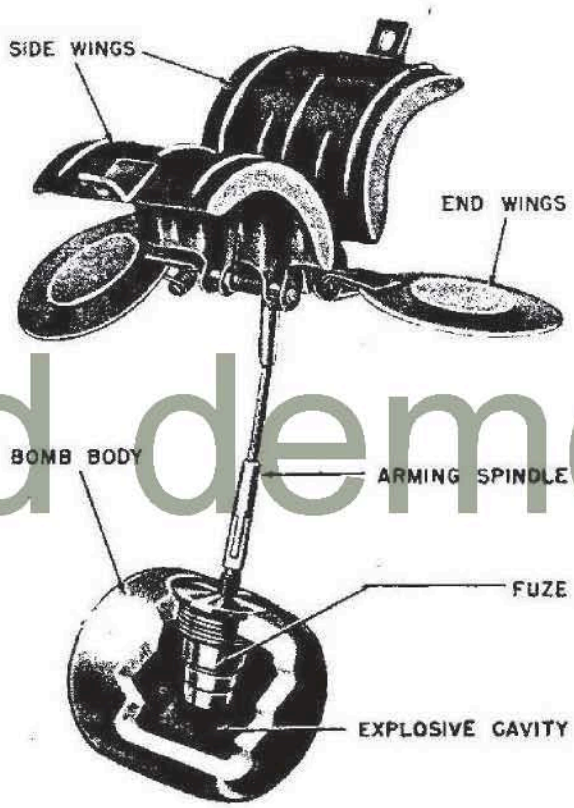

Figure 39B—SD 2-Kg "Butterfly" Bomb

Chapter 3

GERMAN ROCKETS

INTRODUCTION

General

The value of the rocket as a weapon of war has been proved during the conflict of the past 5 years. Even with the vast amount of work that has been done on the rocket during this war, there is a great deal of work still to be done in perfecting it.

During the past few years research work in this field has brought about the following improvements over the old types:

1. The accuracy has been increased by rotating the projectile. This is effected by using skew venturi. The rotations developed range between 1,000 and 1,500 r. p. m. and considerably reduce the deviations of the projectile due to the influence of the wind.

2. The range has been increased by using a greater weight of propellant in addition to the development of a new powder: Nitrodiglycol. This new powder is more efficient than black powder and results in greater range and less smoke formation on firing.

3. Multibarrel projectors carrying up to 42 rounds have been developed by the Germans to effect a greater rate of fire. Reloading these new projectors is carried out mechanically.

When these first new efforts proved successful, great new exertions were made on the part of the Germans to develop more effective rocket weapons: rocket-propelled depth charges, antitank weapons, antiaircraft rockets, flares and aircraft bombs with rocket propulsion were tried out; and at the peak of the research program came the radio-controlled long range rocket which was still under development at the end of the war in Europe.

Solid Fuel Rockets

For the purpose of this book it is not necessary to go into the original work done on the powder rocket. The following is a brief résumé on the construction of the rocket at the beginning of this war. The rocket motor consists of the combustion chamber sealed at one end and the base plate which threads into the open end of the combustion chamber. The base plate has a series of holes in it some of which are parallel to the axis of the rocket and some of which are inclined 45° to the axis.

PROPELLANT. The propellant used at this time is the solid nitrodiglycol type. Its advantage lies in the high calorific value and smokelessness, also in the slow rate of burning. Its density is 1.5 kg/m³, which is less than black powder, but this is compensated by the higher calorific value. The range for an 8.6 cm rocket using this type of propellant is 1,200 meters. Maximum velocity is 200 m/sec with a burning time of 5 seconds. This is not considered very good performance and so the rocket is used only against low level attacks.

As long as long range is not required, powder may be used for rocket propulsion. It must, however, be remembered that powder rockets are heavy (heavy combustion chamber) and that the charge weight ratio is small. An attempt might therefore be made to develop powder rockets of light construction, by using some arrangements for reloading the combustion chamber so that a larger weight of propellant may be carried. This should increase the range. Experiments on these lines have been carried out in Germany, but it was found that in order to insure reliable operation, the constructional complications became very great. This reduces use of the main advantages of rockets—less weight and simple construction.

STABILIZATION. The foundation for the method of stabilization was the spinning shell. By placing the ventureis askew to the main axis of the rocket produced a sufficient spin. This action gives rise to a gyroscope effect and tends to resist all external disturbing forces. This method has given very good results and is greatly superior to the fin stabilization, which is inherently subject to wind errors.

Figure 192—1400 FX

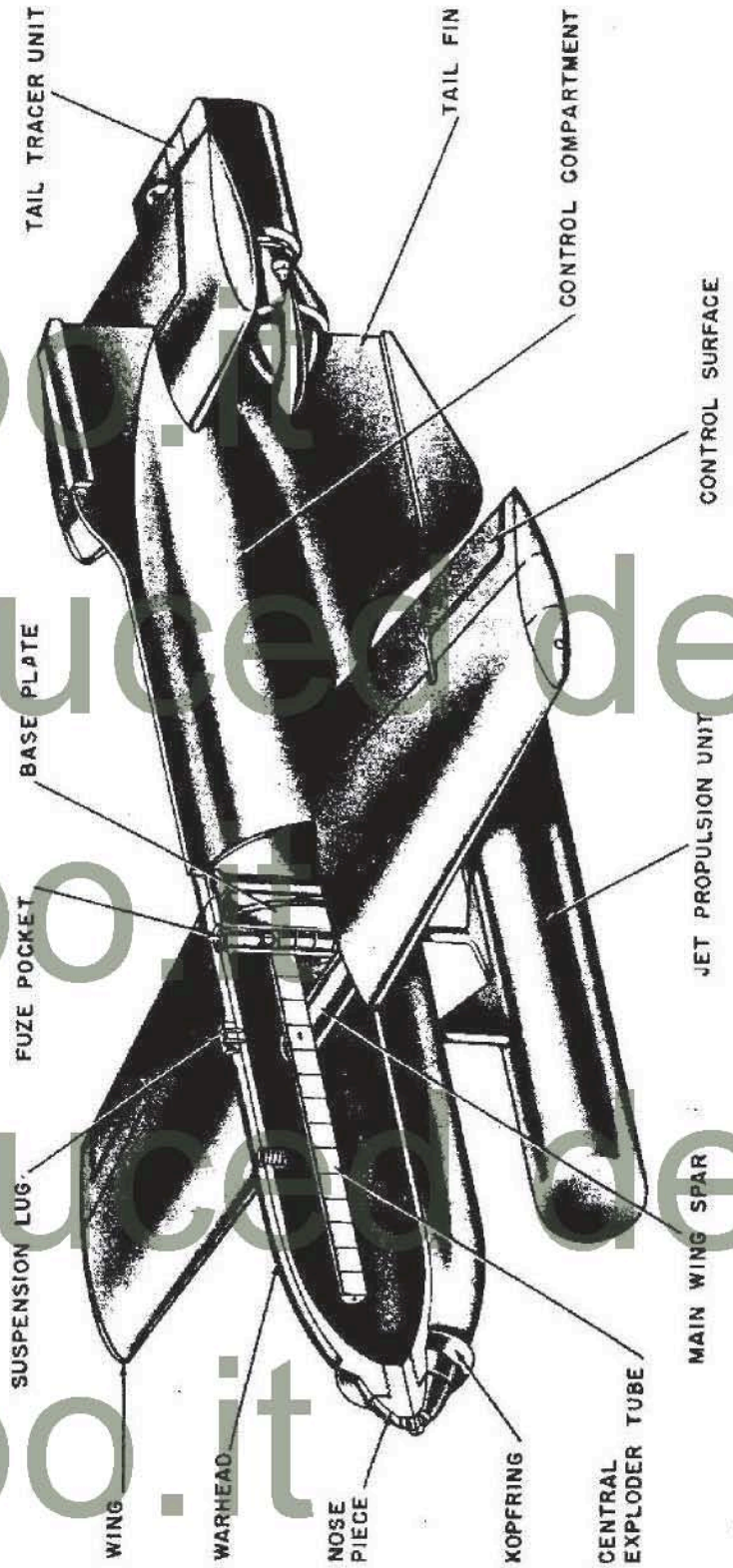

Figure 194—Hs 293 Glider Bomb, Hs 298

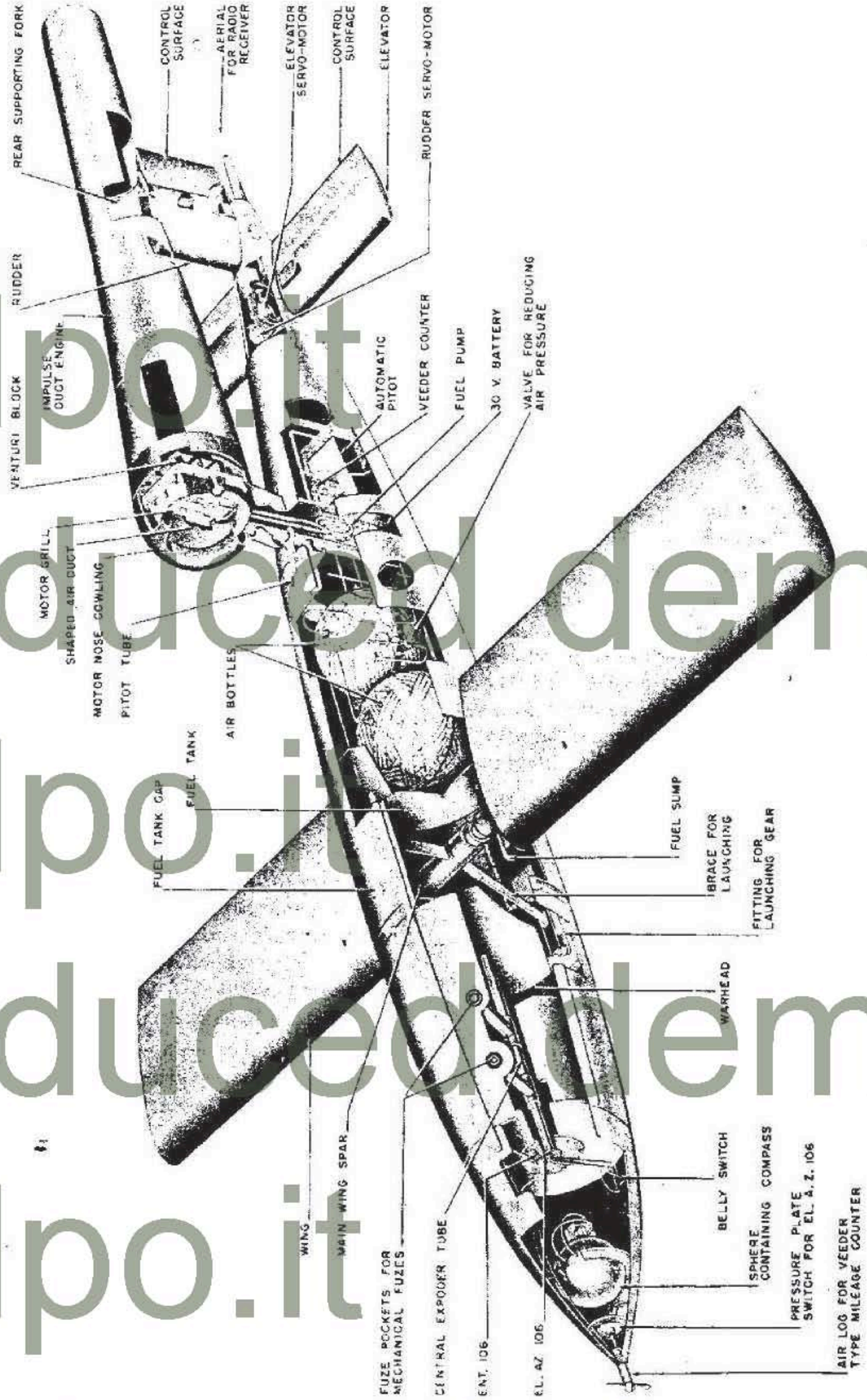

Figure 195—F. Z. G. 76 "V-1" Flying Bomb

Figure 196—A-4 "V-2" Rocket

C. PERFORMANCES: Individual Parts:

1. Control Room:
   Two Batteries: 27 volts, 20 ampere hours.
   One "Kommando" Battery: 50 volts, 1.3 ampere hours.
   Firing Circuit: 27 volts.
   Three Invertors: DC/AC 3-phase.
   Invertors: Motor: 27 volts, 12 volts, 10,000 r. p. m.
   Generator: 40 volts, 500 cycles, 180 watts.
   Three Regulators for Invertors: Regulation 1 percent.
   "Verdoppler" Transmitter: Output 15 watts, wavelength 6.5 meters, frequency 46 Mc.
2. Engine Block:
   Electrical Armatures: Constructed for 24 volts.
   Turbines:
      Capacity Ca.: 21 kg/sec.
      Revolution: 3,800 r.p.m.
      Output: 460 hp.
      Additional thrust by Venting Ca.: 50 kg.
   A-Pump: Revolutions Ca.: 3,800 r.p.m.
      Output: 190 hp.
      Output pressure: 18.7 atm.
      Output Ca.: 72 kg/sec.
   B-Pump: Revolutions Ca.: 3,800 r.p.m.
      Output: 270 hp.
      Output pressure: 22 atm.
      Output Ca.: 58 kg/sec.
   T-System: T and Z output pressure: 31 atm.
      T-Stoff Flow Ca.: 2.1 kg/sec.
      Z-Stoff Flow Ca.: 0.2 kg/sec.
      Pressure in Steam Chamber: 25 atm.
      Steam Produced: 2.3 kg/sec.
      Fresh Steam Temperature: 385° C.
      Pressure Reducing Setting: 31 atm.
   P-Batteries: Number of Bottles: 7.
      Contents: 7 liters per bottle.
      P-Pressure: 200 atm.
      Total Amount: 12.25 kg=9,600 liters.
   Heat Exchanger Flow: 0.3 kg/sec. of A-Stoff; 2.3 kg/sec of steam.
      Temperature of Outflow: 280° C.
      Temperature of A-Stoff (After Going Through Heat Exchanger) Ca.: 0° C.
   Motor: Fuel Consumption per Second in Preliminary Stage:
      A-Stoff Ca.: 38 kg.
      B-Stoff Ca.: 35 kg.
      Total Ca.: 73 kg.
      Fuel Consumption per Second in Main Stage:
         A-Stoff Ca.: 72 kg.
         B-Stoff Ca.: 58 kg.
         Total Ca.: 130 kg.
      Mixing Proportion: B:A: 0.81.
      Fuel Injection Pressure into Motor: 18 atm.
      Pressure in Combustion Chamber: 14.5 atm.
      Temperature in Combustion Chamber: 2,000° C.
      Exit Velocity of Gases Ca.: 2,000 m./sec.
      Inner Efficiency (WA/WA TH=Actual to Theoretical Exit Velocity): 95 percent.
      Thrust: 25,700 kg.
3. Total Apparatus:
   Shooting range Ca: 300 km.
   Ceiling Ca.: 80 km.
   "Brennschluss" height Ca.: 28 km.
   "Brennschluss" range Ca.: 25 km.
   "Brennschluss" Maximum Velocity Ca.: 1,500 m/sec.
   Burning time Ca.: 60–63 sec.
   Flight time Ca.: 320 sec.
   Speed at target Ca.: 800 m/sec.
   Angle with Perpendicular At "Brennschluss": 47°.
   Greatest Impact Pressure: 8–10,000 kg sq/meter (Reached in 45 sec at 12 km height at 650 m/sec).
   Highest heating of the Skin: 300°–500° C.
   Lifting Acceleration Ca.: 1g. (9.81 m/sec²).
   Maximum Acceleration (at Top of 25-ton thrust) Ca.: 6g.

D. OTHER DATA—TOTAL APPARATUS.

Evaporation Out of the Filled Device of the A-Stoff:
In the first hour Ca.: 320 kg.
In the second hour Ca.: 160 kg.
In the third hour Ca.: 130 kg (and following hours.)
Rigidity of the apparatus:
Untanked: up to 23 m/sec wind speed.
Tanked: up to 35 m/sec wind speed.
Transportation.
Height of the Device: 4.2 meters.
Transportation.
Width of the Device: 3.22 meters.
Transportation.
Length of the Device: 14.7 meters.

Figure 197A—X-4 Missile

The apparatus with full A-Stoff can stand up to 6 hours without impaired function.

The servo-motors must warm up 30 minutes before shooting. Taking into consideration the insulation condition of the wiring system a detanking of A-Stoff can not take place in the meantime, since in most cases an undesirably high deterioration of the condition of the wiring system is unavoidable as a result of the sweating. The insulation coefficient for the 27 volts wiring system measured at the break-away plug at terminals 1–4 against the body is 10,000 ohms.

X–4

GENERAL DESCRIPTION. The X–4 is a fin-stabilized guided missile with a proximity fuzed warhead developed specifically for use by fighter planes against enemy bomber formations. (See figs. 197A and 197B.)

Stabilization is obtained by four large fins fitted symmetrically to the body and steering is achieved by rake spoilers operating in four small tail fins which are interdigitated with respect to the large fins. In appearance, it is quite similar to "Fritz X" except that it is much smaller, the warhead

Figure 197B—X–4 Missile

weighing only 20 kg and the total weight being 60 kg. It is launched without assisted take-off from fighter planes. It can be either wire-controlled by an operator in the fighter plane or it can be used as a self-steering target seeker by the use of acoustic homing. If it is wire-controlled, some sort of rocket propulsion is to be used; while if acoustic homing is used, it is proposed to dispense with the rocket propulsion unit.

OPERATIONAL ASPECTS. The principal operational use of the X–4 would be for fighter use against large enemy bomber formations. Of course, the wire-control version would necessitate the launching plane remaining in the vicinity in order to control the flight of the missile and this would in turn seriously restrict its maneuverability. On the other hand, if acoustic homing were used, the X–4 could be launched and the parent plane could immediately execute an evasive maneuver.

With the 20-kg warhead, it is extremely doubtful that much damage could be done to a four-motored bomber at a distance of 15 meters, the operating range of "Kranich." The effectiveness would undoubtedly be increased if the power plant were dispensed with and the payload doubled, as would be the case if acoustic homing were utilized.

If the X–4 with acoustic homing were used in conjunction with a plane of the ME 262 type, it would be quite a formidable weapon to counter enemy bomber formations, and could probably be used for other tactical purposes as well.

DETAILS. AIRFRAME. The airframe of X–4 consists of a cylindrical body 190 cm in length and 22 cm maximum diameter on which are mounted four large plywood fins fitted to the midsection of the missile and four small tail fins in which the rake spoilers are mounted. The main wing span is 58 cm.

Rotation about the longitudinal axis achieved by small trim tabs attached to the four large stabilizing fins. These give a rotational speed of 1½ r.p.s., which in turn is used to give greater stability in flight and also permits greater manufacturing tolerances in the entire assembly. The main fins are swept back at an angle of 45°, which gives a maximum air speed of 270 m/sec. However due to the comparatively short range over which this weapon is to be used, it is not expected to attain a velocity of greater than 240 m/sec before it reaches the target.

Steering is effected by means of rake spoilers located in the tail fins. These spoilers vibrate at a rate of 5 cycles per second, control being effected by making the period during which the spoiler projects from one side longer than that during which it projects from the other. When the two periods are equal, no control is applied. This method of steering has the disadvantages of appreciable drag and a certain amount of delay, but has the advantage of simplicity and instantaneous mechanical response.

DESIGN DATA:

Launching weight: 60 kg.
Weight less fuel: 50 kg.
Wing surface: 0.56 sq. m.
Wing loading: 200 kg/m. 2.
Maximum speed in horizontal flight at 6,500 m altitude: 270 m/sec.
Lateral acceleration in horizontal flight at 6,500 altitude: 40 m/sec.2.
Total energy available during 33 sec burning time: 1,600 kg/sec.

POWER PLANT. The Bi-fuel liquid propellant motor is the BMW 109–548 rocket motor using a mixture of Salbei (98 to 100 percent nitric acid) and Tonka 250 (57 percent crude m-xylidine with 43 percent triethylamine). This motor is capable of delivering an initial thrust of 150 kg which drops to about 25 kg after 30 seconds.

The solid propellant which it was proposed to use was "Mixture 167" by Wasag. Initial thrust is 120 to 140 kg which is also reduced to about 25 kg after 30 seconds.

Of course, there were also plans under way to eliminate the propulsion unit entirely, in which case the payload could have been appreciably increased.

INTELLIGENCE AND CONTROL SYSTEM. In all the proposed versions of X–4, the missile rotates and therefore only one gyro is needed. When wire control is used, the principal purpose of the gyro and commutator system is to translate the right-left and up-down signals into the proper pulses to feed to the rake spoilers in the tail fins. The gyro is spun up while the missile is still attached to the launching aircraft. During the flight of the missile, the gyro is not power driven. The gyro was made by Th. Horn. Leipzig.

The wire control system consists essentially of a small joystick control unit mounted in the aircraft, a pair of control wires and a receiving unit in the missile consisting of a gyroscope and a pair of relays. The control unit contains two drums which revolve at a rate of r.p.s., one drum controlling azimuth and the other elevation. The control wires consist of 2 insulated single strand Swedish spring-steel wires of 6,000 m length and 0.22 mm diameter. The receiving unit in the missile is quite simple consisting primarily of a polarized relay for azimuth control and unpolarized marginal relay for elevation control. The polarized relay responds only to polarity changes in the direction of the current flow through the wires while the unpolarized marginal relay responds only to changes in the value of the current, regardless of its polarity. In this way, both azimuth and elevation control signals can be transmitted simultaneously over the same pair of wires.

The relays are connected to the spoiler solenoids in the tail fins, through the gyro commutator system. This arrangement converts the left-right and up-down signals into the proper pulses which are to be fed to the solenoids actuating the spoilers. The power supply is a small 9-volt dry battery located in the afterbody of the missile.

During the flight tests, there were no detrimental effects from static electrical charges accumulating on the wires and the mechanical difficulties had been solved by paying out the wire from the bobbins on the missile and similar bobbins on the parent plane simultaneously. Wire control was selected primarily because, compared to radio remote control, it is practically jamproof.

In March 1945, there was also under development a plan to dispense with the power plant and wire control and to use an acoustic homing system "Pudel" as the control device. This system is based on the same fundamental principles as the acoustic proximity fuze "Kranich." It consists essentially of a mica and 0.03 mm aluminum foil diaphragm connected to a carbon microphone, the output of which is fed to a single stage amplifier and relay output. This assembly is mounted at an angle of approximately 60° to the longitudinal axis of the body and the sound passes into the diaphragm through a series of wire mesh screens which serve to attenuate differences of air pressure due to rotation but not the sound of motors and propellers of enemy aircraft. A small lyre arrangement is attached to the vibrating system in such a way as to broaden out the mechanical resonance curves of the individual components of the system. The composite curve of the acoustic system with the 15-wire lyre attached is practically flat from 200 to 400 cycles. The wire mesh screens attenuate the slow air pressure variations about 40 or 50 db, whereas the sound vibrations of 200 to 400 cycles are attenuated only 1 db.

As the X–4 rotates, if the missile is homing directly on the target, the output of the microphone will be constant and there will be no modulation output and consequently no steering corrections. If the missile is not aimed directly at the target, there will be generated a modulation frequency of 1½ cycles per second, the rotation speed of the X–4. This modulation frequency of 1½ cycles per second is used to transmit information to the spoilers through the gyrocommutator system. For this purpose, the normal gyrocommutator system has been modified to some extent. Only 8 models of "Pudel" have been built and so far no flight tests have been made.

The modification of X–4 with "Pudel" and also equipped with the "Kranich" acoustic proximity fuze when launched from a fighter plane of the ME 262 type appears to be a weapon of great promise, since after launching, the fighter pilot can immediately take evasive action. The range of the acoustic homing device is expected to be about 1,000 meters, so that if it were launched at a range of 2,000 meters, the first 1,000 meters of its flight would be uncontrolled.

WARHEAD AND FUZE. When X-4 was originally conceived, it was expected to use a 20-kg. cast-steel warhead enclosing the explosive material. However, due possibly to the shortage of steel in Germany at the beginning of 1945, some thought was being given to the use of an uncased molded plastic type of warhead which was to be attached to the afterbody by wood screws and had an adaptor for the nose fuze attached to the nose in the same way.

The fuzing system consisted of the acoustic proximity fuze "Kranich" which forms the nose of the missile, an impact and graze fuze, and a self-destroying fuze which operates 35 seconds after release. The acoustic and impact fuzes are armed 7 seconds after release. The acoustic fuze consists of a light diaphragm actuated mechanism which

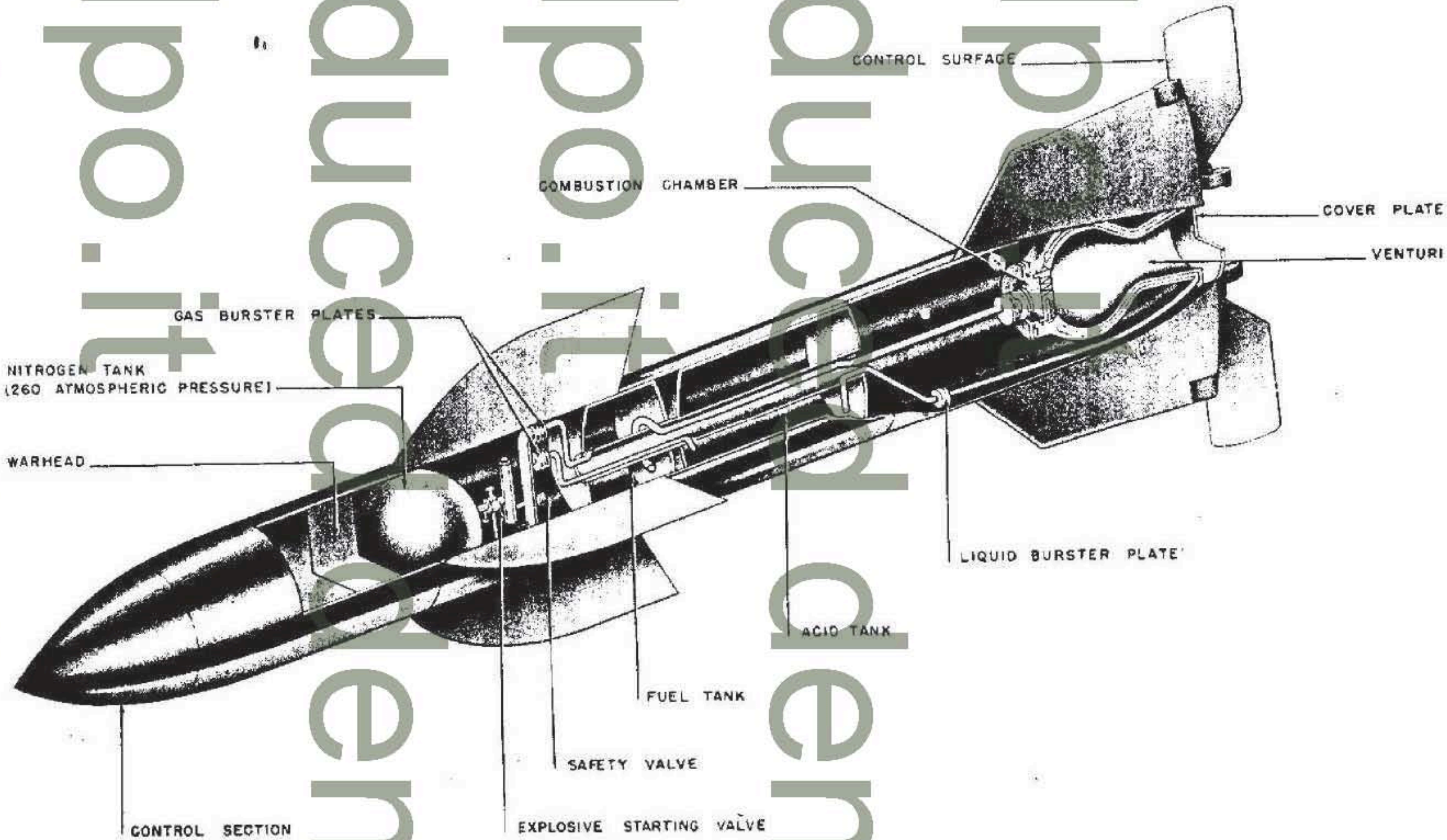

Figure 198—Wasserfall

responds to the sound of aircraft propellers at a range of 15 meters. This fuze has a time delay of 1/50 second to make it more effective. A complete description of "Kranich" has been given in other Intelligence Reports. Specimens have been shipped to Naval Research Laboratory, Washington, D. C., on Consignment Tag No. 3980.

LAUNCHING DEVICES. Originally the X–4 was being carried only by the Focke-Wolf 190. However, it was later planned to use it also in connection with ME 262 and DO 335. The missile is suspended from the parent craft by means of ETC70AI, which is a modified 70-kg bomb-rack with a 7-prong umbilical cord and provision for two control wires. The X–4 is released electrically when the pilot presses the bomb release switch.

WASSERFALL C–2

GENERAL DESCRIPTION

A. This flak rocket was given the name Wasserfall and the designation C–2 8/45.

B. The C–2 was designed to be launched vertically from the ground, and traveling at a supersonic speed to be guided into bomber formations where it would be exploded.

C. The Wasserfall resembles a half-size V–2 with small wings. It has a similar motor and is launched in much the same manner. Its control gear is also similar. (See fig. 198.)

It could reach a maximum speed of about 770 meters per second in about 45 seconds after which time the speed would decrease as the fuel would be exhausted. It could still chase targets until its speed had dropped to about 350 meters per second. Its maximum fighting ranges were: 18 kilometers in height and 26 kilometers in horizontal range. It was designed to withstand maneuvers of up to 4.4 g. The missile was guided by radio signals from the ground until approaching the target at which time a self-contained homing system was to lead it in. It was planned to incorporate a proximity fuze to explode the weapon close to the bombers.

With these properties the Germans expected every other missile to bring down a bomber making 2 g evasive maneuvers at a speed of 250 meters per second.

OPERATIONAL ASPECTS

A. The Wasserfall was planned for use from the ground against air targets, specifically bombers. Suggested locations for launching sites were along the French coast and the approaches to major targets of bombers.

B. The launching site requires much equipment and, although mobile, would thus be subject to attack. Lack of maneuverability against relatively slow airplanes would have inhibited its effective use.

C. The Wasserfall was expected to be both cheaper and more effective than ordinary flak for the results obtained. Only operational use could prove this point.

CONCLUSIONS. The Wasserfall was not completed and thus offers no immediate possibilities as a weapon without much further work on the control system.

RECOMMENDATIONS. It is believed that an intensive study of the Wasserfall will yield much information on the principles and the use of a supersonic guided missile.

DETAILS

AIRFRAME. A. TYPE AND DESCRIPTION. In over-all appearance the Wasserfall resembles a half-size V–2 with small wings. The approximate dimensions are:

Length: 7,800 mm.
Caliber: 880 mm.
Wing span: 1,890 mm.
Tail span: 2,500 mm.

There are four small biconvex dorsal wings at the center of gravity to assist in making turns. In line with these wings are four stabilizing fins at the tail. Control surfaces are fitted on the stabilizing fins both in the air stream and in the gas stream of the jet motor.

B. AERODYNAMIC CHARACTERISTICS. The Wasserfall is designed to catch, while traveling at a supersonic speed, a target having a velocity of 250 meters per second doing 2 g maneuvers.

Essentially the missile travels at and is designed for supersonic speeds. However, the transition from zero speed at launching to the supersonic range is not instantaneous and some additional control is desirable during this interval. This is supplied by the gas stream fins which are present for the first 5–15 seconds of flight. Once the supersonic range is reached the air stream fins supply sufficient control while the jet stream fins add a drag. Consequently they are jettisoned at that time.

The missile is designed to stand maneuvers up to 4.4 g. The wings will support a lift of 8,000 kg per pair to which the body, tail, etc., add about another 4,000 kg making a total lift of 12,000 kg.

The missile weighs about 3,500 kg at take-off, but the weight drops continually to about 1,500 kg by the time the fuel is exhausted. Thus at take-off the lateral acceleration should not exceed 3 g, increasing to 4.4 g as the fuel is consumed. To allow for this the control applied to the servo is made weak at first and is gradually brought up to its full power.

Wind tunnel tests of models made may be found in report No. UM 6013 dated February 1945 in the Goettingen documents. Evidence obtained at the wind tunnels at Kochel shows that at least six different shapes have been tried out to get the best aerodynamic results.

C. Design Data. The missile is fabricated from mild steel to the shape shown in Figure 198. It may be broken down into the following parts:

1. Nose: Contains the homing device (zielsuchendes Geraet) fuzes (Zuender) and explosive (Sprengstoff).
2. Nitrogen tank: (Druckluftbehaelter).
3. Visol tank: (Brennstoffhaelter).
4. Wings: (Fluogel).
5. Salbei tank: (Salbeibehaelter).
6. Control system: Mounted to rear of Salbei Tank.
7. Tail: Supports motor (Brennkammer), tails (Flosse), air rudders (Luftruder), and jet rudders (Stahlruder).

D. Production Data. The following remarks apply to all parts of the missile. The only production was by the Electromechanische Werke at Peenemunde for the developmental testing. Estimates of this production range from 40 to 275 units.

Estimates were drawn up for the men, material and space needed for the mass production of 5,000 monthly.

PROPULSION SYSTEM. A. Type and Description. A liquid jet motor drive is used which develops an 8,000 kg thrust for 45 seconds. The motor burns a self-igniting mixture of Salbei (nitric acid) and Visol (a hydro-carbon mixture) in a chamber with a venturi nozzle.

B. Characteristics:

Thrust: 8,000 kg.
Total impulse: 360,000 kg.
Launching acceleration: 1.2 to 2.6 g.
Final acceleration: Ca. 4 g.
Fuel consumption: 41 kg/sec.
Specific impulse: 180 to 195 sec.

C. Design Data. The general arrangement is indicated in figure 198. The foremost flask contains nitrogen at a pressure of 200–300 atmos. This flask is 8 to 13 mm thick and is not wire wound. The compressed gas passes through a reducing valve to 30 atmos and is used to force the liquids out of their storage tanks. This flask and the two storage tanks are made of rolled and welded steel.

The forward storage tank contains about 400 kg or 430 liters of Visol. Visol is a rather variable fuel according to the ingredients available or the intended use. A typical Visol mixture is: 40 percent isoprophyl alcohol; 40 percent vinyl ether; 2 percent water; 18 percent of four other ingredients including 1 percent of a dope to control the ignition delay time.

Visol is a contracted code name for vinylisobutylether. A Diesel oil may also be used in place of Visol.

The rear tank contains about 1,500 kg or 1,100 liters of the oxidant Salbei. Salbei is a mixture of 90 percent nitric acid (including 3 percent water) and 10 percent sulfuric acid. No attempt is made to make the acid water free as it would be reabsorbed from the air before it was ever used. The sulfuric acid was added to prevent corrosion by the nitric acid of the steel available for the tanks.

As already mentioned, the fuel and oxidant were forced out by pressure. The fuel is removed through a swinging pipe hanging down in the tanks. As this pipe is subjected to the same acceleration as the fuel, its end is always covered by liquid. This design gives a lightweight removal system which removes practically the last drop of liquid although the liquids are being swished around in the tanks. It is said this system increased the maximum altitude obtainable by 4 kilometers over a pump arrangement that was tried.

Both fuel and oxidant are passed through a valving arrangement which introduces both liquids into the motor at the same time under full flow.

Valves in the various pipe lines are opened simultaneously by explosive charges. Just before each liquid enters the motor there is a diaphragm. These diaphragms stop the liquid until it has built up to practically full pressure at which time the diaphragm bursts and allows a full flow of liquid, from the start, to enter the motor.

The ratio of liquids by weight is Salbei to Visol from 5 to 1 up to 8 to 1 depending upon the actual Visol mixture being used.

The Visol is fed directly to the nozzle head. The Salbei first passes through the cooling jacket of the motor before going to the nozzle head. In some cases some of the Salbei is also injected through cooling holes into the combustion chamber. The two liquids ignite within 0.01 to 0.1 second after contact. An expansion ratio of 2.5 to 1 up to 3.9 to 1 is obtained in the motor. The gas exit velocity is approximately 1,850 meters per second.

Brennschluss (turning off of the motor) had not been settled. Provisions were made for several methods, which were:

1. Letting the motor use up all of the fuel
2. Turning off the motor by radio signal
3. Turning off the motor at a predetermined velocity by means of an integrating accelerometer.

INTELLIGENCE AND CONTROL SYSTEM

A. Type and Description. Many systems were tried or proposed which, although radically different in details, are very similar in function. Three gyros are used to prevent oscillations about the three axes. Remote radio control is used to guide the missile toward the target. A homing device is to be used in the final part of the chase to guide the missile to within killing distance of the target. Finally a proximity fuze is to explode the missile. In addition there is a relay transmitter in the missile to enable the personnel on the ground to follow it.

B. Characteristics. The control system must be capable of guiding the missile very close to a target which is making 2 g curves at a velocity of 250 meters per second.

C. Design Data. 1. Rudders and Rudder Machines. In each of the four tail fins there is a pair of rudders in the air stream and the jet stream. Each pair of rudders is driven by one all-electric servo motor. The armature of the servo motor oscillates at 50 cycles a second to reduce the back lash to almost zero. Roll control is applied to all rudders.

2. Gyros. Three course gyros are used to prevent the missile from oscillating. The take-off cards on the gyros are positioned by the remote radio control to keep the gyros oriented with respect to the desired path.

3. Remote Control Radio Receiver. This unit receives command signals from the ground control station to direct the missile towards the target. The "Strassburg" E230V is employed as the receiver.

4. Relay Transmitter. A transpondor triggered from the ground radar to indicate the angle of roll of the missile by measurement of the polarization of the wave transmitted is known under the code name "Reuse."

5. "Mischgeraet". An electrical computing device which receives signals from the control radio and the gyro, mixes these signals, and sorts them out for the various rudder motors.

6. Homing Device. A device to make the missile home in very close to the target. None had been sufficiently developed to test in the missile. It is a prerequisite as the ground control is not sufficiently accurate to guide the missile close enough to the target to do damage.

7. Power Supply. Batteries, invertors, regulators, etc., to power the control system.

8. Warhead, Fuze, Firing Circuit. About 305 kilograms of explosive were to be used. Of this about 100 to 150 kg would be concentrated in the nose. The remainder would be distributed throughout the body much in the form of primer-cord. This distributed charge was necessary to destroy the missile in mid-air as it would be used over friendly territory. The warhead was expected to have a destructive range of 40 meters.

9. Auxiliary Equipment. The Wasserfall required considerable ground equipment for the remote control. Equipment is required not only for the transmittal of control signals to the missile, but also to track both the missile and the target. The missile is guided so that it is always on the line between the target and the ground observer.

Preferably the tracking is done optically. In this case, the operator has only to keep the missile and the target lined up in the optical field. However, radar tracking must be provided for the

Figure 199—Taifun

many times that optical tracking will be inadequate. The radar tracking system and control system known as the "Elsass" consists of the following functional parts:

Mannheim radar.—Radar set to track the target. It also measured the distance between the target and the missile.

Rheingold.—The Rheingold follows the missile and measures the roll position of the missile by determination of the angle of polarization of the signals sent out by the "Ruese" relay transmitter in the missile.

Indicator.—The indicator displays information obtained from the Mannheim and the Rheingold:

Azimuth and elevation of target and missile.
Distance to target and missile.
Roll position of missile.

Kehl control transmitter.—An operator sits before the indicator and by means of a joy stick control keeps the missile in line with the target. This joy stick controls the command signals sent out by the "Kehl" control transmitter to the "Strassburg" receiver in the missile. By this transmitter the operator may also fire a fuze in the missile when his indicator shows the missile is at the target.

TAIFUN BILIQUID ROCKET

GENERAL. The rocket Taifun is a biliquid rocket reputed to be fired in groups of 65 from a launching machine known as the Dobgerate. From all indications, it never passed beyond the experimental stage.

The projectile is approximately 2.1 meters long and 10 centimeters in diameter. The greater part is taken up with the fuel tanks which contain Visol and acid. The acid is housed in a central aluminum tank, while the Visol is contained in the annular tank between the inside tank and the outer skin of the missile. The walls of both tanks are 1 mm thick. (See fig. 199.)

The acid tank is supported in the rocket shell by two aluminum end plates bolted to its end flanges. These end plates are perforated so as to connect the fuel tanks at the upper end to the cartridge pot, and at the lower end to the liquid sprays. A thin aluminum rupturing diaphragm covers the holes in the two end plates.

Behind the solid steel nose piece there is a hollow chamber for housing the 500 grams of explosive, the impact fuze, and the igniting device for setting off the cartridge pot.

The cartridge pot is just aft the chamber which houses the warhead and the fuzing system. When the contents of the cartridge pot begin to burn, a gas is generated which is used to expel the liquids from the tanks and force them into the combustion chamber.

The combustion chamber and venturi are made of mild steel mostly 1 mm thick, but the thickness increases at the venturi throat to 2½ to 3 mm. At the end of 2 seconds operation, the temperature of the venturi reached 300° to 400°. It was possible to use a venturi experimentally for five runs, after which it had to be renewed.

DATA:

Dimensions:
Total length: 2.10 meters.
Maximum diameter: 0.10 meter.
Length of tanks:
Acid tank: 1.15 meters.
Annular tank: 1.20 meters.
Diameter of tanks:
Acid tank: 0.08 meter.
Annular tank: 0.10 meter.

Weights:
Nose Piece: 1.30 kg.
Outer Shell: 3.25 kg.
Tanks: 1.75 kg.
Combustion Chamber: 1.50 kg.
Thrust Block: 0.73 kg.
Thrust Disk: 0.70 kg.
Rest: 1.77 kg.
Total (empty): 11.00 kg.
Charge in Warhead: 0.50 kg.
Expellant Cartridge: 0.50 kg.
Acid: 8.60 kg.
Fuel (Vizol): 2.30 kg.
Total (loaded): 22.90 kg.

FEUERLILIE MODEL F–25

DESCRIPTION. The F–25 is one of the "Feuerlilie" series of rocket-propelled guided missile which the LFA (Luftahrtforschungsanstalt Hermann Goering E. V.) located at Volkenrode/Braunschweig, Germany, was developing in order to obtain aerodynamic data in the near sonic and supersonic regions. Although the primary purpose of the Feuerlilie series development was to obtain aerodynamic data, some

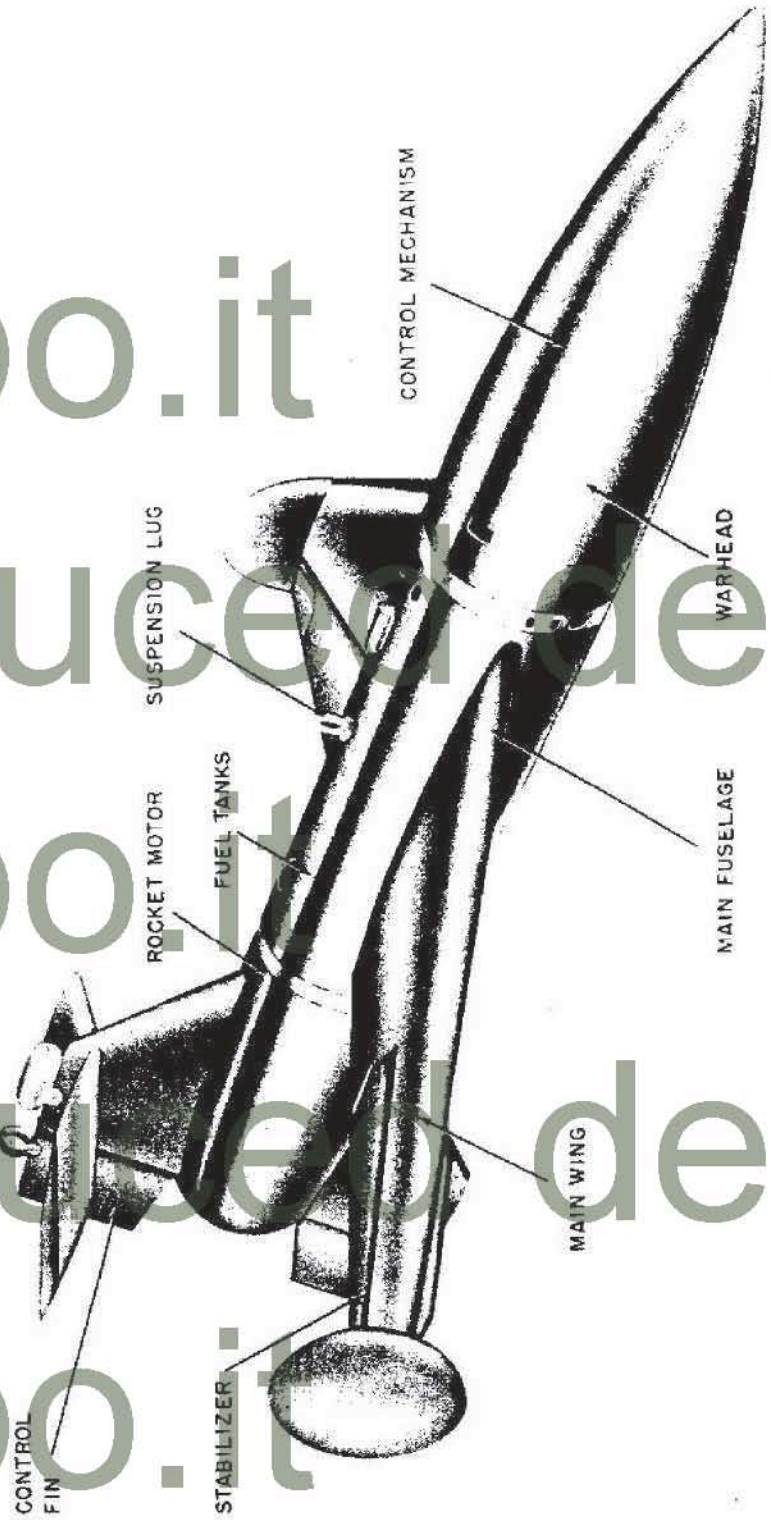

Figure 200—Feuerlilie F-25; Feuerlilie F-55

thought was also being given to the possibility of using certain models, such as the F–25, for actual production as a weapon of war. This model has a fuselage 2 meters in length and 25 cm maximum diameter with two wings attached to the midbody. The main wing span is 112 cm. The rocket drive is of the solid propellant type. The F–25 was a ground-launched rocket, which could reach an altitude of 3,000 meters with a horizontal range of 5,000 meters.

HISTORY OF DEVELOPMENT. Development work on F–25 was started in the spring of 1943 by Dr. Gerhard Braun of LFA. The fuselage was built by the Ardelt Werke, located in Breslau. About 20 models were built, of which 10 or more were tested successfully at Leba, near the Ostsee in Pomerania. However, the low maximum speed of 220 meters per second makes the results of no great significance. Development work was stopped in the fall of 1944.

CONCLUSIONS. Since the Feuerlilie F–25 was primarily a research project, it is of interest from an historical standpoint only.

DETAILS. AIRFRAME. The airframe of the F–25 consists of a 2-meter fuselage to which two main wings are attached near the mid body. The wings are provided with ailerons to give roll stabilization in flight. (See fig. 200.)

POWER PLANT. The power plant used for F–25 is of the solid propellant type RI 502 and was built by Rheinmetall-Borsig.

DESIGN DATA:

Weight of propellant: 17.5 kg.
Burning time: 6 sec.
Thrust: 500 kg.
Total weight of missile: 115 kg.

To produce an even thrust for aerodynamic data purposes, a blowoff valve located between the two venturis is provided. This valve opens at a pressure of 100 atmos.

CONTROL SYSTEM. The roll stabilization system used for F–25 was the same as that used for Hecht; i. e., one gyro was installed with its axis perpendicular to the missile axis in such a way as to increase the effective moment of inertia of the missile in roll. If a disturbance sets up a roll moment, the gyro would tend to precess, which would in turn cause the ailerons to reverse the roll of the missile. When no damping was provided with this system, excessive roll occurred. A mechanical dash-pot was added to remedy this condition.

The main reason for the choice of this type of gyro control was that the weight and space requirements were less than for the conventional available auto-pilot devices. The gyros were procured from Kreiselgerat, Berlin.

No attempt was made to remotely control the flight of Feuerlilie F–25.

WARHEAD AND FUZING. Since the F–25 was only a test model, no warhead was provided.

A Rheinmetall-Borsig time fuze was used to ignite the flares mounted on the wing tips to insure satisfactory tracking of missile in flight.

LAUNCHING. The F–25 was launched from the ground at an angle of 10°–30° to the vertical.

FEUERLILIE MODEL F–55

DESCRIPTION. The F–55 is another of the Feuerlilie series of rocket propelled guided missiles which the LFA (Luftahrtforschungsanstalt Hermann Goering E. V.) located at Volkenrode/Braunschweig, Germany was developing in order to obtain aerodynamic data in the transonic region. Although the primary purpose of the Feuerlilie series development work was to obtain aerodynamic test data, there is evidence that a certain amount of thought was being given to the possibility of using the F–55 as a weapon.

The Feuerlilie F–55 has a fuselage 4.8 meters in length and a diameter of 55 cm. The wing span of the two main fins which are attached to the afterbody of the fuselage is 2.6 meters. The first F–55 had a solid propellant rocket drive, but later models used a liquid rocket motor with a dry powder assisted take-off unit.

The F–55 was to be ground launched and it was expected to reach an altitude of 4,800 meters with a maximum horizontal range of 7,500 meters. Elaborate plans were also being made to install telemetering and to follow the flight path of the missile by cine-theodolites.

HISTORY OF DEVELOPMENT. Development work on F–55 was started about May 1944 by Dr. Gerhard Braun of LFA. The body for the F–55 was built by Ardelt Werke, Eberswalde, Breslau.

The production scheduled for experimental models of F–55 for the year 1945 called for a total of 35 with deliveries of at least 3 per month for the first 10 months of the year. These were to be tested with various stabilizing systems and the later models were also to be equipped with telemetering and remote control equipment.

The first model of F–55 with solid propulsion was tested at Leba, Pomerania in May 1944, with satisfactory results, a Mach number of 1.25 being attained. The second model with a liquid fuel system and take-off unit was tested at Poenemunde on 11 December 1944; this model went into a spin about its pitch axis shortly after leaving the launching track. The third model had been sent out to Poenemunde for testing, but had not yet been tested.

CONCLUSIONS. Since the Feuerlilie F–55 was primarily a research project, it is of interest largely from the standpoint of the methods tried and the techniques of flight observations used.

As the F–55 like the F–25 was a manifestation of the Velkenrode research groups' ideas, it undoubtedly represents a high order of an aerodynamic development and requires treatment as such. The Braunschweig documents, duplicated by the United States Army Air Forces and evacuated to Wright Field, Dayton, Ohio, include comprehensive reports on the Feuerlilie series.

DETAILS. AIRFRAME. The airframe of the Feuerlilie F–55 consists of a fuselage 4.8 meters long, and having a maximum diameter of 55 cm. There are two sharply swept back wings having a span of 2.6 meters. Two vertical fins are mounted at the extremities of the wings, this position being chosen to keep them out of the wake of the body.

The outer halves of the training edges of the wings are movable so as to give aileron control. No rudder is provided, yaw control being obtained from aileron action.

POWER PLANT. The power plant used for the first model of F–55 was the RI 503 solid propellant type built by Rheinmetall-Borsig. For the second and third propulsion unit designed by Dr. Contrad of DVX (Deutsche Versuchsanstalt fur Kraftfahrzeug und Fahrtzeugmotoren) located in Berlin. In addition, an assisted take-off unit. "Pirat," a solid propellant rocket was used.

DESIGN DATA:	SG 20	PIRAT ATO.
Thrust	6,400 kg	10,000 kg.
Time of burning.	7 sec	2.7 sec.
Weight of fuel	210 kg	150 kg.
Impulse	45,000 kg sec	27,000 kg sec.

CONTROL SYSTEM. On the first model of F–55, no roll stabilization was used. On the second and third models, gyro equipment developed by Fischl of DFS (Deutsche Forschungsanstalt fur Segelflug) was tried. This system used a single gyro with Askania pneumatic rubber servos. It was expected that the rubber would provide the necessary mechanical damping, but due to the fact that the only test flight on which this system was used failed, it was impossible to determine whether or not this was the case. On subsequent models, it was proposed to use a Horn gyro system consisting of two gyros, one of which was used for damping only. This system was also to be used with the Askania pneumatic servo systems of remote control.

In connection with the Feuerlilie program, a new telemetering system "Stuttgart" had been developed which had 12 channels and gave 20 values per second with an accuracy of ±5 percent. This system was designed by the Forschungsanstalt Graf Zeppelin, located at Stuttgart/Ruit.

WARHEAD AND FUZING. Since the F–55 was primarily a research missile in the early stages of its development, there was no provision made for a warhead. Like the F–25, a Rheinmetall-Borsig time fuze was used to ignite the flares mounted on the wing tips to insure satisfactory tracking of the missile in flight by means of cine-theodolites.

LAUNCHING. The F–55 was launched from an inclined ramp built by Ardelt Werke, Breslau. The launching angle was 20° to the vertical.

RHEINTOCHTER

GENERAL DESCRIPTION. The Rheintochter is a radio-controlled antiaircraft rocket designed for ground launching against bomber formations. The first model Rheintochter 1, is a two stage rocket having a total launching weight of 1,750 kg. The starting rocket has a burning time of only 0.6 second, after which it drops off, the main stage then being automatically ignited. Stabilization was achieved by six fins attached to the

rear of the main body of the rocket and four fins attached to the starting unit. The rocket was to be remote radio controlled with the possibility of using an infra-red homing device together with a proximity fuze to detonate the missile in the midst of the bomber formation. The control surfaces were located at the nose of the missile. It attained a final velocity of 360 meters per second, and could reach a height of 6 kilometers with a maximum horizontal range of 12 km.

The Rheintochter 1 was replaced by the development of the Rheintochter 3. The remainder of this discussion will be on the second model and will go into considerable detail.

In the Rheintochter 3, the rear take-off unit was dispensed with and replaced by two auxiliary take-off units mounted on the sides of the body of the rocket. The main rocket stage could be either a liquid or a solid propulsion unit, depending on the availability of fuels. The Rheintochter 3 is designated as R–3f when a liquid propulsion unit is used and R–3p when a solid propellant is employed in the main rocket stage. The control and steering mechanism are identical in both Rheintochter 1 and Rheintochter 3. The Rheintochter 3, however is allowed to rotate about its axis in flight and instead of six stabilizing fins, it is provided with only four. (See fig. 201.)

DETAILS. Airframe. The Rheintochter 3 consists of a main fuselage 500 cm. long and 54 cm. in diameter, having four large swept-back main fins and two auxiliary take-off units mounted on the sides of the body between the two pairs of fins. As in the Rheintochter 1, the control surfaces are mounted in the nose section but are of a somewhat different aerodynamic design.

The main fin span is 220 cm. the four fins being attached to the body so that the angle between successive fins is 90°.

As in Rheintochter 1, the main fuselage is constructed partly of aluminum plate, partly of steel alloy plate and partly of a material called ELEKTRON. The fins were to be constructed of LIGNOFOL, a highly compressed laminated wood, but for mass production purposes, plywood could have been used.

DESIGN DATA:

Dimensions:
- Length: 500 cm.
- Span: 220 cm.
- Diameter: 54 cm.

Weight:
- Empty: 525 kg.
- Take-off units: 440 kg.
- Main stage fuel: 88 kg.
- Main stage oxydizer: 336 kg.
- Main stage compressed air: 18 kg.
- Explosive: 160 kg.
- Launching weight: 1,570 kg.
- Weight at target: 685 kg.

POWER PLANT

A. R–3f Liquid Propulsion Unit. The R–3f liquid propulsion unit requires fuel tanks carrying 336 kg of Salbei, 88 kg of Visol and 18 kg of compressed air at a pressure of 250 atmospheres to provide pressure feed to the combustion chamber.

B. R–3p Solid Propellant Unit. The R–3p solid propellant unit utilizes 5 rods of diglucol dinitrate weighing 90 kg each, making a total weight of 450 kg.

DESIGN DATA (R–3f):
- Launching altitude: Angle.
- Total launching impulse: 105,000 kg/sec.
- Velocity at end of combustion: 410 m/sec.
- Velocity at target: 400–200 m/sec.
- Take-off units: 2 dry powder rockets.
- Take-off unit impulse: 25,000 kg/sec.
- Take-off unit thrust: 28,000 kg.
- Main stage rocket impulse: 80,000 kg/sec.
- Main stage burning time: 45 sec.
- Main stage thrust: 1,700–2,300 kg.

CONTROL SYSTEM. Since remote control radio roll stabilization was found to be unsatisfactory, it was decided that Rheintochter 3 would be allowed to rotate at the rate of one revolution per second about its longitudinal axis, just as X–4 rotates. Since the X–4 gyrocommutator system for converting control impulses to the proper control surfaces in turn was available, it was thought that this system could also be used for Rheintochter 3.

The combination radar tracking and remote control system "Elsass" or possible "Brabant," the decimeter version, was to be used for guiding the flight of the "Rheintochter 3," just as proposed for Rheintochter 1. However, the "Elsass" development was not far enough along to permit field tests to determine whether it was satisfactory.

WARHEAD AND FUZING. In the liquid propulsion version R–3f, the warhead is carried between the Salbei and Visol fuel tanks in that sec-

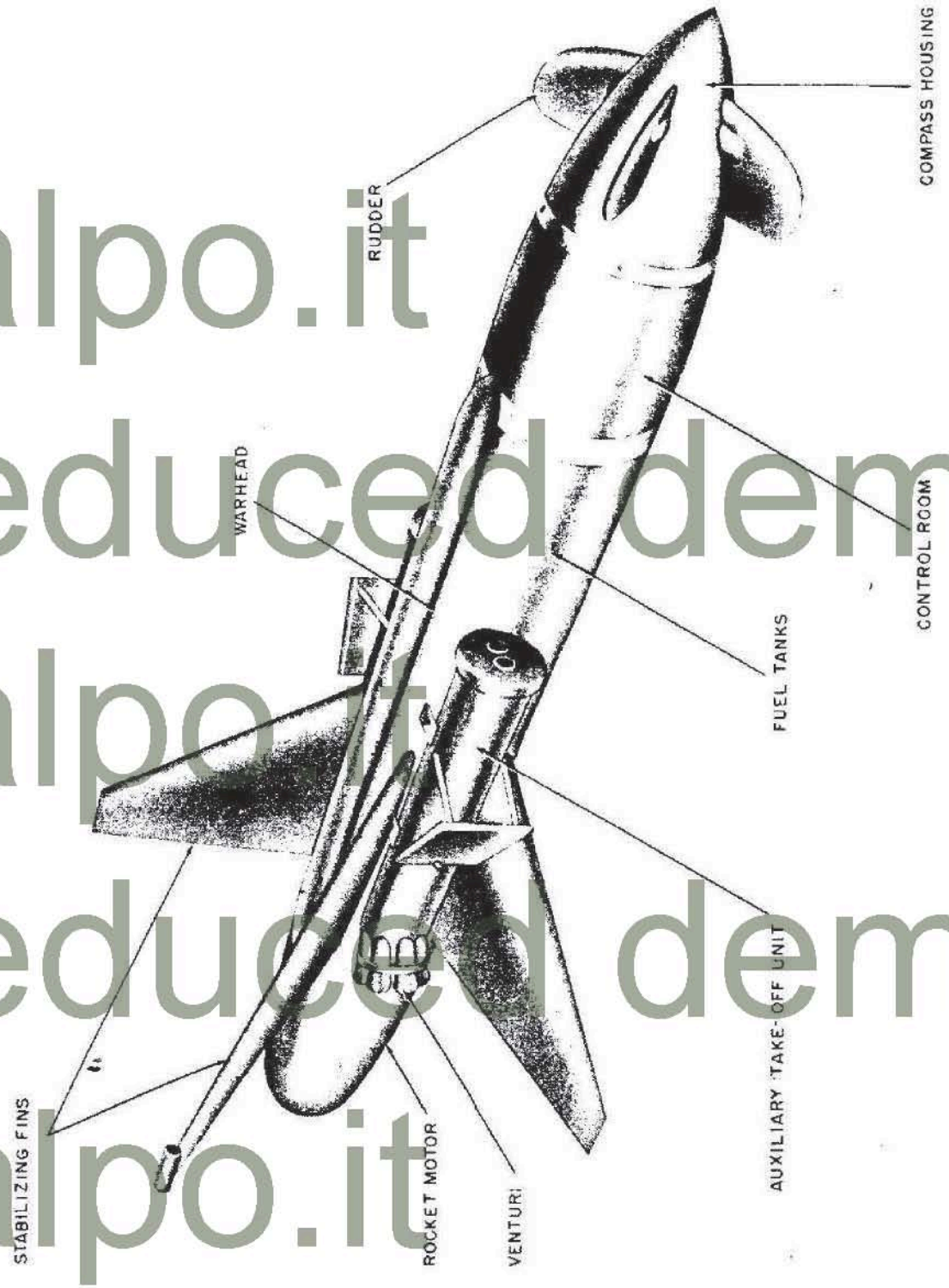

Figure 201—Rheinfochter R-3

tion of the main fuselage to which the main fins are attached.

In the solid propellant version R–3p, the warhead is located farther forward between the control compartment and the propelling charge. The warhead consists of 150 kg of high explosive.

The fuzing system for Rheintochter 3 had not been finally decided upon. Several plans were under consideration, all of which contemplated the use of a complicated fuzing system, which would not only serve to detonate the missile, but also take care of detaching the ATO units after one second and igniting the main jet. In addition of course, a time feature would be embodied to detonate the missile after 50 seconds in the air so that it would not fall and explode on friendly territory. The Rheintochter 3 was also to be fitted with an impact fuze and a proximity fuze of some sort, either acoustic, infra-red, or radio. Among the proximity fuzes considered were "Kranich," "Kakadu," "Marabu," "Fox," and several others.

As pointed out in the History of Development, plans were also under way to utilize some sort of homing device in "Rheintochter," but these plans were still in a very nebulous state.

AUXILIARY EQUIPMENT. Like Rheintochter 1, Wasserfall and the other guided AA rocket, Rheintochter 3, requires a great deal of auxiliary ground equipment, such as computers, optical gear, range finders, etc., for remote control purposes.

LAUNCHING EQUIPMENT. The launching equipment for Rheintochter 3 is identical with that used for Rheintochter 1 and has already been described in the report on the latter missile.

GREAT ENZIAN

DESCRIPTION. The Enzian was conceived as a ground to air flak weapon. Its secondary purpose was that of an air-to-air weapon. Models E–1, E–2, and E–3 were the test and experimental articles. All flight tests were carried out with the E–1. The E–4 was the production design using an improved rocket motor, designed by Dr. Conrad instead of the Walter biliquid used in the earlier designs. As the foregoing is the only major difference in the four models, they will be discussed as one: however, there exists another type, E–5, which being a basically different type will be covered in a separate report to avoid confusion.

The E–4 is a flying wing design of striking similarity to the Me–163. Its total weight is 1,800 kg which includes the weight, 320 kg of the four assisted take-off units. The war heads weight is 500 kg. The airplane is constructed of wood, having an over-all length and span of four meters. It attained its velocity of 300 m/sec with a main thrust unit delivering 2,000 kilograms initially decreasing to 1,000 kg during the flight. Duration of power was 72 seconds, resulting in a vertical range of 16,000 meters and a horizontal range of 25,000 meters.

The four assisted take off units deliver a combined thrust of 6,000 kilograms for 4 seconds, giving the missile which attains an end speed of 24 m/sec and an acceleration of 3.6 g from a launching ramp 6.8 meters in length. The assisted take-off units are jettisoned after 5 seconds.

Although it was anticipated that E–4 would be used as an air-to-air weapon with slight modification, principally reduced fuel load, all experimental flight testing had been done from ground to air. A standard 88 mm gun carriage was adapted for use as a launching platform by the simple addition of two iron rails 6.8 meters long. A traverse of 360° and a vertical firing arc from 0° to 85° were obtained. Air launching of the device was routine; i. e., dropping free from underneath the parent aircraft flying in the direction of the target.

The speed on leaving the launching rails is 24 m/sec; to avoid the possibility of stall no control is applied until the flying speed has reached approximately 55 m/sec. For practical purposes an elapsed time of 5 seconds is allowed between the triggering of the launching mechanism and the first control signal. The Enzian, as were practically all German guided missiles, was directed to the target vicinity by radio control. When the target approach was within the range of the homing device, the latter took charge of the missiles final run in. Coincidence or line of sight navigation was used under favorable conditions; however, several methods were accepted for night or reduced visibility use.

AIRFRAME. The Enzian E–4 airframe was a flying wing type having no horizontal stabilizer and a fixed vertical fin. Control was effected through trailing edge flaps which act together as

Figure 202—Enzian E-4

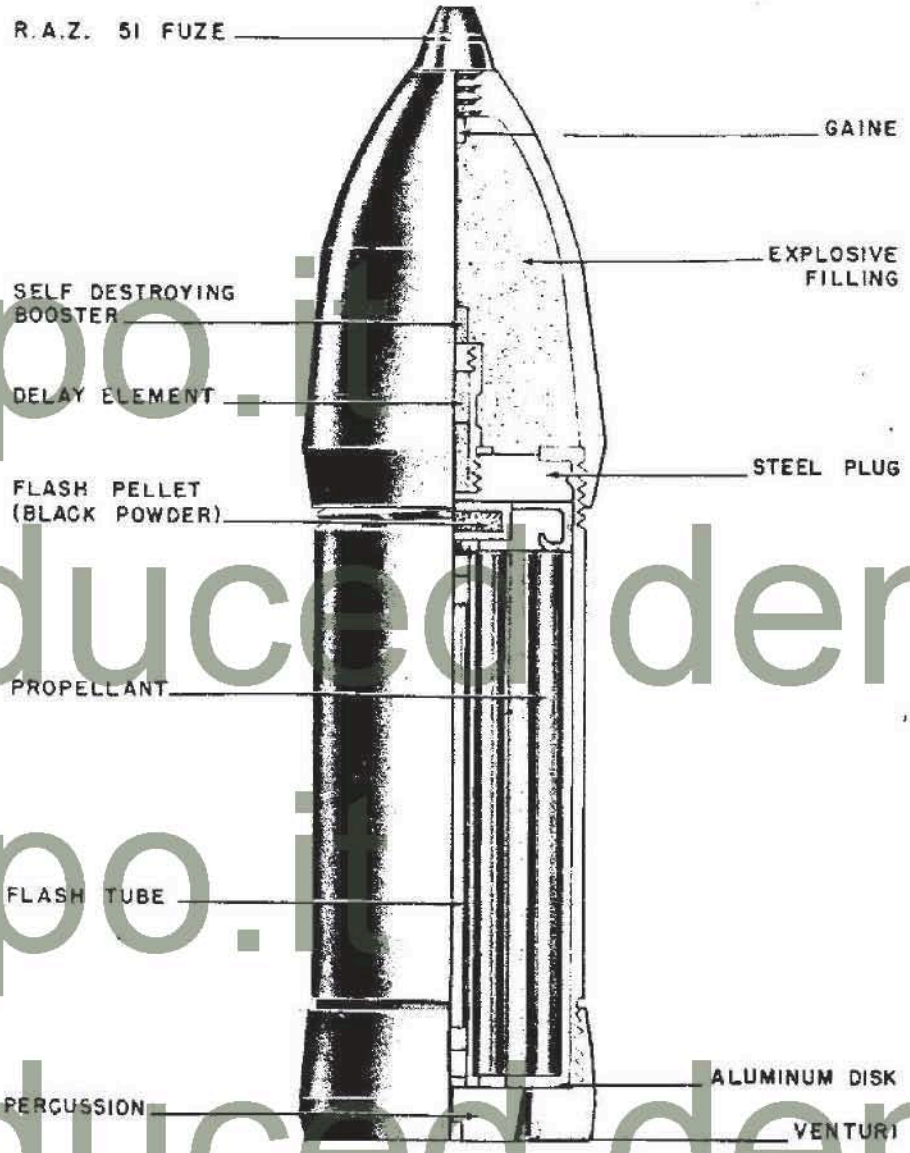

Figure 205—7.3-cm R. Sprgr Rocket

explosive charge. Below this plate is a stamped metal supporting ring containing the ignition charge for the propellant.

The base plate, which screws on the rear end of the body, has seven outer offset venturi, seven straight venturi, and a central drilling for a percussion primer.

The propellant charge consists of a single cylindrical stick with a central perforation and eight outer perforations. Raised ribs around the circumference of the propellant serve to keep it clear of the motor body and permit external burning. Two ⅛-inch blocks of powder, cemented to the base of the charge, act as spacers and keep the venturi free from obstruction.

The charge is ignited by the flash from the percussion primer. The flash is transmitted along a celluloid tube in the central drilling to the ignition charge at the forward end of the propellant. The celluloid tube is of conventional design. It contains a quickmatch train and is closed at each end by a cylindrical block of gunpowder.

8-cm RAKETEN SPRENGGRANATE (H. E. AIRCRAFT ROCKET)

DATA:

General:

Caliber: 78 mm.

Over-all length: 28.5 inches.

Weight (complete round): 15 pounds 3 ounces.

Filling: Flaked TNT.

Warhead: Material: Steel.

Dimensions:

Length: 8 inches.

Diameter: 3 inches.

Rocket motor: Material: Steel.

Dimensions:

Length: 12.8 inches.

Diameter (outside): 3.07 inches.

Diameter (inside): 2.75 inches.

Weight: 4 pounds, 5.25 ounces.

Venturi: Material: Steel.

Dimensions:

Length: 7.48 inches.

Outside length of fins: 5.31 inches.

Rear diameter across fins: 7.87 inches.

External.

Internal: 3.34 inches.

Weight: 2 pounds, 0.25 ounces.

Inlet:

Maximum diameter: 2.48 inches.

Minimum diameter: 0.782 inch.

Length: 0.92 inch.

Throat: Diameter: 0.782 inch.

Outlet:

Minimum diameter: 0.782 inch.

Maximum diameter: 1.653 inch.

Grid:

Diameter: 2.72 inches.

Thickness: 0.51 inch.

Weight: 3 ounces.

Propellant: Double base powder in mono perforated stick form.

DESCRIPTION. This is a fin-stabilized projectile with an appearance typical of small caliber aircraft rockets. The internal arrangement of the projectile suggests that it was possibly copied or adapted from a standard Russian aircraft rocket. Although this rocket almost certainly was designed primarily as an aircraft weapon, it was also fired from a multiple-frame ground launcher known as the 8-cm Raketen Bielfachwerfer. The projectile consists basically of an H. E. warhead, a rocket motor, and a tail unit incorporating a single venturi and stabilizing fins.

WARHEAD. The warhead of the projectile is a steel cylinder with an ogival nose into which is built a fuze system. The rear of the head is closed by an adapter plug which also forms the junction with the rocket motor.

The main H. E. filling consists of a pressed flake TNT and is built up from three perforated pellets which fit around the exploder tube incorporated in the fuzing system. At the nose end is a small cardboard washer; at the base are two waxed-paper washers; and around the exploder magazine is a waxed-cardboard tube. Between the shell wall and the explosive is a thin layer of bituminous material. The outer surfaces of the pellets are waxed.

ROCKET MOTOR. The body of the motor is formed by a cylinder which is machined down slightly between the ends. The forward end of the cylinder is threaded internally to screw over the adapter plug which forms the junction with the warhead. Four studs in the body, two at each end, guide the projectile in the launcher. The base of the motor body is closed by the motor closing plate, which is in the form of a single venturi to which four stabilizing fins are spot welded.

The propellant consists of six sticks, of which two are slightly shorter than the other four. The four longer sticks are located by a supporting grid which is a push fit in the venturi assembly. The other two sticks are supported on the two primary igniters attached internally to the walls of the rocket motor.

The ignition system consists of two ignition charges, one at each end of the propellant, and a primary igniter. The primary igniter is in the form of two copper tubes, each screwed internally over the end of the steel guiding studs which pass through the motor body at the rear end. A brass rod, insulated by a rubber sleeve, passes through the guiding stud and bears against a brass contact inside the copper tube. This contact passes through the tube into a small cardboard container holding a loose composition charge of gunpowder. Wires from the contact to the walls of the copper tube serve to ignite the charge. The circuit is presumably formed by two leads, one to the brass rod in each guiding stud, and is grounded to the rocket body.

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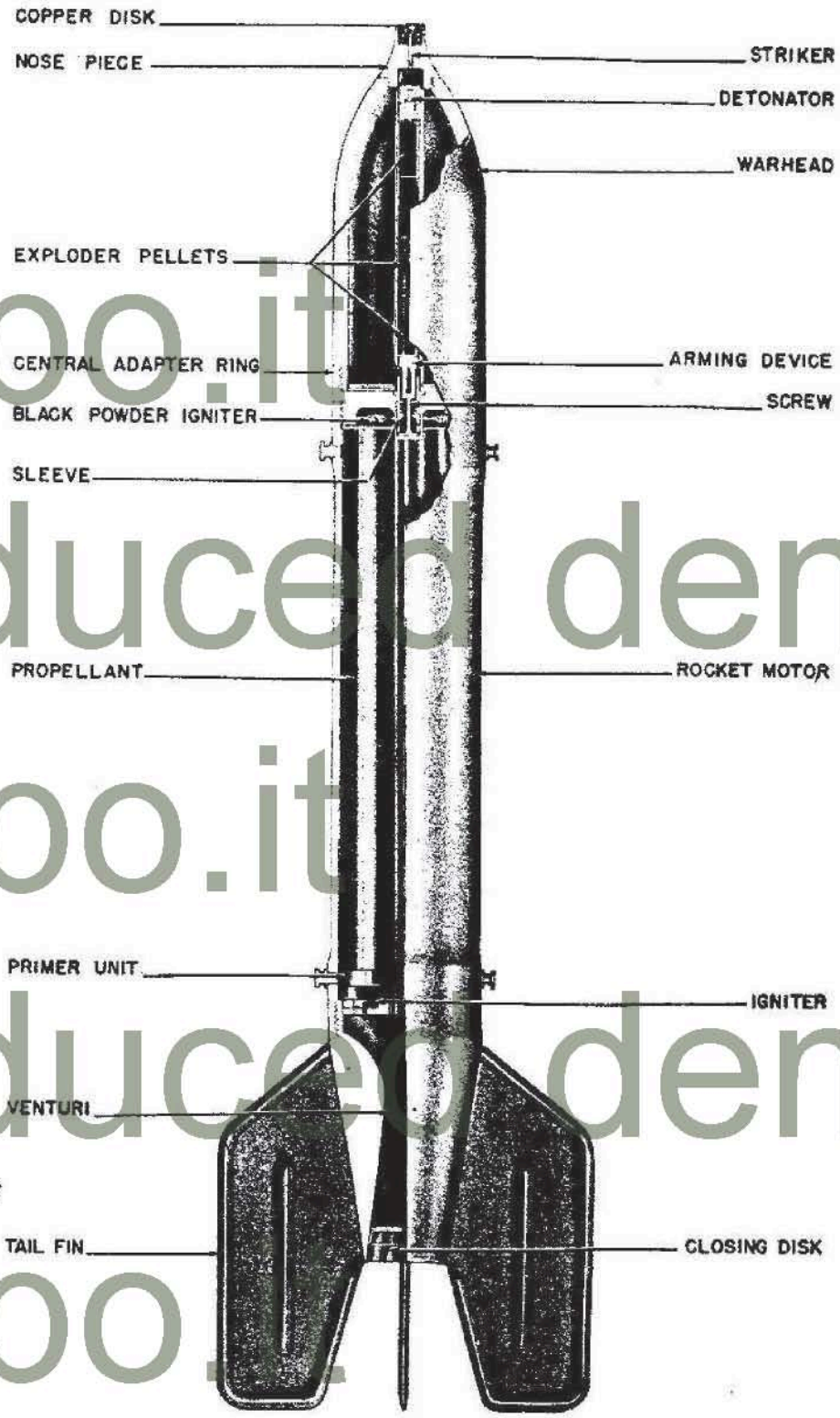

Figure 206—8-cm Aircraft Rocket

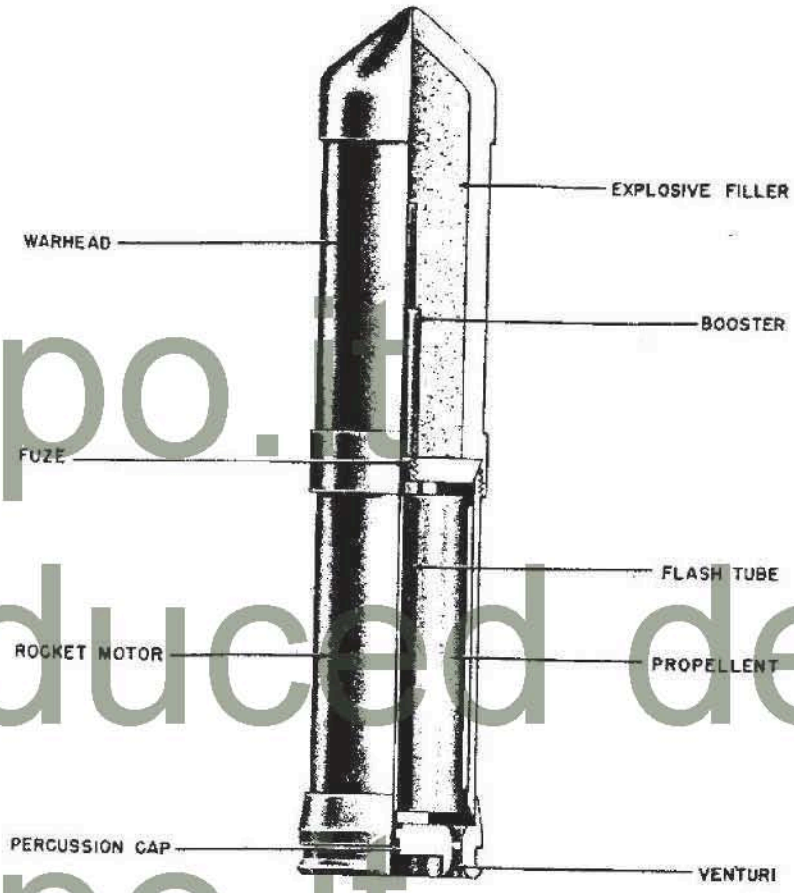

Figure 207—8.6-cm H. E. Rocket (Naval)

FUZING SYSTEM. This rocket has a fuze which has been designed specifically for it. The arrangement of the system is shown in figure 206. The fuze consists of a steel nose piece which contains a light alloy striker supported by a light creep spring. Below the nose piece is a steel magazine tube, into the forward end of which is screwed the detonator housing. Directly below the magazine tube is the arming mechanism which consists of a metal sleeve containing a spring loaded screw and the plunger. Holding the spring loaded screw and the plunger in position is a fusible metal ring. When assembled, the plunger fits into the lower end of the magazine and the booster pellets rest on it.

When in the position as shown in figure 206 the detonator is beyond the reach of the striker and the fuze is unarmed. When the rocket is fired, the heat of the burning propellant is conducted through the wall of the spigot and melts the fusible metal ring. The plunger, magazine, and detonator are then free to move forward under the action of the spring. The extent of this forward movement depends upon the acceleration of the rocket. Approximate measurements indicate that if this is less than 40–50 g the detonator is sufficiently forward to be fired by the striker.

8.6-cm H. E. ROCKET (SPIN STABILIZED)

DATA:

Nature of projectile: Multiple base-venting, spin-stabilized pusher rocket.
Caliber: 8.6 cm.
Over-all length: 16.25 inches.
Over-all weight: 17 pounds 15 ounces.
Nature of filling: H. E.
Nature of fuze: Base.

Warhead:
Length: 9.55 inches.
Diameter: 3.35 inches.
Type of filling: Cast TNT.
Rocket Motor:
Length: 6.7 inches.
Length of propellant chamber: 6.08 inches.
External diameter: 3.18 inches.
Internal diameter: 2.94 inches.
Weight of filled motor: 6 pounds 12.25 ounces.
Propellant length: 5.90 inches.
Diameter of propellant: 2.78 inches.
Weight of propellant: 2 pounds 7.75 ounces.
Analysis:
Potassium nitrate: 75.5 percent.
Carbon: 15.35 percent.
Sulphur: 9.15 percent.
Volatile material: 0.86 percent.

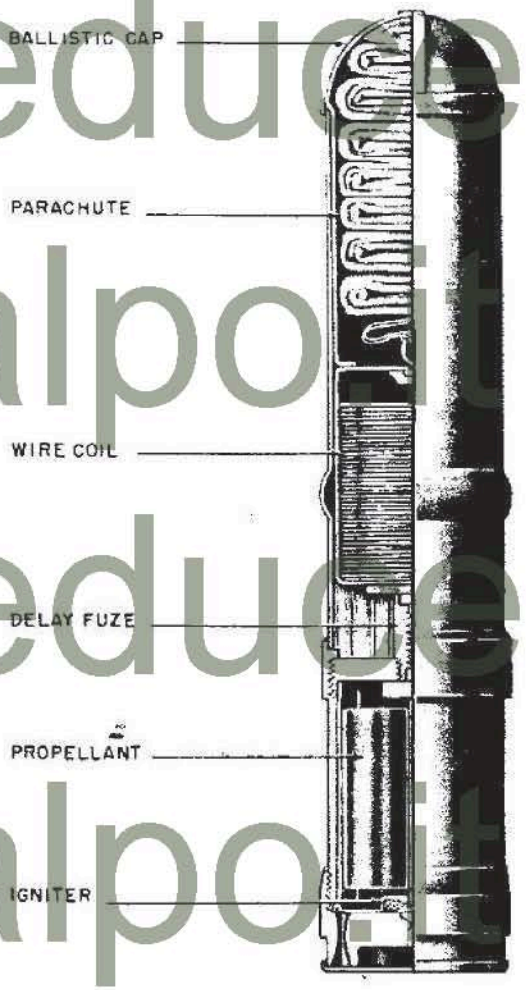

Figure 208—8.6-cm Illuminating Rocket (Naval)

DESCRIPTION. This rocket consists of a H. E. head, a motor, and a venturi assembly. An integral base fuze, centrifugally armed and pressure fired, is located in the base of the H. E. head. A standard booster assembly is employed. (See fig. 207.)

The H. E. head threads over the rocket motor housing, which contains a single, multiperforated, propellant grain. A venturi assembly, with eight jets drilled in it, is threaded to the base of the motor. A single threaded hole in the center of the venturi assembly contains a percussion primer.

On the forward end of the motor housing is a fitting which receives one of three interchangeable delay trains. The rockets bear markings to indicate which of the delay trains have been assembled. Those marked "/400/" and "/800/" contain, in addition to the delay train, a fuze with a striker retained by four arming balls and a spring collar. A light anticreep spring is placed between the striker and the detonator.

Centrifugal force causes the balls to move outward against the collar and arm the fuze. The delay train is initiated by the propellant grain, and when the delay expires, the pressure developed forces the striker against its spring and into the detonator. Impact with some resistant object before the expiration of the delay will force the striker into the cap. In the case of the round marked "/600/" no striker mechanism is included, and the delay initiates the detonator and booster directly, giving only self-destroying action.

REMARKS. This is a naval round, designated "8.6 cm R. Spr. 400 Wsm. (600 Wsm, 800 Wsm.)."

The H. E. head is painted canary yellow overall; the motor body, dark green.

It is estimated that this projectile would reach a maximum height of 8,000 feet, if fired at a quadrant elevation of 90°.

8.6-cm R Lg 1000 ROCKET

DESCRIPTION. The 8.6 cm R lg 1000 (flare) and the 8.6 cm R Dg 1000 (wire) differ only in the contents of the body. The flare rocket contains a parachute-suspended flare having a burning time of 30 to 35 seconds. The wire rocket contains, in place of the flare element, a spool of wire which is suspended by the parachute. No explosive is attached to either the parachute or the wire. (See fig. 208.)

The flare element is contained in a light metal can which is directly above the base delay pyrotechnic fuze. The parachute fits above the wooden plug midway up the tube. The forward end of the body is closed with a light ballistic cap which is pushed out by the ejecting parachute-flare unit. The base of the body is closed with a wooden block which rests on the lip of the adapter. The adapter is welded to the body and serves as a bourrelet as well as the attachment between the motor and the body. The pyrotechnic time base fuze of 8.5 seconds burning time is ignited by the burning of the propellant in the rocket motor.

The motor is similar to that of the 8.6 cm R Sgr L/4.8 except that the nozzles are changed to accommodate the reduced propelling charge.

The black powder propellant grains 100 mm long and 70 mm in diameter, weighing 750 grams, is mounted in a manner similar to the Spgr L/4.8. The diglycol propellant consists of two concentric cylinders 80 mm in length and having diameters of 70/40 and 35/5 mm, weighing 420 grams. A flash tube runs through the central 5-mm diameter hole of the inner grain from the rear igniter up to the forward igniter. The ingniters and grains are held in position by a three-armed grid at each end of the grain. It is indicated that the grid is of plastic material instead of the usual metal construction.

DATA:

Motor:
- Propellant: Black powder, diglycol.
- Nozzles: 8, 4.
- Throat diameter: 4.50, 5.45.
- Cant angle: 9°.
- Nozzle K: 234, 480.

Performance:
- Thrust: 150.
- Burning time: 1.20.
- Impulse: 80.
- Range: 1,000 m.

Nozzle design factors:
- Diameter of Jet ring: 69±0.1 mm.
- Entrance cone angle (first): 60°.
- Entrance cone angle (second): 15°±15 min.
- Length of cone (first): 1.5 mm.
- Length of cone (second): 5.5 mm.
- Throat length: 3.0±0.5 mm.
- Expansion cone angle: 1.0°±10 min..

LAUNCHING. The launcher used in the various tests consists of a single barrel weighing 40 kg. It is denoted as the 8.6 cm R Ag M 42.

8.6-cm ANTIAIRCRAFT ROCKET SPIN STABILIZED

DATA:

Over-all length: 16.5 inches.
Diameter: 3.39 inches.
Total weight: 11.0 pounds.

DESCRIPTION. This rocket is constructed of steel in four sections; Projectile body, parachute container, cable container, and rocket motor. (See fig. 209.)

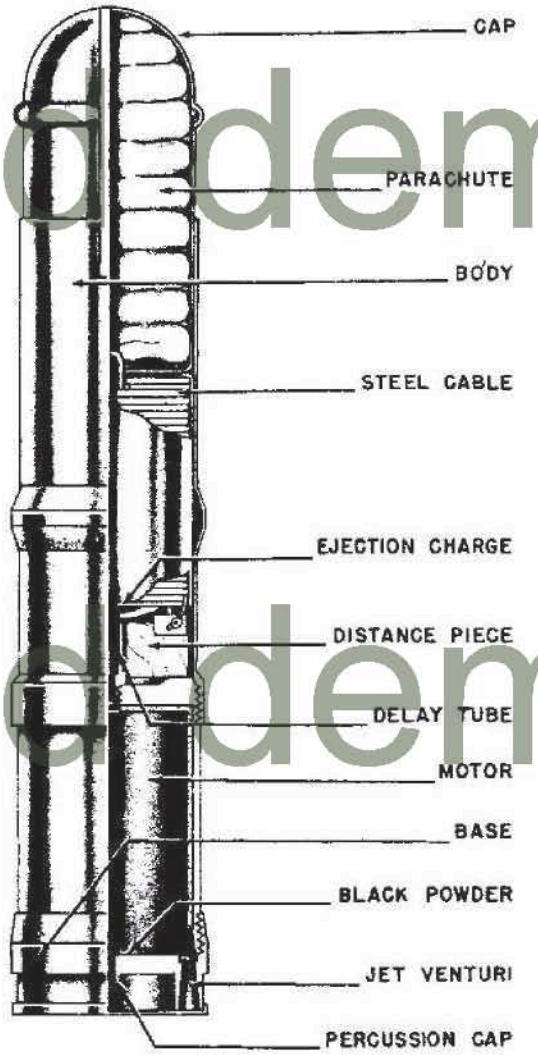

Figure 209—8.6-cm Antiaircraft Rocket (Naval)

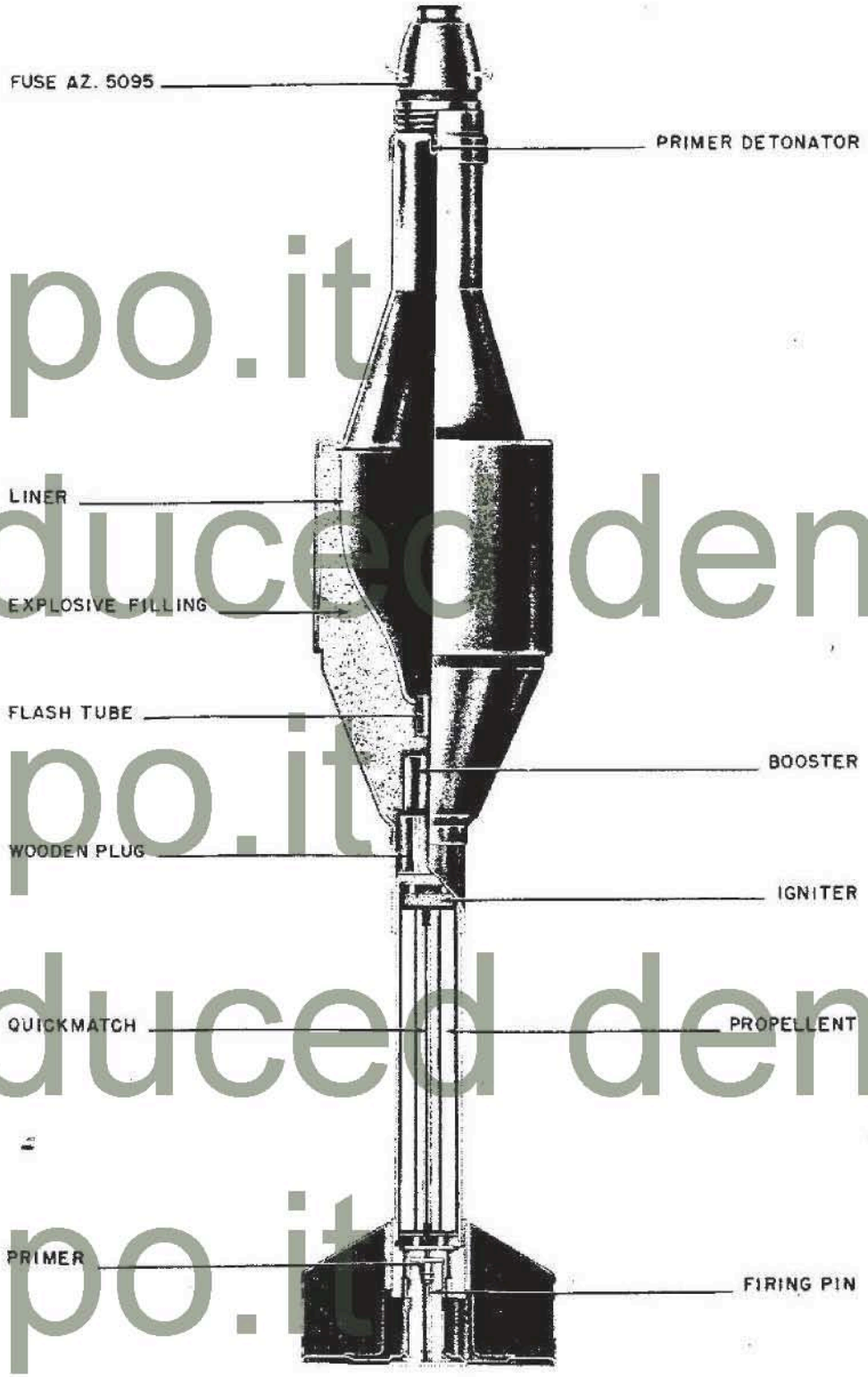

Figure 210—8.8-cm Hollow Charge Antitank Rocket

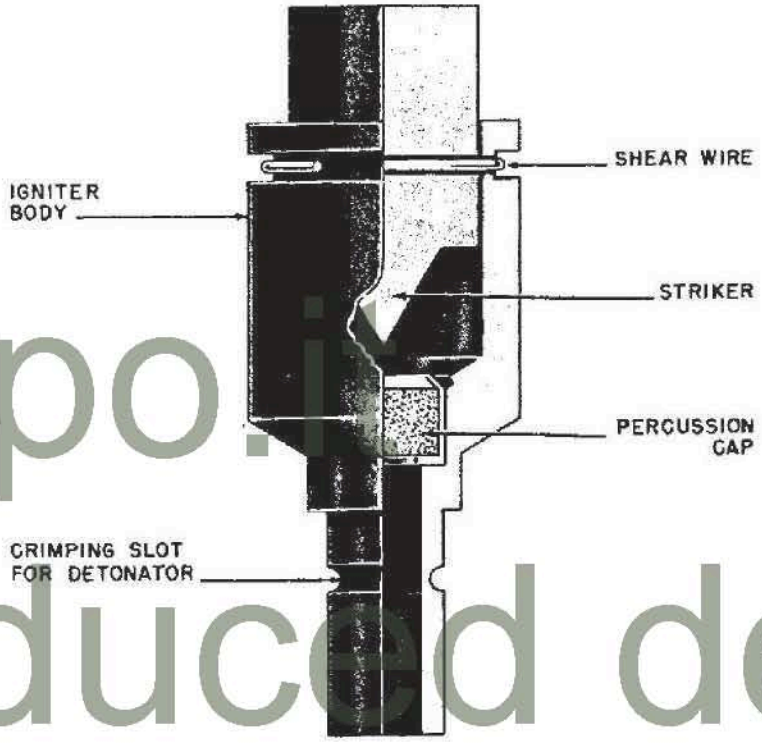

Figure 274—Fi. Es. Mi. Z. Pressure Igniter

the detonator, thus igniting the primer and finally the main charge of the mine. (See fig. 273.)

EMPLOYMENT. Designed for use with the Topf mine.

FI. ES. MI. Z. (PRESSURE TYPE)

DATA:

Length: 1.5 inches.
Diameter: 7/16 inch.
Color: Dark green.
Pull or pressure required: 11 pounds.
Material: Brass.

DESCRIPTION. The body of the igniter forms a housing for the striker and for the detonator cap. The lower end terminates in a sleeve to which the detonator can be crimped. Holes are drilled in the body to accept the copper shear wire which passes through the striker, the ends being bent into the cannelure. (See fig. 274.)

OPERATION. Pressure on the head of the striker shears the copper shear wire and forces the striker into the detonator cap. The subsequent flash passes to the detonator which in turn initiates the main charge of the mine.

EMPLOYMENT. This igniter was designed for use with the antipersonnel glass bottle mine (Eismeine 42).

ALL-EXPLOSIVE DEVICE (PRESSURE RELEASE TYPE)

DATA:

Total weight: 9½ ounces.
Height: 1⅛ inches.
Length: 3⅞ inches.
Width: 2 inches.
Color: Greyish black.
Pull or pressure required: 1 pound.
Material: Cast explosive brass.

DESCRIPTION. The body of the device is made up of two oblong blocks of molded explosive, held together by two hollow brass bolts. The explosive, a greyish-black substance of smooth texture, is believed to be one of the many forms of Nipolit. The inner surfaces of both blocks bear molded recesses to retain the metal striker mechanism. A threaded detonator well is positioned at one end to receive the cap and detonator assembly. Four holes pass through the charge, two at either

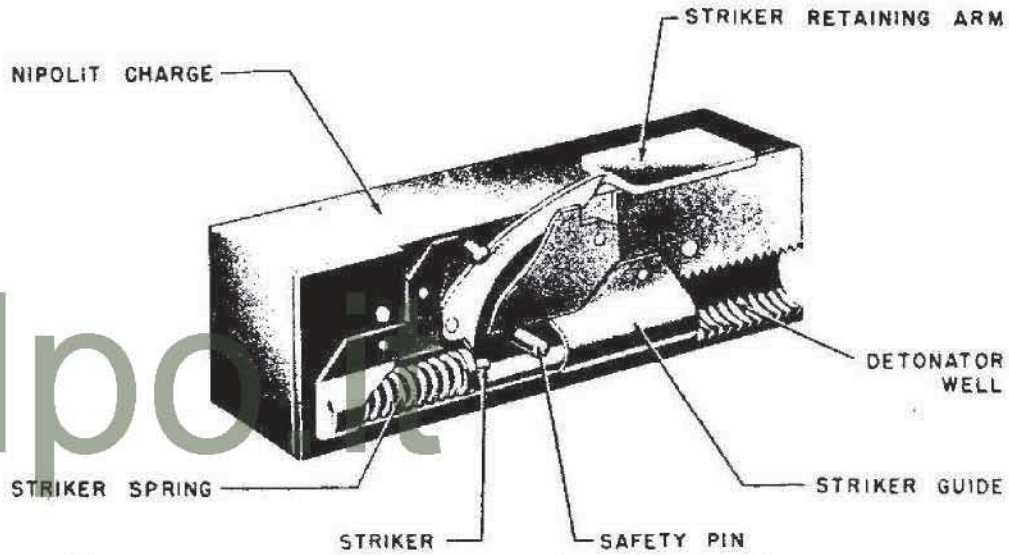

Figure 275—All-Explosive Pressure Release Device

end, for the bolts and two for the safety pins. The cap and detonator assembly is believed to consist of a hollow threaded plug of the same explosive material. The cap and detonator drop into the plug and are then screwed into the wall. (See fig. 275.) The striker mechanism consists of a stamped sheet metal housing, a striked retainer arm, striker spring and striker. In the armed position the striker spring and striker are positioned in the tubular striker guide at the base of the housing and are restrained from firing by a notch or detent in the retaining arm which bears against the shoulder of the spring-loaded striker. The retaining arm pivots at one end on a small bolt positioned above the detent. The two safety pin holes in the metal housing coincide with holes that pass through the explosive body. The upper safety pin passes directly over the retaining arm and prevents it from pivoting. Another hole passes through the tubular base of the housing and is an added safety precaution in that it prevents the striker from striking the cap.

OPERATION. After the device has been placed under the object to be booby trapped, the safety pins are removed. When the external weight is lifted, the striker retaining arm, under the pressure of the striker spring, pivots upward releasing the striker and firing the percussion cap. The cap in turn fires the detonator and the main charge. No booster is required.

EMPLOYMENT. This device is designed for use as a booby trap and can be readily used beneath ordinary household objects as well as mines and other suitable objects.

BUCK IGNITER, CHEMICAL CRUSH-ACTUATED TYPE

DATA:

Length: 1⅝ inches.
Diameter: 13/16 inch.
Color: Tan.
Pull or Pressure Required: Approximately 5 pounds.
Material: Brass tube; Aluminum alloy foil.

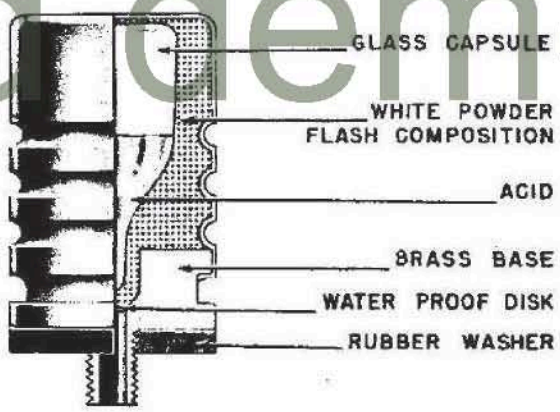

Figure 276—Buck Igniter—Chemical Pressure

DESCRIPTION. The igniter consists of a thin aluminum alloy foil drum containing a glass ampoule of sulphuric acid and a white powdered flash composition containing naphthalene. (See fig. 276.) The drum is crimped to facilitate crushing from vertical pressure. The glass ampoule is fixed to the top of the drum with pitch. A waterproof paper disk confines the flash composition powder in the igniter and prevents moisture from entering. The drum is secured to a brass base by crimping and a rubberized washer is placed around the threaded portion of this base. The thread is standard and will fit any German booby trap or demolition device.

OPERATION. When pressure is applied, the foil drum is dented and the ampoule is broken. The sulphuric acid contained in the ampoule mixes with the powdered flash composition and the flash resulting from the chemical reaction fires the detonator.

EMPLOYMENT. This igniter has been used principally with the antipersonnel "Pot" mine, but is adaptable for use with any type of German booby trap or demolition device.

LONG-DELAY IGNITER (CLOCKWORK TYPE)

DATA:

Length: 3⅝ inches.
Diameter: 1¼ inch.
Color: Black.
Pull or Pressure Required: 21-day maximum.
Material: Bakelite.

DESCRIPTION. The body houses a rotating disk used for setting the delay, a clockwork mechanism, a battery, and an electrical circuit with a match composition bridge.

The rotating disk has 21 graduations corresponding to the number of days of delay required. The setting is accomplished by rotating the disk until the number corresponding to the number of days delay required corresponds with the pin which is held in tension against the side of the disk by the spring (A). (See fig. 277.)

The clockwork is geared to the rotating disk by gear wheels and is wound by to and fro movements of the winding ring.

A bakelite cover is threaded onto the body over the time disk while a detonator is screwed into the bottom of the igniter.

OPERATION. When the slot in the time disk comes opposite the pin, the pin is forced into the slot by spring (A). This closes the electrical circuit between the casing and the battery and fires the match composition.

EMPLOYMENT. This igniter is used in conjunction with large scale demolitions where a long delay is required. Several of the igniters may be used on each charge. Although the charges are generally composed of blocks of cast explosives, these igniters will be imbedded in pieces of plastic explosive which is in contact with the main cast charge.

J-FEDER 504 (CLOCKWORK LONG-DELAY)

DATA:

Length: 7 inches.
Diameter: 3⅜ inches O. D.
Color: Black.
Pull or Pressure Required: ¼ hour to 21 days.
Material: Aluminum or bakelite.

DESCRIPTION. The body is an aluminum casting which in its upper portion houses the clock, and in its lower portion the striker mechanism. The top is closed by a screwed cap with a rubber ring washer below it and into the base is screwed the cap holder having leather washers as shown. A key is provided for screwing home this holder. (See fig. 278.)

On removing the cover the clock is exposed. The knurled cylinder is provided for winding the clock while the center knob stamped Zt, is for setting the clock for any desired delay up to 21 days. The minimum delay is ¼ hour.

The delay times are marked on the edges of the disks; the days figured in red, and the hours figured in black. The setting is visible through the window and is indicated by the pin. This latter is connected with the lever arm which allows the trip lever to release the striker at the end of the delay period.

At the 24-hour marking on the black-inscribed disk and at the 21-day marking on the red-inscribed disk are slots which allow the pin to move into the channel. These slots are aligned at the zero reading at which position the striker is released. The slot in the disk is covered by a

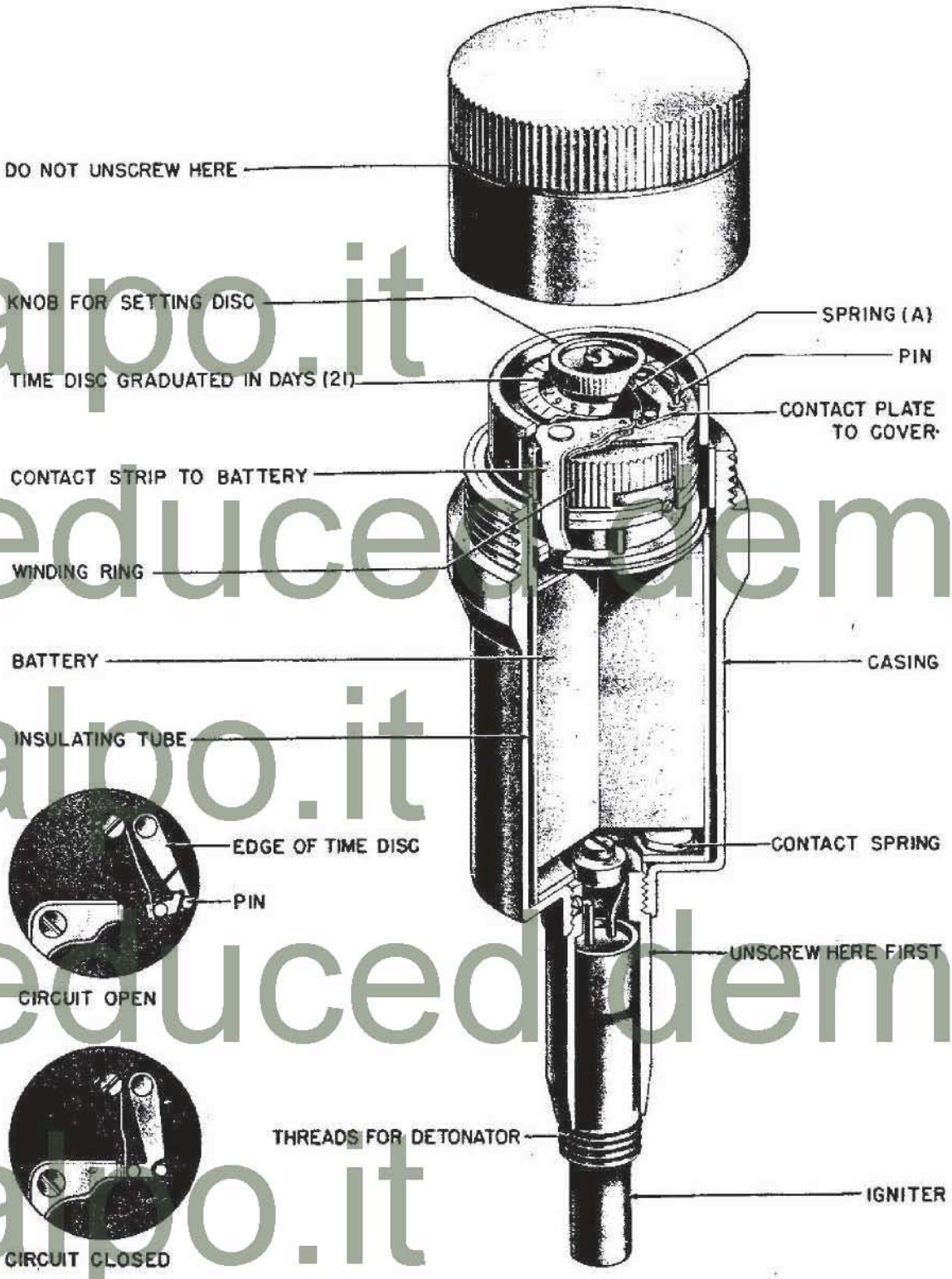

Figure 277—Long-Delay (21-day) Clockwork

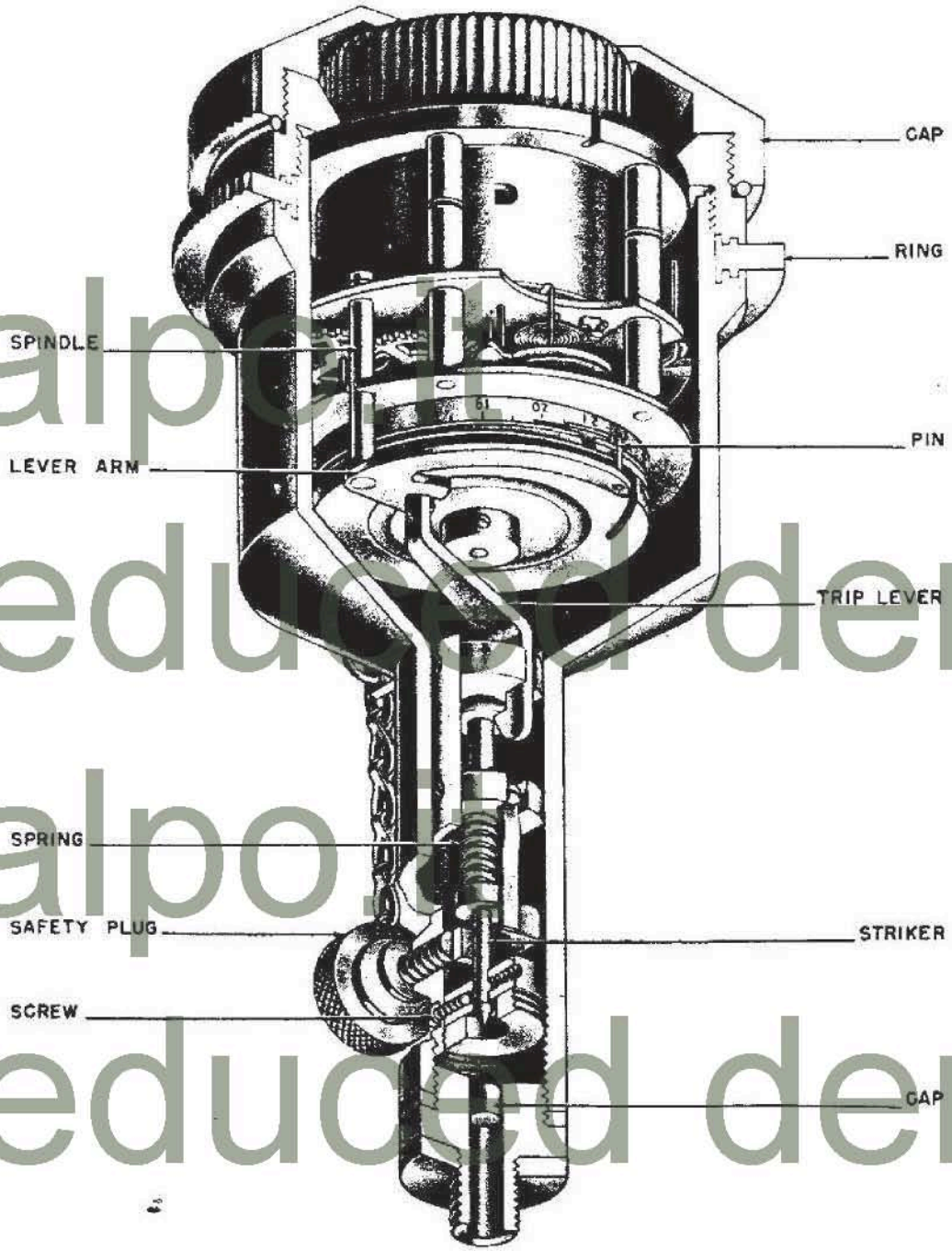

Figure 278—J-Feder 504 Clockwork

lightly-sprung steel strip which is pushed back by the pin as the clock approaches the zero setting. As this strip can only be pushed in one direction, it provides a safety device to prevent the striker being released while the clock is being set by the knob. A further safety device for the preservation of the clock mechanism is provided by the bent steel wire. This passes through, and is secured to, the spindle, so that when the latter rotates with the lever at the end of the delay period

the short limb of this steel wire presses against the balance wheel and stops the clock. If this was not provided the clock could continue working and by further rotation of the disks, the pin would jam or would be deformed. This is important since provision is made for testing the clock and it is thought that the clock mechanism may be intended for re-use.

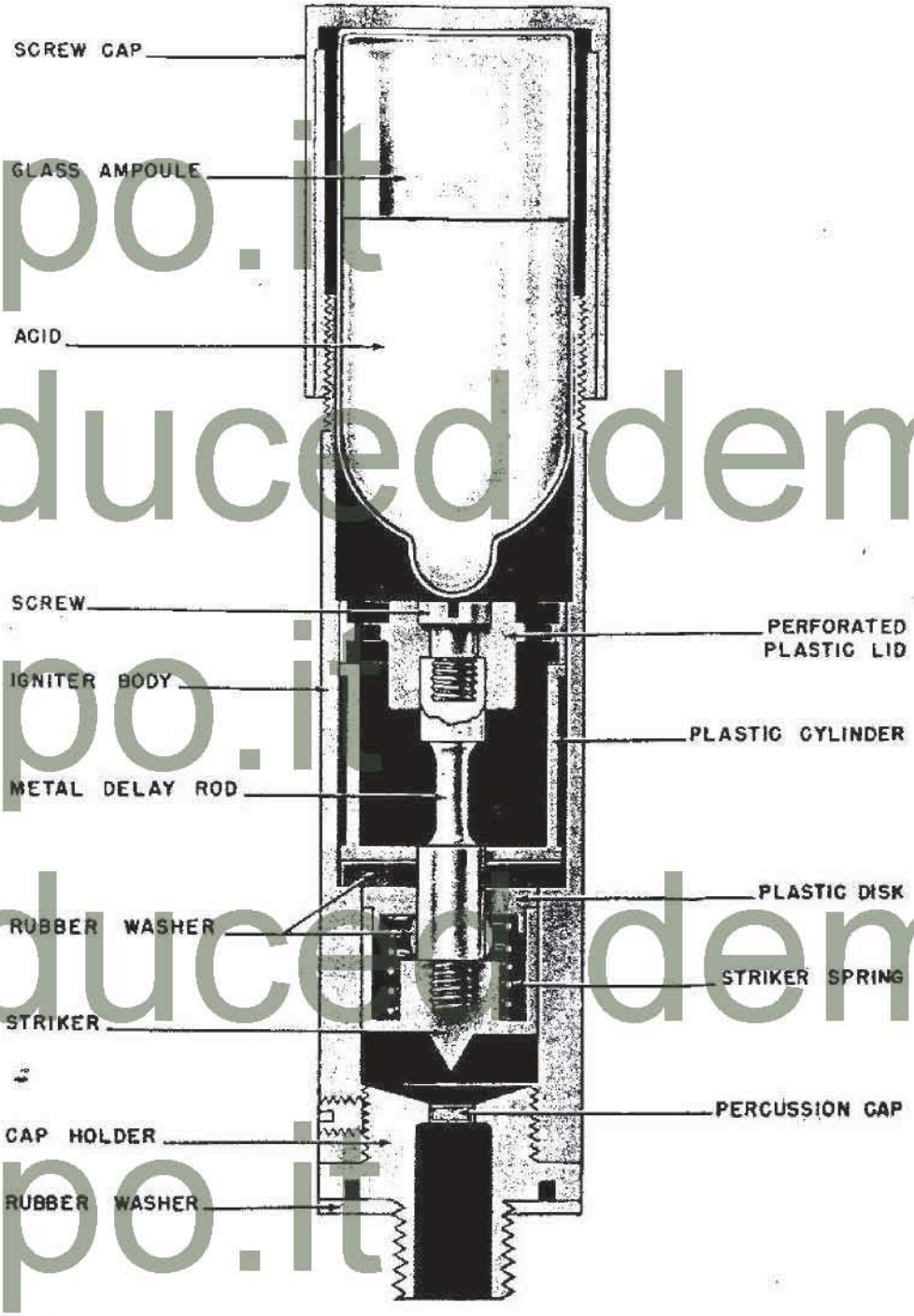

Figure 279—C. M. Z. 41W Chemical Delay Igniter

The clock is started by the movement of the ring through an angle of about 30°. Two screws, passing through the ring, project into the clock mechanism. Between them is the lever arm to which is attached a thin spring steel strip. In the stop (steht) position this latter is in contact with the balance wheel of the clock and holds it. When the red mark on the ring is moved to the go (geht) position the lever moves the steel strip so that it gives motion to the balance wheel and then moves clear of it. The ring is held in either the "stop" or "go" positions by the shaped steel spring, and the lever arm is held by the shaped spring.

The striker mechanism is retained in the body by the four screws. The striker is held in the cocked position by the trip lever. The movable piece is a transport safety device. In the "safe" position this is pushed over by the spring strip so that the striker is prevented from reaching the cap. The screw marked "SCHARF" replaces this when the apparatus is set for action. The stem of this screw projects far enough into the striker mechanism to push over the movable safety piece to allow the full movement of the striker when released. The accessory is provided with the equipment. It screws in, in place of the cap holder, and is to be used for recocking the striker after test or after use.

OPERATION. At the end of the delay period, the lever arm on the rotating control disk bears against the trip lever, causing it to release the striker. The striker, driven by the striker spring, is then forced into the percussion cap, firing it.

EMPLOYMENT. Used for large scale delayed demolitions. Delays are possible from ¼ hour to 21 days.

C. M. Z. 41W (CHEMICAL-MECHANICAL TYPE)

DATA:

Length: 5½ inches.
Diameter: 1¼ inches.
Color: Brown.
Material: Bakelite.

DESCRIPTION. Externally, the igniter consists of a cylindrical brown bakelite housing with a male thread at one end to take a deep bakelite arming cap. The other end bears a female thread into which a metallic percussion cap and detonator assembly is screwed. (See fig. 279.)

Internally, a glass ampoule containing the liquid chemical agent rests on a bakelite striker retaining disk so that approximately half the ampoule protrudes from the housing into the threaded arming cap. The striker retaining disk rests on a narrow shoulder of the igniter housing and has four seep holes that pass through it to the reaction chamber below. A partition in the igniter housing is positioned below the striker retaining disk, and with it, forms the enclosed reaction chamber. The spring loaded striker shaft is made of a special white metal and is fastened to the striker retaining disk by means of a small screw.

The striker shaft passes through the reaction chamber and terminates in the striker head. Only a restricted portion of the striker shaft is exposed to corrosion within the reaction chamber. All other parts are carefully covered with rubber sealing washers to prevent the liquid agent from seeping out of the reaction chamber and coming into contact with other metal parts. The striker spring is compressed between the shoulders of the striker head and the housing partition. The percussion cap and detonation assembly is threaded to fit any standard German charge and is fitted with a rubber washer and transit cap.

The delay periods have been calculated for the following temperatures:

68° F., 3 to 5¼ days.
32° F., 21 to 31 days.
−31° F., 96 to 167 days.

The chemical reaction ceases below −40° F. but resumes as soon as the temperature rises above that point.

OPERATION. The threaded arming cap is removed and the glass ampoule is inserted into the igniter body, neck first, in order to insure complete drainage. The cap is then screwed on until a slight resistance is felt by its contact with the ampoule. A Sprengkapsel No. 8 is placed in the percussion cap and detonator assembly and the igniter is screwed into the mine or charge. By turning down the threaded cap still further, the glass ampoule is broken and the liquid chemical agent trickles through the four seep holes of the striker retaining disk into the reaction chamber below. The igniter is now "functioning" but may be handled for a period of 5 hours. The chemical corrodes through the exposed portion of the striker shaft, releasing the spring loaded striker

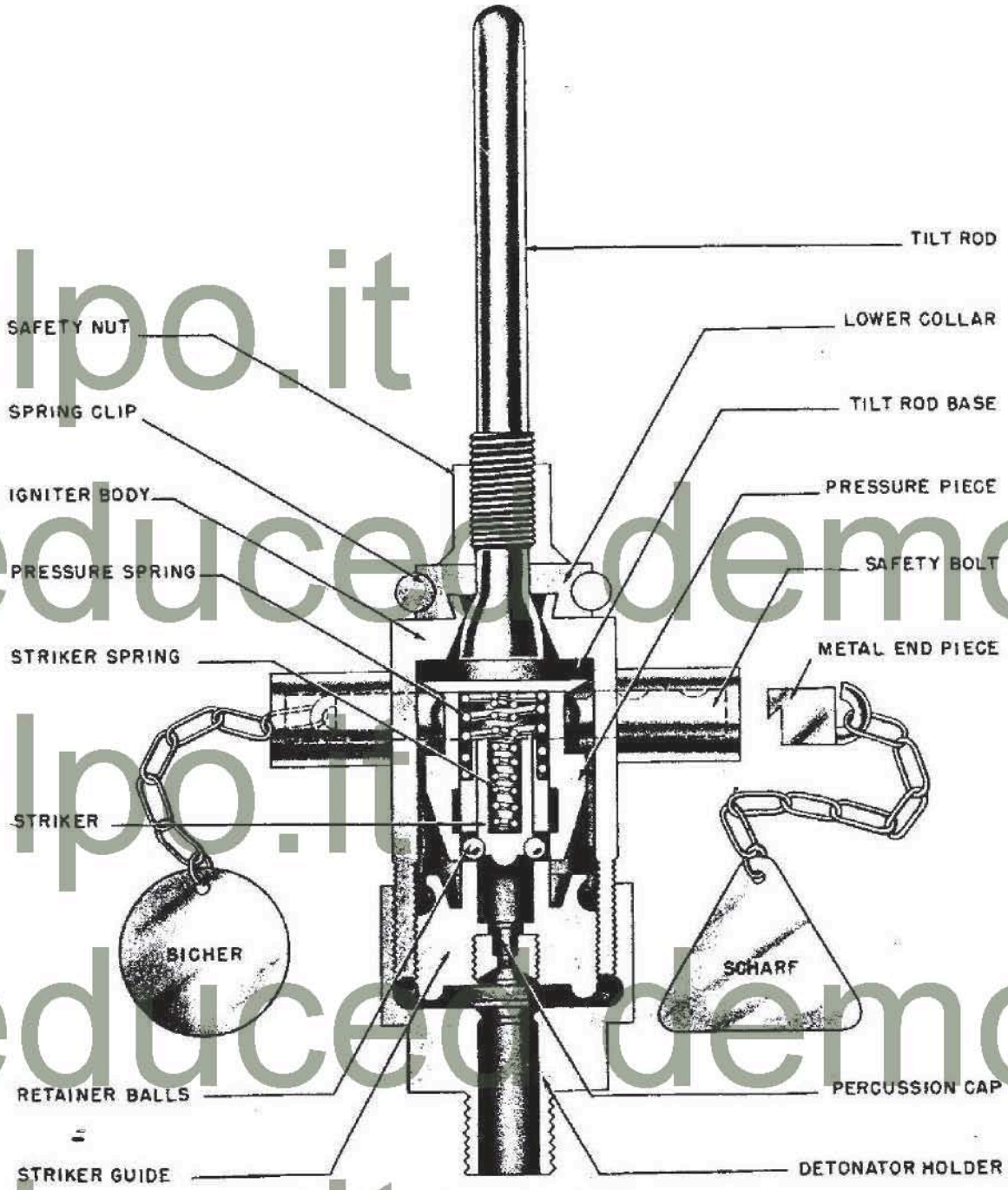

Figure 280—Kippzunder 43, Tilt Type

which fires the percussion cap, detonator, booster and main charge.

EMPLOYMENT. This igniter is used for delayed action demolition.

KIPPZUNDER 43 (TILT TYPE)

DATA:

Length: 3-inch body; 24¾-inch extension rod.
Diameter: ⅞-inch O. D.

Color: Black.
Pull or Pressure required: 15 to 25 pounds (1¼ pounds with extension rod).
Material: Brass.

DESCRIPTION. The igniter consists of a tilt rod, and a 24-inch extension rod, connected to a cylindrical body containing the striker mechanism into the base of which is screwed the cap and detonator assembly. The igniter is designed to function when the tilt rod is tilted in any direction. (See fig. 280.)

The igniter body contains the tilt rod and tilt rod base; these are locked firmly against the top flange of the body by the safety bolt. Waterproof packing seals the joint between the tilt rod base and the body.

Inside the igniter body is a concentric hollow cylinder known as the pressure piece. The pressure spring is held against the top of the pressure piece by a striker guide, containing two holes in which are positioned two locking balls which hold the striker in a cocked position against the striker spring.

A retainer nut screws over the underside of the body and holds the entire striker mechanism inside the igniter body. A striker guide nut is screwed into the inside thread of the striker guide in order to distance the percussion cap.

A separate cap and detonator assembly is used with this igniter and is designated the "Zundersprengkapsel 43." It consists of an externally threaded sleeve to hold the cap and detonator which can be screwed into the igniter and into standard igniter sockets of mines. Two washers are provided for waterproofing.

The end of the tilt rod is fitted to take an extension rod which increases the leverage considerably.

OPERATION. Lateral pressure of 15 to 25 pounds exerted in any direction on the tilt rod, or 1½ pounds if the extension rod is used, causes the sliding pressure piece to be depressed. When the pressure piece has been depressed sufficiently, the locking balls are freed and striker is released. The striker, driven by the striker spring, sets off the percussion cap.

EMPLOYMENT. This igniter is primarily intended for use on antitank mines. It is screwed into the booby trap wells on the undersides of standard antitank mines, the mines then being laid upside down. It is ideal for use on booby traps and antipersonnel mines.

NEW TYPE TILT IGNITER
(PRESSURE (TILT) TYPE)

DATA:

Length: Approximately 5 inches.
Diameter: 15/16 inch.
Material: Metal.

DESCRIPTION. The basic principles of this igniter are similar to those of the Kippzunder 43. The striker, striker guide, pressure piece, striker spring, pressure spring, retaining balls, and tilt rod base are all the same as the Ki. Z. 43 igniter. This igniter, has, however, an entirely different safety device. A safety nut is screwed down tightly against a four-piece collar that is retained in place by a spring clip. This nut and collar, which are about the base of the tilt rod, restrain the movement of the tilt rod, making it less sensitive. (See fig. 281.)

A safety bolt is housed on the side of the igniter and fits under one side of the tilt rod base preventing its movement. The safety bolt runs through a safety bolt housing stamped at the ends "SICHER" (safe) and "SCHARF" (armed). There is a curved indentation in the safety bolt which allows free movement of the tilt rod base when this indentation is positioned directly under the rod. Movement of the safety bolt is controlled by a spring loaded ball fitting into one of three recesses. At either end of the safety bolt are metal pieces connected to lengths of chain.

The igniter is normally carried with the safety bolt held in position by the spring loaded ball being in the middle recess. Both metal end pieces will then be in the safety bolt housing.

After positioning the igniter in the mine, a pull on the wire "SCHARF" will move the safety bolt until the spring loaded ball drops into the recess at that end. The curved indentation will then be directly under the tilt rod base and the igniter armed. The metal piece will pull away from the "SCHARF" end of the safety bolt. The safety nut and collar may be removed or left in position as required.

OPERATION. Pressure on the tilt rod lowers the pressure piece, releases the retaining balls and frees the striker to impinge upon the percussion cap.

EMPLOYMENT. This igniter is designed for use with antitank mines. The igniter is screwed

body is drilled transversely and a thin bushing is passed through the body and the snapping piece to form a guide for the assembly of the safety pin. The ends of the safety pin are drilled to accept an arming cord and a retaining wire respectively.

The type II igniter consists of a main body and an extension, which houses a striker, a striker extension piece, and a striker spring. The extension is waisted just above the main body of the igniter. This weakened portion is protected during transit and installation by a safety collar in the form of an outer removable collar. The striker is screwed into the brittle, plastic striker extension piece. A female socket in the other end of the extension piece, strengthened by a ferrule, accommodates a retaining stud. The striker is retained in a cocked position by a retaining pin which passes through the retaining stud.

OPERATION. Both types of igniter are armed by removal of their respective safety devices. Lateral pressure on the extensions will cause the igniters to function.

The extension in the type I igniter will bend and tend to snap at the junctions of the tubular sections. The tension hooks will, in consequence, exert a pull on the snapping pieces and the striker. The striker spring will be compressed until the striker bears against the shoulder of the striker stop when further tension will cause the snapping piece to break at its weak link. The striker, thus released, is forced forward under the influence of its spring to hit the cap and explode the mine.

Lateral pressure on the type II igniter will cause the extension to snap at its weakened point, and will also break the plastic striker extension piece, thus releasing the striker to impinge upon the cap and so explode the mine.

EMPLOYMENT. These snap igniters were designed to insure the functioning of antitank mines lying between two tracks of enemy mines. In addition, they are suitable for use under thick snow layers which prevent the functioning of the usual type of antitank igniter. When used with Reigel mines, or Tellermines, on the surface, the mines are secured with four supporting stakes and held down by tension wires or hooked pickets. An additional charge of 10 pounds of H. E. is laid with these mines. Tellermines are laid upside down with the snap igniter screwed into the bottom igniter pocket.

E. Z. 44 ANTILIFTING DEVICE (RELEASE OF PRESSURE TYPE)

DATA:

Height: 1¾ inches.
Diameter: 5 inches.
Pull or Pressure Required: Release of weight.
Material: Metal.

DESCRIPTION. The device consists of four

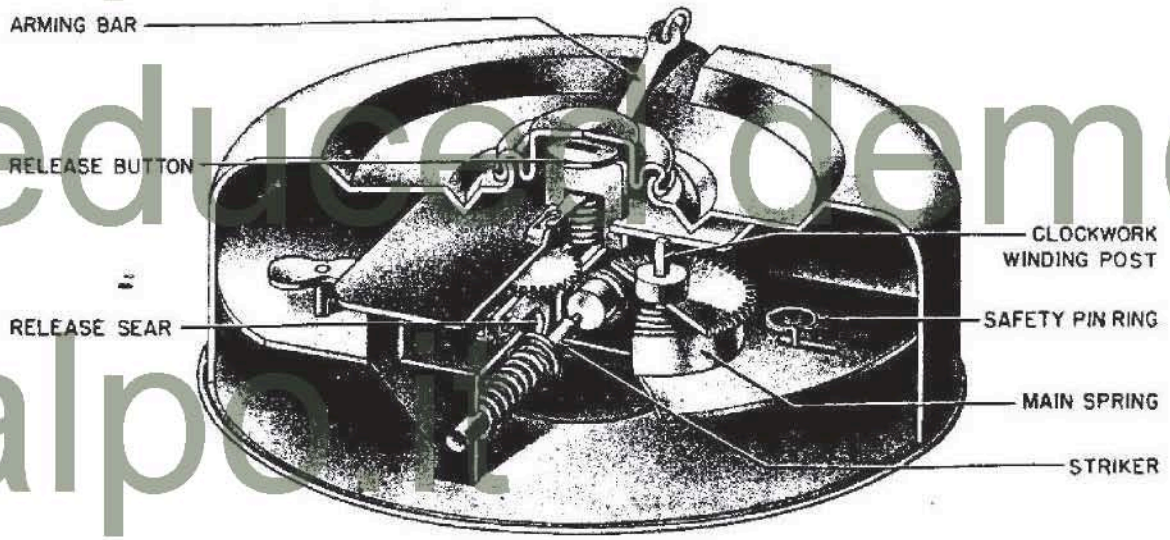

Figure 283—E. Z. 44 Antilifting Device

main parts: The upper casing, the base plate, the clockwork and striker mechanism, and the explosive filling. It is of sheet steel approximately 1 mm thick. (See fig. 283.)

UPPER CASING. The upper casing of sheet metal is of one piece and has strengthening corrugations on its upper surface. Situated centrally is an opening 1 inch in diameter, through which protrudes the release button keyed to a metal release fork. In the upturned lip of the opening is a small slot ⅜ inch long to allow passage of the arming bar. This latter is a thin steel bar having a ring at its outer end. The clockwork mechanism winding post protrudes through the upper casing and the hole is made weatherproof.

BASE PLATE. The base plate is of sheet steel and has a circumferential lap joint to secure the upper casing. This base plate is not secured to the internal parts.

EXPLOSIVE FILLING. The explosive filling consists of two circular segments of cast TNT enclosed in waxed paper. The lower portion has a housing for the cap and standard detonator assembly.

STRIKER MECHANISM. The internal metal structure consists primarily of a semicircular metal plate to which all the parts are clamped. On the underside of the plate is fixed the striker assembly, consisting of a spring-loaded metal striker. The metal sear is pivoted and is held down at its inner end by means of the small spring fitted to the release button fork. The sear holds back the striker at the beveled stop so long as pressure is applied to the release button. The striker is further secured before arming by the safety pin which is of thin steel wire 2 inches long and passes through a small slot in the base plate and terminates in a small ring.

CLOCKWORK MECHANISM. The clockwork mechanism consists of a strong main spring which drives the governing spinner by a set of gear wheels enclosed in metal casing. The mechanism is wound at the post by means of a key. (No specimen of this latter has yet been recovered.) In the safe position the clockwork is jammed by the arming bar which also holds down the release fork and button.

No exact figure can be given for necessary pressure to hold down the release button, but this is probably between 4 to 6 pounds. The device will function when the button is allowed to rise about ½ inch.

OPERATION. To arm, the clockwork mechanism is wound and the device placed under any object, for instance a mine. The arming bar is then pulled out by means of a cord or wire attached to the ring.

When released, the clockwork runs for about 35 to 40 seconds and the expanding mainspring gradually forces the safety pin ring outwards, thus withdrawing the safety pin. This latter operation taking an average of 10 to 15 seconds. The striker is now only retarded by means of the sear, which in turn, is held in place by the compressed spring of the release button. Removal of the weight from the release button allows the striker spring to force up the sear by means of the beveled stop. The striker thus moves forward to fire the cap and so detonates the TNT. Such detonation, if under an antitank mine, would thereby also detonate the mine.

EMPLOYMENT. This mechanism is used beneath land mines as an antilifting and antiremoval device.

STICK HAND GRENADE MODELS 24 AND 39, STIELHANDGRANATES 24 AND 39

DATA:

Model 24:
- Over-all Length: 1 foot 2 inches.
- Diameter of body: 2¾ inches.
- Color of Body: Olive drab.
- Weight: ½ pound.
- Weight of Explosive Filler, 6 ounces.
- Explosive Filler: TNT.
- Igniter: B. Z. 24.
- Delay: 4 to 5 seconds.

Model 39:
- Over-all Length: 1 foot 4 inches.
- Color: Olive drab.
- Weight: 1 pound 6 ounces.
- Weight of Explosive Filler: 7 ounces.
- Igniter: B. Z. 24.
- Effective Blast Radius: 16 yards.
- Delay: 4 to 5 seconds.

DESCRIPTION. These grenades are similar in all characteristics except size.

Figure 284—Model 24 Stick Hand Grenade; Model 29 Stick Hand Grenade

These grenades consist of a thin iron or steel casing, or head, containing the explosive filler, which is screwed onto a hollow wooden handle, through the center of which runs a double length of cord. This cord is attached at one end to a lead ball which is part of the igniter, and at the other end to a porcelain ball. The cavity in which the poreclain ball rests is closed by a metal cap that screws on. Inside the cap is a spring-actuated metal disc that prevents movement of the porcelain ball. (See fig. 284.)

These grenades use igniters B. Z. 24 consisting of a lead tube or sheath connected to a threaded brass fitting by a short steel tube. The steel tube is threaded on both ends and contains the powder delay pellet. The lead tube contains the copper capsule which holds the friction composition. The friction wire is cast in the friction composition and contained in the capsule which is coiled at the bottom to provide resistance to pulling and joined to the "pull" loop at its opposite end. When the loop is pulled, it frees itself from the lead tube drawing the wire through the friction composition and the resulting flame ignites the delay pellet.

OPERATION. The metal cap is unscrewed from the handle and the porcelain ball is pulled. This will pull a wire through the delay pellet. The grenade is then thrown and after a 4- to 5-second delay the delay pellet will initiate the detonator.

STICK HAND GRENADE, MODEL 43, STIELHANDGRANATE 43

DATA:

Over-all Length: 1 foot 3 inches.
Diameter of Body: 2¾ inches.
Weight: ½ pound.
Weight of Explosive Filler: 6 ounces.
Explosive Filler: TNT.
Igniter: B. Z. E.
Delay: 4 to 5 seconds.

DESCRIPTION. This grenade consists of a thin iron or steel casing, or head, containing the explosive filler. This is secured to the wooden stick handle by four deep stabs. (See fig. 285.) The igniter screws into the top of this head and is of the standard pull friction type, had a blue head and a 4- to 5-second delay.

This grenade differs from the standard Model 24 stick grenade only in the position of the igniter

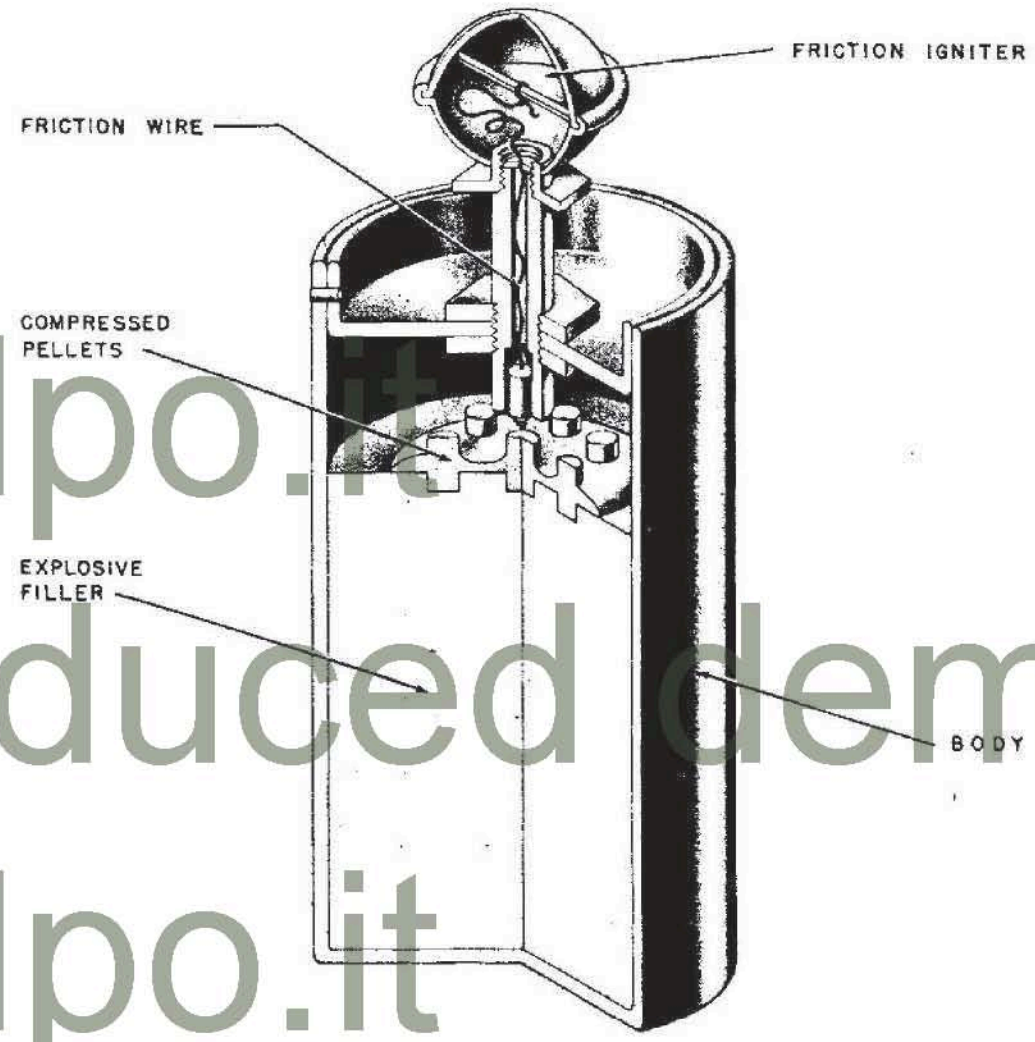

Figure 287—Shaving Stick Hand Grenade

hand grenade of this type containing a spotting charge with the B. Z. E. igniter. The German designation of this is the Eierhandgranate 39 (Ub). A modified egg grenade has also been found with a ring attachment on the base.

SHAVING STICK GRENADE

DATA:

Over-all Length: 3⅝ or 4 inches.
Color: Body is painted yellow; the head of igniter blue.
Maximum Diameter: 2 inches.
Igniter: B. Z. E.
Delay: 4 to 5 seconds.

DESCRIPTION. This is a thin-cased "offensive" grenade with the B. Z. E. friction igniter screwed into the top. The body of this grenade is an aluminum cylinder painted yellow. There are two models of this grenade, one being 3⅝ inches in length and the other 4 inches in length (See fig. 287.)

OPERATION. The head of the igniter is unscrewed and pulled, thus drawing the wire through the friction composition and igniting the delay pellet. The grenade is then thrown and after a 4- to 5-second delay, the delay element will initiate the detonator.

REMARKS. This grenade may be used as a booby trap by the insertion of a D. Z. 35 pressure igniter.

MAGNETIC ANTITANK GRENADE, HOFT HOHL LADUNG 3 kg

DATA:

Over-all Length: 4⅜ inches.
Maximum Diameter: 3$^{1}/_{16}$ inches.
Color: Field grey.
Total Weight: 7 pounds 11 ounces.
Filler: RDX/TNT.
Weight of Filler: 3 pounds 5 ounces.
Igniter: B. Z. '24.
Delay: 4.5 or 7 seconds.

DESCRIPTION. This grenade is painted field grey and is fitted with magnets which are sufficiently powerful to cause it to adhere to a vertical surface. The main filling is contained in a pressed metal container which is conical in shape with an elongated apex serving the dual purpose of forming a hand-grip and accommodating the exploder pellet of PETN/Wax. This latter is housed in a metal tube protruding from the underside of the screw-threaded closing cap. The metal tube is screw-threaded internally to receive the igniter. (See fig. 288.)

Attached to the base of the conical portion by means of six bolts protruding through the container is a plywood framework carrying three horseshoe type magnets. During transit these magnets are fitted with a keeper which must, of course, be removed before using the charge. A brass chain terminating in a hook is attached to the frame.

This charge is reported to penetrate as much as 110 mm. of armor. The penetration is acquired through the use of the shaped charge formed around the 60° angle cone.

There are two igniters used in this grenade: one having a delay of 4½ seconds and the other having a delay of 7 seconds. The first igniter has a blue cap and the second has a yellow cap.

OPERATION. The friction igniter is pulled and this will ignite the delay element. When the grenade strikes a tank the magnets cause it to cling to the side and at the end of the delay time the igniter will detonate the exploder pellet and main filling.

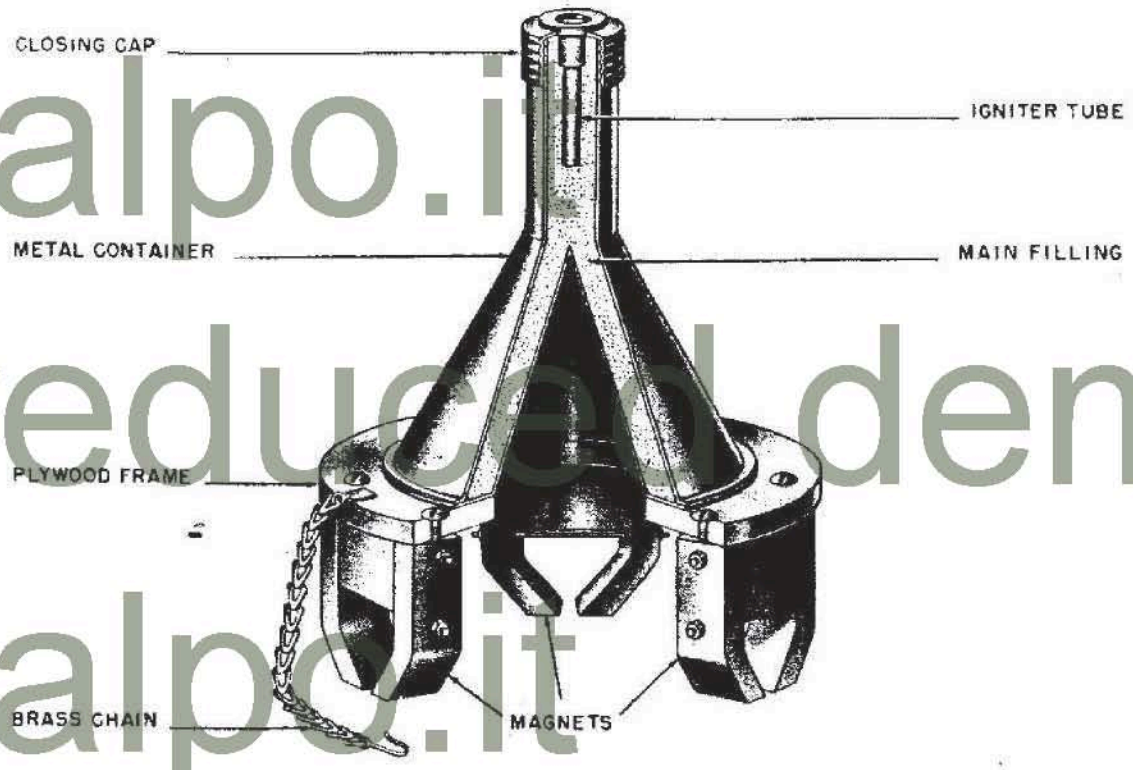

Figure 288—Magnetic Antitank Hand Grenade

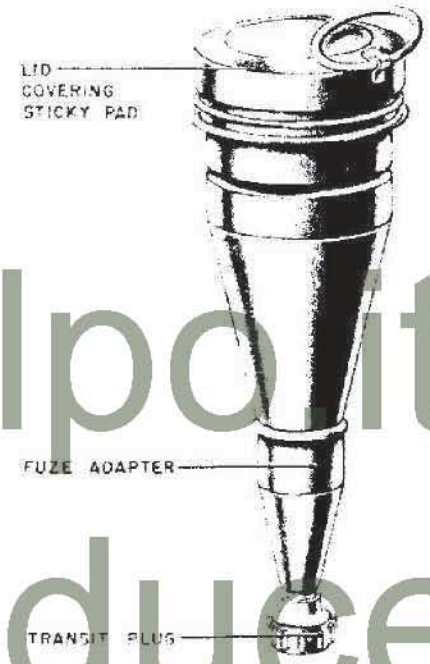

Figure 289—Hollow Charge Sticky Hand Grenade

HOLLOW CHARGE GRENADE (STICKY TYPE)

DESCRIPTION. The grenade consists of a tapering steel body containing the hollow charge with a flat sticky pad at the nose covered by a press-on lid with a small handle. The base of the grenade is fitted with a tapering fuze adapter terminating in an internally threaded hole for an igniter. This hole is covered by a black plastic plug in transit. It is presumed that the standard egg grenade igniter is used with this grenade employing a 4½-second delay and used with a No. 8 detonator. (See fig. 289.)

REMARKS. No information is available as to whether this grenade is thrown or placed against the target. It is possible that it may be lobbed for short distances.

ANTITANK GRENADE (PANZERWURFMINE)

DATA:

Over-all Length: 21 inches.
Length or Body: 9 inches.
Length of Fins: 11 inches.
Diameter of Body: 4½ inches.
Color of Body: Grey.
Markings: P. W. M. 1 (L).
Weight: 1 kg.
Filling: Cast TNT.

DESCRIPTION. The grenade consists of a metal body and a wooden handle to which are attached four canvas fins. The fins are held against

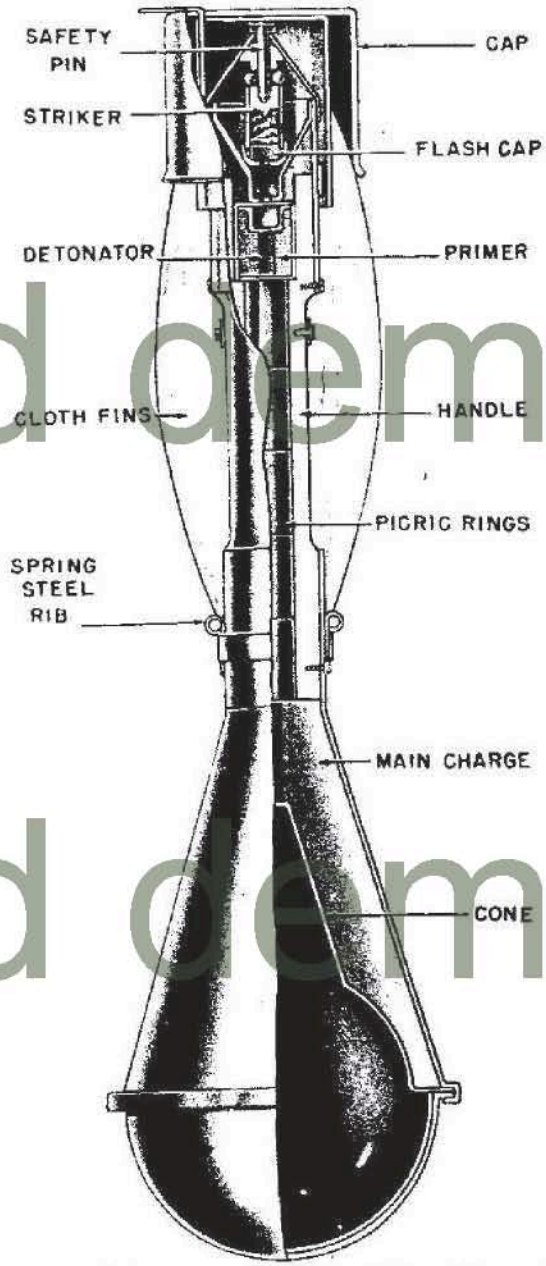

Figure 290—Panzerwurfmine Hollow Charge Hand Grenade

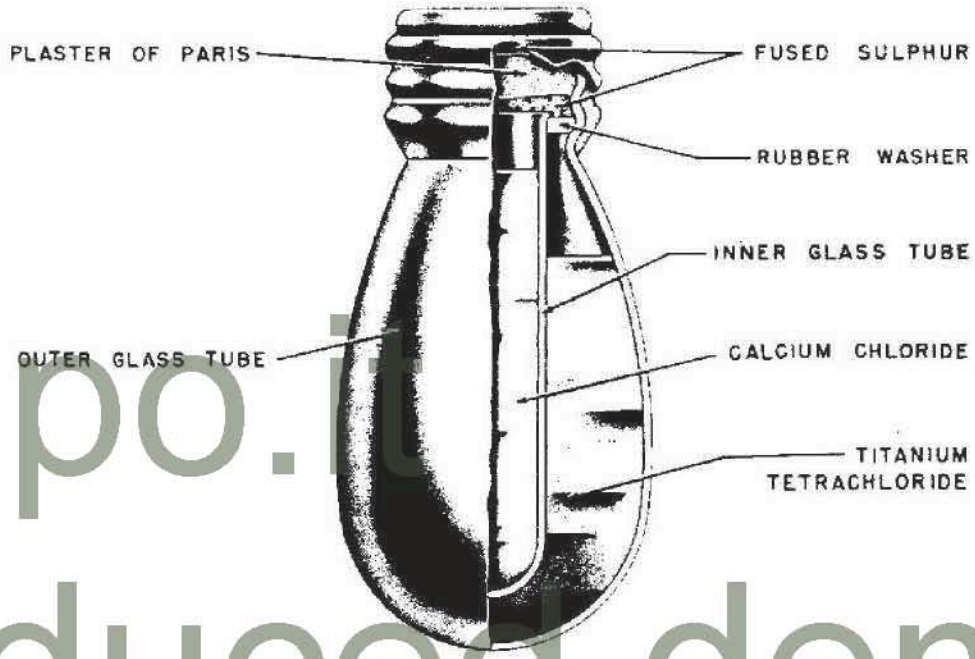

Figure 294—Blendkorper 24 Smoke Hand Grenade

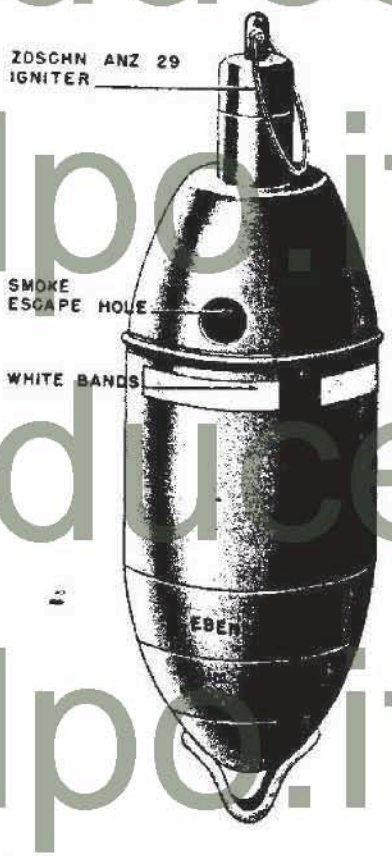

Figure 295—Egg Type Smoke Hand Grenade

SMOKE GRENADE (BLENDKORPER 24)

DATA:

Over-all Length: 4.8 inches.
Maximum Diameter: 2½ inches.
Total Weight: 17 ounces.
Filling and Filling Weight: 270 g. titanium tetrachloride (outer flask). 36 g. aqueous solution of calcium chloride (inner flask).

DESCRIPTION. The grenade consists of an outer glass bulb of molded construction and an inner glass tube which seats and is sealed on the neck of the outer flask. (See fig. 294.) There is a white plastic washer at the junction. The grenade is sealed by a sulphur and cement plug. The solution of calcium chloride is supplied in the inner tube to provide water necessary for the reaction so that the grenade will cause an effective smoke at conditions of low relative humidity. The calcium chloride has probably been added to lower the freezing point of the water, thus the grenade is practical in a cold dry climate.

OPERATION. The grenade is thrown and upon impact with a hard object it breaks causing a smoke.

EMPLOYMENT. It is for use to blind the enemy and also to repair gaps in larger screens.

SMOKE HAND GRENADE (EGG TYPE)

DATA:

Over-all Length: 5.3 inches.
Over-all Diameter: 1.96 inches.
Body Length: 4.1 inches.
Body Diameter: 1.7 inches.

DESCRIPTION. The grenade body is of thin metal and is of an elongated egg shape. At the bottom a small metal loop is welded or riveted on, and at the top there is a threaded hole to take the igniter. Near the top are three holes in the body for smoke emission. (See fig. 295.)

The igniter used with this grenade is the standard pull type ZDSCHN ANZ 29. This igniter has a brass body and a steel ring at the top. The igniter screws into the top of the grenade and functions when the ring is pulled.

The grenade is identified by three white bands stencilled around the body and the letters "NB Eihgr. 42." A label near the bottom of the grenade warns that the fumes can be fatal in an enclosed space.

HAND SMOKE SIGNAL (RED) (HANDRAUCHZEICHEN-ROT)

DATA:

Over-all Length: 4.9 inches.
Maximum Diameter: 1.8 inches.
Total Weight: 4.4 ounces.
Filling: Red Dye-ortho methoxy phenylazo B-naphthol, 55 percent; potassium chlorate, 20 percent; lactose, 10 percent.
Unidentified light oily material, 15 percent.
Total Weight of Filling: 54.0 grams.
Ignition: Match-head striker.

DESCRIPTION. This signal is included as an example of many German colored smoke signals. (See fig. 296.) It is a cardboard cylinder with a

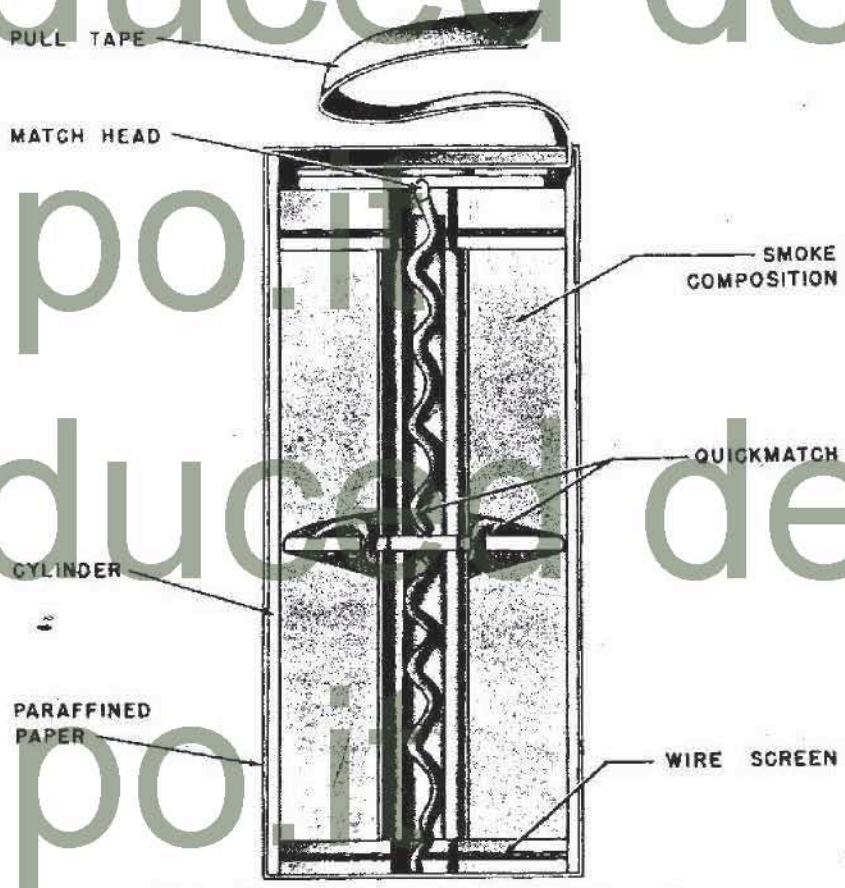

Figure 296—Red Smoke Signal Hand Grenade

cardboard pull tape lid at the fuze end and a glued-in cardboard disk with an emission hole at the other end. The whole signal is wrapped in red paraffined paper upon which the name and instructions are printed. Beneath the pull tape lid is a cardboard striker ring, one half the top side of which is coated with a red phosphorus abrasive mix. A paper wad separates this and the match head. Beneath the match head is a cardboard inner cover and a wire screen. A perforated metal cylinder containing the quick-match sheath is partitioned in the middle by a cardboard disk which is impregnated with gun-powder and has two diametrically opposite holes in it. At the emission end is another wire screen and the cardboard disk with a tissue paper covered emission hole.

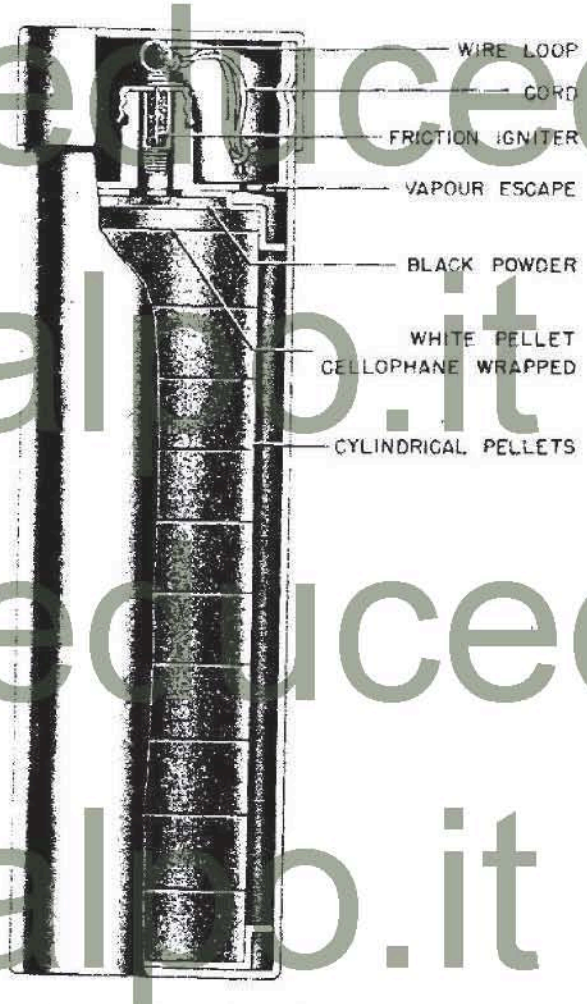

Figure 297—Lachrymatory Hand Grenade

OPERATION. By striking the striker ring on the match head the quickmatch is ignited. This burns its entire length and ignites the gun powder disk which is in direct contact with the inflammable smoke mixture. Smoke is then emitted at both ends of the cylinder. The signal may be placed or thrown.

REMARKS. German smoke signals numbers 350, 160, and 80 which are orange, are analogous to this signal but differ in some respects. There are also similar signals in yellow and violet.

EMPLOYMENT. It is used as a signal from the ground to an air observer.

LACHRYMATORY GRENADE

DATA:

Over-all Length: 5 inches.
Maximum Diameter: 1½ inches.
Color: Aluminum.
Filling: C. A. P.

DESCRIPTION. The case is made of thin sheet aluminum. Within the case, below the lid, is a cylindrical holder retained in position by four indentations in the case which correspond to four indentations in the holder. This holder has a screwed projection to take the friction igniter. The latter has a short piece of cord, 10 cm in length, attached to a wire loop. Below the holder is a dish-shaped aluminum piece which contains a small compressed charge of black powder. On the upper side of this charge is a thin disk of white powder. The main filling consists of ten cylindrical pellets of a yellow compound and one pellet of a white substance wrapped in cellophane. The charge is held between the two dish-shaped pieces. The grenade generates a lachrymatory vapor when ignited and the vapor escapes through the holes in the holder. The containers are unpainted aluminum, and the lid is secured by a piece of adhesive tape colored blue. They are safe to handle when the lids are in place. To disarm the grenade, the igniter may be unscrewed from the holder, taking care not to twist the wire in so doing. (See fig. 297.)

OPERATION. The lid is removed and the friction igniter is pulled. The vapor will be emitted through the holes in the holder.

grooves cut on the inside. An arming spring is compressed between a lip on the arming collar and a second collar at the bottom of the striker body. Around the inside of the arming collar and resting on the striker body is a steel tape which acts as an additional safety device and prevents any possibility of the fuze being accidentally armed when screwing on the base plug.

The entire assembly is closed by a base plug which positions the fuze by a stem which fits into a recess in the rear of the striker body.

OPERATION. On firing, the shock of discharge causes the arming sleeve to set back against its spring. The four prongs of the retaining spring are forced out of the lower groove in the arming sleeve and engage in the upper groove, retaining the arming sleeve in its lower position. This allows the steel tape to unwind and the striker is then free to move forward on impact firing the gaine.

37-mm H. E. ANTITANK STICK GRENADE

DATA:

Over-all Length: 29⅛ inches.
Length of Stick: 16$^{7}/_{16}$ inches.
Length of Body: 12¼ inches.
Total Weight: 18 pounds 12 ounces.
Weight of Filler: 5 pounds 5 ounces.
Explosive Filler: Dinitroanoline with TNT.
Base Fuze: Bd. Z. 5130.
Point Fuze: A. Z. 5075.

DESCRIPTION. The complete round, which is made up of the hollow charge stick grenade and the propellant, is fired from the 3.7-cm P. A. K. gun. (See fig. 303.)

The stick grenade has a steel rod which fits into the bore, and a concentric perforated sleeve which fits around the barrel of the gun. A pressed steel cap forms the nose of the grenade giving it the required stand-off distance. The hollow charge is at the rear of the steel cone and consists of two blocks of dinitroanoline with TNT. Two detonators are set in the base of the grenade, one facing in each direction. A nose fuze of the instantaneous percussion type and a tail fuze also instantaneous are present.

The steel rod which fits into the bore of the gun is a hollow tube closed at the base end. The base fuze is a percussion type fuze very sensitive to shock. It is armed by setback which releases a

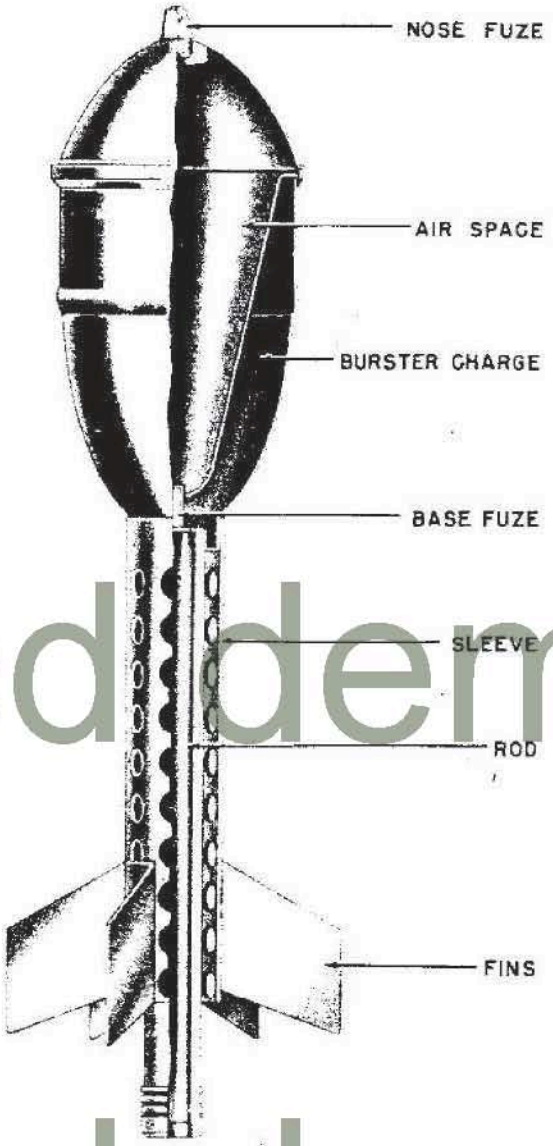

Figure 303—37-mm Hollow Charge Rifle Grenade

spring loaded detent allowing a steel ball to move away from the striker. Upon impact the striker moves forward against the action of a very weak creep spring.

The nose fuze consists of a striker held away from the primer by a creep spring and a coiled spring. Around the coiled spring is an inertia pellet resting on four fingers of a stirrup spring fixed in the base of a stirrup spring retainer. The inertia pellet has a groove cut around its internal circumference.

Two detonators are located at the base of the main charge. One detonator faces toward the nose fuze to receive the flash from there, and the other detonator faces the tail fuze to receive its flash.

The propelling charge is contained in a steel cartridge case. The charge consists of diethylene glycol dinitrate tubular stick powder with an igniting charge of nitrocellulose granular powder, and a percussion type primer consisting of mercury fulminate and black powder.

OPERATION. On discharge the inertia pellet of the nose fuze is driven downwards and the ends of the stirrup spring are forced into the grooves of the inertia pellet thus holding it down. The clock spring is now held in position by the collar of the striker pin and the stirrup spring retainer. On deceleration the clock spring flies outward, assisted by centrifugal force, into the recess in the fuze body. At the same time the base fuze is being armed. In the event of direct impact the nose fuze will function the grenade, but in the event of graze action, the base fuze will function the grenade.

Figure 304—Large Hollow Charge Rifle Grenade

LARGE ANTITANK RIFLE GRENADE, GROSS GEWEHR PANZERGRANATE

DATA:
Over-all Length: 7 inches.
Maximum Diameter: 1¾ inches.
Color: Black over-all.
Total Weight: 13½ ounces.
Weight of Filler: 4½ ounces.
Filler: TNT.
Range: 100 yards.

DESCRIPTION. This grenade is fired from the rifled 3-cm discharger cup (Schiessbecher) which can be fitted to most types of German rifles. It is of the hollow charge type and consists of a steel head containing the explosive and light alloy or steel and plastic stem containing the fuze and gaine. (See fig. 304.) The propelling cartridge contains a wooden bullet.

The body which is of pressed steel contains a steel cone around which the main filler of TNT is cast. A steel washer with a small central hole rests on the open end of the cone and above the latter is a steel ballistic cap. At the bottom of the TNT is an exploder pellet of penthrite wax.

Two varieties of the stem have been found, one entirely of light alloy, the other of plastic with a steel shank by which it is screwed on to the head of the grenade. At the base of the stem is a rifled band which corresponds with the rifling in the discharger cup. The stem is divided into compartments by a perforated septum, the lower containing the fuze, the upper the gaine. In the

septum is a small flash pellet held in place by a perforated screw plug. The gaine consists of a light alloy container into which is inserted a light alloy top hat containing the detonator, the space below being filled with penthrite wax.

The fuze is in the after portion of the stem and consists of a striker over the top of which fits a retaining spring with four prongs bent downward into grooves in the striker body. Around the striker body is an arming collar which has two grooves cut on the inside. An arming spring is compressed between a lip on the arming collar and a second collar at the bottom of the striker body. Around the inside of the arming collar and resting on the striker body is a steel tape which acts as an additional safety device and prevents any possibility of the fuze being accidentally armed when screwing on the base plug.

The entire assembly is closed by a base plug which positions the fuze by a stem which fits into a recess in the rear of the striker body.

OPERATION. On firing, the shock of discharge causes the arming sleeve to set back against its spring. The four prongs of the retaining spring are forced out of the lower groove in the arming sleeve and engage in the upper groove, retaining the arming sleeve in its lower position. This allows the steel tape to unwind and the striker is then free to move forward on impact firing the gaine.

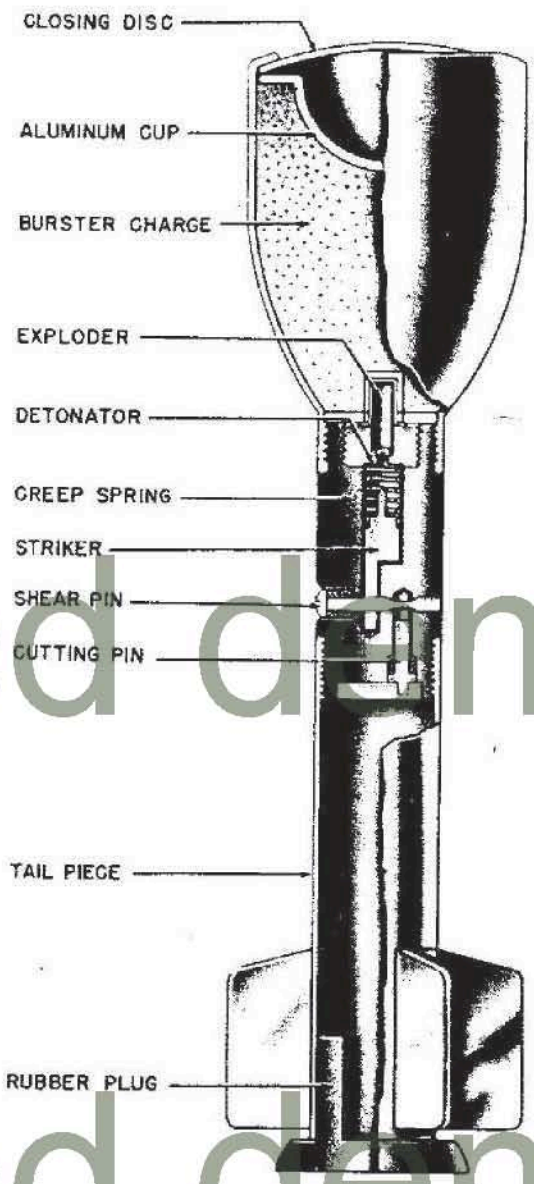

Figure 305—Schuss Gg. P–40 Hollow Charge Rifle Grenade

HOLLOW CHARGE GRENADE (SCHUSS Gg. P–40)

DATA:

Over-all Length: 9.3 inches.
Maximum Diameter: 2.4 inches.
Color: Olive green.
Markings: Blue band around projection at the base of body.
Length of Body: 3.1 inches.
Filler: Cyclonite/Wax.

DESCRIPTION. The grenade consists of a stream-lined bell-shaped body, with a slightly convex closing disk of aluminum, a graze fuze which screws into a projection on the base of the body, and a vaned tail unit which screws on the base of the fuze and is closed by a rubber plug. (See fig. 305.)

The body is made of thin steel and is streamlined with a cylindrical projection welded at the base. The projection is screw-threaded internally for the insertion of the fuze. A hole in the base of the body is fitted with an aluminum cup to accommodate the protruding magazine of the fuze. The head of the body is closed by a concave disk of aluminum which is secured by the overturned rim of the body.

The bursting charge consists of cast cyloncite-wax with a hemispherical cavity in the head. The

cavity is fitted with an aluminum liner of corresponding shape with a flange which fits inside the body at the head.

The fuze is cylindrical with an external screw-thread at each end for assembly as the connecting piece between the tail unit and the body. A central recess contains the striker and creep spring and is closed at its enlarged front end by an aluminum magazine which is screwed in and contains a detonator and an intermediary explosive. A transverse channel near the base contains a spring-loaded screwed shearing pin which engages in a recess in the stem of the striker. Another channel containing a cutting pin with spring, is bored from the base of the body and communicates with the shearing pin at a point where the shearing pin is reduced in diameter. A circular plate, secured in a recess in the base of the body by two screws, retains the cutting pin in its channel. The base end of the cutting pin passes through a hole in the circular plate and is thus exposed to the pressure of the propellant gases.

The tail unit screws on to the base of the fuze and consists of a drawn-steel tube with six vanes formed in pairs. The cartridge is placed inside the tube for transport and the tube is closed at the base by a rubber plug. The cartridge is of the 7.92-mm small arm type with an undyed hollow wooden bullet.

OPERATION. The grenade is fired from the spigot type discharger. On firing the hollow wooden bullet is shattered by the propellant gases, which project the grenade. The propelling gases overcome the spring of the cutting pin and drive the pin forward, causing it to cut the shearing pin away from its screwed end. The shearing pin is then ejected by the spring held in compression under its head, and thus leaves the striker held off the detonator only by the creep spring. On graze the momentum of the striker overcomes the creep spring and the detonator is pierced.

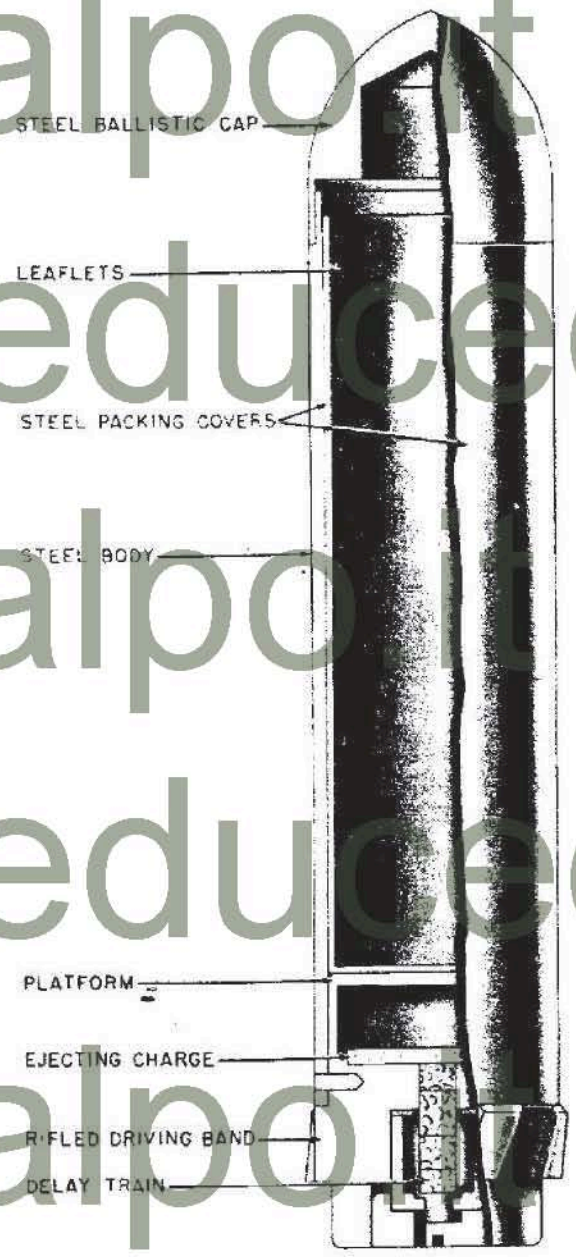

Figure 306—Propaganda Rifle Grenade

PROPAGANDA RIFLE GRENADE—GEWEHR PROPAGANDA GRANATE

DATA:

Over-all Length: 5.7 inches.
Total Weight: 8 ounces.
Weight Without Leaflets: 7 ounces.
Delay: 9 seconds.
Range: 500 yards.

DESCRIPTION. This grenade is fired from the rifled 3-cm discharger cup (Schiessbecher) which can be fitted to most types of German rifles. The body of this grenade is a steel case with a pre-rifled base. (See fig. 306.) Inside the base there is a 9-second delay fuze and an ejecting charge for the pamphlets. Two steel leaflets packing covers are held loosely inside the case and fitting over the top

of these is a removable steel cap. The leaflets are inserted by removing the steel cap and rolling the leaflets tightly making sure that they do not show above the rim of the case. The cap is then replaced.

The case and cap are varnished to protect them from rust and the ejecting charge is protected by a cardboard disk to prevent moisture from causing deterioration.

The propelling cartridge is distinguished from other rifle grenade cartridges by a red ring around the base.

OPERATION. When the grenade is fired, the propelling cartridge will ignite the delay fuze.

Approximately 9 seconds after discharge, the delay fuze will set off the ejecting charge, blowing off the cap and forcing the leafllets out the nose.

ILLUMINATING STAR ON PARACHUTE RIFLE GRENADE — GEWEHR FALLSCHIRM-LEUCHTGRANATE (Gw. F. S. St. Gr.)

DATA:

Length: 6.88 inches.
Diameter: 1.18 inches.
Weight: .280 g.
Color and Markings: White cap. "Gewehr Fallschirmleuchtgranate" stencilled on body.
Propellant: 1.5 g propellant enclosed in a cartridge case which is closed with a wooden bullet.

DESCRIPTION. This grenade consists of a thin-walled body which contains another internal container. (See fig. 307.) The internal container holds the parachute and illuminating star. The grenade has a thin conical cap and is fitted with two delay pellets and two ejection charges.

OPERATION. On firing, delay 1 is ignited by the flash from the propellent gases. After 6.5 seconds of flight, ejection charge 1 is initiated. This ejects the container holding the star and parachute. At the same time, delay 2 is initiated. During this part of the flight, the cap hangs from the container by means of a cord. After delay 2 has burned through (2 seconds), ejection charge 2 is initiated and the parachute and star ejected. It is stated that distances up to 650 meters may be illuminated.

REMARKS. Each grenade is packed together with a propellent charge in a cardboard container.

HOLLOW CHARGE GRENADE FAUSTPATRONE

DATA:

Over-all Length: 41 inches.
Length of Tube: 31.5 inches.
Length of Body: 19.5 inches.
Caliber of Tube: 1.75 inches.
Weight of Grenade: 6.62 pounds.
Weight of Tube and Grenade: 11 pounds.
Weight of Filler: 3.4 pounds.
Effective Range: 33 yards.

DESCRIPTION. The Faustpatrone consists of

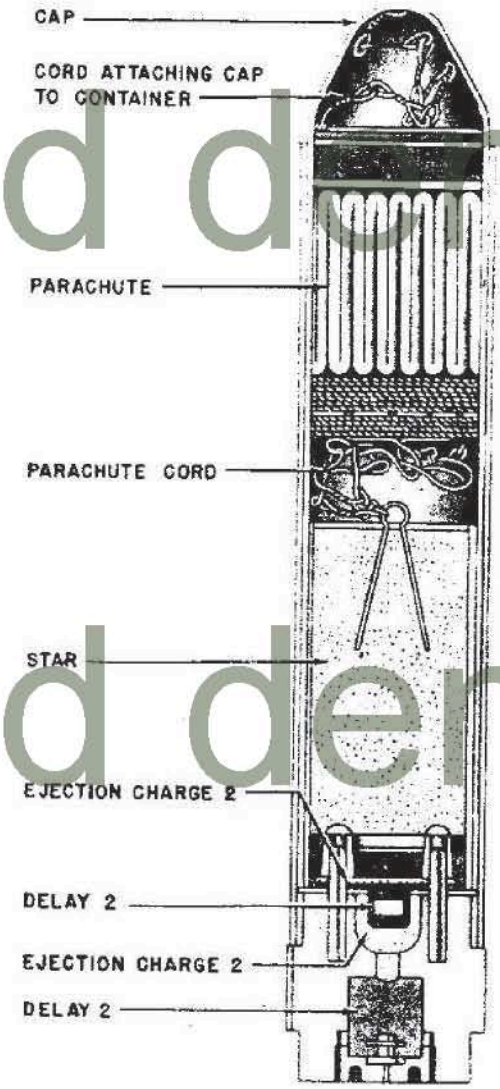

Figure 307—Illuminating Rifle Grenade

of two brass tubes which are held in position by a central cannelure into which the inner container is indented and fixed by means of a steel pin. The outer tube has one set of six flash holes which coincide with the inner surfaces of the six stars. The inner tube has six sets of holes in the outer tube by means of the setting cap, which is fixed to the inner tube by a spring retaining clip on the closing screw. The inner tube contains gunpowder and is closed at the inner end by a screwed plug which contains a delay pellet. It is used for signaling.

OPERATION. The desired combination of colored stars is obtained by moving the index mark on the setting cap to the appropriate position on the scale, which is graduated from 0 to 40. The six combinations of stars are:

(1)	(2)	(3)
3 red	1 red	3 red
3 green	2 green	1 green
(4)	(5)	(6)
1 red	2 red	2 red
3 green	2 green	1 green

Commencing with 3 red and 3 green at "0", its other combinations would be obtained at settings 7, 14, 21, 27, and 34 respectively.

In firing, the inner container is ejected, and after the delay pellet has burned through, the flash passes immediately along the whole length of the inner tube, igniting and ejecting the stars in accordance with the setting. The stars which are not ignited remain in the container and fall to earth intact.

Table 2.—German rifle grenade propelling cartridges

Cartridge for—	German Name	Powder Filling Nz. T. P. (1.4; 2; 0, 5/0; 25) Grams	Marking	Used Only by	Remarks
1. Large A. P. grenade.	G. Treib. Patr. fur Gr. G. Pzgr.	1. 9	Black wooden bullet.	Large A. P. grenade.	
2. Propaganda grenade	G. Kart. fur G. Propgr.	1. 7	Red ring	Propaganda grenade.	In the future to be used only for rifle propaganda grenade.
3. Propaganda grenade (old type).	G. Kart. (Alter Art) fur G. Propgr.	1. 7	2-mm wide red ring on neck of cartridge case.	Propaganda grenade.	Obsolete.
4. Small A. P. grenade.	G. Kart. fur G. Pzgr.	1. 1	Black ring	A. P. grenade	Packed attached to grenade.
5. Small A. P. grenade.	G. Kart. (Alter Art) fur G. Pzgr.	1. 1	Black ring(partly).	Small A. P. grenade.	Obsolete.
6. H. E. grenade	G. Kart. fur G. Sprgr.	1. 0	Yellow ring	H. E. grenade (288 g).	In the future to be used only for H. E. grenade.
7. H. E. grenade (old type).	G. Kart. (Alter Art) fur G. Sprgr.	1. 0	Yellow ring (partly).	H. E. grenade (288 g).	Obsolete.
8. H. E. grenade (old type).	G. Kart. (Alter Art) fur G. Sprgr.	. 85		H. E. grenade (288 g).	Packed attached to grenade.