GERMAN UNDERWATER ORDNANCE
MINES

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ORDNANCE PAMPHLET 1673A

GERMAN UNDERWATER ORDNANCE: MINES

1. Ordnance Pamphlet 1673A provides basic information on each type of German sea mine used or in development during World War II. It is not an exhaustive analysis of these mines, but an overall survey of the German discoveries, experiences and achievements.

2. The only attempts to compile existing information on German mines into published form were in OP 1330 and OP 898, both of which were limited in scope. OP 1330 was intended solely for mine disposal officers and OP 898 was an identification manual for general service personnel. This publication includes some of the information from each of these previous pamphlets. Other information has been taken from letter and technical reports prepared by the Naval Technical Mission in Europe, intelligence reports forwarded by the Commander, Naval Forces in Europe and Commander, Naval Forces North African Waters, and field intelligence reports from mine disposal officers assigned to Mobile Explosive Investigation Units Numbers 2 and 3. These reports are listed in the Bibliography.

3. The information relating to several of the mine items described herein is incomplete for one or more of the following reasons:

a. No specimens were found.
b. No documents relating to it were available.
c. Reliable information could not be obtained through interrogation.
d. Specimens have not as yet been analyzed by the cognizant technical activities.

4. This publication is RESTRICTED and shall be safeguarded in accordance with the security provisions of U. S. Navy Regulations, 1920, Article 76.

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Vice Admiral, U. S. Navy
Chief of the Bureau of Ordnance

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Chapter 1

HISTORY

Beginning in the early 1920's, the German Navy developed an extensive marine mine research program, and by the outbreak of World War II possessed a number of revolutionary types ready for mass production. These included seven contact mines, eight influence mine cases, and three magnetic units. Among them were ground and moored mines suitable for laying by aircraft, surface vessels, and submarines.

The German Navy had already perfected highly efficient contact mines during the first World War, but Allied countermeasures seriously limited their effectiveness. Consequently, in 1923, research began upon mines operating on non-contact principles, and was first directed toward the development of a magnetic unit.

MAGNETIC UNITS

Magnetic units of either the induction or the needle type were feasible; but, since Germany was not self-sufficient in the copper and nickel essential to induction units, work centered upon the needle unit. The first needle type, E-Bik, was completed in 1925, and in subsequent years it was improved and adapted to ground and moored mines. By 1939 the M 1 (unipolar), M 2 (unipolar), and M 3 (bipolar) magnetic units were ready for operational use.

During the war, the Navy continued research for improvements to the M 2, and M 3, and for methods to keep ahead of Allied countermeasures. This resulted, before the end of the war, in the M 4 (unipolar) and M 5 (bipolar). The M 4 was an improvement of the M 3 type, designed for use in either moored or ground mines in combination with other units. It possessed a maximum sensitivity of 2.5 mg., and contained a device which reset the unit automatically when it was actuated or disturbed. The M 5, a small, improved M 1 designed for use in ground mines in combination with other units, was abandoned in favor of the more satisfactory M 4. The latter was used operationally; the M 5 was not.

Raw material shortages prevented large-scale German production of induction-type units. A limited research program failed to develop substitutes for copper windings and nickel rods. Aluminum windings on high permeability steel rods were tried; but, despite the use of up to eight rods in a single mine case, the loss in sensitivity was too great.

Attempts were also made to develop amplified induction units for use in combination with other units. The Luftwaffe, which was in a favored position throughout the war, obtained small amounts of copper and nickel to develop the AJD 102 and JDA 105 combination induction units. Neither one of these was used operationally.

DEGAUSSING

Concomitant with the development of magnetic mine units, the German Navy pressed an intensive countermeasure program designed to defend itself against the magnetic mines which it thought the British had developed. All German warships were degaussed by 1939, and the Merchant Marine by 1940.

ACOUSTIC UNITS

The Germans assumed erroneously that the British, who had laid the first magnetic mine, would have developed sweeping techniques and established degaussing procedures to counter it. Consequently, in 1938, when the magnetic mine program was well advanced, they commenced research upon acoustic mine firing mechanisms.

Because of the unexpected initial success of magnetic mines, acoustic research continued at a low pace until the British inaugurated effective countermeasures in the spring of 1940. The German Navy in May assigned a sonic acoustic project with highest priority to Dr. Heil Firma. By September Dr. Firma had developed the A 1 unit ready for operational use. Thereafter, he made steady improvements in it, and sought other types of acoustical units.

The A 3 acoustic unit for use with the EMF and SMA moored influence mines proved unsatisfactory. In one test, 100 of these units, fitted in EMF cases, were laid in the Kattegat, and almost all of them simultaneously prematured. Dr. Firma sought to remedy the defects of the A 3 in the A 7, which was in its final test stages when World War II ended.

Other research developed the AT subsonic units (also known as AA units) and the AE supersonic units. The AT units were used operationally from 1942 to the close of the war, but the AE units did not progress beyond the advanced development stage. The AE, which functions satisfactorily in greater depths than other acoustic types, was intended for use in moored mines to be laid in the relatively deep water off the American coast.

Other acoustic units embodying devices designed the A 4, AA 4 and Seismik. The first two differed from the A 1 principally in that the A 4 depended on the rate of the change of the sound level and the AA 4 depended on the directional characteristics of the sound. The Seismik(Sismograph Microphone) consisted of a simple electrical circuit utilizing a carbon-button microphone mounted within a modified D 1 pressure unit and intended to respond at the subsonic levels of 5-8 cps. The circuit was intended for use in combination with other mechanisms such as the M 4, A 4, and D 2.

RESEARCH AFTER 1941

By 1941, British countermeasures against magnetic and acoustic mines were so effective that the Germans began a new research program to develop units using new firing principles, combined units, and auxiliary devices calculated to hinder or defeat British sweeping methods.

PRESSURE UNITS

The first objective was realized by 1943, when the pressure firing mechanism D 1 and D 101 were completed and readied for operational use. These were used with the M 1 and A 104 units to form the combined units DM 1 and AD 104. Subsequently, the D 2 and D 102, designed to provide against actuation by nearby explosions, were developed for use in the same combination as their prototypes.

A series of uncombined pressure units, the D 103, D 113, D 123, and D 133, were designed for rivers or other relatively smooth waters. Only the D 103 was used operationally, the others were still under development at the end of the war.

A general rule prohibiting the employment of mines for which no countermeasures existed prevented pressure units from being employed until after the Allied Invasion of France in 1944. The military situation by then was so grave that the Germans even laid early defective types with natural rubber bags, which allowed the air to escape in as little as three weeks after the unit was underwater. This flaw, discovered only a short time before the invasion, was remedied by substitution of leakproof synthetic rubber bags.

EXPERIMENTAL UNITS

An over-all plan to examine all physical laws that might be applied to influence mine units led the Germans to undertake varying degrees of experimentation with the following types of units: optical, cosmic ray, infra red, UEP(Elektroden Effekt), gravitation, and Wellensonde(wave probe).

Optical. The Navy devised a number of experimental optical units. Those designed for use in the open sea presented serious difficulties, and none was perfected before the end of the war. However, a river unit used operationally in the latter stages of the war against river bridges, achieved some success. All these units utilized photoelectric cells so arranged that decreases in light of prescribed intensity and rate would actuate the unit.

Cosmic Ray. Preliminary development was begun upon a cosmic ray unit that would operate on the increase of the underwater cosmic ray level caused by the passage of a ship. The earliest experiments were conducted with twentyfour standard Geiger-Muller counter tubes cast into the explosive of an LMB mine case. Difficulties in obtaining a satisfactorily high potential supply and in regulating this potential slowed the project to such an extent that it was still in little more than the "idea stage" at the war's termination.

Infra Red. Although the Germans made inquiry into the possible application of the underwater action of infra red rays, no information on the progress in this field was obtained by U.S.Naval investigators, and, to date, no reports have been received from British sources.

Underwater Electrical Potential (Elektroden Effekt). During the course of World War II the German Navy discovered that the passage of a ship created an electrical current in the water which could be detected by copper electrodes placed on the sea bottom. They termed this phenomenon the "Electroden Effekt" and sought to develop a mine unit that would operate on this principle. Progress was slow, and at the close of the war the investigation was still in the preliminary stages.

Gravitation. The Askania Werke, Berlin, attempted to create a mine mechanism that would work on a principle similar to that of the Askania Gravity Balance. The Werke made certain calculations in conjunction with the Geophysical Institute of Potsdam, but the idea made relatively insignificant progress.

Wellensonde(Wave Probe). The Germans sought to utilize the distortion which passing vessels would effect upon high frequency alternating currents emanating from a mine case, in order to fire a unit. The principle was similar to the U.S.Navy's Electrical Discontinuity Discriminator, but the German application never progressed beyond the experimental stage.

COMBINED UNITS

To thwart British countermeasures and give greater life and sensitivity to units, the German Navy developed a series consisting of a combination of two or more firing mechanisms, each of which operated on a different principle. The earliest of these, the MA 1, built in 1941, combined the M 1 magnetic and A 1 acoustic units. Improved versions known as the MA 1a, MA 2 and MA 3 followed. The Luftwaffe made a similar combination, the MA 101, with imrpovements designated MA 102 and MA 105.

In 1942 the pressure-magnetic DM 1 went into production; the following year, the pressure-acoustical AD 104. These early pressure combinations were followed by the DA 102 pressure-acoustical series of seven different units. Of these, only the DA 102 was used operationally.

Another important series of combined units, the double acoustics, utilized a sonic acoustic system for triggering the subsonic or supersonic systems. These units were known as the AT 1, AT 2, AT 3 and AA 106(All subsonic) and the AE 1 and AE 101(both supersonic).

By May 1945, three-unit combinations were reaching the operational stage. They consisted of the MDA 106(Magnetic-pressure-acoustic), JDA 105(induction-pressure-acoustic) and the AMT 1 and 2(acoustic-magnetic-subsonic). Two miscellaneous combined units which never reached an operational stage were the DS 1 (pressure-seismik) and the JD 102(induction-pressure).

AUXILIARY DEVICES

Arming Clocks. As a necessary accessory to the first influence mine units, the German Navy designed a six-day arming clock, the UES I. The primary purpose of the arming clock was to allow influence mines of the ground type to settle securely in the bottom prior to arming. Secondarily, it was used to hinder sweeping operations. The range of the clock was from one-half hour to six days, and the settings were always for the maximum period consistent with the military objective. Various improvements were made both prior to and during the course of the war, but basic operation was never altered.

Late in the war the German Navy introduced a new type of arming clock, the ZE III. This clock could be set from five to two hundred days, and could be utilized either for arming or for disarming. A similar 360-day clock, also known as the ZE III, was under development at the close of the war. The only other delaying arming clock used was an eighty-hour type employed with the BM 1000 mines to permit proper orientation of the case prior to arming.

Period Delay Mechanisms. Another important series of clockwork mechanisms used in German mines were the Period Delay Mechanisms ZK I, ZK II and ZK IIa through ZK IIf. The mechanisms were so designed that from one to eighty-five actuations within prescribed time periods were necessary to fire the mine. The first of the mechanisms, which possessed a span of only six actuations, was intended to defeat the practice of having minesweepers safeguard outgoing vessels by preceding their passage from port. The last model, the ZK IIf, which could be set up to eighty-five, was designed to make clearance sweeping extremely burdensome.

Sterilizers. The third large group of clockwork mechanisms consisted of seven different types of sterilizers, with maximum time periods as follows: ZE (80 days), ZE I (80 days), ZE II (6 days), ZE III (200 days), ZE III (360 days), ZE IV (45 days) and ZE IVa (60 days). In addition, a 200-day electrolytic cadmium cell sterilizer was developed.

All the sterilizers were used in various German mines to limit the life of minefields in accordance with tactical requirements. They were widely used to permit the replenishment of E-boat laid minefields off the English coast.

Pausenuhr. Several clockwork mechanisms served special purposes. The most important was an 18-day clock, the Pausenuhr, which armed and disarmed a mine once in every 24 hours. The German Navy developed this clock after it observed that the British normally made morning sweeps after minelaying sorties and allowed traffic to resume by midday.

Twelve-Hour EW. Another clock, the twelve-hour EW, was used with the M 3 unit in moored influence mines. The EW tested the mine circuit for a period of up to twelve hours after laying, and scuttled the mine at the end of the set period if it planted improperly or was otherwise disturbed.

Prevent-Stripping Mechanisms. To protect influence mines from capture, the Germans devised a variety of mechanisms commonly referred to as "booby-traps" or "Prevent-Stripping Mechanisms." They consisted of specially designed bomb fuzes to explode aircraft mines that fell on shore, photoelectric cells which fired the mine if it were exposed to light by the removal of the unit dome, sea cells to explode the mine if the unit was exposed to moisture, a variety of anti-withdrawal and anti-removal devices, and a unit to fire the mine if it were moved into shallow water or inadvertently laid in tidal flats. These devices were used widely in the early phases of the war. However, after several accidents involving the loss of German mining personnel, they fell into disfavor. During the latter part of the war they were used infrequently.

Raumschutz. When the Germans acquired complete information on Allied magnetic sweeping procedure through the capture of a BYMS off Leros, they undertook development of Raumschutz (area protection) to defeat the LL-type sweep. These units, for use with the M 1, MA 1 and MA 1a mines, were to be designated M 1r, MA 14 and MA 1ar. They were in production in 1945.

Raumschutz was a rubber-covered cable 165 feet in length with one copper electrode secured to the end and another mounted on, but insulated from, the mine case. In operation, the sea current produced by an LL-type sweep was picked up by the electrodes and, through a sensitive relay, the mine was rendered passive for the duration of the sea current plus a predetermined period. According to reports, the Germans attempted to fit Raumschutz to aircraft-laid mines using the MA 105 unit. However, considering the nature of the device, probably the inherent mechanical difficulties were insurmountable.

NAVAL MINE CASES

By May 1945, the German Navy and the Luftwaffe had either laid or undertaken the development of an imposing array of 96 different types of naval mine cases. This total does not take into consideration captured foreign mines which the Germans used. The mines fall into two separate groups -- contact and influence.

Contact Mines. The Germans started World War II with seven different types of moored contact mines: the EMA, EMB, EMC, EMD, FMB, FMC, and UMA. The EMA and EMB, identical except for the weight of charge, were World War I mines designed for laying by submarines. A limited quantity were laid during World War II out of stocks remaining on hand. The Japanese JA mine, used operationally in the Pacific after 1941, was a copy of the EMA.

The German Navy developed the remaining five types between 1923 and 1939. It placed especial emphasis upon the EMC, which was the most widely used and the most adaptable. During the course of the war, the Navy made major changes in chain moorings; added cork-floated snag lines, mounted antenna and mechanical cutters on the mooring cable; and in other ways improved these types to remedy defects or conform with changing military requirements.

In addition, a number of new contact mines were developed. The UMB, a larger UMA, was designed; an aircraft-laid, moored, contact mine, the BMC, was introduced; the EMS series of drifting, decoy, contact mines were readied for operational use; the OMA series of moored, surface-contact mines and the EMG shallow-water, constant-depth assembly appeared. This group of moored contact mines was fortified by the development of a ground contact mine made of concrete and known as KMA. With this mine arsenal, the Germans had a series of diversified Naval mines adequate for composing a contact minefield that would meet the requirements of any given tactical need.

Contact-Influence Mines. Two interesting contact-mine developments were undertaken during the war. The first of these was the design of two combination contact-influence mine cases, the EMK and EMU. These mines were intended to overcome the following shortcomings found in previous German moored mines:

1. In deep water, hydrostatic pressure sometimes prevented arming by counterbalancing the pull of the mooring cable.

2. In shallow water, rough seas caused excessive arming and disarming.

3. The use of explosive containers within the mine reduced the damage radius and served to render proper mine orientation more difficult.

4. The plummet-type standard surface anchor was not suitable for delayed-rising mines.

Since this development was assigned a low priority it proceeded at a slow pace and was never completed.

ANTI-ASDIC RESEARCH

The Germans began another development when the relatively small mine damage in the initial amphibious assaults at Anzio and Salerno indicated that the Allies had perfected a method of detecting moored mines by ASDIC. The U-Boat Command for some time had been seeking an answer to the problem through special paints and coats of rubber. The Mine Command tested and rejected these. Very late in the war it hoped to eliminate rather than merely reduce the response obtained from cases with a metal core through design of an all sponge-rubber case with a minimum of rubber fittings.

CONCLUSION

When the Germans launched their research for a magnetic mine unit, they simultaneously undertook the development of a mine case to house it. The earliest of those cases were the RMA and RMB ground mines, both of which were hemispherical in shape, of all-aluminum construction, and designed for laying by surface vessels. The hemispherical design was to insure proper orientation of the magnetic unit after planting. When experimentation showed that the case tended to sled on laying, a specially designed float was added to the mine. The purpose of the float was similar to that of a drogue, i.e. to slow the descent of the mine in water and to prevent sledding and tumbling.

During the war, additional mines of the RM series were developed. This series consisted of surface-laid ground mines which could be utilized as influence and/or controlled mines. These were the RMD, RME, and RMH. The RMD could be fitted with any of the various firing units; the RME was for use in rivers with an M 1 unit; and the RMH was a wooden-box sea mine of simple design which also housed an M 1 unit. This RMH was intended for local fabrication, so that overtaxed transportation facilities could be partially relieved from carrying bulky and heavy mine cases over long distances.

After completing the RMA and RMB, the Germans sought to exploit the potential value of influence mines that could be laid by aircraft. Accordingly, they developed the parachute mines LMA and LMB. These were ground mines, cylindrical in shape and of all-aluminum construction. They were used very widely during the war, with satisfactory results except for one important factor: the maximum laying speeds and altitudes were too low. This led the Luftwaffe to push the perfection of a high-altitude, high-speed mine that would provide greater safety for the laying aircraft. The answer found was the Bomb-Mine 1000, which is discussed in later paragraphs.

The LMA and LMB received several interesting wartime modifications. When British airpower and antiaircraft fire made aircraft mining extremely hazardous, the mines were changed so that they could be laid by E-Boats, and redesignated LMA/S and LMB/S. They differed from the air types only in the type of tail used and the elimination of the bomb fuze. A further innovation in all these mines was the substitution of pressed paper(Prestoff) for aluminum in the fabrication of the mine case, in order to reduce the high cost and to forestall any future aluminum shortage. It was difficult to keep these types, the LMA/F and LMB/F, watertight, but, as they were found stored at operational airfields in France and Belgium, they were in use or ready for use.

The LMA and LMB mines presented an additional problem. Since they were of the ground influence type they could not be employed in depths of up to 1,000 feet. Later a modified LMF, the LMF/S was introduced for laying by E-Boats.

The Luftwaffe, being unsatisfied with the LM mines because they necessitated low-altitude drops at low speeds, pushed the development of their cylindrical, manganese steel bomb-mines, the BM 1000 series. By 1945 they had developed mines that they could drop from heights of up to 21,000 feet at speeds of over 400 m.p.h. This was achieved by the use of break-away flat noses, small parachutes, and other accessories. Of thirteen different types of bomb-mines, five were used operationally. One, the BM 1000t, was a moored mine intended to attain the same results as the LMF. However, this mine proved unsatisfactory during dropping tests and was abandoned in 1944.

To round out their influence mine program, the Germans developed a variety of ground and moored types for laying from submarines. The earliest were those which could be laid from submarine torpedo tubes, the TMA (moored) and the TMB (ground). In 1939 the TMC, a larger version of the TMB, was developed to meet field requests for a submarine-laid mine with a heavy charge. TMC housed over 2,000 lb. of hexanite.

When these mines had been completed, the development of a mine torpedo (MTA) was undertaken. This project was successfully completed by 1942, and mines of this type were used operationally during the war. The mine was intended for use in harbors, to be laid by being fired from submarines standing off shore. The advantages were that it reduced the risk of detection by harbor defenses and permitted safe replenishment of fields already laid.

The other series of submarine-laid mines were all of the moored type for laying from the vertical shafts of special minelaying submarines. The first of this series was the SMA, which was laid off the Americas in fields off Halifax and Panama in 1942-1943. In 1943 a clock was added to the SMA anchor to obtain a delay of up to 60 days in separation of mines and anchor. This modified assembly was called the SMC. The development of an additional type of SM mine, the SMB, was undertaken prior to the war but never progressed beyond the preliminary design stage because of the low priority assigned to the project. This mine was intended for use in depths of up to 9,000 feet, especially off the American coasts.

Simultaneously with the development of the TM mine series, the German Navy perfected a moored influence case for surface laying, the EMF. This assembly was designed for use in depths of up to approximately 1,600 feet as opposed to the maximum of about 125 feet for the ground influence mines; it was used extensively during the war.

Chapter 2

THE GERMAN MINE ORGANIZATION

The earliest German establishment charged with the technical development and the testing of Sea Mines was the Navy's Mine and Mine-Sweeping Group (SVK: Sperrversuchskommando) which fitted into the over-all German Mining Program as shown in Figure 1. In 1938, the Luftwaffe had decided that the LM-type parachute mines developed by SVK would not meet future tactical requirements and contracted with the private firm of A.E.G. for the development of a bomb-mine. However, SVK remained in complete control of mine development until 1941, when the Luftwaffe created a separate and independent organization known as the Test Station (E-Stelle: Eprobungstelle) for the purpose of pushing the development of the bomb-mine. (The E-Stelle was established within the Luftwaffe, as shown in Figure 2.). In 1943, SVK was shorn of further responsibilities with the formation of an independent Navy testing establishment known as the Trials Group (SEK: Sperrwaffenerprobungskommando).

FUNCTIONS OF MINE AND MINE-SWEEPING GROUP(SVK)

Until 1941, SVK was charged with the development of all German Naval mines, including aircraft types. The specifications and requirements for the mines were laid down by the General Staff, after consultation with SVK. If, during the progress of the work, it was found that original requirements could not be met, the specifications were modified accordingly. In addition, SVK furnished first drafts of instructional and operational pamphlets, as required by Mine Inspection SI (Sperrwaffeninspektion), and made manufacturing drawings of the mines and mine components for contracting firms.

PERSONNEL OF MINE AND MINE-SWEEPING GROUP(SVK)

The Personnel of SVK was under the supervision of Kdr, Kapt. Zur See Bramesfeld, and were divided into two departments (1) Naval and (2) Technical. The Naval Department was assigned approximately 500 Naval personnel who were allocated, as needed, among the Department's four sections; (1) Mines, (2) Influence Sweeps, (3) Depth Charges, etc., (4) Sweeps, and a flotilla consisting of about 200 vessels ranging in size and purpose from steamships to motor boats. The Technical Department consisted of about 450 personnel, about 60 of whom were in the scientific and design division, which was divided as follows: (1) Mines, general mechanical, (2) Sweeps, (3) Influence devices and physical fields, (4) Depth charges and aircraft mine cases.

The drafting rooms and shops were allocated 50 and 300 personnel respectively, the remaining personnel being administrative and clerical. Some Technical personnel held special Naval rank, while others remained in a civilian status. In practice, the scientific, technical, and design work was handled by the Technical Department and the Marine experience added by the Naval Department.

FACILITIES OF MINE AND MINE-SWEEPING GROUP(SVK)

The principal buildings comprising the SVK installation at Kiel were as follows:

1. Main laboratory and administration building, including a large wing for drafting, files, and reproductions.

2. Main shop buildings in the form of a quadrangle with the magnetic laboratory (all-wood construction) in the center of the quadrangle.

3. Mine School building and barracks.

4. Foreign Mine Museum building.

5. Assembly and storage building beside the docks.

6. Tank building similar to that of NOL, Navy Yard, Washington, D.C.

7. Miscellaneous service buildings.

The major testing equipment available to SVK was as follows:

1. Physical testing machines of the type normally found in metallurgical laboratories.

2. Pressure tanks of various sizes, including types large enough to accommodate mine cases.

3. Several laboratory ships, suitable for testing mines on the sea bottom.

4. Electrical and acoustical laboratory instruments.

5. Drop testing equipment and shock testing gun.

Since SVK preferred to make field measurements of mine units on the sea bottom, they made no attempt to perfect large acoustical tanks or simulation equipment for testing magnetic units.

TRIALS GROUP(SEK:SPERRWAFFENERPROBUNGSKOMMANDO)

In the Fall of 1943, the SEK was established under the command of a Fgt. Kpt. Broeckelmann for the purpose of testing mine material for serviceability from the seaman's point of view.

This command was based at Kalundborg, Denmark and consisted of a flotilla of mine layers, mine sweepers and work boats. Approximately 700 officers and ratings comprised the staff. Departments were set up for each type of mine and gear, such as controlled mines, moored mines, ground mines, mechanical mine-sweeping gear, etc. An aircraft mine section, headed by an Air Force officer, was created; but, on account of the shortage of planes, fuel and personnel, little aircraft testing was carried out, the task being left to the Luftwaffe.

Apparently, there was no set pattern for acoustic or magnetic trials of mines. Target ships provided the actuation under the supervision of a specialist officer, who had familiarized himself with the unit being tested by working together with SVK. Tests were designed to simulate field conditions as closely as possible.

Trials Group (SEK) reported the trial results to Mine Inspection (SI) and made its own recommendations; if the item was already operational, SEK could advise discontinuance. Drafts of publications prepared by SVK and covering the item under test were checked by SEK from an operational viewpoint.

FUNCTIONS OF TEST STATION (E-STELLE)

The function of E-Stelle, Section E-7 (Mines) was mainly the testing of aircraft mines. However, this group was also responsible for the coordination of development work being carried on by various outside agencies and for some independent development work. (E-Stelle differed from SVK in that practically all of the former's research, development, and drafting work was done by outside agencies which consisted mainly of private manufacturing firms).

PERSONNEL OF TEST STATION (E-STELLE)

The personnel of E-Stelle were under the immediate control of a Luftwaffe Captain Eitel. They consisted of 12 technical men, about 50 men to discharge miscellaneous mechanical and ordnance tasks and about 60 men to handle the various planes and boats assigned to the Section. The 12 technical personnel were bolstered by about 50 independent scientists and technicians, under contract to the private manufacturing firms associated with E-Stelle.

FACILITIES OF TEST STATION (E-STELLE)

The buildings comprising the E-Stelle establishment at Priwall were as follows:

1. Hangar space (Used for offices and small workshops).
2. Workshop and Laboratory buildings.
3. Parachute handling building.
4. Storage sheds.
5. Explosive storage sheds for fuzes, flares, and other miscellaneous small explosive charges.

The vessels assigned to the section were as follows:

1. One ship of about [illegible] tons, the "Grief".
2. One ship of under 600 tons, the "[illegible]".
3. Two motor boats.
4. Two crash boats.
5. One medium-sized work boat with mine and cable handling gear.

COORDINATION BETWEEN THE NAVAL MINE AND MINE-SWEEPING GROUP (SVK) AND LUFTWAFFE TEST STATION (E-STELLE).

As a result of the interservice rivalry, the coordination between the two mine development groups, as well as between the various technicians of SVK, was spotty. By this method the separate information of each organization was informally pooled and technical difficulties discussed. When requested, the facilities of SVK were made available to E-Stelle, for whatever purposes desired.

Since the E-Stelle's primary responsibility lay in the testing of items received from manufacturers, they established certain general rules for determining the acceptability of material received. Thus where a lot of one hundred items was received, twenty specimens were selected at random and tested. If 20% or more were unsatisfactory, an additional twenty were selected and tested. If 10% or more of the second lot were defective, the material was rejected. Under special circumstances this method could be altered so that it was more or less stringent, but in every case reports of the tests were forwarded to Air Development (FLE), with explanations and recommendations. In addition, E-7 made spot checks on accepted material stored at the various depots, in order to determine the effect of aging.

Where development work was involved, the first step was the preparation of specifications and requirements by Headquarters with the assistance of Air Development: Mines (FLE-7) and Test Station: Mines (E-7). Thereafter a manufacturer was selected and the project assigned. Members of E-7 technical staff were assigned to provide liaison with the firm. If modifications requested by firms were of minor importance, not affecting the working properties of the article to be made, they were generally allowed. If the firm requested important modifications, because of lack of suitable manufacturing equipment, or if it was unable to carry out important modifications found necessary when the article was put to use, then steps were taken to provide the firm with the requisite equipment. Sometimes there were difficulties which were in reality due only to the policy of the firms in question. In these cases, the advice of outside manufacturing experts, not directly interested in the matter, was requested before any decisions were made. At other times, the firm taking up the manufacture of a particular part would require some patent process of another firm. E-Stelle then arranged to borrow special engi-

ORGANIZATION CHART - SVK

Navy High Command
(OKM: Oberkommandomarine)

I

Mine Command
(SW: Sperrwaffen: Adm. Bachenkohler)

I

Assistant for Mines, etc.
(SWa: Sperrwaffen: Konter Admiral Muller)

I

Mine Inspection
(SI: Sperwaffeninspektion: Vice Admiral Michels)

I

Trials Group
(SEK: Sperrwaffen erprobungs kommando: Fgt. Kpt. Broekelmann)

Naval Mine and Mine-Sweeping Group
(SVK: Sperrversuchskommando: Kpt. Zur See Bramesfeld)

Mine School

Arsenals

Naval
- 1 - Mines (von Linden) Flotilla (Rodiger)
- 2 - Influence Sweeps (Lambrecht)
- 3 - Anti-Submarine and depth charges (Davids)
- 4 - Mechanical Sweeps (Gemein)

Technical
Baudirektor von Ledebur
- T -1 Cases Moored Mines (Schuller)
- T -2 Sweeps (Behrens)
- T -3 Firing Units (Hagemann)
- T -4 Cases Aircraft Mines (Kersten)

Drafting Rooms
Mine Groups

Shops

Personnel & Administration

Foreign Mines

Above organizational details supplied by Fgt. Kpt. von Linden.

Figure 1 - SVK Organization.

neers or master mechanics familiar with the work, from the second firm for the contractor.

THE EFFECT OF ALLIED BOMBING ON THE MINE PROGRAM

Aside from the creation of transportation bottlenecks, the Allied bombing of Germany had no effect on the production, research, development, or storage of Naval Mines. To safeguard production, the Germans dispersed their contracts among various factories and required that critical parts be manufactured by at least two separate firms. This arrangement proved entirely satisfactory, and no further precautions were taken. On the other hand, the research and development installation of SVK and E-Stelle, although particularly vulnerable to air attack, escaped damage throughout the war solely because the Allied Air Forces chose to neglect them. Similarly the mine depots, with the exception of the one at L'Isle Adam, France, escaped damage throughout the war. The escape of these latter activities was, at least in part, due to their location within heavily wooded areas and to their excellent camouflage, both of which combined to make detection from the air extremely difficult.

ORGANIZATION CHART - LUFTWAFFE

Airforce High Command
(OKL: Oberkommando der Luftwaffe)
I
Operations Staff

Chief of Technical Air Armament
(TLR: Technischen Luft Rustung)

General Staff

Air Development
(FLE: Flugtwicklung)

Procurement

FLE-9
(Torpedoes)

FLE-7
(Mines)

Other Sections

LF-12 (Military Control located at Hamburg)

Commander of Test Stations
(KDE: C Kommander der Erprobungsstellen
Military Control located at Hamburg)

Travemunde

Other Test Stations
(Erprobungsstellen)

E-5

E-7
(Mines)

E-9
(Torpedoes)

Hauptmann Eitel

Group 1
(St. Ing. Spieler)

Group 2
(Hpt. Ing. Kern)

Group 3
(St. Ing. Doorman)

Figure 2 - Luftwaffe Organization.

Chapter 3

CRITIQUE

Throughout a large part of the war, Germany possessed a high degree of technical advancement in the field of marine mines, but never fully exploited it. A number of factors prevented the German mines from reaching their point of potential destructiveness against the Allies. At first the Navy placed little importance upon them; subsequent inter-service rivalries seriously impaired their effectiveness; and, in the latter stages of the war, shortages curtailed operations. In addition, miscalculations at several points marred the program.

At the beginning of the war, the German Navy emphasized guns and torpedoes. Apart from a small group of specialists, it was not interested in mines. Even the specialists believed that while mines, intelligently used, could be powerful weapons, they were very likely to be discredited by injudicious use. This liability to fortuitous rise and fall in the stock may well have contributed to deprive mine development of the consistent direction and drive to be seen in German torpedo development.

Mining suffered consistently from its subordinate standing. No one in the Navy held operational control over mining; no one in the Mining Command possessed sufficient drive and grasp to present the case for mining with enough force before the High Command. As a result, the direction of mine warfare failed to rise above its second-rate position.

The weakness of the Mining Command was readily apparent in operations. The decentralization of control over operations and operation policy contrasted markedly with the highly centralized control the Mining Command held over materials. The German Navy had no specially built, high-speed minelaying vessels capable of large-quantity plants. Although Schnell boats, submarines, destroyers, cruisers, and certain merchantmen were fitted for minelaying, none of these vessels was ever available in sufficient number of combination to meet the strategic requirements of the mine group.

Because mine priority was disproportionately lower than that of torpedoes, too few submarines were assigned to minelaying in American waters. As a result, there were no effective minefields in the western Atlantic to disrupt coastwise shipping and convoys to Europe.

The field commanders persisted in laying only those mines designed to sink merchant tonnage, since such sinking made better press-release material and created higher morale than did the sinking of small minesweeping vessels. Pressure from the High Command finally resulted in a change of policy, but by then it was too late.

The greatest weakness in the mining program was the lack of cooperation between the Navy and the Luftwaffe, and on a lesser scale between the Navy and the Army. The Luftwaffe insisted upon its own independence, and the Naval Mining Section (1 Skl) had no jurisdiction over its minelaying activities. The Navy maintained that every minelaying operation was a naval operation. Accordingly they tried to influence policy, although they could not exercise control; but even in this they had little success.

After the collapse of France, when the Navy came to the view that an effective sea blockade of England would bring her to her knees, the Luftwaffe continued to use bombs, the results of which were tangible and of greater propaganda value. Admiral Muller declared, "Goering was interested in showing Hitler and the German people pictures of bombed and burning English cities, and was not content with the invisible and often immeasurable results of Naval Mine Warfare."

At the same time, the Luftwaffe preempted much of the Navy's jurisdiction over both operation and production. The pre-war plan had been for aircraft minelaying to be confined to estuaries and such coastal waters as could not be reached by surface craft or submarines. One Luftwaffe formation based in northwest Germany and cooperating with the Fleet was to carry out all aircraft laying. The exclusion of German naval forces from British waters led the Luftwaffe to extend its area of operation, and the plan quickly broke down. In its minelaying it so completely ignored the Navy that it prematurely laid two new types of mines before they were ready in large numbers, and thus helped destroy their surprise effect.

Interservice politics undoubtedly had their part in the decision of the Luftwaffe, taken about the beginning of the war, to develop its own bomb-mine to replace the Navy parachute mine. The Luftwaffe placed an order for the first bomb-mine without any knowledge of the principles of that type of mining, and with the sole specification that it be of the same size and shape as a bomb. The tactical considerations behind the decision were no doubt sound enough, but, at the time, the Luftwaffe had no technical staff of its own which was sufficiently versed in mining problems to obtain a balanced solution.

When the Luftwaffe undertook mining developments, available experimental and testing facilities were very small and temporarily makeshift. The only equipment available was some generally used for torpedo work at Travemunde. Adjoining was an airfield originally used for experimental work with seaplanes. Subsequently a testing station for mines was constructed, and changes made in personnel.

At the time developments began at Travemunde, the staff had no experience with mines. The original suggestion to transfer trained personnel from the Navy was rejected, and it took some time to train the necessary staff and initiate testing and development on the requisite scale. Finally, after much argument, an officer with mine experience was assigned to the station in 1943. Later a strong technical staff and considerable development resources, mainly in industry, were built up.

Ultimately the Luftwaffe put much effort into the design of firing systems and corresponding modifications of the BM(bomb mine). Nevertheless, the BM was more restricted in its condition of drop than the Navy LM (parachute mine). With the exception of the pressure unit, which was a special case, the Navy had already produced all essentially new firing systems, and installed them in the LM.

When production work started on the pressure mine, the Luftwaffe and the Navy disagreed on principles and design. As a result, both services manufactured their own versions. Later, when the unit was ready for laying, the services again disagreed on its use in combination with other units. The Navy insisted on combining it with the magnetic unit, while the Luftwaffe preferred its use with an acoustic unit.

The Navy seldom attended trials of new devices at Travemunde, but it did receive completed specimens,sent for information and suggestions.

While the war lasted, the diversion of effort involved in the dual development continued. Luftwaffe Colonel Rommel complained that the naval system was far too rigid to get results quickly. Since the Luftwaffe did not get them any quicker, the view of German naval officers that the separation was thoroughly undesirable, seems to be sound.

To a lesser extent, the same sort of division existed between the Navy and the Army. Although the Navy was responsible for harbor security and control mines, they had no cognizance of any over-all beach defense mining plans developed by the Army. Coastal defenses and anti-invasion matters were under the jurisdiction of area commanders. Mines intended for use against river shipping, against bridges, and for anti-invasion purposes were extremely simple to manufacture, and therefore produced and procured locally by area commanders. The Navy was seldom informed about such improvisations, and believed that in closer cooperation with the Army better results might have been obtained.

TECHNICAL DEVELOPMENT

Despite the fact that the first German magnetic mine unit was ready for operational use in 1925, at the outbreak of the war in September 1939, insufficient stocks of magnetic mines were on hand to wage an all-out and effective mining campaign against England and her Allies. This shortage existed because the war came at a time when the Navy was still engaged in improving existing operational models and had not, as yet, gone into mass production. The existing stocks of magnetic mines were very small. They consisted of approximately six hundred LMA's and LMB's and several hundred RMA's and RMB's.

The German technical development of mine firing systems fell into three stages. The first, the period from October 1939 to the Summer of 1941, was one of significant innovations. It saw the introduction of the magnetic mine with its successive modifications, followed by the rush development of the audio frequency acoustic and the combined magnetic-acoustic mines.

The German Navy expected the magnetic mine to suffice for the war, but within a year the British were applying successful countermeasures. The Navy placed the blame for this upon the Luftwaffe, which in 1939 laid the mines in the Thames estuary before enough were available for a heavy attack. The Navy felt that these were far more likely to be recovered than ship-laid or submarine-laid mines, which might safely be laid in small numbers.

Even before the British negated the effect of the magnetic mine, the German Navy began the rush development of the audio frequency acoustic and combined magnetic-acoustic mines. As a result, they were actually producing acoustic mines in small numbers within three months after the outbreak of the war. Quickly they overcame the operational limitations of the first models, and proceeded in 1941 to develop a combined magnetic-acoustic mine. Once more the Luftwaffe stultified the effect through premature laying.

By the end of the period the effectiveness of the magnetic mine had seriously diminished. The Germans began, as the basis for a policy of technical surprise, a systematic study of ships' influence fields.

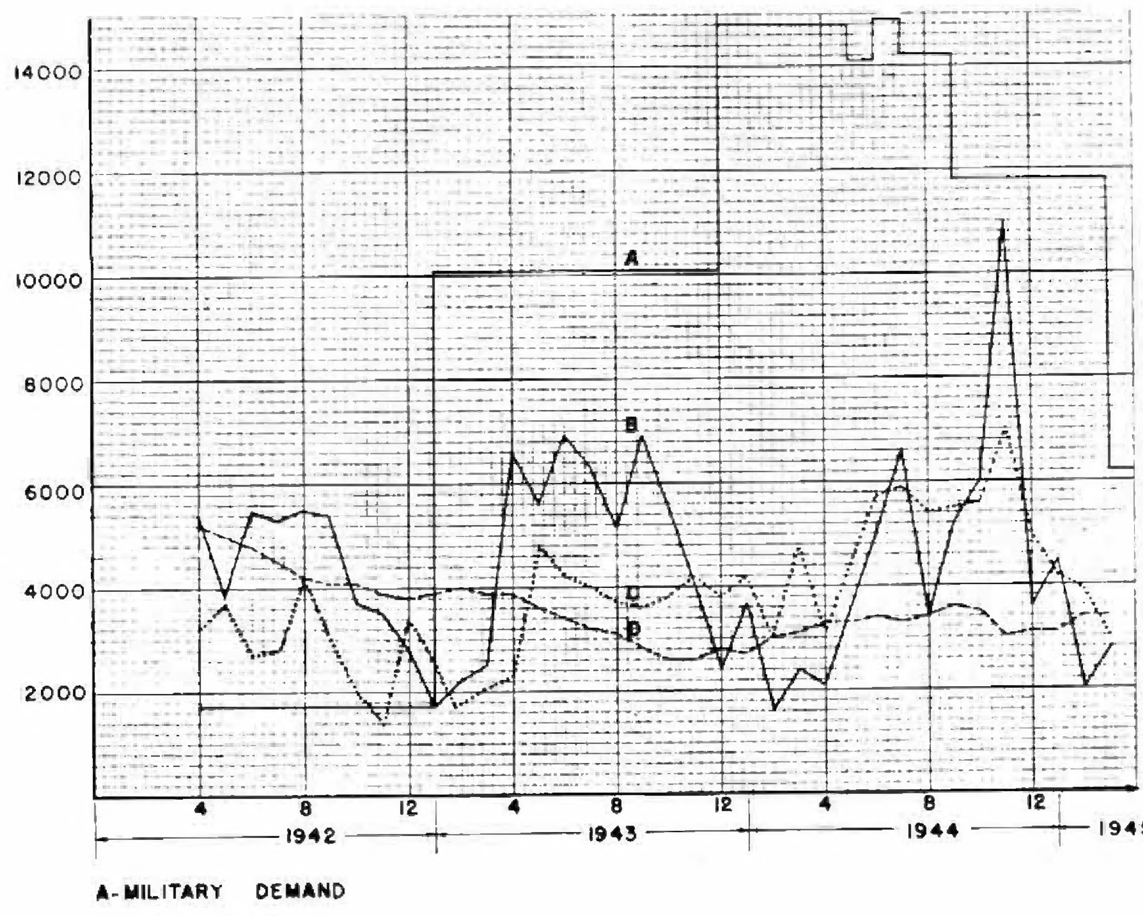
The second period, from the introduction of the magnetic-acoustic mine in the Summer of 1941, to the end of 1943, was one of steady research but no essential novelties. In April 1942, the German Navy had approximately 50,000 mines of all types ready for operational use. Through 1942 the monthly demand for mines was extremely low and at a constant level. Subsequently, as Allied action became more aggressive, especially in the Mediterranean, the demand accelerated. Ironically, now that no new weapons were coming out and successful countermeasures for the old ones were in operation, the Luftwaffe took mining more seriously and put forward its biggest minelaying effort.

During the third period, from the beginning of 1943 to the end of the war, the design work of the previous two and a half years bore fruit. The pressure, the low-frequency acoustic, and variants of the audio frequency circuits came into service, and the Navy had under development a wide variety of other weapons. From 1942 on, the Allies had studied the technical problems involved in countering many of these weapons; but their use would, none the less, have been very unwelcome.

The Germans had developed not only new types but also new techniques. Since no single mine is insurmountable, the weapon was the minefield, not the individual mine. Mine warfare operated on the principle of statistics. At the same time that German mines were becoming increasingly complicated in firing principles, first the Luftwaffe and subsequently the Navy, late in the war, arrived at the general policy of laying mixed fields. These greatly increased the problems of sweeping.

The demand for mines reached its peak in the invasion year, 1944. By then the Naval High Command appreciated the value of mine warfare, but was forced to cut orders to conform with the maximum possible production. At the same time, the laying capacity of the Luftwaffe declined heavily as a result of the German reverses on all fronts. This took the sting out of the new armory of mines. E-boats and other naval craft took over the mining offensive in the last stages of the war, but their scale of operations was necessarily small.

The Allies were fortunate that, very much as in the case of German submarines and torpedoes, the bomber position was not in phase with the weapon position. If the Luftwaffe had regained its offensive power, the Allied mine defense would have deteriorated.



A-MILITARY DEMAND
B-MINES LAID
C-AMOUNT RECEIVED
D-SUPPLIES ON HAND (X10)

Figure 3 - Graph of Mines Laid.

MINES LAID

Year	Month	BMC	FMB	FMC	UMA	UMB	OMA/I	BMC/S	BMS	BMA	BMB	TMB I/II	TMB III	TMC I	TMC II	KMB	LMA/S	LMB/S	BMA II	BMF	LMF/S	SMA	Total
1943	10	1140	64	305	6	1324			4			60		8				403		497	50	95	3956
	11	328		53		679			3		166	178		80				94		907		27	2515
	12	1536			330	574			5	37	47	30					150	937		192			3888
1944	1	885	11			284				3	40			129				180			28		1560
	2	1184			44	549		26				117						191		247			2358
	3	1678				126				22	24	8						63		246			2167
	4	1074			186	499		21	5									752		1095		30	3602
	5	2008	16		73	1341		63			140	45					194	642		66	36		4854
	6	1429		54	34	1723		364		174	82	70					310	1846		253	200	28	6572
	7	73			234	937		156		1	27	44						1117	7	1015		1	3612
	8	1541			850	838		180	15	163	129	99		1	60	1	70	874		158	130		5107
	9	767			510	506		150	26	57	199	433		98			364	2183		429	100	51	5972
	10	3485		8	830	2105			19	27	598	57	8	20		16	77	1917	1	1697		173	11016
	11	1514			86	593		1	5	24		58	12	47	15	10		1056		148		66	3635
	12	1135			84	694				201		158				1041		950		245			4508
1945	1	830				329										29		194	94	557			2033
	2	664			1	559	100		1					40	6	1002	1	367	91	64			2895
	3	1269			497	500				50		19	90	155	12	14		532					3136

TOTAL NUMBER OF MINES LAID PRIOR TO OCTOBER, 1943

Year	Month	Total
1942	3	5400
	4	3800
	5	5500
	6	5300
	7	6000
	8	5400

Year	Month	Total
1942	9	3700
	10	3500
	11	2800
	12	1700
1943	1	2300
	2	2500

Year	Month	Total
1943	3	5600
	4	5600
	5	6800
	6	6300
	7	5200
	8	5800
	9	5400

Figure 4 - Mines Laid

CONTACT AND MOORED INFLUENCE MINES

THE GERMAN EM (EINHEITSMINE) MINE SERIES

The German Einheits Minen (EM) mine series consisted of 13 different types of sea mines. These types were designated EMA, EMB, EMC, EMD, EME, EMF, EMG, EMH, EMI, EMK, EMR, EMS, and EMU. With the exception of the EMS, which was a drifting mine, all of the series were moored mines laid by surface and/or underwater craft.

The EMH, EMI, EMK and EMU either were abandoned in the developmental stage or were incomplete at the close of the war, and no specimens of any of these types or documents relating thereto were found. Consequently, the information contained herein on such mines is based solely on statements made by German prisoners of war and should be treated accordingly.

The EMA Mine. The EMA was developed during World War I and was the first German mine with a chemical-horn firing system. Accordingly, to differentiate it from the pendulum-type mines then in use, it was designated Elektrische Mine type A. Its production was discontinued at the close of the war. Its appearance in World War II is accounted for by the fact that stocks remained on hand in 1939.

The mine existed in two models, one for laying by surface craft and the other by submarine. Only the surface craft type was laid in World War II, since the other type required specially fitted submarines which were not available.

Description of Case

Shape	Two hemispheres, joined by a 12-in. cylindrical mid-section.
Material	Steel
Diameter	34 in.
Length	46 in.
Charge	330 lb. block-fitted hexanite

Description of External Fittings

Horns	Five: one in center of upper hemisphere; four, equally spaced, around upper hemisphere
Arming switch and booster release	On mid-section, secured by keep ring
Detonator carrier mounting	In bottom center of case
Mooring bracket and white metal mooring switch	Bolted to two lugs on lower hemisphere

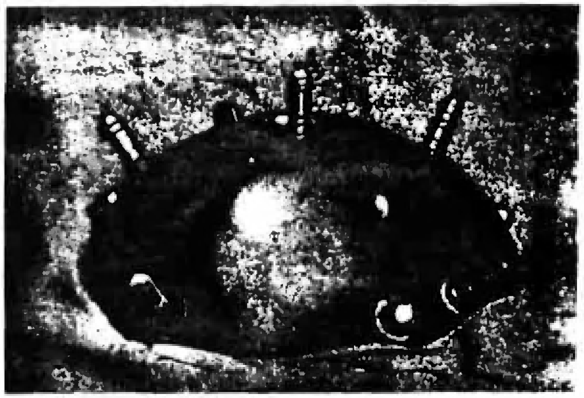


Figure 5 - EMA Mine Afloat

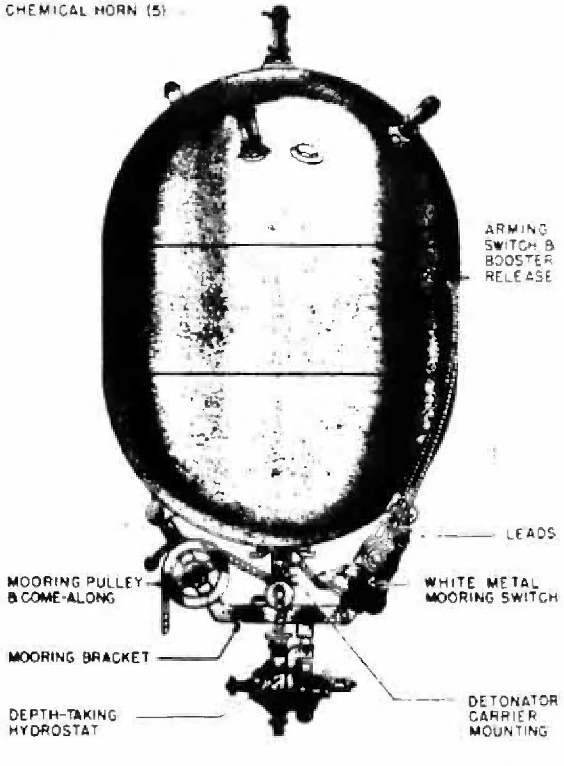


Figure 6 - EMA/EMB Mine

Mooring pulley and "come-along"	Attached to extension of mooring bracket
Depth taking hydrostat	Bolted to extension on mooring bracket

Two pair of electrical leads extend from the white metal mooring switch, one set to the detonator carrier, the other to the arming switch.

Operation. Mine takes depth by hydrostat. Separation of the anchor and case withdraws a safety pin from the arming switch and booster release, making the circuit from the horn batteries to the detonator and allowing the booster to drop over the detonator. Mooring tension extends the spindle of the white metal mooring switch, arming the circuit of the internal horn to arm the mine.

The EMB Mine. This mine is identical to the EMA except for the weight of charge, which differs as follows:

1.	EMA	330 lb.
2.	EMB	485 lb.

It is a moored contact type fitted to take seven chemical horns, and was designed for use against surface and underwater craft.

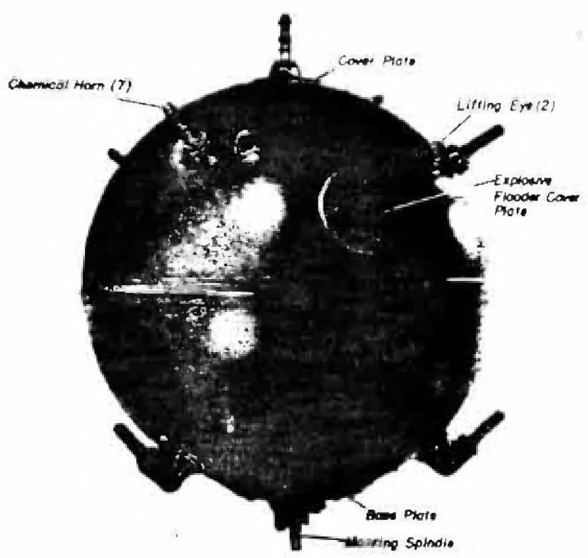


Figure 7 - EMC I Mine

The EMC I Mine. The original EMC mine was completed in 1924. (figure 7). It utilized a bronze base plate and an eighth horn (KE) which was placed on top of the mooring safety switch. In 1936 the mine was improved. The eighth horn was moved to the side of the mooring switch; a soluble plug was substituted for a dash-pot type of delay system; fittings were provided for antennae and scuttling devices; and the base plate parts were redesigned to give greater life and watertightness. The improved model was designated EMC II and the original type redesignated EMC I.

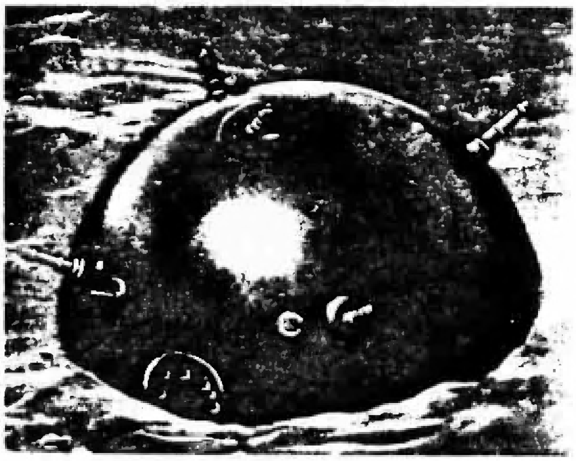


Figure 8 - EMC Mine Afloat

EMC I - EMC II - EMC II (Upper Antenna)

General

Moored, contact, chemical-horn mine, laid by surface craft.

Offensive or defensive mine, for use in maximum depth of water of 1700 feet.

Maximum depth of case when moored is 245 feet.

Description of Case

Shape	Two hemispheres, joined by a 2 cylindrical midsection
Material	Steel
Diameter	46 in.
Length	48.5 in.
Charge	660 lb. block-fitted hexanite

Description of External Fittings

Horns	Seven: one in center of cover plate; four equally spaced around upper hemisphere, 22 in. from center; two, on brackets, 39 in. apart, 17 in. from center of lower hemisphere
Cover plate	7½ in. diameter, in center of upper hemisphere, flush type, secured by 10 bolts

Figure 9 - EMC II Mine with Rubber Snag Line

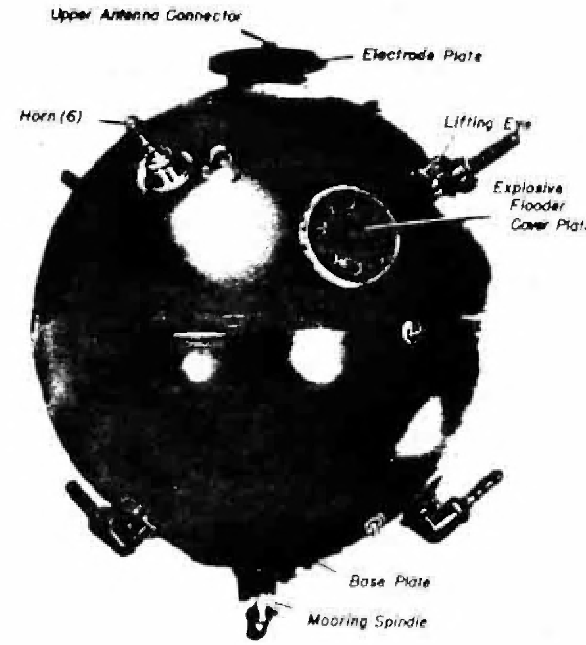


Figure 10 - EMC II Mine

Base plate	Standard type EMC II
Lifting eyes	Two, 19 in. apart, 22 in. from center of upper hemisphere

Operation. Mine takes depth by plummet. Mooring tension pulls out the mooring spindle, closing the mooring safety switch, tripping the booster release lever and the mine is armed.

Standard chemical-horn firing.

The only self-disarming device is the mooring safety switch which is designed to disarm the mine by opening the firing circuit upon release of mooring tension.

EMC II Mine. The EMC II existed in the six types shown in figure 49a. The general characteristics of each of the various types are as follows:

EMC II with Upper and Lower Antenna

Upper antenna	130 ft.
Lower antenna	100 ft.
Depth setting	3 to 190 ft.
Max. depth of case	245 ft.

EMC II with Tombac Tubing

Tombac tubing is an anti-sweep cable fitted over the mooring cable

Tombac Tubing	100 ft.
Depth Setting	3 to 190 ft.

EMC II with Lower Antenna

Lower antenna	100 ft.
Depth setting	3 to 190 ft.

EMC II with Cork-Floated Upper Antenna

Upper antenna	65 ft.
Depth setting	3 to 190 ft.

EMC II with Chain Mooring

Chain mooring	20 ft. of 5/8-in. chain
Depth setting	3 to 190 ft.

EMC II with Chain Mooring and Cork-Floated Snag Line

Chain mooring	20 ft. of 5/8 in.
Snag line	80 ft. with cork floats
Depth setting	40 ft.

In 1940 the eighth horn was removed from all German base plates, because experience had shown that this device was often actuated in heavy seas. The upper antenna was abandoned in 1941 because of the excessive numbers that broke loose in rough waters; and, in 1943, the lower antenna was abandoned because of the copper shortage then prevalent.

Experiments were conducted to obtain delayed rising of the mine. A fifty-foot bight of the mooring cable was flaked on the top of the anchor and kept in a locked position by a six-day clock. In operation the mine would plant at its set depth and, when the clock had run

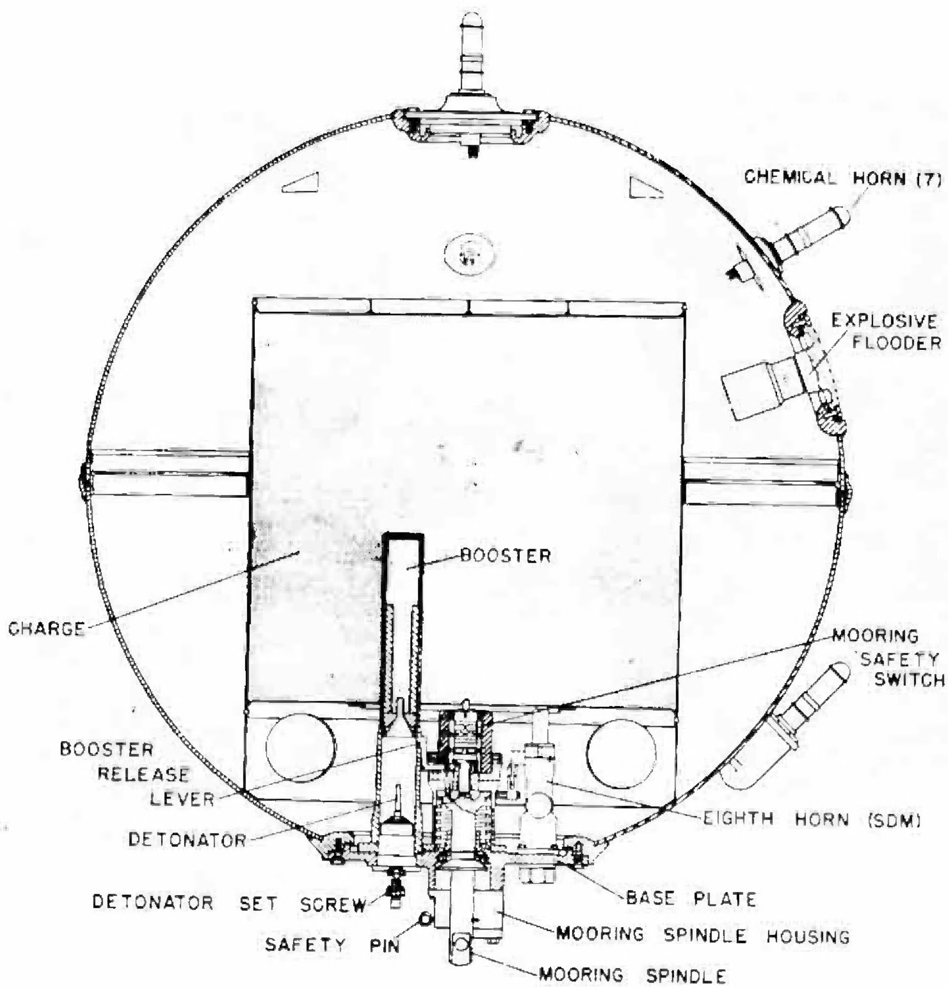


Figure 11 - EMC II Mine - Cross Section

off, rise 50 feet. This idea proved unworkable because of the excessive strain created on release of the bight.

In 1944, because of a critical shortage of lead, steel horns were developed and substituted for the standard Hertz lead-acid horn. The steel horns were so constructed that the metal and welds would not part if bent to an angle of 90 degrees. A pull of approximately 130 pounds is sufficient to bend the horn and break the inner vial. Although the lead horns were considered superior, the steel type proved satisfactory operationally.

Early in 1944, the German Navy experimented with a 32-second clockwork release device to replace the standard dash-pot plummet delay. This clockwork was standard Luftwaffe equipment used to obtain delays in the opening of cargo parachutes, etc. This device was simple and easy to produce. It operated as follows:

The time delay desired, up to 32 seconds, was selected by turning a dial on the face of the clock. The clock was simultaneously wound and started by pulling a wire lanyard at the base of the device. At the opposite end, another wire was run off; the wire lanyard was snapped in by the spring-loaded clock drum and the safety pin withdrawn.

When, with relatively minor casualties, the Allies succeeded in penetrating the field of moored contact mines laid off Salerno, the German Mining Command suspected that ASDIC was being used to locate the moored mines. Accordingly, they gave some thought to the development of a mine case that would resist location by such methods. They sought to attain this end by coating mine cases with rubber and using special type paints. To this extent, their efforts paralleled those of the German Submarine Command, which sought to apply anti-detection methods to submarines. However, the foregoing methods proved unsatisfactory, and it was finally decided that the best anti-detection type mine would be one employing

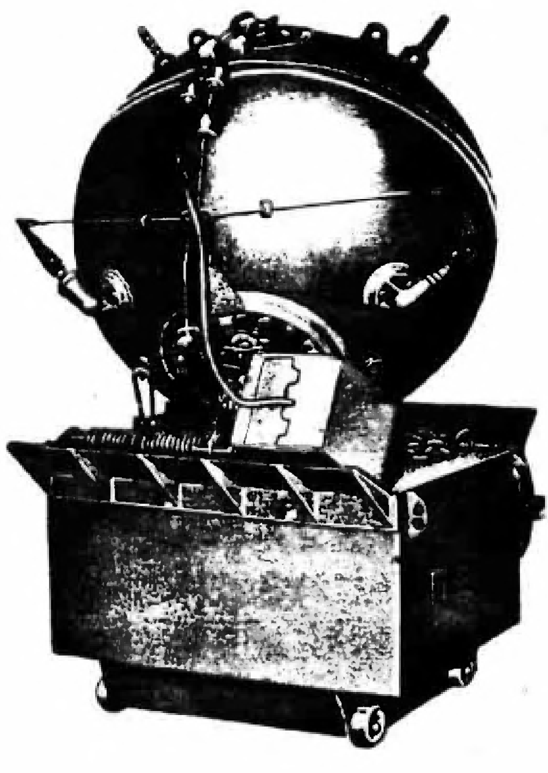


Figure 12 - EMC II Mine with 80-ft. Rubber Snag Line

Figure 13 - EMC II Mine with 20-ft. Mooring Chain

an all sponge-rubber case. Limited experimentation was commenced to determine the response of various types of synthetic sponge-rubber to ASDIC. The end of the war caught these experiments in their early stage. Consequently, no mine cases of this type were actually built.

Both models of this mine were laid operationally. (A field of EMC I mines was laid in the South Pacific, some of which were recovered by U. S. Navy Mine Disposal Personnel.)

The EMD Mine. The first EMD mine was ready for operational use in 1924. It was a moored contact type fitted for five chemical horns, and was designed for use against surface craft only; consequently, it had no lower horns. Except for the absence of such horns and its smaller size, the EMD is practically identical to the EMC. (Both mine types use the same base plates, anchors, and accessories). In 1936 it was improved along the same lines as the EMC, the new model being designated EMD II and the original type EMD I. A small cover plate, 6.5 inches in diameter, equidistant from the lifting eyes and 25 inches from the center of the upper hemisphere, was added to accommodate an 80-day clock and flooder. Later, an electrode plate mounted on a plastic cover and

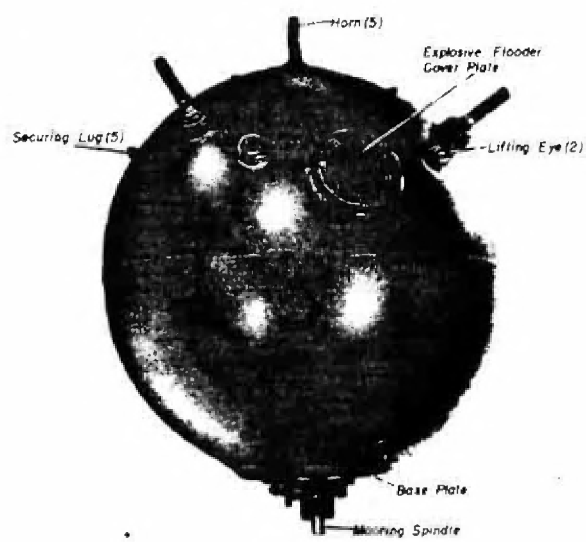


Figure 14 - EMD I Mine

Figure 15 - EMD II Mine - Upper-Lower Antenna

placed in the center of the upper hemisphere was added as an antenna connector.

The manufacture of EMD II was discontinued in the early part of World War II to permit greater production of the EMC II, which was considered more suitable. Existing stocks of EMD I and EMD II were laid operationally.

General

Moored, contact, chemical-horn mine, laid by surface craft.

Offensive or defensive mine, for use in maximum depth of water of 1300 feet.

Description of Case

Shape	Spherical
Material	Steel
Diameter	40 in.
Charge	330 lb. block fitted hexanite

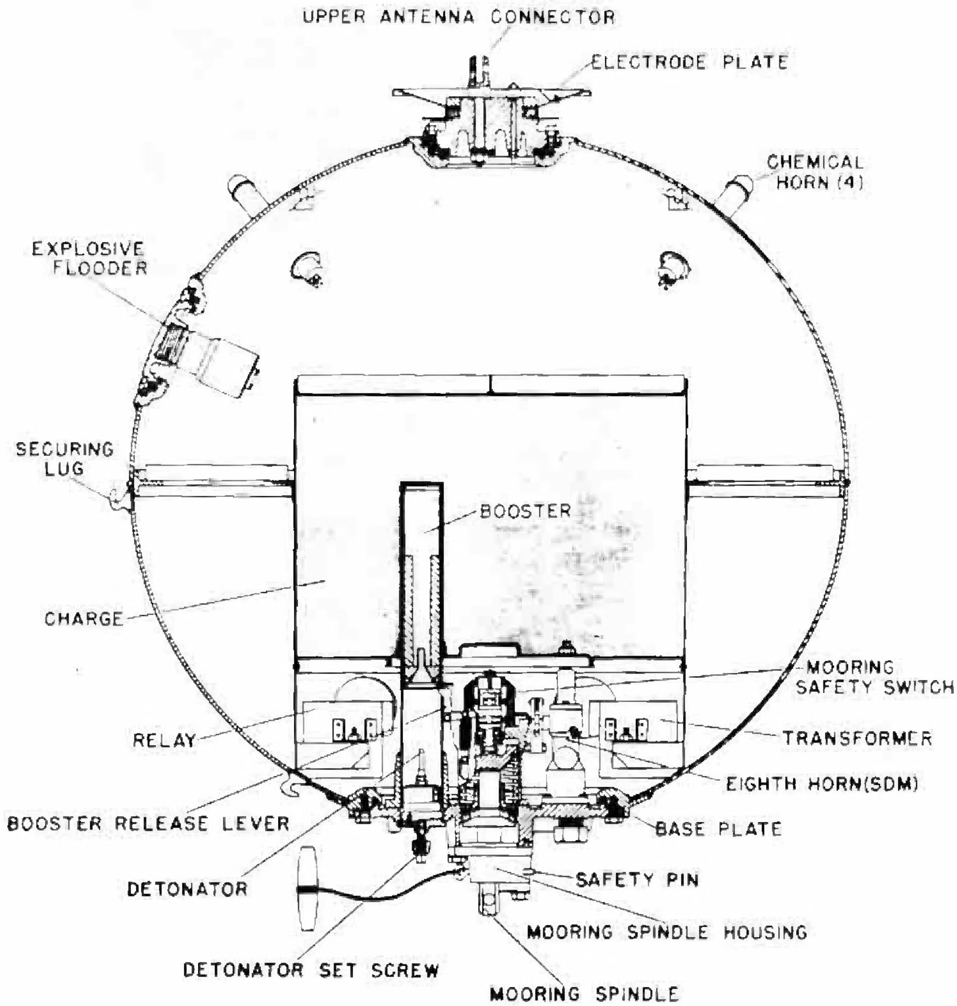


Figure 16 - EMD II Mine - Cross Section

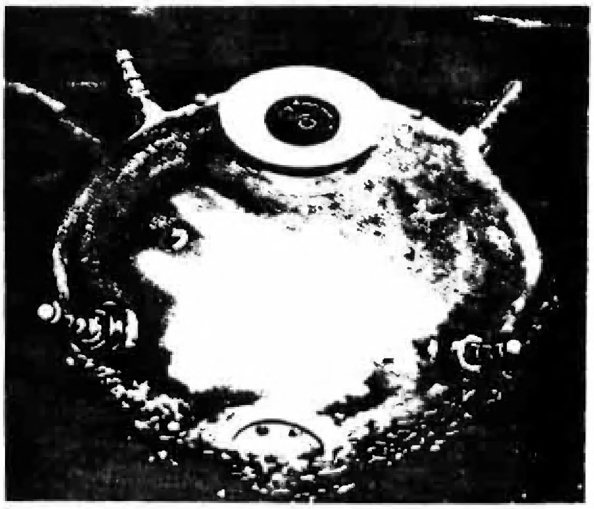


Figure 17 - EMD II Mine Afloat

Description of External Fittings

Horns	Five; one in center of cover plate; four equally spaced around upper hemisphere, 20-in. from center
Cover plate	7.5-in. diameter, in center of upper hemisphere flush type, secured by 10 bolts
Base plate	Standard Type EMC II
Lifting eyes	Two, 16.5 in. apart, 22.5 in. from center of upper hemisphere
Securing lugs	Five; one 22.5 in. from center of upper hemisphere; one 31 in. from center of lower hemisphere; three, staggered, 12 in. from center of lower hemisphere

Operation. Mine takes depth by plummet. Mooring tension pulls out the mooring spindle, which closes the mooring safety switch, trips the booster release lever, and arms the mine.

Standard chemical-horn firing.

The only self-disarming device is the mooring safety switch which is designed to disarm the mine by opening the firing circuit upon release of mooring tension.

The EMD Mine. This mine was a moored contact type bought from a British firm and designated "Elektrische Mine Englische" (EME). It was used solely for experimentation. No details of this mine are available.

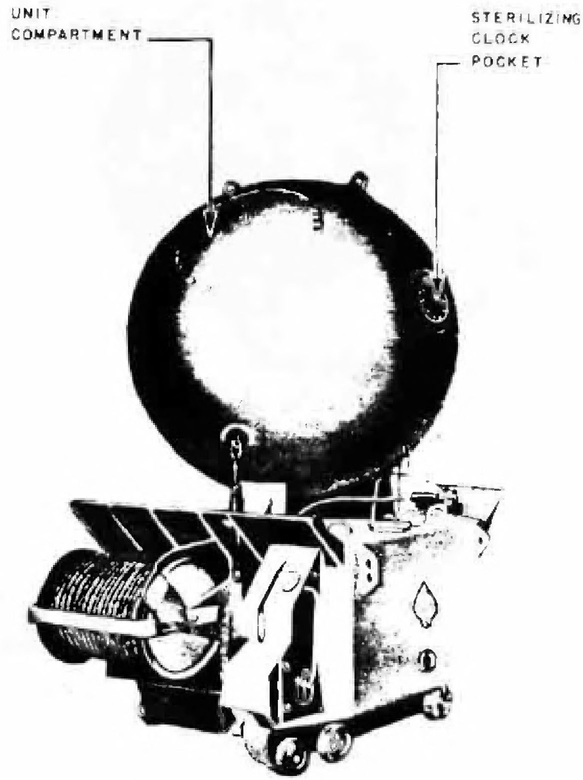


Figure 18 - EMF II Mine

The EMF Mine. The EMF was the first moored influence mine developed by the Germans. Its design was undertaken in 1928 and completed in 1931. In 1936 the base plate was revised and the mine put into production. By 1939 it was ready for operational use, but the magnetic unit in existence proved unsatisfactory. In 1941 the M 3 had been perfected and adapted for use with the EMF. At about the same time unsuccessful attempts were made to fit this mine with an acoustic unit known as A 3. The mine was laid operationally only with the M 3 unit. It was contemplated that the following influence unit should be fitted to the mine:

1. M 4
2. AA 4 (Unit abandoned in 1944)
3. A 7
4. AE 1

The EMF used the EMC anchor and was designed for surface laying only (figure 18). Its larger counterparts, the SMA, SMB, and SMC were, on the other hand, designed for submarine laying only.

The first model was a spherical case consisting of two hemispheres welded together. Its flooder plate was located 26½ inches from the center of the upper hemisphere; however, there were no provisions for an 80-day clock. In the final model the case was improved in

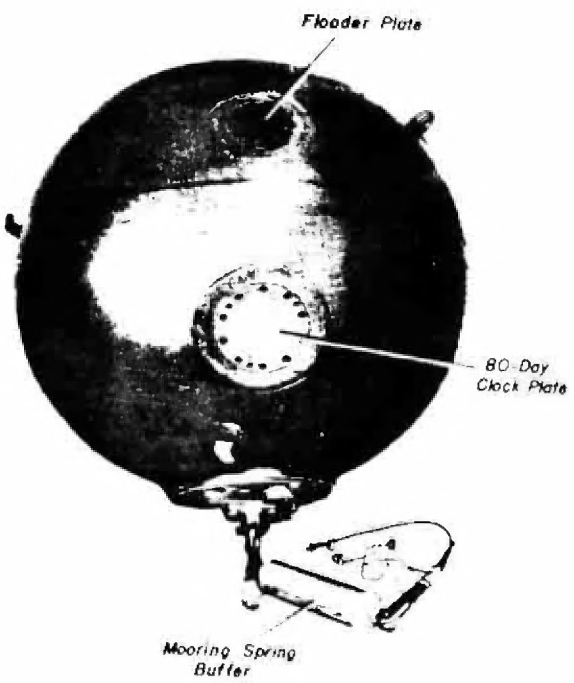


Figure 19 - EMF Mine

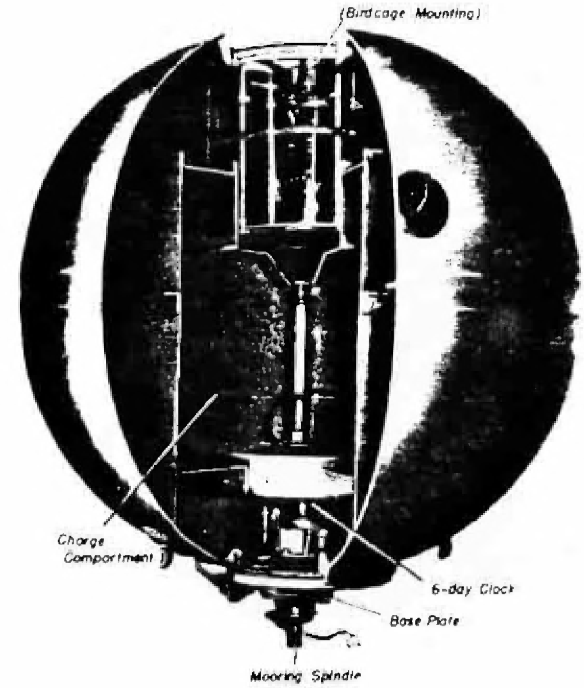


Figure 20 - EMF Mine with K 3 Unit

construction; a soluble plug and disarming switch were added; and the depth taking mechanism was improved.

Description of Case

Shape	Two hemispheres, joined by a cylindrical mid-section
Diameter	45 in.
Length	57 in.
Charge	750 lb. block-fitted hexanite

Description of External Fittings

Lifting eyes	Two 60° apart on upper hemisphere, 20½ in. from center
Anchor-securing lugs	Three, hook shaped: two on lower hemisphere, 160° apart, 11¼ in. from center; one on upper hemisphere, 28½ in. from center
Flooder plate	6-in. diameter, on upper hemisphere, 28½ in. from center, secured by 10 bolts
80-day clock cover plate	8-in. diameter, on lower hemisphere, in line with flooder plate, 23½ in. from center, secured by 10 bolts

Operation. The mine takes depth by plummet. Mooring tension pulls out the mooring spindle, tripping the booster release lever and releasing the locking balls from the clockwork spindle. Water pressure depresses the clock spindle at a depth of 15 feet, starting the clock. The clock runs off its delay period, and the unit starts its testing cycle. If the mine does not orient itself properly after a pre-set time of up to 12 hours, a scuttling charge will fire to sink the mine.

The only self-disarming device is the 80-day clock, which is designed to scuttle the mine if the clock stops at any time prior to completion of its set period or upon completion of its set period.

The operational characteristics of this mine are as follows:

Laying heights and speeds	13 ft. - 25 knots 16 ft. - 18 knots
Laying depths	325 ft. - with cable ½ in. 650 ft. - with cable 7/16 in. 985 ft. - with cable 3/8 in. 1640 ft. - with cable 5/16 in.

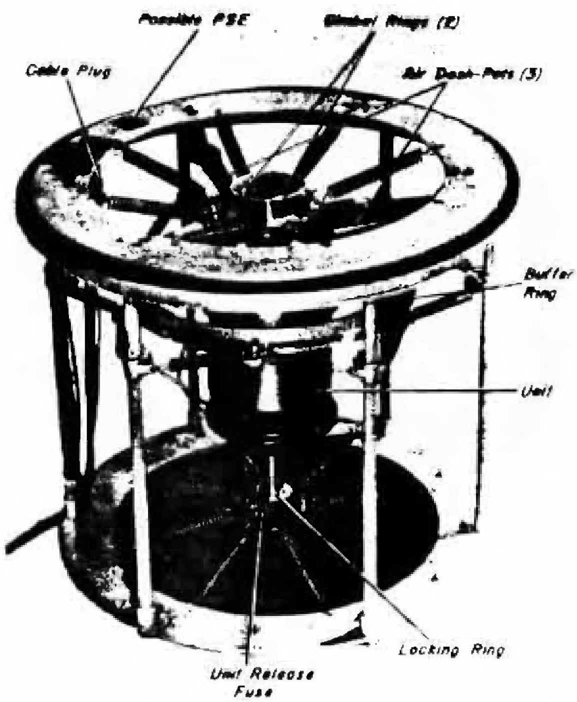


Figure 21 - EMF Mine - Birdcage Suspension for M 3 Unit

Minimum laying depths	130 ft. (80 + 50)
Minimum and maximum case depths	50 to 115 ft.

In 1944 experiments were conducted with an EMF case made of a plastic material called "Eternit". This model was known as EMF (Et) and consisted of two Eternit hemispheres bolted together to form a sphere similar in dimensions and fittings to the normal EMF. It was undergoing tests at the close of the war.

The EMG Mine. The EMG was a moored, contact, constant-depth mine assembly designed for defense against small surface craft such as torpedo boats.

The assembly was designed in 1940 to protect German shipping in the English channel from attack by British torpedo boats and other similar craft. (The original plan contemplated that this assembly would be employed to protect the flanks of German shipping lanes established in an invasion of England.) The assembly was used operationally until 1943, at which time it was abandoned in favor of the UMA/K and OMA type mines.

The EMG assembly consisted of a ballasted EMC mine case with the lower horns blanked off, an EMC anchor, a float, and a weight arranged for constant depth. The assembly was so designed that it maintained a constant depth of eight feet, regardless of the stage of the tide.

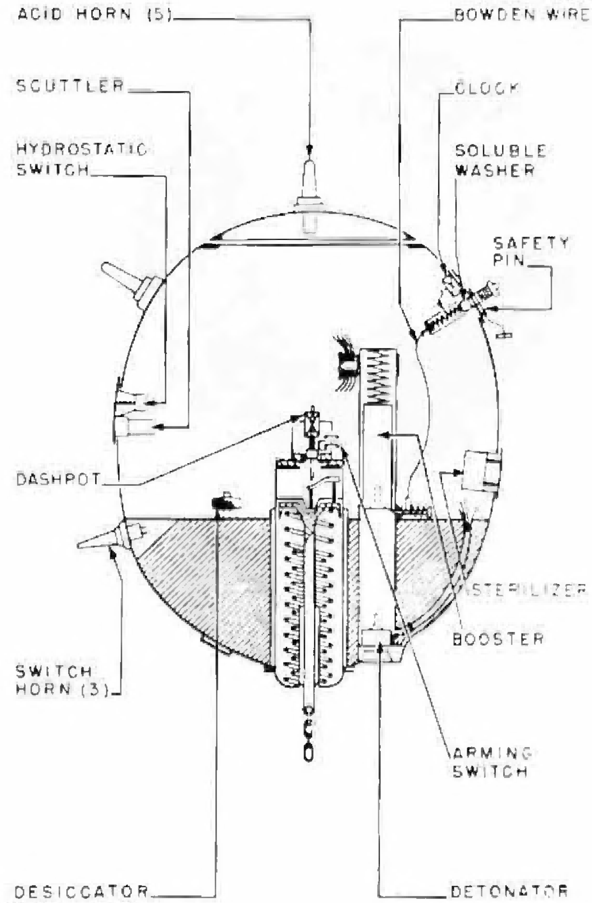


Figure 22 - EMG Mine

This assembly could be laid in depths ranging from 30 to 190 feet; but, by lengthening the mooring cable between the anchor and the weight to 820 feet, the assembly could be used in greater depths.

Since the EMG float rode slightly above the water-surface, mine fields utilizing this assembly were easily detected and avoided. To make this apparent disadvantage inure to their own benefit, the Germans developed a dummy EMG assembly which consisted merely of the normal float and anchor, and a 325-foot length of mooring cable. These dummies were laid in separate fields or together with EMG's. They were designated "Simulacker fur EMG."

The EMH Mine. In 1942 the Germans were still seeking to develop an acoustic unit for use in moored mines. Since the aluminum EMF was expensive to build, it was decided to design a cheaper moored mine case of sheet-iron construction, to be known as the EMH. However, since the design of an acoustic unit for moored mines was progressing very slowly, the development of the EMH was discontinued.

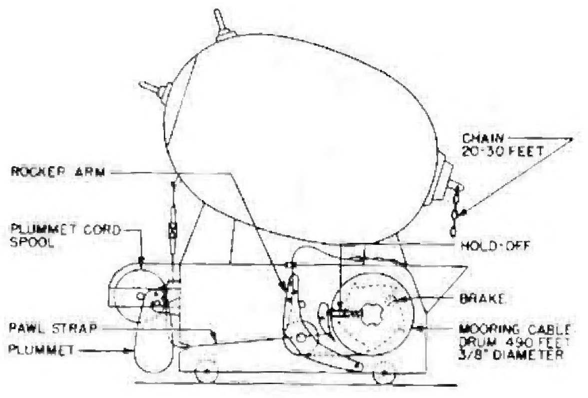


Figure 23 - EMU Mine and Anchor

It was intended that the EMH be laid by surface craft, be the same size as the EMC, use an EMC anchor, and be capable of the same depth settings as the EMC.

The EMI Mine. In 1940 the Germans undertook the development of a mine case that would house an induction-type magnetic unit. To reduce development work, they intended to utilize a suitably modified EMC case, which was to be known as EMI. After preliminary development work had been done, the mine was dropped for the following reasons:

1. Shortages of nickel and copper prohibited the large scale use of naval induction units.

2. Induction units had not been sufficiently developed to permit their use in moored mines.

The EMI was the only attempt by either the German Navy or the Luftwaffe to develop a moored induction-type mine.

The EMK and EMU Mines. The development of the EMK was undertaken in 1940, the mine being intended for use as a moored contact and/or influence-type mine. In 1944 its development, which was still incomplete, was discontinued in favor of the smaller EMU. Since the EMK and EMU were identical, except for size (EMK 44 inches in diameter and EMU 40 inches), they are discussed together in the following paragraphs.

The EMK was dropped in 1944 in favor of the EMU because of a shortage of explosive. (The EMK was designed for a charge of 660 lb., the EMU for 220 lb.) Since these mines were radical departures from previous German types (figures 22, 23), their development progressed slowly. Consequently, at the end of the war neither the EMK nor its successor, the EMU, was completed.

By 1940 the Germans had realized that their standard-type base plates for moored mines had two serious shortcomings:

1. In deep water, hydrostatic pressure sometimes prevented arming by counterbalancing the pull of the mooring cable.

2. In shallow water, rough seas caused excessive arming and disarming, and frequently wore out the spindle-mechanism membrane.

To cure these defects an entirely new type of base plate was designed. (figure 22). This base plate utilized an inverted spindle action, so that water pressure and mooring-cable tension combined to arm the mine. In depths over 30 feet, hydrostatic pressure alone would maintain the mine in an armed position, regardless of vertical motion of the mine case. In water depths of less than 30 feet, disarming due to vertical motion of the case was prevented by a dash-pot mechanism which maintained arming of the mine for 60 seconds after release of tension on the mooring spindle.

The method of placing the main charge in the EMK and EMU differs from normal German practice. Whereas all other German moored mines employ a charge container, the EMK and EMU were designed to house the charge on the bottom of the mine case. The Germans felt that loading the mines in this manner would give the mine a greater lethal range and permit better mine orientation.

The anchor of the EMK and EMU mines was also of new design. Its most noteworthy feature was the fact that it was so designed as to permit depth setting either by plummet or by hydrostat (figure 23). The plummet-line drum was designed to accommodate 100 feet of 3/16-inch cable, and the mooring-cable drum 500 feet of 7/16-inch cable. An 18- 30-foot length of chain was to be used between mooring spindle and mooring cable. Because of its departure from previous German types, the development of this anchor progressed slowly and was not completed at the end of the war.

EMR and EMR/K Mines. These mines were actually sweep-obstructors utilizing an EMC mine case moored to an EMC anchor by a single or double length of 5/8-inch standard chain.

The EMS Mine. The EMS (Sehrohrtreibmine S) is a drifting decoy or anti-pursuit type of mine. It existed in three forms, which were designated EMS I, EMS II, and EMS III.

The three types of this mine employed the same mine case; they differed only in the method of flotation.

The characteristics of the mine case are as follows:

Method of firing	5 sensitive switch horns
Weight of charge	24-30 lb.
Weight of case without flotation gear	100 lb.
Height of case	21 in.
Diameter of case	13 in.
Diameter of case including horn bosses	18.5 in.

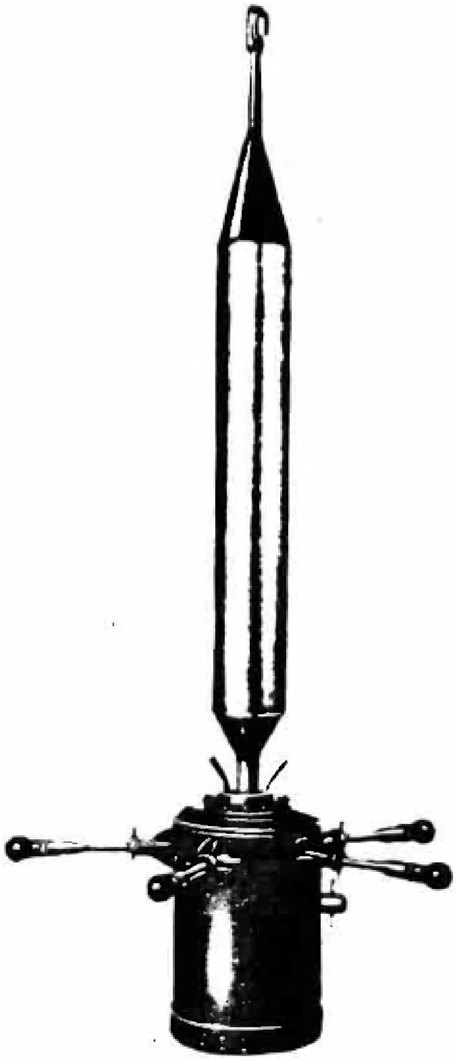


Figure 24 - EMS I Mine

Case material and thickness	Rolled steel - 1/8 in.
Method of laying	Surfaced U-boat or surface craft
Maximum laying height	10 ft.
Maximum laying speed	18 knots
Minimum water depths	10 ft. (approx.)
Arming time	15-20 minutes (soluble washer)
Self Destroying Mechanism	6-day clock

Figure 25 - EMS II Mine

The Characteristics of the three types of flotation gear are as follows:

EMS I employed a steel float designed to resemble a periscope, which is 66½ inches long and 6½ inches in diameter. When laid, the mine drifted with the upper portion of the float protruding several inches above the surface (figure 24).

EMS II employed a camouflaged, elliptical, steel float which was approximately 13 inches in diameter and eight inches high. This float was designed to ride flush with the surface of the water and to be invisible to pursuing vessels (figure 25).

EMS III employed a hemispherical, plexiglass float designed to resemble the dome of the Marder (midget submarine). The float was painted with a silhouette of the head and shoulders of a man as he would appear when operating a Marder. This float was approximately 25 inches in diameter and 14 inches high, and was designed to create the illusion of a partially submerged midget submarine with its dome exposed (figure 26).

Work on the EMS mine with periscope was started in 1941 and completed in 1942. It was designed to be laid by surfaced U-boats against all antisubmarine craft. These mines were stowed inside the submarine and had to be handed up through the conning tower when needed. They were assembled on deck and laid by hand by a two-man team. Because of handling and stowage difficulties, danger to laying personnel, and the extremely sensitive switch horns, only a few of these mines were used operationally, and the project was abandoned. During the same period, experiments were conducted with the EMT mine. This mine employed the same case as the EMS, but the periscope was replaced by a camouflaged elliptical float. Later, the EMT was designated the EMS II, and the EMS mine became EMS I. The EMT mine was primarily designed as a drifter for surface-craft laying; how-

Figure 26 - EMS III Mine

ever, it was abandoned at the same time as the EMS, for the same reasons.

In the fall of 1944 the German Sneak Attack Command (KDK) requested a floating mine with a plexiglass cupola attachment to resemble the dome of a midget submarine. These mines were intended to be laid by small motor boats or "Linsen" boats as decoys against patrol craft in heavily protected sea lanes. The first consignment of cupolas with the silhouette of a midget submarine operator for use with the EMS mine case was delivered in November 1944. Very few of these modified EMS mines were laid, because of operational difficulties and a small supply of cupolas. This modification had no German designation, and consequently, for purposes of identification, it is referred to as EMS III.

THE FM MINES

The German Fluss Minen (FM) mine series consisted of three types, FMA, FMB, and FMC. The FMB and FMC were completed and used operationally; the FMA was abandoned shortly after production was started.

The FM mines were small moored contact mines intended primarily for use in shallow waters of the Baltic and Black Seas and in rivers and estuaries. The FMA was designed and developed in 1920, but was abandoned in favor of FMB. The FMB was completed in 1926; however, none were produced during World War II, and only supplies on hand were laid. The

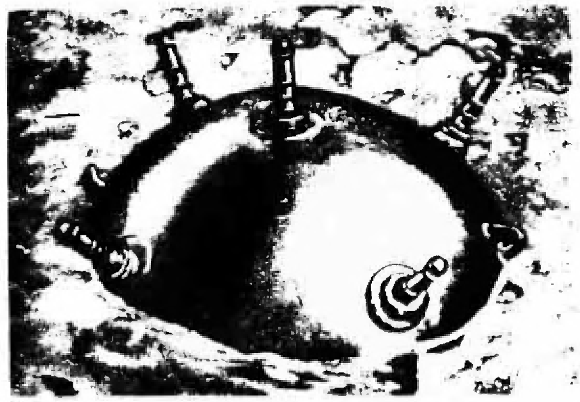


Figure 27 - FMC Mine Afloat

FMC was developed and produced between 1926 and 1928, and only the supplies on hand at the beginning of the war were laid operationally. The FM series was considered ineffective, primarily because of the small explosive charge and the ease with which it could be swept. It was abandoned in favor of later improved models.

FMA Mine. The FMA was the first of the Fluss Minen series to be designed and developed as a moored, contact, surface-laid mine for use in the estuaries of the Baltic. It consisted of a hemispherical steel case approximately 22½ inches in diameter, with five chemical horns, a mooring buffer and wire cable mooring, and a charge of approximately 22 pounds of block-fitted hexanite. This mine was replaced by the FMB.

FMB Mine. The FMB was completed in approximately 1926. It was a surface-laid, moored, contact, chemical-horn mine using a cylindrical preset-type anchor (Anker mit absteckbarein ankertau).

FMC Mine. The FMC Mine was developed and completed between 1926 and 1928. It was a surface-laid, moored, contact, chemical-horn mine using the normal plummet-type anchor and containing a heavier charge than the FMB Mine.

Details. The FMB and FMC both used a wire cable mooring and a spring buffer; however, only the FMC took depth by plummet. Mooring tension pulled out the arming spindle, closed the mooring safety switch and the "A-E" switch, and tripped the booster-release lever to arm the mines. The "A-E" switch in these mines served only to open or close a switch in the horn circuit. The FMB had two lifting eyes welded to the upper hemisphere. FMC had one lifting eye welded to the upper hemisphere and three anchor-securing lugs; one on the upper hemisphere and two on the lower hemisphere. There are two designations for the FMB mine: FMB and FMB(35). These differ only in the weight of explosive, 28 pounds and 44 pounds, respectively. The FMB and FMC differ from each other as follows:

Figure 28 - FMB Mine

Figure 29 - FMC Mine

FMB Mine

Diameter of mine case	26 in.
Weight of charge	28 lb. or 48 lb.
Number of horns	5; one, in center of upper hemisphere; 4 equally spaced around upper hemisphere
Depth setting	preset
Minimum depth setting	----
Mooring cable	25 ft. long 1/2-in. diameter 50 ft. long 1/2-in. diameter

FMC Mine

Diameter of mine case	30 in.
Weight of charge	88 lb.
Number of horns	same as FMB
Depth setting	1 ft. to 15 ft.
Minimum depth setting	13 ft. plus length of depth-setting mechanism
Mooring cable	160 ft. long - 7/16-in. diameter 475 ft. long - 5/16-in. diameter

The only self-disarming device is the mooring safety switch, which is designed to disarm the mine by opening the firing circuit upon release of mooring tension.

THE OMA MINES

The OMA (Oberflachen Mine A) was a moored, contact, surface mine the development of which was undertaken in late 1942. It utilized a novel type of mine case and was designed in five models, which were designated OMA I, OMA II, OMA III, OMA IV, and OMA/K. Of these five models only the OMA I and OMA/K were used operationally. The OMA II and OMA III were abandoned in the preliminary development stage, and the OMA IV was unperfected at the close of the war.

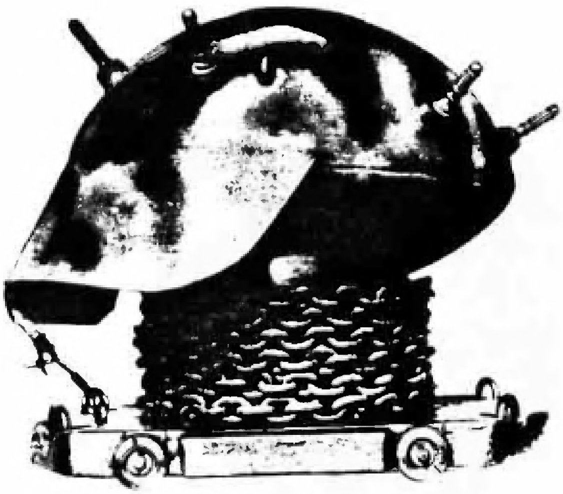


Figure 30 - OMA/K Mine

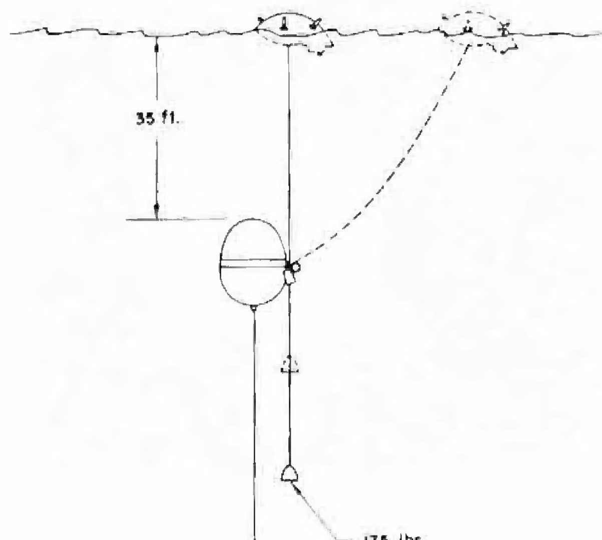


Figure 31 - OMA IV Mine

The first moored, contact, surface mine developed by the Germans was a jury-rig affair designated UMA/K; it was laid in 1941. In the fall of the same year the development of a more efficient mine was undertaken, this type being designated OMA I. Original requirements for the OMA I called for its use in water depths up to 65 feet, but these requirements were subsequently increased to 325 feet. The development of this mine was completed in February 1943, and it was laid in the fall of 1943.

In 1944 the German Navy Department, alarmed by the large number of OMA I mines breaking loose, reduced the water-depth requirements to a more suitable depth of 50 feet and requested an appropriate modification of the mine. The resulting modification was designated OMA/K.

With the development of OMA/K the problem of preventing excessive drifters was successfully met for depths up to 50 feet. (The OMA/K, when tested in the extremely rough waters of the Elbe Estuary, lasted for more than five months.) However, since the buoyancy of the OMA case precluded the use of a double chain mooring in depths over 50 feet, the problem remained unsolved for use in greater depths.

Late in 1943 the development of a moored, contact, surface mine for depths up to 985 feet was undertaken. This mine was to consist of an EMC anchor, a large steel float with a guide arrangement, an OMA Mine case with a normal spindle-type arming and disarming switch, and a 175-pound weight. A schematic representation of the assembly is shown in figure 31. This assembly was designated OMA IV. Because of the relative complexity and low priority of this mine, its development was incomplete at the close of the war.

Neither the OMA I nor the OMA/K was fitted with the normal disarming devices found in moored mines. This was due to the fact that these mines had a slack mooring cable and could not be fitted with switches of the normal mooring-spindle or hydrostatic types. Therefore, since these mines broke adrift fairly often, their use created an unacceptable hazard to German shipping and shore installations. To remedy this situation the development of the OMA II and OMA III was undertaken. The OMA II was to incorporate a mechanical-type disarming device and the OMA III an electrical type. However, both types presented a great number of difficulties and were abandoned in the preliminary development stage.

Since disarming devices of the normal type could not be applied to the OMA I and OMA/K, the German Navy Department ordered that they be fitted with a ZE IVa. (60-day disarming clock).

The five models of this mine utilized the same type of mine case. The characteristics of the case are as follows:

Figure 32 - UMA Mine Afloat

Method of firing	[illegible] chemical horns
Total weight	352 lb.
Weight of charge (cast)	66 lb.
Positive buoyancy	440 ± 22 lb.
Total height	31½ in.
Diameter less skirt	42½ in.
Delay in arming	20-35 minutes (Soluble washer)

The significant design feature of this mine case was the steel skirt fitted to the underside of the case. The purpose of this skirt was to eliminate dipping of the mine.

The OMA I and the OMA/K were identical except for the types of mooring and anchors used. The OMA I mooring consisted of a length of chain secured on one end to the mine case and on the other end to a length of steel cable leading from the mine anchor. The OMA/K mooring consisted of a 35-foot bight of chain secured on one end to the mine case and on the other end to a length of chain leading from the mine anchor. The anchors were substantially the same, except that the cylindrical mine stool around which the mooring was coiled was higher on the OMA I than on the OMA/K.

THE UM MINES

The U-Bootsa wehrmine (UM) mine series consisted of three types of moored, contact, surface-laid mines, the UMA, UMA/K and UMB.

The UMA Mines. The first of this series was developed in 1928. It was a moored, contact, chemical- and switch-horn mine, laid by surface craft, intended for use primarily against submarines. In 1936 the prototype

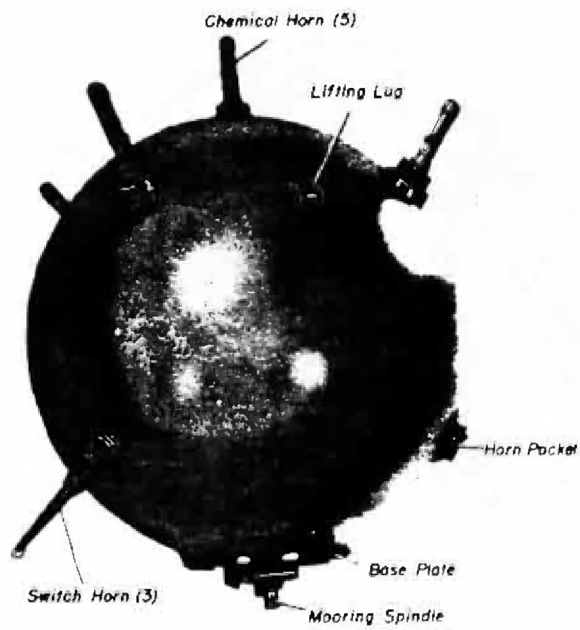


Figure 33 - UMA Mine

of this series became the UMA I when, after slight modifications in the case and mooring, the UMA II was introduced. In 1938 the UMA III appeared. Basically, it was the same as its predecessors, with improvements in the anchor and mooring spindle.

Description of Case

Shape	Spherical
Material	Steel
Diameter	32 in.
Charge	66 lb. block-fitted hexanite

Description of External Fittings

Horns	Eight: one chemical, in center of upper hemisphere; four, chemical, equally spaced around upper hemisphere, 15½ in. from center; three, switch, equally spaced around lower hemisphere, 17 in. from center
Base plate	Standard type UMA
Lifting eye	One 19 in. from center of upper hemisphere

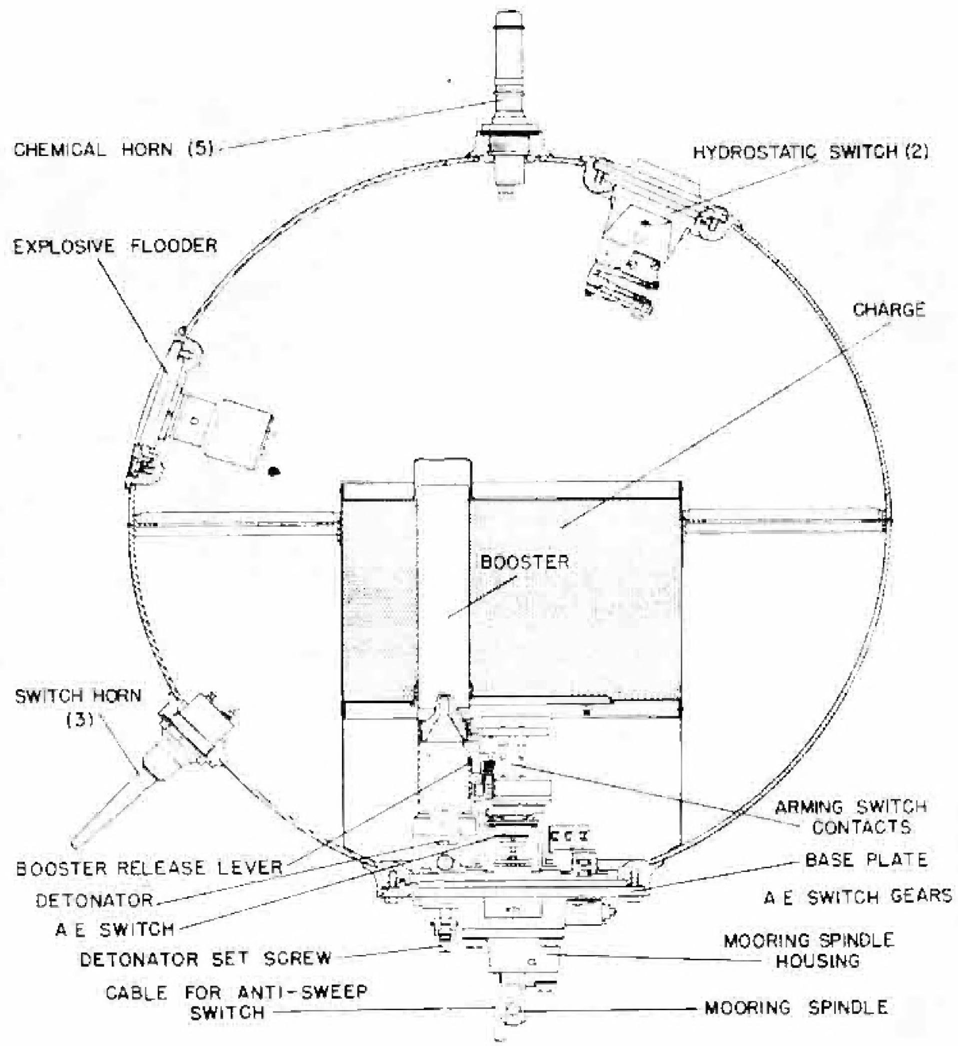


Figure 34 - UMA Mine - Cross Section

Lifting lug	One, 180° from lifting eye, 19 in. from center of upper hemisphere

Operation. The depth of the mine case is preset and determined by the amount of mooring cable used. Mooring tension pulls out the mooring spindle, closing the mooring safety switch, tripping the booster-release lever, and the mine is armed.

The only self-disarming device is the mooring safety switch which is designed to disarm the mine by opening the firing circuit upon release of mooring tension.

The German UMA/K mine assembly was designed and developed in late 1942 to defend the sea approaches to Northern Europe from Allied attack. It replaced the EMG mine assembly, which was considered unsatisfactory for the defense of such waters, and was used operationally until 1944, when it was in turn replaced by the OMA/K.

The UMA/K consists of a normal UMA mine case with the lower horns blanked off, a cast-iron 110-pound weight and a cast-iron anchor weighing 500 pounds. The assembly of the above components before and after laying is shown in figures 35 and 36.

The assembly is so designed that the mine case remains on the surface, regardless of the stage of the tide. It may be laid in depths of 85 to 165 feet. For depths of 85 to 150 feet, a 65-foot mooring cable is used between the mine case and weight; for depths of 100 to 165 feet, the mooring-cable

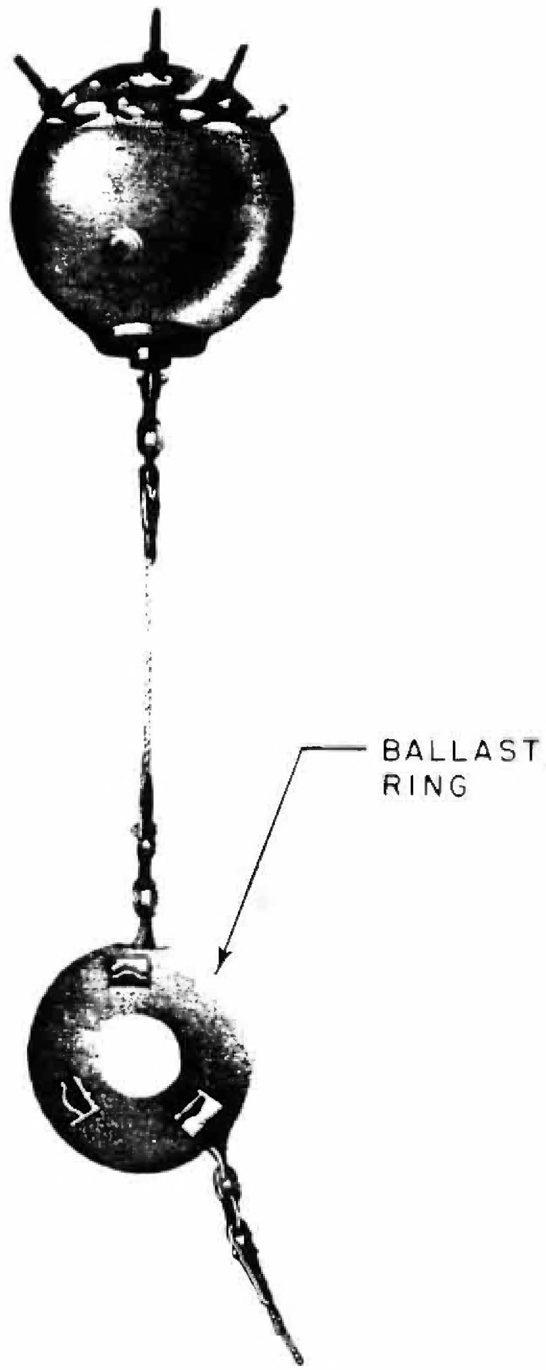


Figure 35 - UMA/K Mine

Figure 36 - UMA/K Mine

length is increased to 85 feet. In both cases, the mooring cable between the anchor and weight is 165 feet in length.

<ins>The UMB Mine</ins>. The UMB mine was first started in 1941, and it appeared in four forms. It was a moored, contact, chemical- and switch-horn mine, laid by surface craft.

It was an offensive or defensive mine, for use in maximum water depth of 500 feet, against surface craft and submarines. The maximum depth of case when moored is 110 feet.

The Four Forms

UMB with tombac tubing: 1941

UMB with 5-foot chain and mechanical cutter; 1943

UMB with 5-foot chain, mechanical cutter, and cork-floated snag line; 1943/44

UMB with 5-foot chain and two improved mechanical cutters; 1944

Description of Case

Shape	Spherical
Material	Steel
Diameter	33.5 in.
Charge	90 lb. block-fitted hexanite

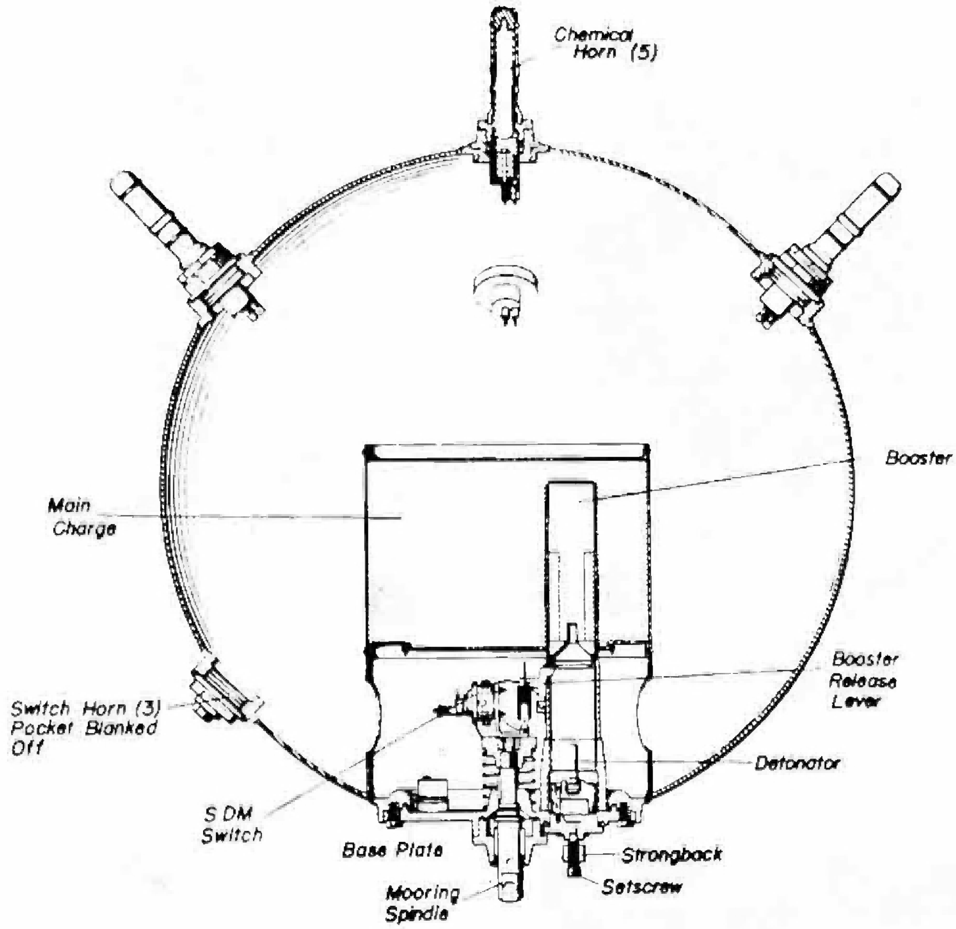


Figure 37 - UMB Mine - Cross Section

Description of External Fittings

Horns	Eight; one, chemical, in center of upper hemisphere; four, chemical, equally spaced around upper hemisphere, 17 in. from center; three, switch, equally spaced around lower hemisphere, 17 in. from center
Base plate	Standard type UMB
Hydrostatic switch covers	Two: 6.5-in. diameter; one, 7.5-in. from center of upper hemisphere; one, 17 in. from center of lower hemisphere
Explosive flooder cover	6.5 in diameter, 23 in. from center of upper hemisphere
Securing lugs	Three; one, 20 in. from center of upper hemisphere; two 20° apart 12 in. from center of lower hemisphere
Snag line (Optional)	79 feet long, secured to center of three-foot length of wire connecting two switch horns. When the mine is so rigged, the chemical horn directly above is blanked off.

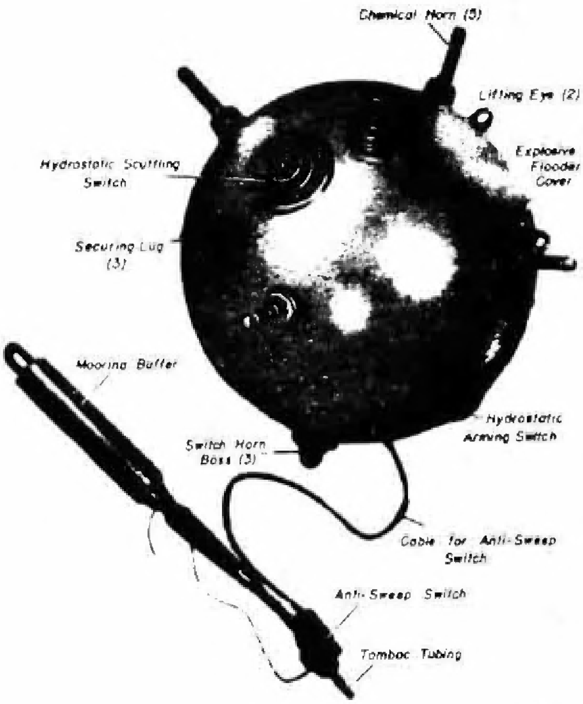


Figure 38 - UMB Mine

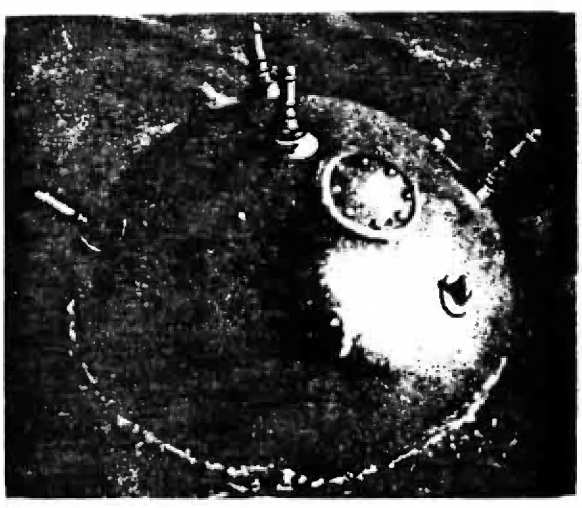


Figure 39 - UMB Mine Afloat

The hydrostatic scuttling switch on the upper hemisphere is an anti-shallow-plant hydrostat which controls a double-pole switch, normally made to one of its contacts. The hydrostat may be set to any one of four depths: 0, 5, 10, or 15 meters. If, upon laying, the mine moors at a depth shallower than that set on the hydrostat, the ex-

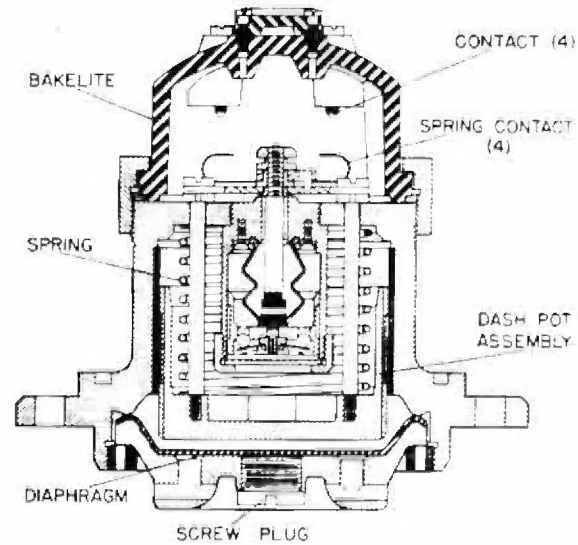


Figure 40 - Hydrostatic Arming Switch for UMB Mine

plosive flooder will fire upon closure of the mooring safety switch. If the mine moors correctly, (i.e., at a depth greater than that set on the hydrostat) the switch changes over to the other contact, permanently breaking the flooder circuit.

The hydrostatic arming switch, figure 40, on the lower hemisphere is designed to open or close the firing circuit when the mine rises above or descends below a depth of six feet. A glycerine-filled dash-pot delays the action of the switch for a period of 20 seconds. A screw plug, fitted to the center of the switch cover, is painted white when the switch is rigged to operate as described above. If the plug is painted red, however, it indicates that the switch has been closed during assembly, being held in that position by a special extension arm added to the screw plug. In this case, the switch will not open under any circumstances.

Operation. The mine takes depth by plummet. The hydrostatic switch closes in six feet of water (if red screw plug is fitted, switch is permanently closed) and, if the mine moors at a depth greater than that set on the anti-shallow-plant hydrostatic switch, the flooder circuit is broken. Dissolution of a soluble plug allows mooring tension to pull out the mooring spindle, closing the mooring safety switch and tripping the booster-release lever, and the mine is armed. A spring-loaded detent is usually fitted to lock the mooring spindle out.

The mine has standard chemical or switch-horn firing. An additional firing method may be incorporated by fitting a "tombac" anti-sweep tubing to the mooring cable. Upward movement of this tubing along the mooring cable, such as might be caused by a sweep wire contacting it, will close a switch on the

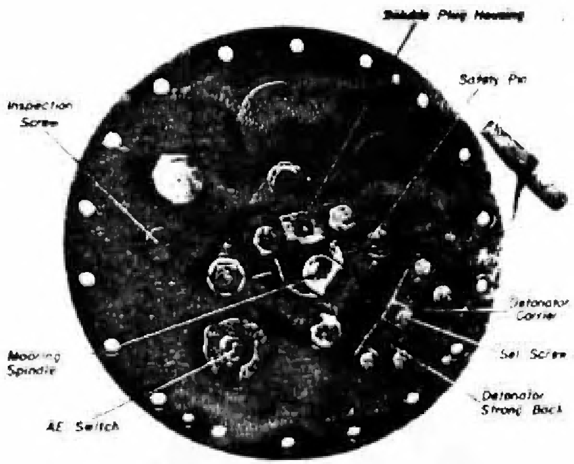


Figure 41 - Base Plate Type EMC II (Exterior)

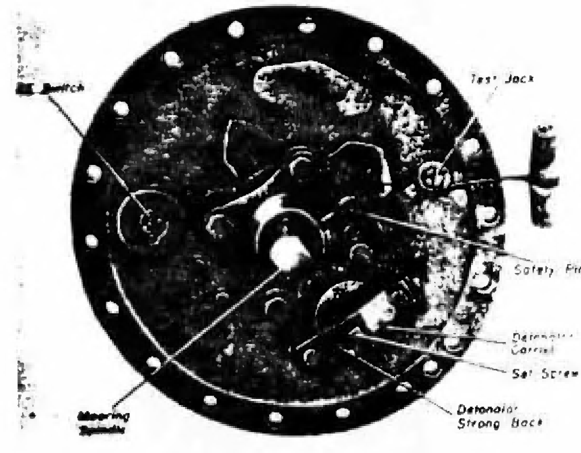


Figure 42 - Base Plate Type UMA (Exterior)

tubing and fire the main charge. Mines fitted with snag lines will not normally be fitted with the "tombac" anti-sweep device nor the locking detent on the mooring spindle.

The mooring safety switch is designed to disarm the mine by opening the firing circuit upon release of mooring tension except when the detent is fitted. The hydrostatic arming switch is also designed to break the firing circuit if fitted with a white screw plug.

BASE PLATES

All German moored contact mines are spherical or have cases consisting of two hemispheres joined by a cylindrical mid-section. The cases are of mild steel, vary in diameter from 26 inches to 46 inches, and are loaded either with cast or block-fitted Hexanite. Chemical and switch horns are employed, either singly or in combination.

Mines of this type usually depend on mooring tension for arming and disarming, these processes being controlled through the mooring spindle on the base plate. General characteristics are given below:

All base plates are fitted with straight-shank mooring spindles which are withdrawn by mooring tension against tension of a coil spring mounted on the inside of the base plate.

Withdrawal of the mooring spindle performs the following functions:

It trips the booster release lever.

It arms the self destroying mechanism.

It closes the mooring safety switch.

The booster release lever is mounted in the booster tube and is connected, by means of a mechanical linkage to the mooring

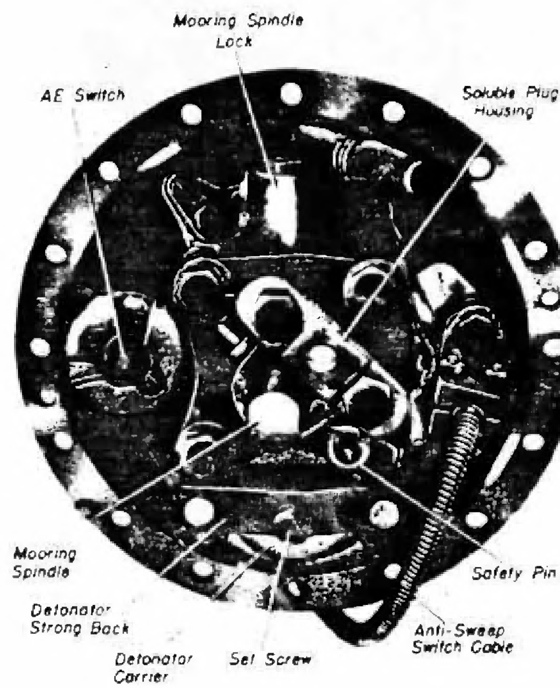


Figure 43 - Base Plate Type UMB (Exterior)

spindle. The lever holds the booster in the "Safe" position above the detonator until the mooring spindle is withdrawn, at which time the lever is tripped and the booster is freed to drop over the detonator.

The self-destroying mechanism may be either an electrochemical internal horn (often referred to as the "eighth horn") used in the Type EMC II base plate, or a

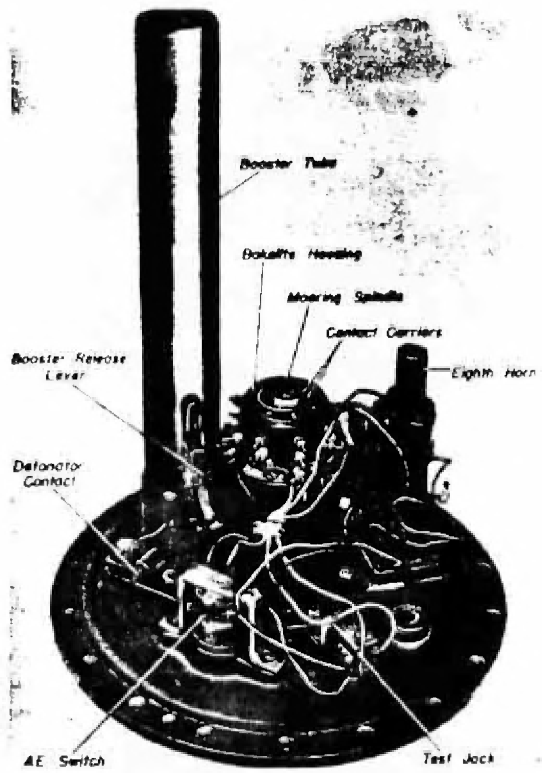


Figure 44 - Base Plate Type EMC II (Interior)

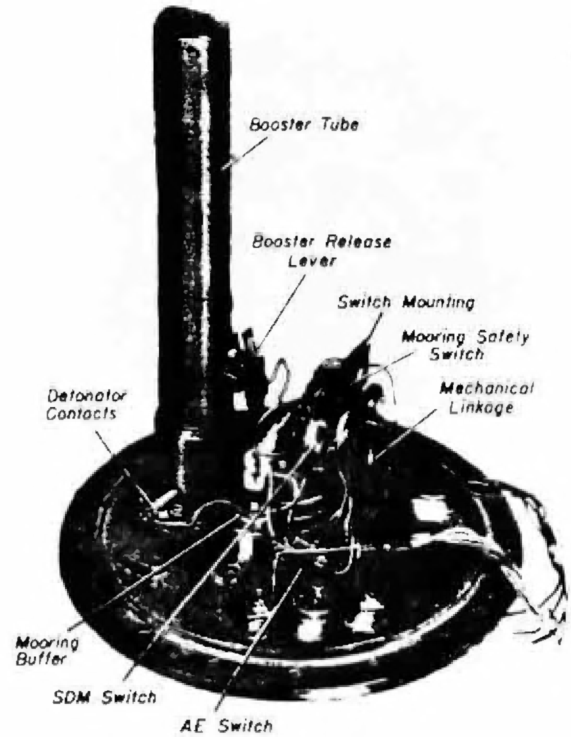


Figure 45 - Base Plate Type UMA (Interior)

rotary, two-position switch used in the Type EMC I or UMA base plates.

The horn-type self-destroying mechanism is mounted in a casting secured to the inside of the base plate by four bolts. Its operation is controlled by a mechanical linkage connected to the mooring spindle. Withdrawal of the spindle allows a cocking pin to move the armed position, and retraction of the spindle pivots the cocking pin and releases a spring-loaded firing pin, which shatters the electrolyte ampoule. The electrolyte then runs into a battery, energizing it, producing a momentary current sufficient to fire the detonator and main charge, if the self destroying mechanism is in the firing circuit.

The switch-type self-destroying mechanism is mounted on a bracket on the inner end of the mooring spindle and is connected to the base plate by a mechanical linkage. Withdrawal of the spindle carries a small pin into position behind a cam. Retraction of the spindle carries the cam back with the pin and closes the switch.

The various base plates use the following types of mooring safety switches:

With Base Plate Type EMC - a switch consisting of four contacts, two of which are mounted on the mooring spindle and two on the mooring spindle housing. Withdrawal of the spindle makes the contacts, arming the horn circuit. Retraction of the spindle breaks the contacts, disarming the horn circuit.

With Base Plates Types EMC I and UMA - a two-position rotary switch mounted on a bracket on the mooring spindle and connected to the base plate by a mechanical linkage. Withdrawal of the mooring spindle closes the switch, arming the horn circuit. Retraction of the spindle opens the switch, disarming the horn circuit.

With Base Plate Type EMC II - a switch consisting of two main parts: a cylindrical, bakelite housing mounted on the base plate and enclosing the inner end of the mooring spindle; two bakelite-covered brass cylinders mounted one above the other on the inner end of the mooring spindle. The latter are fitted with brass contact pieces, and the former with spring-loaded contacts. Withdrawal of the spindle pulls down the two cylinders with respect to the housing, so that the contact pieces make their respective contacts, arming the horn and self-destroying mechanism circuits. Retraction of the spindle breaks the upper set of contacts, disarming the horn circuit. The lower set is in the SDM circuit and remains closed, being locked by a spring-loaded detent.

With Base Plate Type UMB - a switch consisting of eight contacts, four of which are

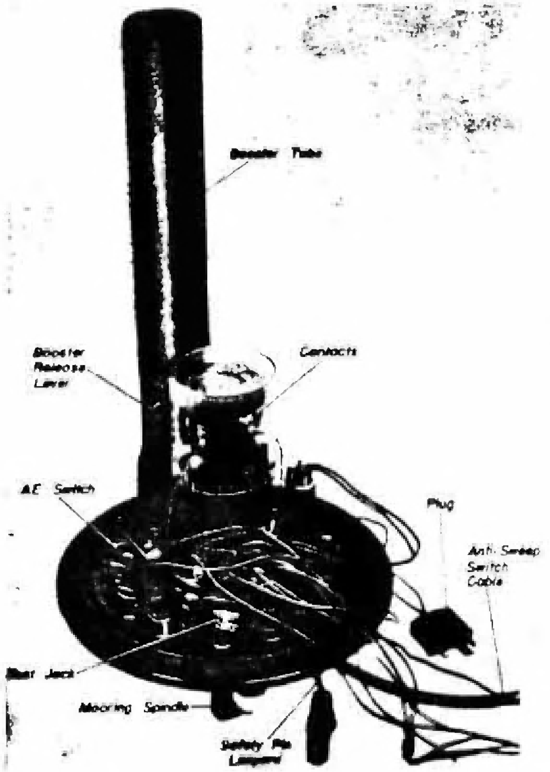
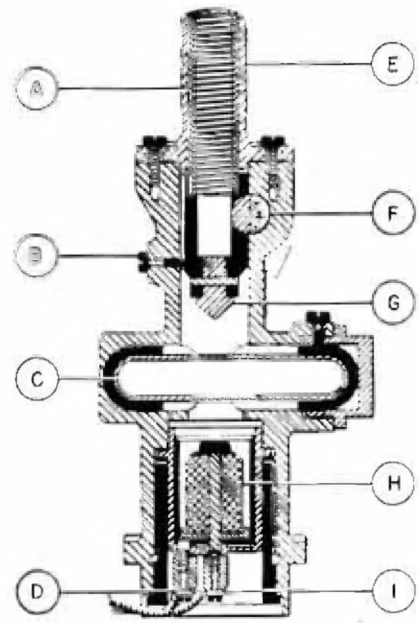


Figure 46 - Base Plate Type UMB (Interior)

mounted on a cross-head on the mooring spindle and four on the mooring-spindle housing. Withdrawal of the spindle makes the contacts, arming the horn circuit. Retraction of the spindle breaks the contacts, disarming the horn circuit. However, the mooring spindle is designed to lock in the "out" position.

A detonator carrier is fitted in a well located externally on the base plate beside the mooring spindle, and is held in place by a strongback and a single setscrew. The screw fits into a boss on the detonator carrier and is secured by a U-pin which fits into an annular groove on the setscrew. Two spring-loaded contacts are mounted on the inside of the base plate, extending vertically upward and then bending at an angle of 90° to enter the booster tube. These contacts make similar contacts on the detonator carrier when it is inserted in the booster tube.

A spindle which controls an internal, two-position rotary switch is mounted at either 90° or 135° from the detonator carrier. A red arrow is stamped on its face to indicate the switch setting and the letters A and E are stamped on the part of the base plate adjoining. This switch is in the circuit of the SBM, except in base plate Type UMB, where it is in the circuit of the UMB, where it is in the circuit of the "tombac" anti-sweep device. If the arrow points to A (painted white), the switch is open and the self-destroying mechanism or "tombac" is not



A - STRIKER SPRING
B - STRIKER GUIDE PIN
C - GLASS VIAL
D - NEGATIVE CONTACT
E - STRIKER SPRING HOUSING
F - STRIKER RELEASE PAWL
G - STRIKER
H - HORN BATTERY
I - POSITIVE CONTACT

Figure 47 - Eighth Horn

in the circuit. If the arrow points to E (painted red), the SBM or "tombac" is in the circuit and both should operate as designed.

A soluble plug holder may be found alongside the mooring spindle, secured by a strongback. A black, plastic disc, about a half inch in diameter, is fitted in the strongback. Withdrawal of the mooring spindle upon dissolution of the soluble plug pushes this disc out of the strongback. Note that the presence or absence of this disc provides a positive means of determining whether or not the mine has ever armed.

In some cases, the following additional base plate fittings may be found:

A gland for connecting a lower antenna or "tombac" anti-sweep device

A slotted screw plug for applying a circuit tester

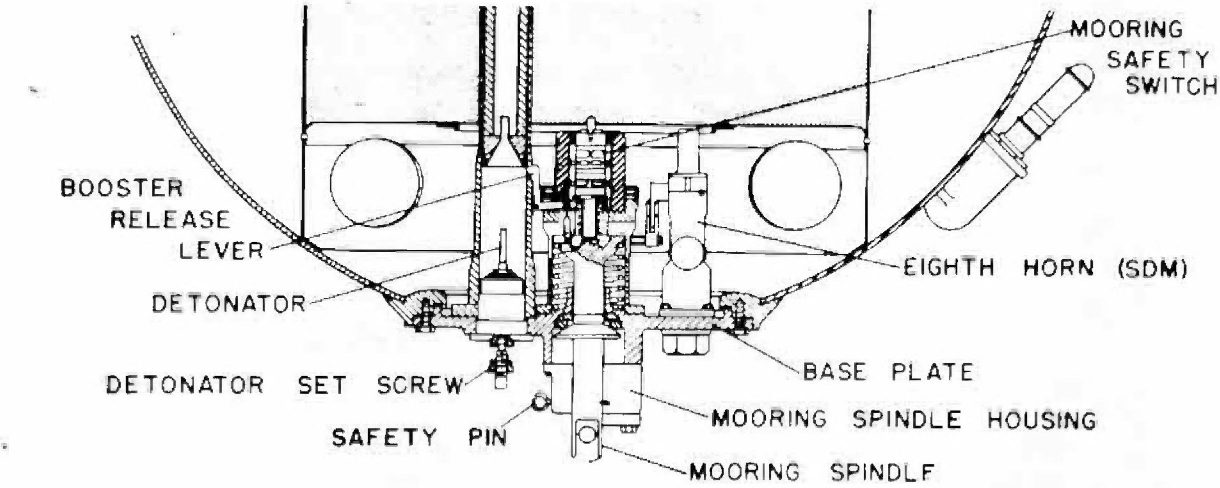


Figure 48a - Diagram of Base Plate Type EMC II

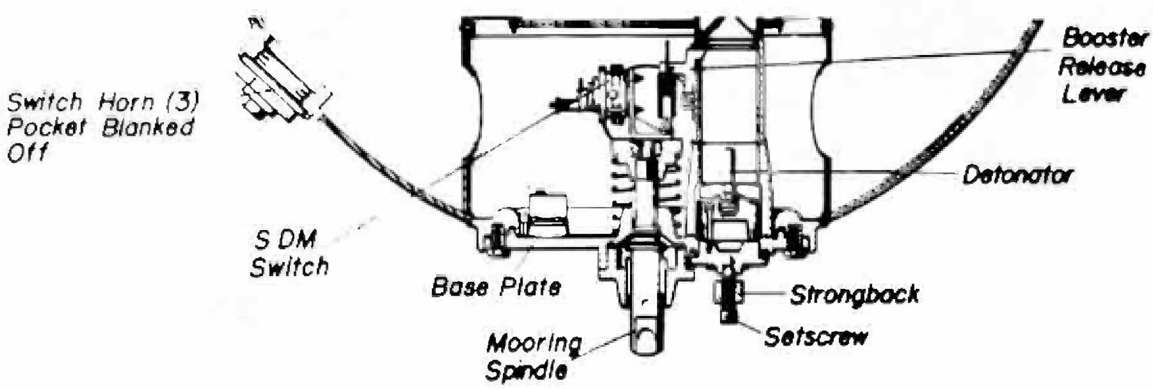


Figure 48b - Diagram of Base Plate Type UMA

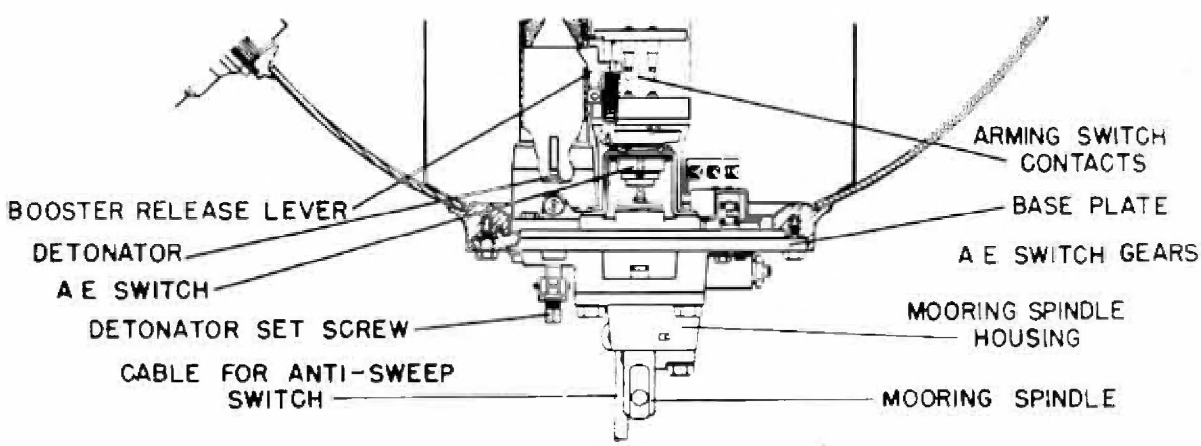
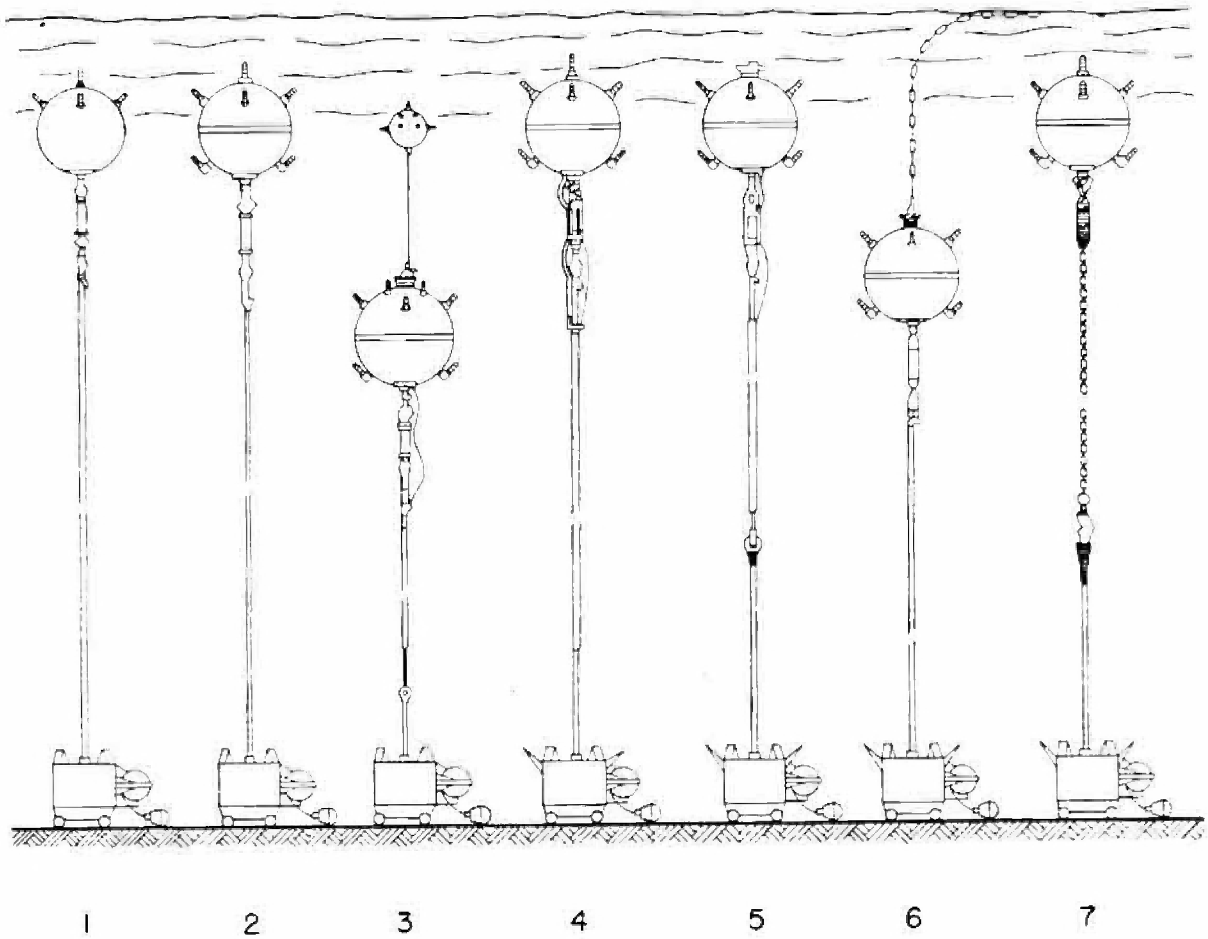


Figure 48c - Diagram of Base Plate Type UMB

TABLE OF BASE PLATES

Base Plate	Where Used	Diameter (inches)	Material	Mooring Spindle Delay	Type of Booster Tube	SDM (self-destroying mechanism)	How Secured	Remarks
Type EMC	EMC EMD	15	Gun metal	Two oil dash pots	8 1/2 in. long, open at top	Chemical horn mounted in top of mooring spindle tube	Secured by 20 bolts	Considered obsolete
Type EMC I	EMC EMD	15	Steel	Two oil dash pots	18 in. long, closed at top	Rotary two-position switch	Secured by 19 bolts	Considered obsolescent
Type C EMC II	EMC EMD	15	Steel	Soluble plug	18 in. long, closed at top	Chemical horn mounted beside mooring spindle	Secured by 20 bolts	Fitted with lower antenna gland 180° from booster tube; gland blanked off with a hexagonal cap, if not, antenna is fitted
Type UMA	UMA	11 1/2	Steel	Two oil dash pots	15 in. long, closed at top	Rotary two-position switch	Secured by 19 bolts	Considered obsolete
Type UMB	UMB	11 1/2	Steel	Soluble plug	15 in. long, closed at top	None	Secured by 16 bolts	Fitted with Tombac firing device gland, 180° from A-E switch and with mooring spindle locking detent, 180° from booster tube

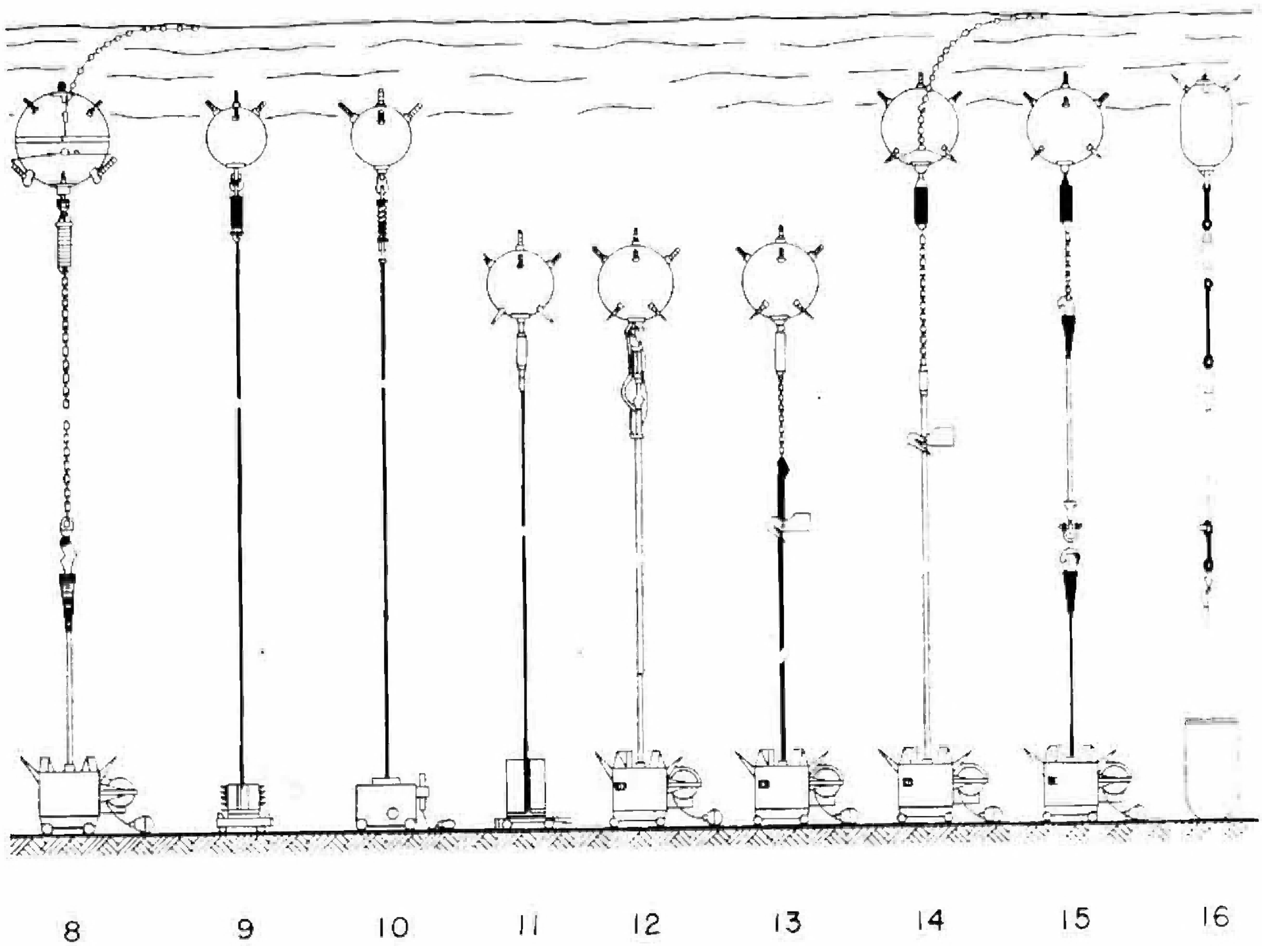
Figure 48d - Base Plates - Table of Data.



KEY TO FIGURE 49a

1. EMD I, II
2. EMC I
3. EMC II - Upper and lower antenna
4. EMC II - Tombac tubing
5. EMC II - lower antenna
6. EMC II - Cork-floated upper antenna
7. EMC II - Chain mooring

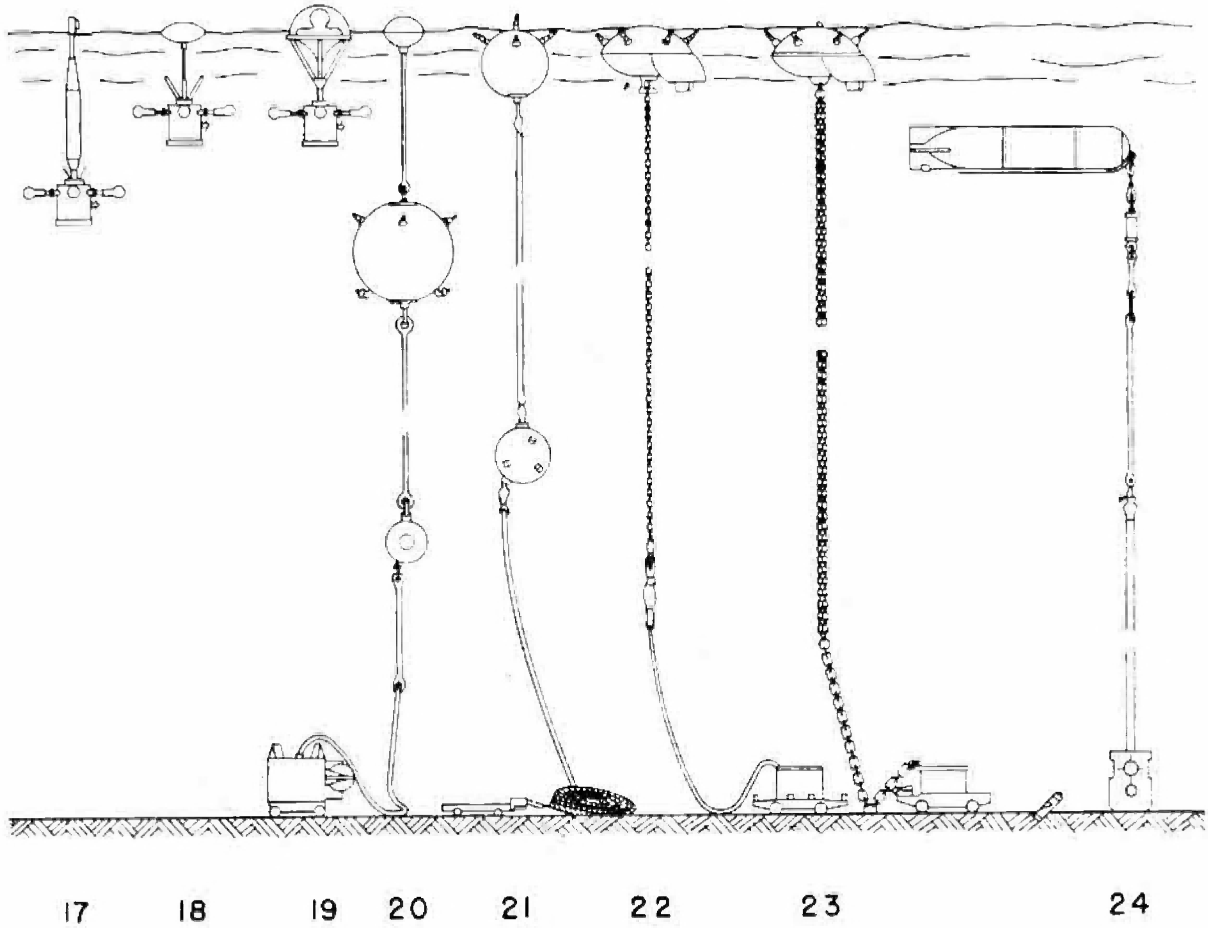
Figure 49a - Operational Mines and Sweep Obstructors



KEY TO FIGURE 49b

8. EMC II - Snag line and chain mooring
9. FMB
10. FMC
11. UMA
12. UMB - Tombac tubing
13. UMB - Chain mooring and mechanical cutter
14. UMB - Snag line, chain mooring, and mechanical cutter
15. UMB - Chain mooring and two cutters
16. BMC

Figure 49b - Operational Mines and Sweep Obstructors (Continued)



KEY TO FIGURE 49c

17. EMS I - Periscope type

18. EMS II - Float type

19. EMS III - Cupola type

20. EMG

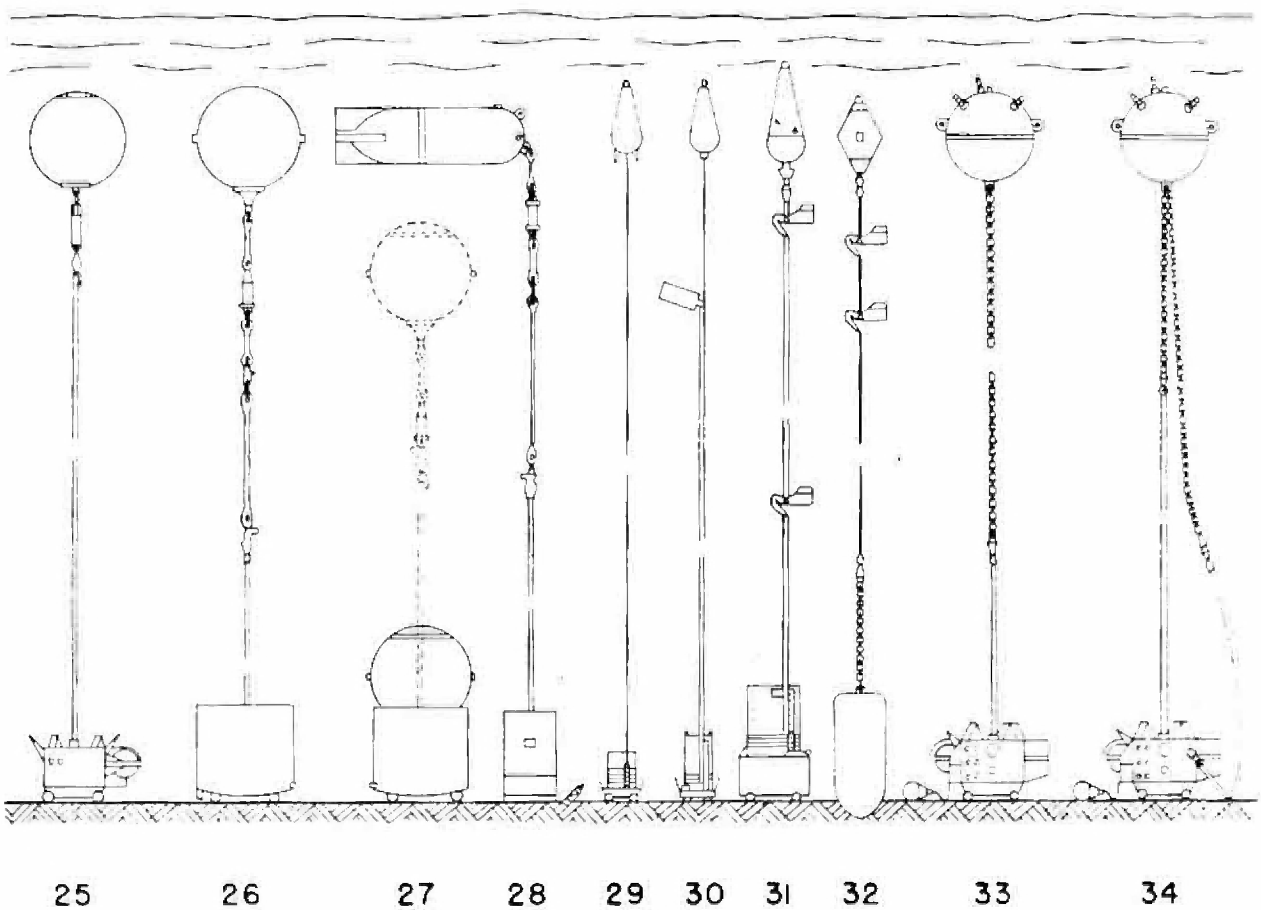
21. UMA/K

22. CMA I - Single chain

23. CMA/K - Double chain

24. EMF

Figure 49c - Operational Mines and Sweep Obstructors (Continued)



KEY TO FIGURE 49d

25. TMA
26. SMA
27. SMC
28. LMF
29. Explosive anti-sweep float C
30. Explosive anti-sweep float D
31. Mechanical anti-sweep float
32. BRB
33. EMR
34. EMR/1

Figure 49d - Operational Mines and Sweep Obstructors (Concluded)

Designation	Stage of Development	Type	Method of Laying	Method of Firing	Wt. of Charge (pounds)	Case Material	Dimensions Diam.	Length
BMC	Operational	Moored	Aircraft	Le-Clanche horn	120	Steel	26	44
BMC/S	Operational	Moored	Surface	Le-Clanche horn	120	Steel	26	44
EMA	Operational	Moored	Surface & submarine	Chemical horn	330	Steel	34	46
EMB	Operational	Moored	Surface & submarine	Chemical horn	480	Steel	34	46
EMC I	Operational	Moored	Surface	Chemical horn	660	Steel	46	48
EMC II	Operational	Moored	Surface	Chemical horn lower and upper antenna	660	Steel	46	48
EMC II (Tombac Tubing)	Operational	Moored	Surface	Chemical horn and tombac tubing	550 to 660	Steel	46	48
EMC II (Lower Antenna)	Operational	Moored	Surface	Chemical horn and lower antenna	550 to 660	Steel	46	48
EMC II (Cork-Floated Upper Antenna)	Operational	Moored	Surface	Chemical horn and antenna	630 to 660	Steel	46	48
EMC II (Chain Mooring)	Operational	Moored	Surface	Chemical horn	550	Steel	46	48
EMC II (Snag-Line and Chain Mooring)	Operational	Moored	Surface	Chemical horn	550	Steel	46	48
EMD I/II	Operational	Moored	Surface	Chemical horn	330	Steel	40	40
EMG	Operational	Moored	Surface	Chemical horn	660	Steel	46	48
EMF	Development	Moored	Surface	Chemical horn and/or influence unit	660	Steel	45	50

Figure 50 - Contact Mines - Table of Data (continued on next page)

Total Wt. (with anchor)	Remarks
1430	Developed by SVK for use by the Luftwaffe. Is only SVK mine in which booster and detonator are married prior to laying.
1430	Same as BMC/S but for laying by E-boat.
2000	A World War I mine which existed in two models, one for laying by surface craft and the other by special vertical-shaft U-boats. Stocks of the surface-laid model which remained on hand in 1939 were laid during World War II.
2200	Same as EMA except for weight of charge.
2375	This was the standard contact mine, and it was in very wide use in the various forms listed.
2400	Differs from Model I by use of upper and lower antenna and improvements to base plate.
2500	Tombac tubing added to mooring cable to provide protection against submarines and to act as anti-sweep device.
2400	This was first type of EMC mine to which ZE III (80-day clock) scuttling clock was fitted.
2400	Developed to defend against shallow-draft vessels such as PT-boats.
2500	Utilizes 18-foot length of 16-mm chain as anti-sweep device.
2500	Developed to defend against shallow-draft vessels.
2100	Developed at same time as EMC but intended for use against surface craft only. Consequently it had no lower horns. Is similar in all other respects to EMC except for size.
2680	A constant-depth assembly designed to protect against shallow-draft vessels. Uses EMC case, float, and special ballast weight.
Unknown	This mine was first attempt to develop a moored mine radically different from the EMC.

Designation	Stage of Development	Type	Method of Laying	Method of Firing	Wt. of Charge (pounds)	Case Material	Dimensions Diam.	Length
EMS I	Operational	Drifting	Surface or submarine	Switch horn	30	Steel	15	75
EMS II	Operational	Drifting	Surface or submarine	Switch horn	30	Steel	15	30
EMS III	Operational	Drifting	Surface or submarine	Switch horn	30	Steel	15	40
EMU	Development	Moored	Surface	Chemical horn and/or influence unit	220	Steel	40	45
FMA	Abandoned	Moored	Surface	Chemical horn	22	Steel	23	25
FMB	Operational	Moored	Surface	Chemical horn	30 or 44	Steel	26	29
FMC	Operational	Moored	Surface	Chemical horn	88	Steel	30	33
KMA	Operational	Ground	Surface	Chemical horn	165	Concrete	47	47
OMA I	Operational	Surface	Surface	Chemical horn	66	Steel	42	41
OMA/K	Operational	Surface	Surface	Chemical horn	66	Steel	42	41
OMA II	Abandoned	--	--	--	--	--	--	--
OMA III	Abandoned	--	--	--	--	--	--	--
OMA IV	Development	--	--	--	--	--	--	--
UMA	Operational	Moored	Surface	Chemical horn & switch horn	66	Steel	29	29
UMB (Tombac Tubing)	Operational	Moored	Surface	Chemical horn & switch horn	88	Steel	33	33
UMB (Chain & Cutter)	Operational	Moored	Surface	Chemical horn & switch horn	88	Steel	33	33
UMB (Snag-Line, Chain & Cutter)	Operational	Moored	Surface	Chemical horn & switch horn	88	Steel	33	33
UMB (Chain & Two Cutters)	Operational	Moored	Surface	Chemical horn & switch horn	88	Steel	33	33

Mines - Table of Data (concluded)

Total Wt. (with anchor)	Remarks
100	Utilizes a flotation chamber made to resemble a periscope.
65	Same as Model I but a camouflaged float used in place of "periscope".
80	Same as Model I but plexi-glass float used in place of "periscope".
Unknown	Smaller model of EMI.
Unknown	Developed about 1920 for use in Baltic; abandoned in favor of FMB.
600	Primarily intended for use in shallow waters of Baltic. Uses preset-type anchor.
920	Similar to FMC except for size. Utilizes normal plummet-type anchor.
2200	Intended to defend against landing barges.
2380	Only mine specially designed for watching on surface.
2380	Same as OMA I except for type of mooring used.
--	Intended to be same as OMA I but with a mechanical disarming device added.
--	Intended to be same as OMA I but with electrical disarming device added.
--	A special assembly for use in depths up to 925 ft., utilizing the OMA I case and EMC anchor and a specially designed float.
1800	Manufacture of this mine was halted prior to 1940, the UMB being considered more suitable. Stocks on hand were laid during World War II. Used preset-type anchor.
1400	Replaced UMA. Uses normal plummet-type anchor.
1400	Differs only in type of mooring used.
1400	Snag line added to defend against shallow-draft vessels.
1400	One cutter mounted high and one deep.

AIRCRAFT MINES-SVK

THE LM MINES

The German Luft Minen (LM) mine series consisted of five different types of sea mines. These types were designated LMA, LMB, LMC, LMD, and LMF. There was no mine designated LME. All these mines were influence mines designed primarily for laying from aircraft with large parachutes. LMA and LMB were ground mines. LMC, LMD, and LMF were moored.

The LMA Mine. The LMA mine was developed between 1928 and 1934, and was the first German aircraft-laid mine. Because of its relatively small (for ground mines) weight of charge, it was not used as extensively during the war as its larger counterpart, the LMB. Manufacture was discontinued early in the war, and existing stocks were used up.

The LMA mine existed in three models, representing progressive development. Originally the mine was known as LMA, but, as the German nomenclature became more systematized, the earlier two models were considered LMA 1 and LMA 11, and the most recent development was designated LMA 111. These models were nearly identical, the differences lying primarily in methods of manufacture, small improvements designed to strengthen the mine case, and modification of the parachute assembly.

The LMA mine could be modified easily to be suitable for surface-craft laying, in which case the modified assembly was designated LMA/S.

The LMA mine is known to have been used with the following units:

1. E-BIK
2. M 1 (SE-BIK)
3. M 3

The following units, although not definitely known to have been used in LMA, could have been used:

1. M 1r	6. MA 1, MA 1a, MA 1r, MA 1ar
2. M 1s	7. MA 2, MA 3
3. M 4	8. AT 1, AT 2
4. A 1	9. DM 1
5. A 4	

Description of case:

Shape	Cylindrical, with hemispherical nose and tapered tail
Material	Aluminum([illegible])
Diameter	2[illegible] in.
Length	
Over-all	6 ft.[illegible]-1/2 in.
Case	[illegible] ft.[illegible]-1/2 in.
Parachute housing	[illegible] ft.[illegible]-1/2 in.
Tail door	[illegible] in.
Parachute cap	1[illegible]-1/2 in.
Charge	[illegible] lb. cast hexanite

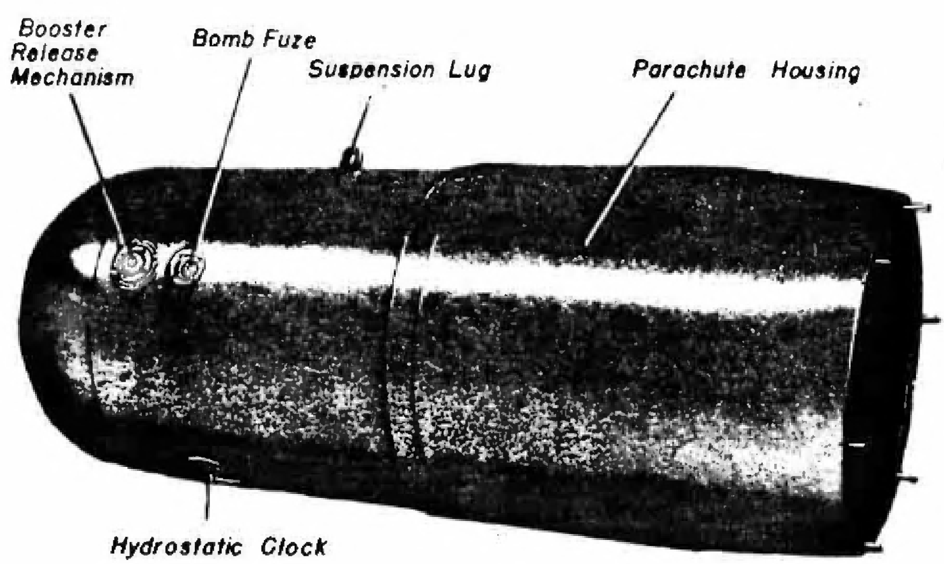


Figure 51 - LMA Mine

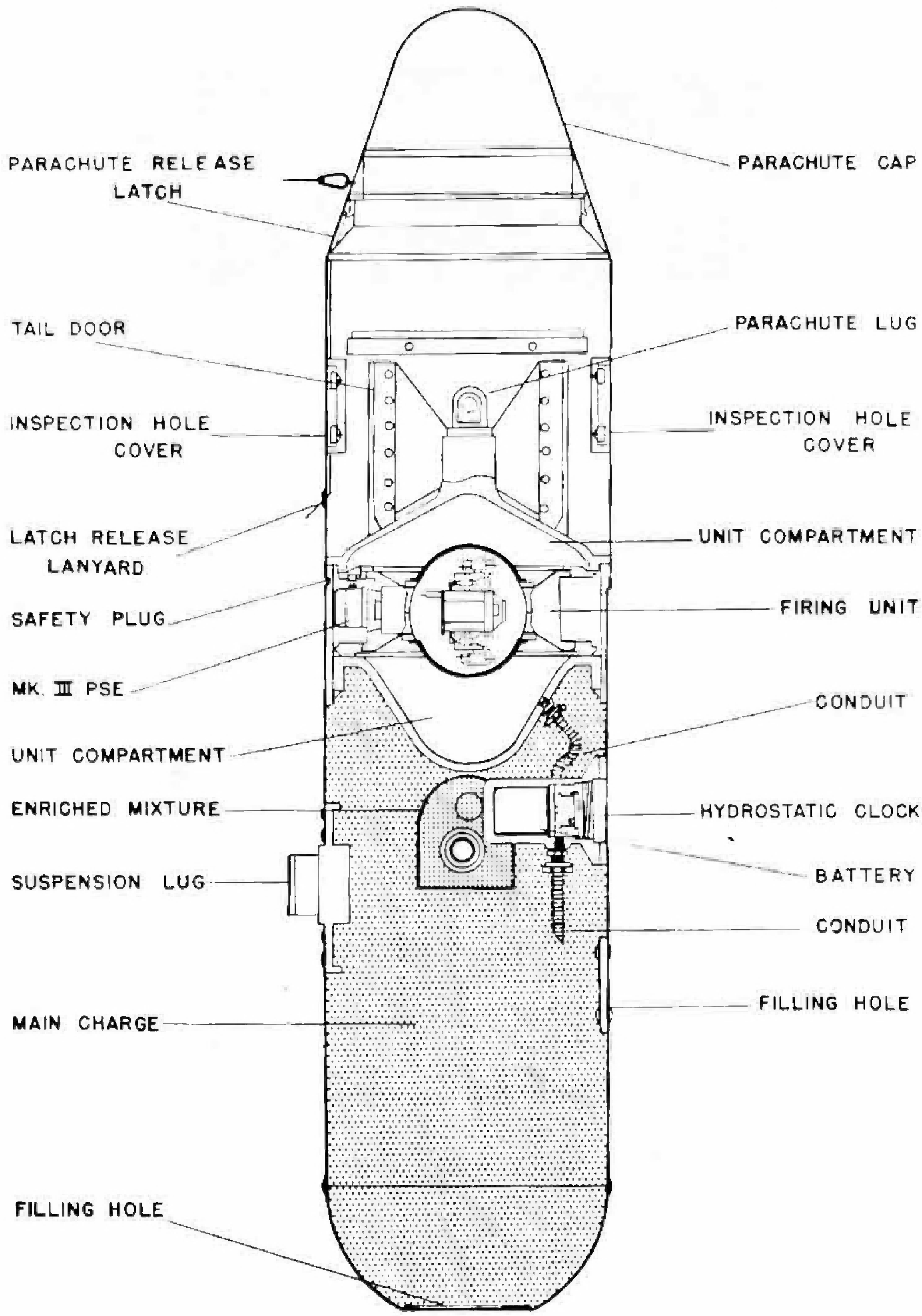


Figure 52 - LMB III Mine - Cross Section

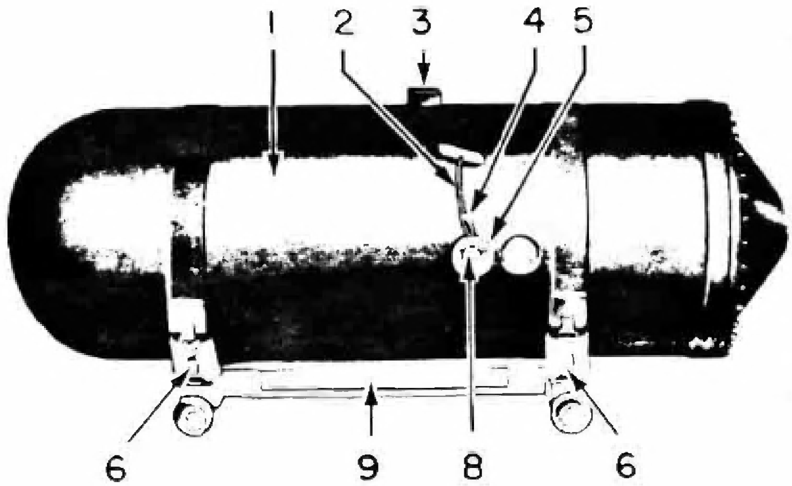


Figure 53 - LMB/S Mine

Description of External Fittings

Suspension lug	On top center line, 24 in. abaft the nose
Parachute lug	Inside parachute housing, on center of tail door
Booster release mechanism	4 in. diameter, 270° from top center line 1[illegible]-1/2 in abaft the nose, secured by keep ring
Hydrostatic clock	6 in. diameter, 180° from top center line, 18-1/2 in. abaft the nose, secured by keep ring
Detonator cover plate	4-1/2 in. diameter, 90° from top center line, 15-1/2 in. abaft the nose, secured by keep ring
Bomb fuze	3 in. diameter, 270° from top center line, 20-1/2 in. abaft the nose, secured by keep ring
Filling-hole covers	Three, 6-in. diameter, one in center of nose; two, 135° and 225° respectively from top center line, 19 in. abaft the nose, each secured by four screws
Inspection-hole covers	Two, 7 in. by 9 in. on top center line and 180° from top center line respectively, 12-1/2 in. from after end; each secured by four screws
Parachute release latch	1/2 in. diameter on top center line, 22 in. from after end
Ejecting plungers	Six, 1/2 in. diameter equally spaced on after end

The LMB Mine. The LMB mine was developed during the same period as LMA (1928-1934), and was ready for use with the E-BIK by the end of 1938. It was modified in 1940 to suit the mounting of the M 3 unit. The LMB was nearly identical to LMA, but carried a larger charge, and the mine case was accordingly longer. Otherwise, except for very small differences, LMA and LMB were identical in method of laying, operational use, and the firing units which could be fitted. LMB was used extensively, perhaps more than any other German influence mine.

The LMB mine existed in four models, representing progressive development. Originally the mine was known as LMB, but, as in the case of LMA, the earlier two models were considered LMB I and LMB II when the nomenclature was systematized, and later developments were designated LMB III and LMB IV. LMB I, LMB II, and LMB III were nearly identical, the differences, as in LMA, lying primarily in methods of manufacture, small improvements designed to strengthen the mine case, and modification of the parachute assembly. LMB IV was a further modification of LMB III in which the cylindrical part of the mine case, excluding the unit compartment, was made of plasticized pressed paper (press-stoff). The hemispherical nose of the mine was made of a type of bakelite. This development was brought about partially because of requirement of a non-metallic mine case for use with the experimental "Wellensonde" unit, and partially because of a shortage of aluminum. Some LMB IV cases were captured in which the whole cylindrical section of the mine case was made of pressed

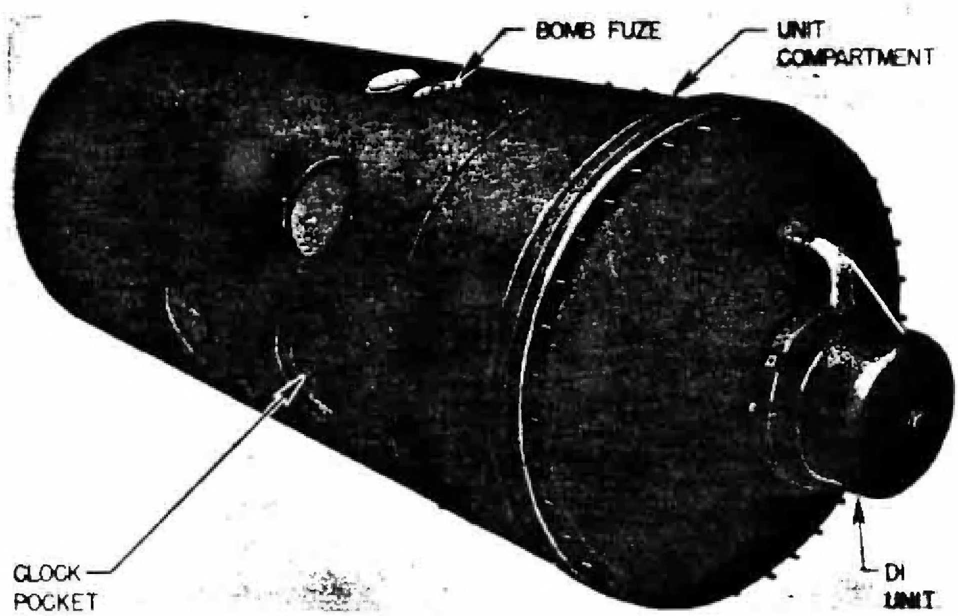


Figure 54 - LMB/S Mine - Plastic, with D 1 Unit

paper. It does not appear, however, that these were used operationally, and there is some indication that they were not water-tight at the joints.

Any model of the LMB mine could be modified easily for surface-craft laying, in which case the modified assembly was designated LMB/S.

The LMB mine was known to have been used with the following units:

1. E-BIK	5. MA 1,MA 1a
2. M 1(SE-BIK)	6. MA 2
3. M 3	7. AT 1,AT 2
4. A 1,A 1-st	8. DM 1

The following units, although not definitely known to have been used in LMB, could have been used:

1. M 1r	5. MA 1r,MA 1ar
2. M 1s	6. MA 3
3. M 4	7. AMT 2
4. A 4,A 4-st	

Description of Case

Shape	Cylindrical,with hemispherical nose and tapered tail
Material	Aluminum (KSS) or press-stoff
Diameter	26 in.

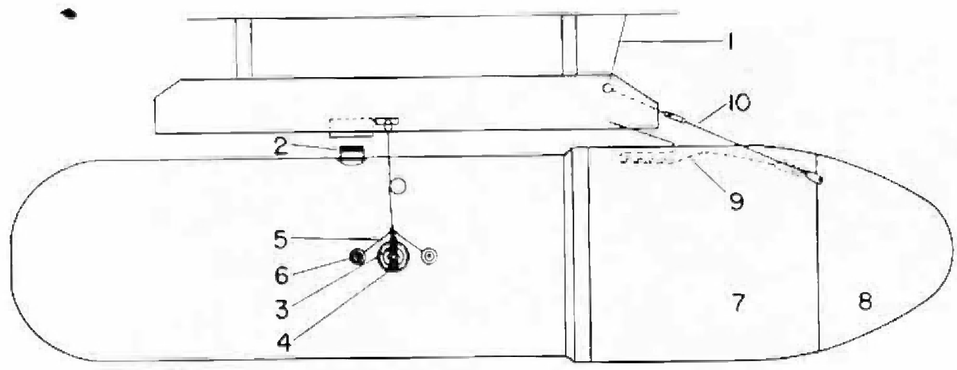
Length

Over-all	9 ft.9-1/2 in.
Case	5 ft.8-1/2 in.
Tail door	19 in.
Parachute housing	2 ft.11-1/2 in.
Parachute cap	13-1/2 in.

Charge	1500 lb.cast hexanite
Total weight in air	2175 lb.

Description of External fittings

Suspension lug	On top center line, 3 ft.5 in.abaft the nose
Parachute lug	Inside parachute housing, on center of tail door
Booster release mechanism	4 in.diameter,270° from top center line, 3 ft.8 in. abaft the nose,secured by keep ring
Hydrostatic clock	6 in.diameter,180° from top center line, 4 ft.abaft the nose, secured by keep ring
Detonator cover plate	4-1/2 in.diameter, 90° from top center line, 3 ft.8 in. abaft the nose, secured by four screws



1 EMERGENCY LANYARD IN PLANE
2 CARRYING LUG
3 SAFETY FORK
4 SAFETY WIRE
5 BOMB FUZE LANYARDS
6 BOMB FUZES (34 B)
7 PARACHUTE HOUSING
8 PARACHUTE CAP
9 STATIC LINE
10 EMERGENCY LANYARD

Figure 55 - LMB Mine and Launching Gear on Aircraft

Bomb fuze	3 in.diameter,270° from top center line, 4 ft.1 in. abaft the nose, secured by keep ring
Filling-hole covers	Four, 6 in.diameter; one in center of nose; one 180° from top center line, 2 ft. 11 in. abaft the nose; two 135° and 225° respectively from top center line, 4 ft. 1 in.abaft the nose,each secured by four screws
Inspection-hole covers	Two, 7 in. x 9 in; one on top center line, 21 in. from other end; one 180° from top center line,21 in.from other end; each secured by four lock-screws
Parachute release latch	1/2 in.diameter, on top center line, 2 ft. 2 in.from after end
Ejecting plungers	Six, 1/2 in.diameter, equally spaced on after end

In some cases this mine had been fitted with an additional clockwork bomb fuze to reduce the possibility of a mine's being found unexploded on land. The additional bomb fuze mounted in place of the booster release mechanism, and the booster was permanently housed over the detonator. The bomb fuze was mounted in an adapter tube which was screwed into the pocket in place of the booster release mechanism and spring. The remaining space was filled with booster pellets and wooden blocks.

Operation. When the mine was dropped, two lanyards were pulled, performing the following arming functions:

One lanyard released the parachute-cap latch, and the cap then served as a pilot chute. When the main chute was fully streamed, the cap fell away.

The second lanyard, a split type, removed the bomb-fuze safety pin and the booster release-mechanism safety fork. Removal of the safety pin allowed the bomb-fuze to arm after a short safety interval controlled by clockwork. Removal of the safety fork allowed the booster to house over the detonator.

Upon impact with any surface, the bomb-fuze clockwork started again and, after a 17-second delay, the bomb-fuze fired the mine unless it had reached a depth of 15 feet or more. Upon reaching this depth, the bomb-fuze was again rendered passive and would or would not become active again if the mine was raised, depending on the fuze fitted.

Dissolution of a soluble plug (may not be fitted) allowed water pressure to depress the clock spindle at a depth of 15 feet, starting the clock. The clock ran off its delay setting, and the firing unit began its

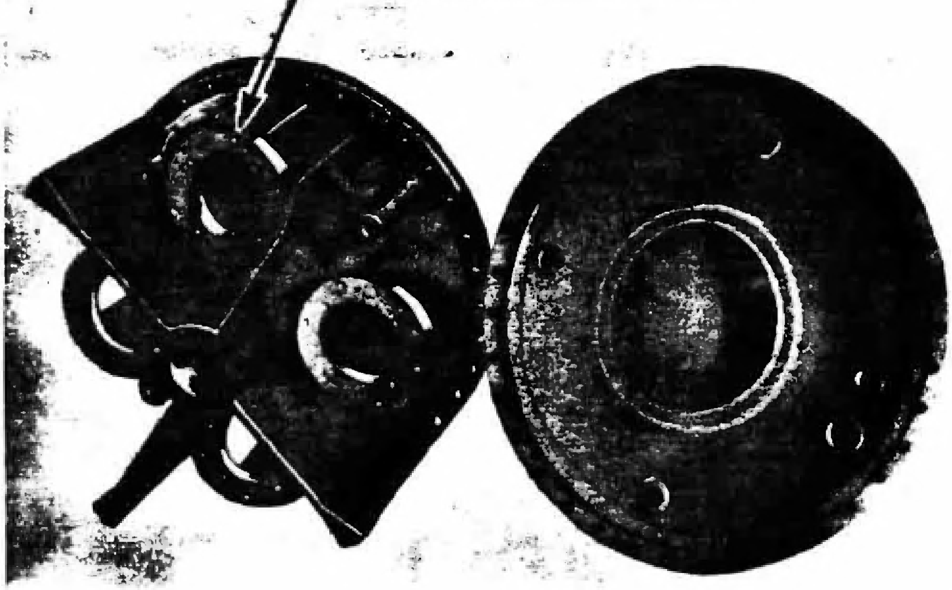


Figure 56 - 4 DM Experimental Dome for LMB Mine

arming cycle. Dissolution of a soluble plug released the parachute.

In some cases, the mine had been rigged as a shallow-water depth bomb by replacing the hydrostatic clock with a hydrostatic switch which operated at a depth of 50 feet and by plugging the bomb-fuze so that it could not be rendered passive by hydrostatic pressure.

No self-disarming devices were fitted.

One type of experimental tail door utilizing four pressure units in combination with the M 1 unit was designated 4 DM. This is shown in figure 56.

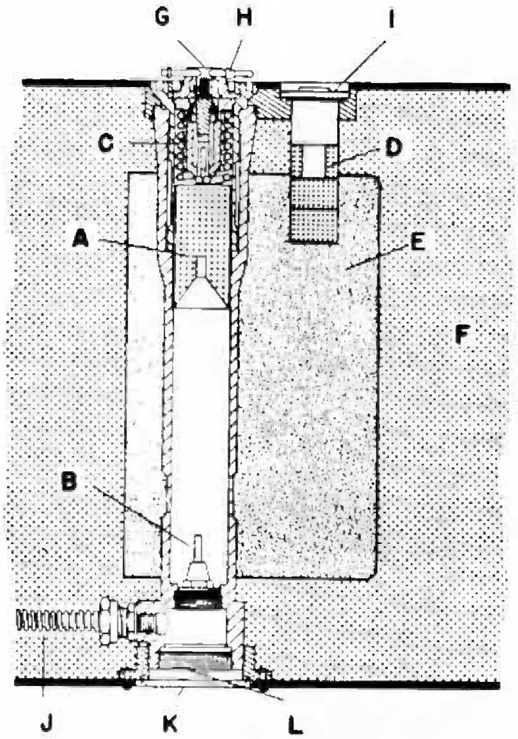
The LMC Mine. This was an experimental development started in 1933. It was a moored mine designated to be laid from "vertical-shaft" aircraft (He 59) which were, however, discontinued. Accordingly, the development of the LMC mine was discontinued, and the information gained was directed to the development of the LMF. It was intended to have the same general shape as the LMB mine, with a total weight of approximately 2200 pounds, and a charge weight of approximately 660 pounds. Information on the firing device used is conflicting. According to one report, influence units were used; according to another, chemical horns were used.

The LMD Mine. This was the first attempt to develop an aircraft-laid, moored, influence mine. The mine was developed for laying by multi-purpose aircraft. LMD had a total weight of approximately 1430 pounds and a charge weight of approximately 550 pounds. Development of LMD was stopped in 1937, and the information directed to development of LMF.

Figure 57 - LMB Mine with D 1 Unit

LM - ZUS Z (34) B Bomb Fuze for LMB. The primary function of the fuze is to explode the mine as a delayed-action bomb if the mine does not reach a sufficient depth of water to depress the hydrostat before the clockwork completes its firing run-off.

The fuze, which is a modification of the German (34) A* bomb fuze is 4-1/16 inches long. The fuze body is of aluminum divided into four parts:



A BOOSTER
B DETONATOR
C SPRING
D SUB-BOOSTER
E ENRICHED MIXTURE
F MAIN CHARGE
G BOOSTER RELEASE MECHANISM
H SAFETY FORK
I BOMB FUZE
J CONDUIT
K DETONATOR COVER PLATE
L DETONATOR COVER BUNG

Figure 58 - Detonator-Booster Assembly for LMB Mine

Head	Contains the hydrostat and clockwork release pin
Clock housing	Encases the clockwork
Clock mounting	Contains firing mechanism and is the base to which clockwork is fastened
Gaine adapter	To which the gaine is threaded.

The four sections are secured together by three cheese-headed screws. The additional length of the fuze permits the insertion of only two picric-acid booster pellets, one annular and one solid.

Water-Entry System. The water-entry system consists of a channel drilled transversely through the fuze head with two offset holes drilled at 90 degrees to it. (See Figure 59). The upper entry hole allows water to enter the channel from under the hydrostatic-valve cover plate, and the lower entry hole allows the water to pass from the channel into the hydrostat chamber. The lower hole is displaced about 1/8 inche from the upper hole.

Hydrostat Assembly. The upper section of the fuze contains the hydrostat assembly, which consists of a steel plate with three holes, a bellows, a spring, a plunger, and a retaining plug which screws into the fuze head, locking the whole assembly in place. The steel plate is secured to the fuze head by a small screw. This plate acts as a screen.

The open end of the bellows rests against the retaining plug and has a rubber ring seal around its flange to make a watertight joint. The spring is between the guide plug and the closed end of the bellows, so that hydrostatic pressure has to compress the bellows and spring as the plunger is depressed. The operating depth of the hydrostat is fifteen feet.

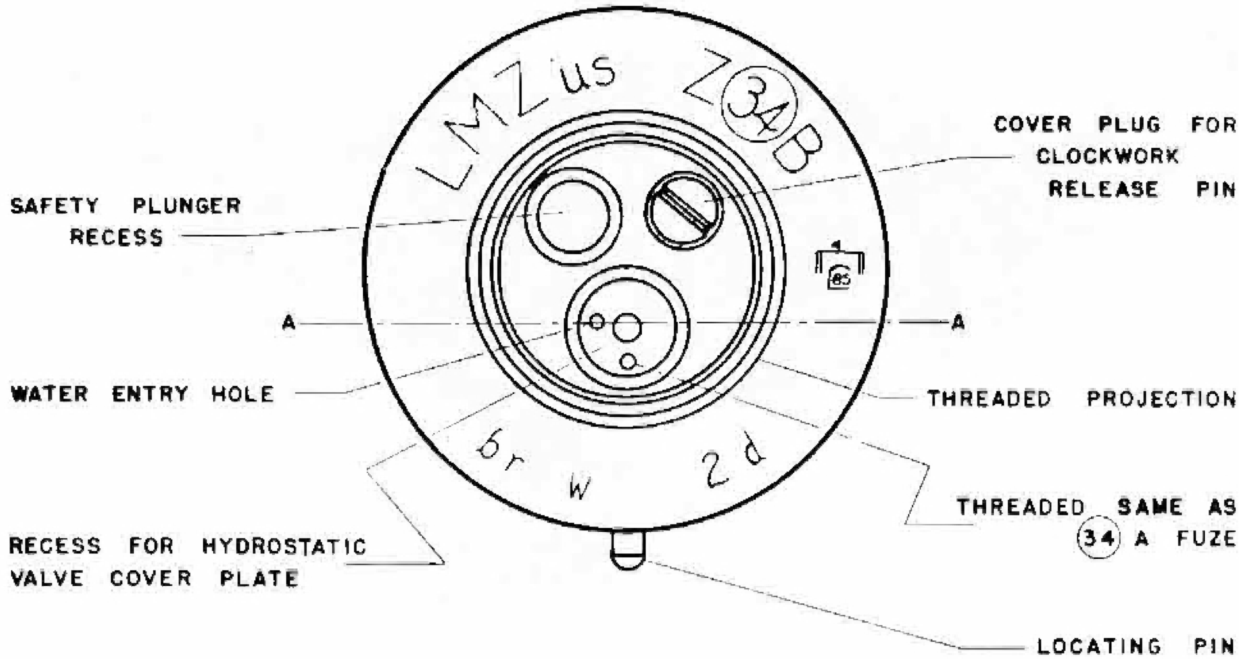
Clockwork and Firing Assembly. The principle of operation is the same as in the (34) A• although there are slight modifications. There is no selection of an "e" or "b" setting. The pin in the small nautilis-shaped cam is a fixed-position pin. The fuze will act as an anti-recovery device upon withdrawal from water.

Operation. Movement of the firing lever is controlled by an arrangement of cams operated by a clockwork.

The clock run-off is divided into two periods:

A seven-second period to arm after the mine leaves the aircraft allows time for the parachute to open without danger that the parachute jerk will fire the fuze.

A 19-second period starts at impact with water or land. At the end of the 19 seconds, the mine will be detonated by the fuze unless it has reached a depth sufficient to operate the hydrostat. In the latter case, the hydrostat piston will have been depressed far enough to prevent movement of the firing lever when it is released by the clockwork-controlled cam.



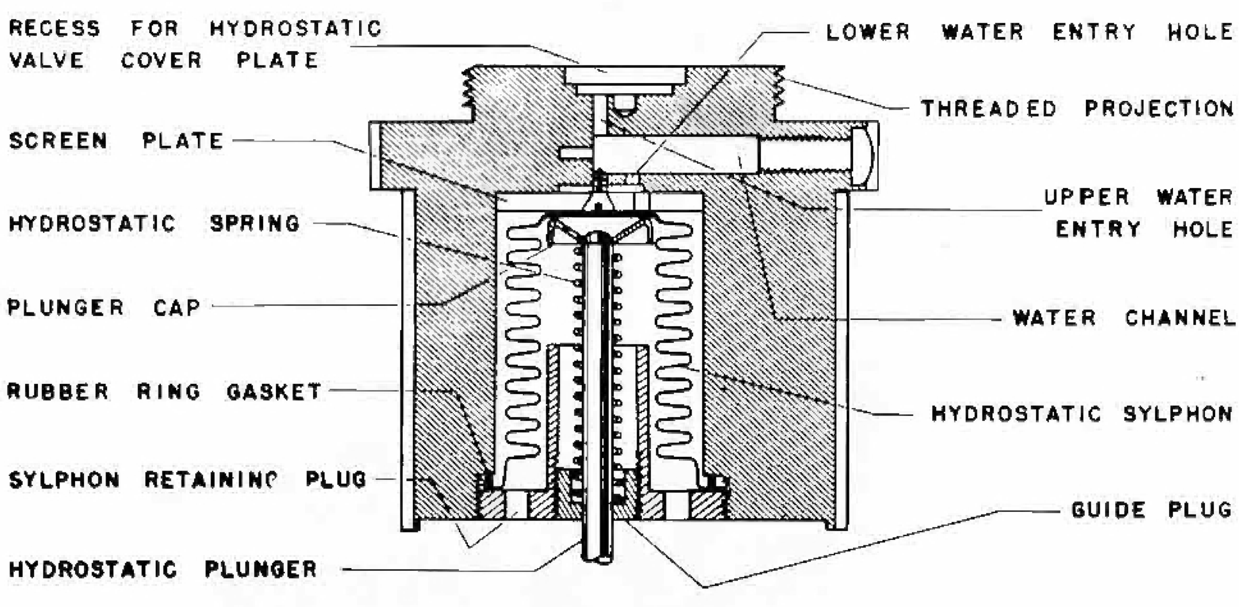


Figure 59 - LM - ZUS Z (34) B Bomb Fuze for LMB

Figure 60 - Parachute - Canopy Type

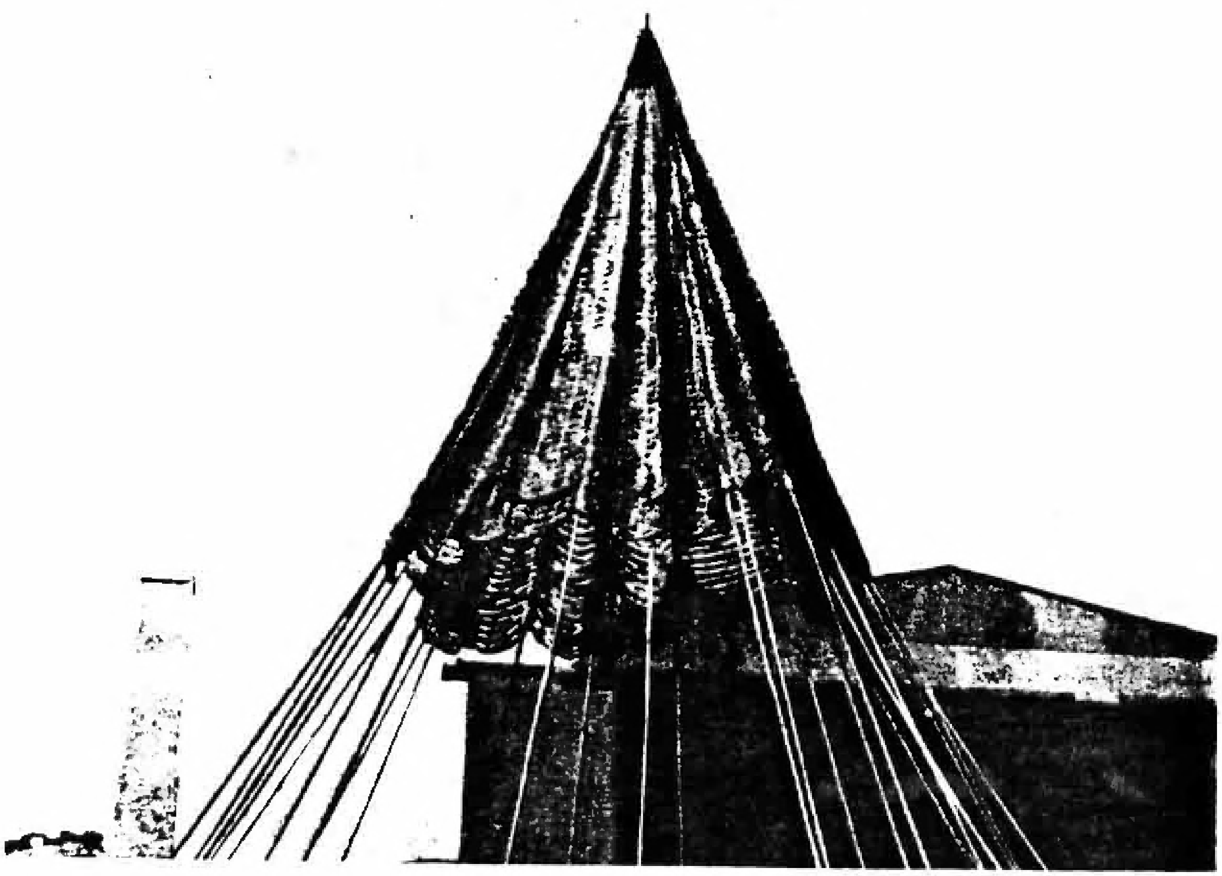


Figure 61 - Parachute - Lattice Barber Pole

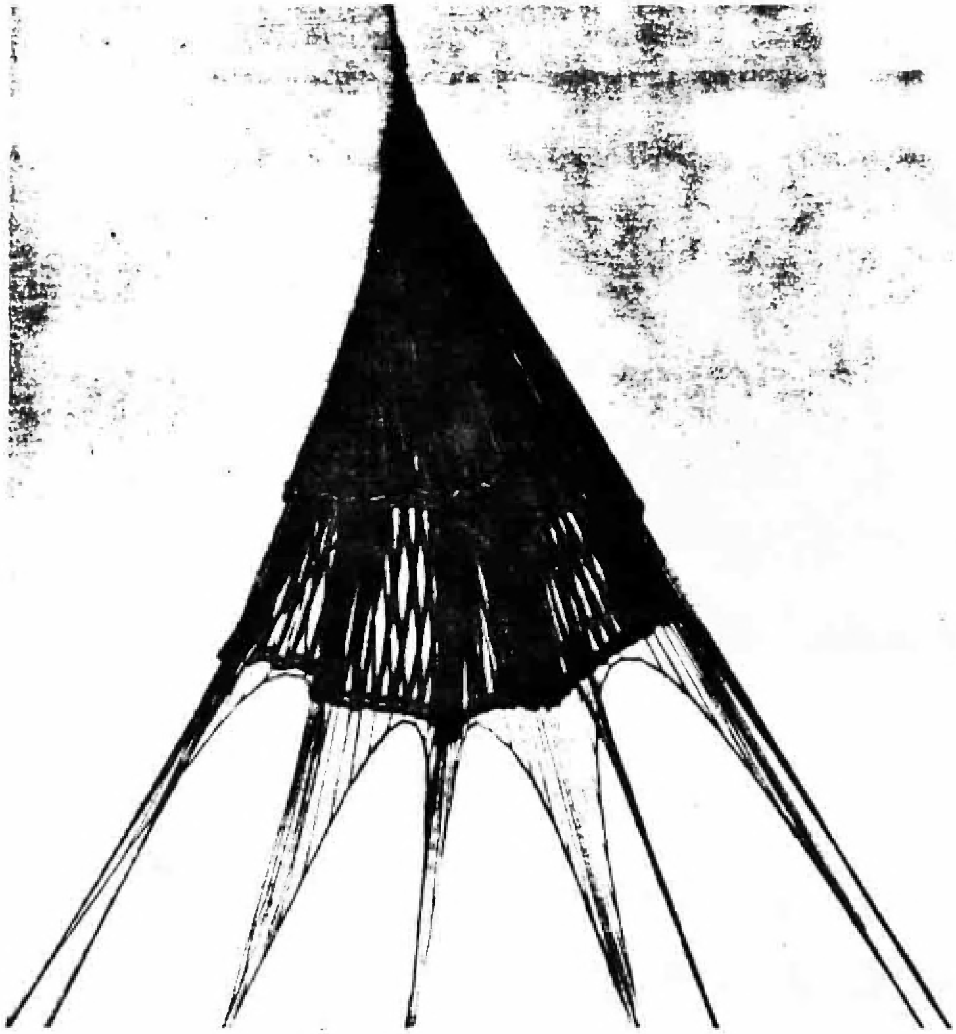


Figure 62 - Parachute - Parallel Lattice

Parachutes for the LMA and LMB Mines.

Canopy Type for LMA and LMB. This parachute closely resembles the standard type aviator's parachute.

The LMA type has 24 shrouds 16 feet long.

The LMB type has 28 shrouds 18 feet 6 inches long.

The parachute is opened immediately upon release from the plane. The tail cap on the parachute housing acts as a pilot chute for the main assembly. The static line releases a slide and roller attachment, allowing spring-loaded plungers in the main housing to eject the cap forcefully. Attached directly to the plungers is an emergency lanyard for use in case the mechanism does not function normally.

Lattice and Barber-Pole Type. These parachutes differ from the canopy type in that the canopy which catches the air and slows the mine's descent is not solid but is composed of a lattice work design. The various lattice work strips may run parallel to the edge of the parachute (parallel type) or may be set in a manner similar to the stripes on a barber pole. The latter type causes the mine to spin during descent, thereby permitting greater accuracy in laying.

These two types of parachutes were used only with the LMB mine.

The lattice type has 32 shrouds 25 feet long.

The barber-pole type has 16 shrouds 18 feet long.

Figure 63 - LMF Mine Afloat

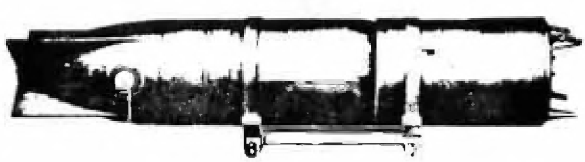


Figure 64 - LMF/S Mine

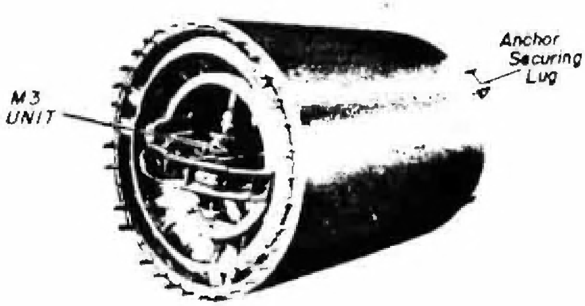


Figure 65 - LMF Mine, Showing M 3 Unit

The LMF Mine. The LMF mine development was started with the aid of the experience gained in work on the LMC and LMB developments. LMF was the first and only German operational aircraft-laid, moored, influence mine. Although it was laid operationally from aircraft, most were laid by surface craft. The LMF mine could be modified easily to be suitable for surface-craft laying, in which case the modified assembly was designated LMF/S.

The LMF mine was known to have been used with the following firing units:

1. M 3
2. M 4

The following units, although not definitely known to have been used in LMF, could have been used:

1. M 2
2. A 7

Description of Case

Shape	Cylindrical, with hemispherical nose and tapered, finned tail
Material	Aluminum([illegible])
Diameter	26 in.
Length	
Over-all	7 ft. 8 in.
Forward section	3 ft.6 in.
After section	4 ft.2 in.
After buoyancy chamber	2 ft.7 in.
Charge	610 lb.cast hexanite

Description of External Fittings

Hydrostatic clock	6 in.diameter on nose, 11 in. from center, secured by keep ring
Detonator cover plate	4 in.diameter,270° from top center line, 2 ft.5 in.from after end, screwed to case
Booster release mechanism	4 in.diameter,90° from top center line, 2 ft.4 in.from after end, secured by keep ring
Anchor-securing lugs	Three, 120° apart, 8 in. from center of nose
Mooring eye	On nose, 8 in. from center
Suspension lug	180° from top center line, 10 in. abaft the nose

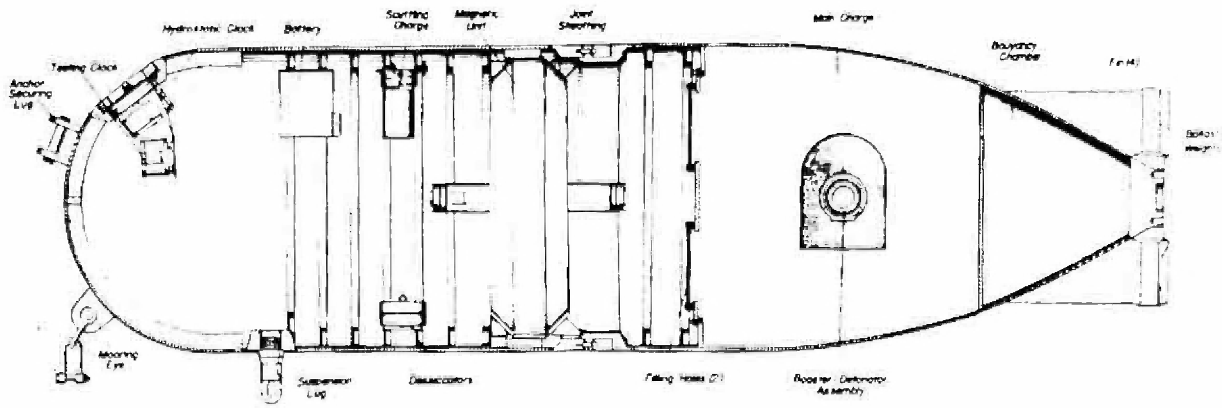


Figure 66 - Diagram of LMF Mine

Joining flange	3 ft.6 in. abaft the nose, fitted with 30 evenly spaced stud holes; covered by two sections of semicircular sheathing, 2 in. wide
Anchor-positioning lugs	Three, 105°, 195°, and 345° respectively from top center of nose
Ballast weights	Six; one on end of each fin; one near end of each lower fin
Fins	Four; 45°, 135°, 225° and 315° from top center line, at after end; 2 ft.5 in.long, 10 in. wide

Operation. When the mine is dropped, a safety fork is removed from the booster release mechanism, allowing the booster to house over the detonator. As the mine separates from its anchor, a pin is withdrawn from the hydrostatic clock. The mine then takes depth by a loose-bight hydrostat system. Water pressure depresses the clock spindle at a depth of 15 feet, starting the clock. The clock runs off its delay period, and the firing unit begins its testing cycle.

No self-disarming devices are fitted.

THE BMC MINE

This mine was developed for the Navy by the Luftwaffe in 1943-1944. Its prototypes, the BMA and BMB, were abandoned because of difficulties with the anchor, balance in flight, and streamlining. These difficulties were overcome, and the BMC in its final form included a seven-day delay rising clock. It is a moored, contact, Le Clanche cell horn mine, laid by aircraft or surface craft for offensive or defensive use in maximum depth of water of 450 feet, against surface craft.

Description of Case

Shape	Two hemispheres, joined by a 22-in. cylindrical mid-section
Material	Steel
Diameter	20 in.
Length	44 in.
Charge	120 lb. cast hexanite

Description of External Fittings

Horns	Four, equally spaced around upper hemisphere, 11 in. from center
Cover plate	8-in. diameter, in center of upper hemisphere, flush type, secured by 8 bolts
Base plate	11-in. diameter, in center of lower hemisphere, flush type, secured by 16 bolts; fitted with mooring lever and anchor-securing boss
Horn-release disc	2-3/4 in. diameter, 1-1/2 in. above center of cover plate
Booster cover plate	Oval-shaped, on cylindrical mid-section, 2-1/4 in. from anchor-securing flange, secured by set screw
Filling-hole cover	4-1/4 in. diameter on lower hemisphere, 10-1/2 in. from center secured by four bolts

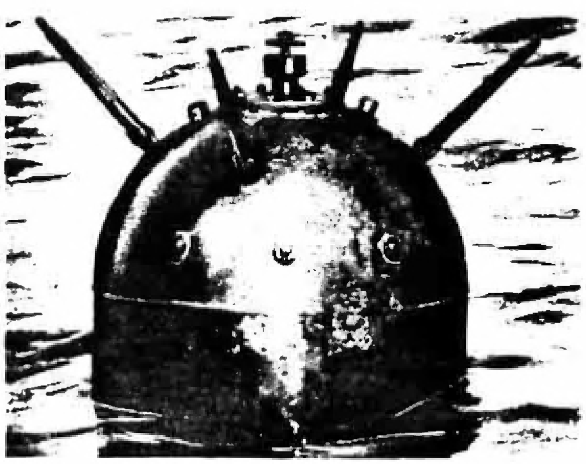


Figure 67 - BMC Mine Afloat

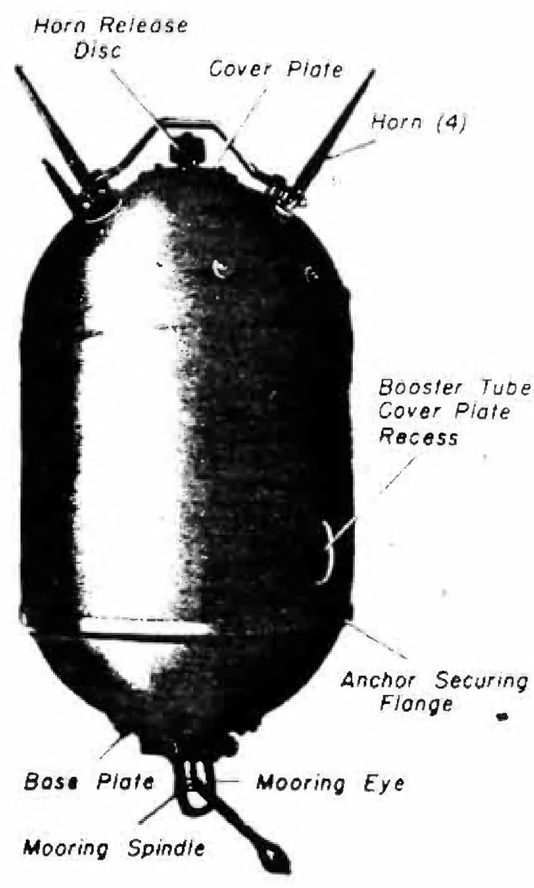


Figure 68 - BMC Mine

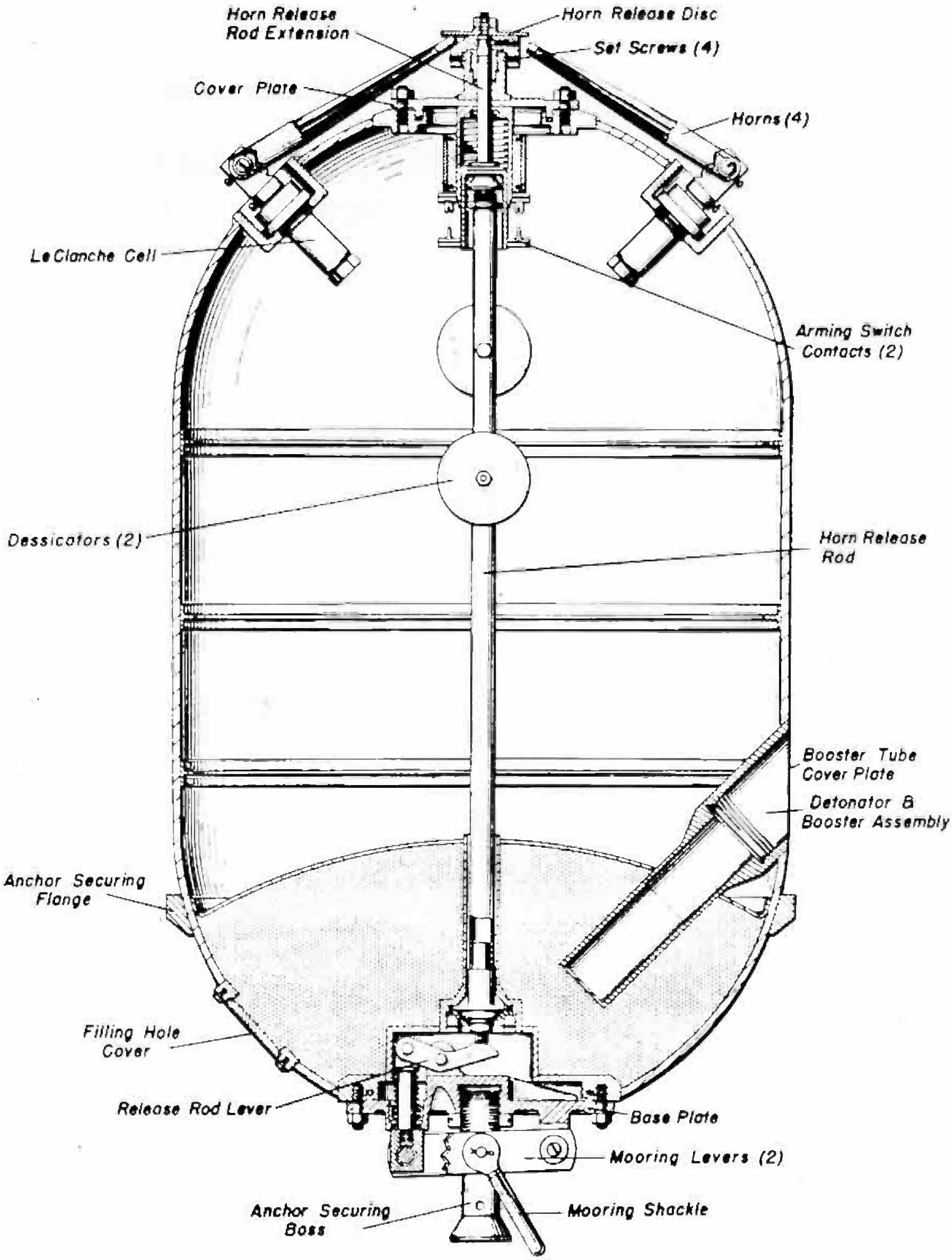


Figure 69 - BMC Mine - Cross Section

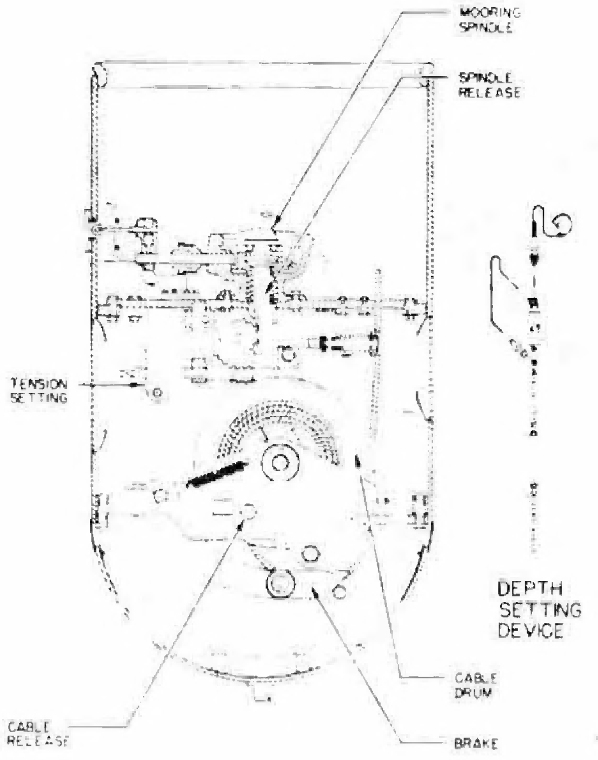


Figure 70 - BMC Anchor

Operation. The mine takes depth by a hydrostat. Mooring tension pulls out the mooring spindle against spring tension on the inside of the base plate. Withdrawal of the mooring spindle forces a catch upward, thereby actuating a horn-release rod which extends through the longitudinal axis of the case to the cover plate. Movement of this rod forces the horn-release disc upward, allowing the horns to snap our and lock in the "out" position, and closes the arming switch on the wiring panel. The mine is now armed.

When a horn is bent, the brass tube at the base of the horn breaks, allowing sea water to enter a Le Clanche cell under the horn, energizing it and producing a current sufficient to fire the detonator.

The only self-disarming device is the arming switch, which is designed to disarm the mine by opening the firing circuit upon release of mooring tension.

THE BM MINE SERIES

The German Bombe-Minen (BM) mine series consisted of fifteen types of influence mines all of which were designed for aircraft laying. These fifteen types were designated BM 1000 I, BM 1000 II, BM 1000 C, BM 1000 F, BM 1000 H, BM 1000 J-I, BM 1000 J-II, BM 1000 J-III, BM 1000 L, BM 1000 M, BM 1000 T, BM 500, BM 250, Winterballoon, and Wasser-

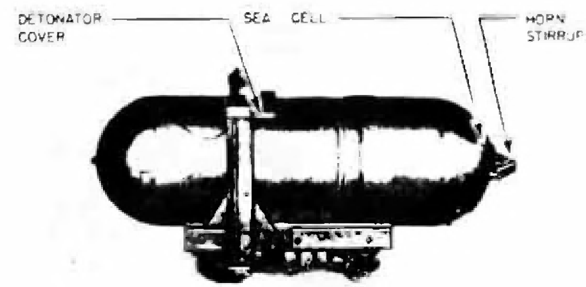


Figure 71 - BMC/S Mine

balloon. The BM 1000 I, BM 1000 II, BM 1000 H, BM 1000 M, and Wasserballoon were used operationally during World War II.

The German Luftwaffe undertook the development of aircraft-laid mines early in 1940. The developments and experiments were separate from those undertaken by the Navy Mine Experimental Command; however, each agency was cognizant of the other activities, and some mines consisted of variations of the original BM 1000 model,(Allied designation, GG) except the BM 1000 T, BM 500, BM 250, Winterballoon, and Wasserballoon.

Basically all the BM 1000 mines are of the same construction, except for minor modifications such as unit housings, size of lifting lugs, and tail doors. The mine case for all BM 1000 mines consists of four separate parts welded together: the nose piece, ogive, cylindrical case, and tail piece. The nose piece is made of pressed steel, and the other three parts are made of non-magnetic, 18% manganese steel.

BM 1000 I. The BM 1000 I was the original model of the BM 1000 mine series and was developed in 1940. Its characteristics are as follows:

Description of Case

Shape	Cylindrical, with ogival nose and truncated cone dome on tail; fitted with break-off tail section; possibly fitted with false nose
Material	Manganese steel
Length of case	64 in.
Diameter	26 in.
Weight of charge	1,500 lb.
Total weight	1,920 lb.
Max. effective distance	115 ft.
Min. effective distance	17 ft.

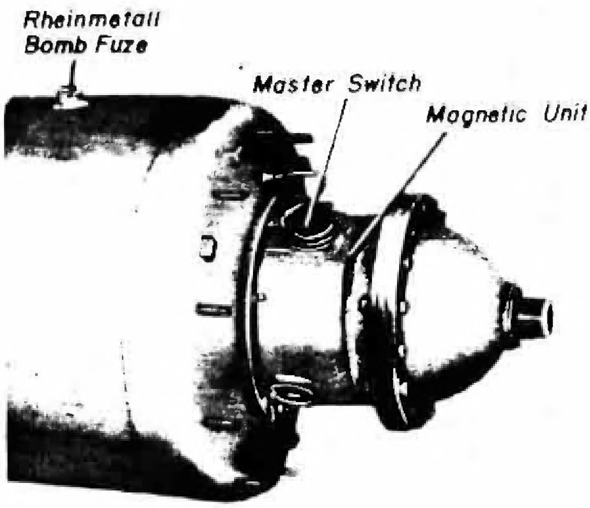


Figure 72 - BM 1000 I/II Mine with M 102 Unit

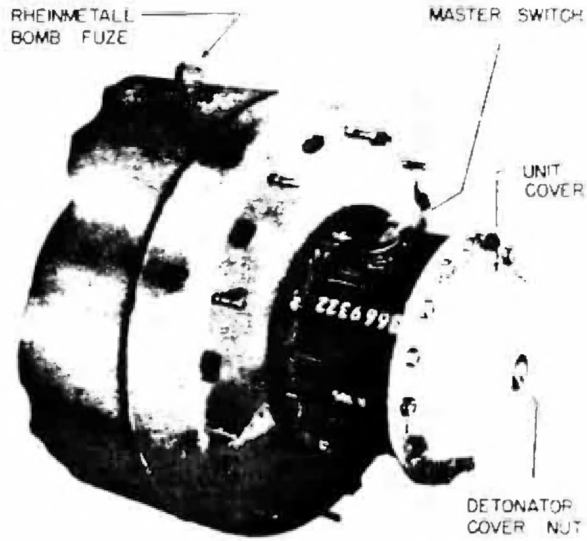


Figure 73 - BM 1000 I/II Mine with A 105 Unit

Description of External Fittings

Rheinmetall bomb fuze	3 in. diameter, on top center line 4 ft. 2-1/2 in. abaft the nose
Suspension lug	On top center line, 3 ft. 6 in. abaft the nose

Dropping heights depend on: speed of the plane, depth of water, and whether or not the mine is fitted with a "Bugspiegle" or parachute.

Without either a "Bugspiegle" or a parachute, the BM 1000 I can be dropped from heights of 325 to 6,500 feet in depths of water from 17 to 115 feet at speeds up to 285 m.p.h.

With a "Bugspiegle" it can be dropped from heights of 325 to 23,000 feet in depths of water from 17 to 115 feet at speeds up to 285 m.p.h.

With a parachute (LS 1 or LS 3) it can be dropped from heights of 325 to 23,000 feet in depths of water from 17 to 115 feet at speeds up to 285 m.p.h with the LS 1, and up to 400 m.p.h with the LS 3.

Operation. When the mine is dropped, the Rheinmetall fuze condenser receives a charge and a split lanyard attached to the false nose is pulled, thereby igniting the two small-delay detonators on the charge case. After a short delay, the delay detonators fire, driving the securing rod forward and thereby removing the small nose cap from the forward end of the false nose. Air travel then forces the petals outward and they fall away. Upon impact with a surface, the Rheinmetall bomb fuze operates as follows:

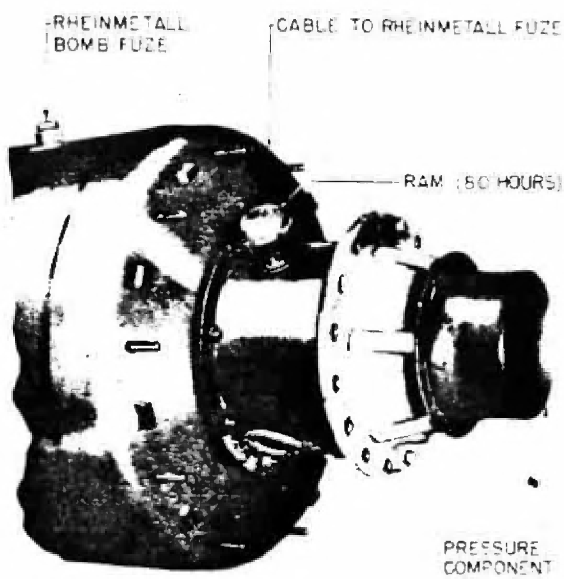


Figure 74 - BM 1000 I Mine with AD 104 Unit

If the rate of deceleration is 20-200g, as in the case of impact with a soft surface such as water or loose earth, the trembler switches close, firing the igniters in the master switch. If the mine does not reach a depth of 24 feet within 90 seconds, it will fire as a delayed-action bomb. If the mine does reach the proper depth within the ap-

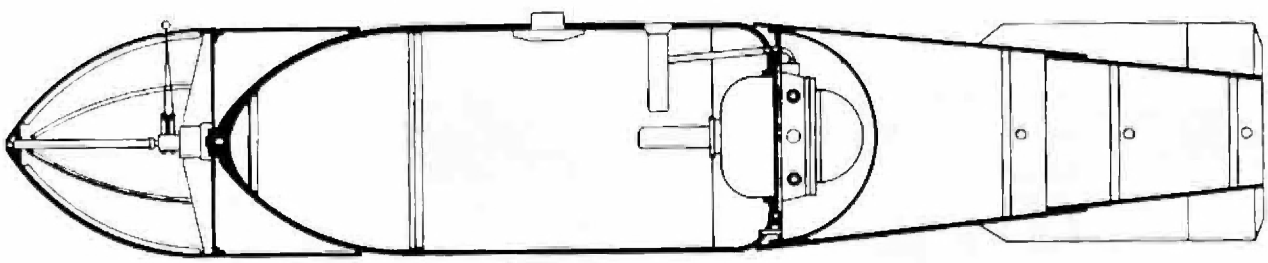


Figure 75a - BM 1000 H Mine with MA 101 and BV 3

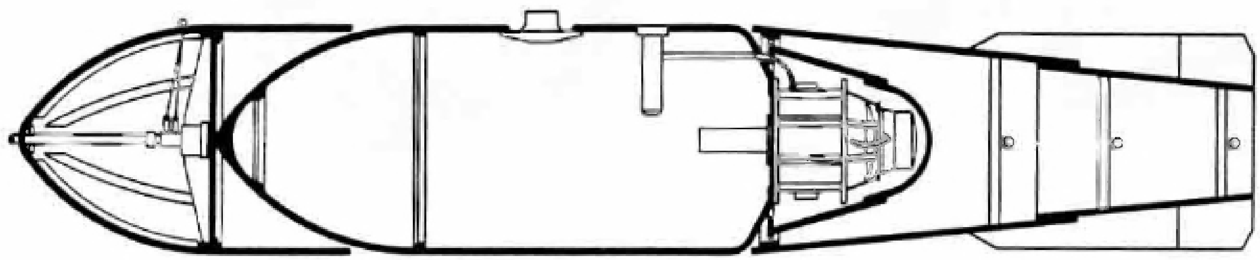


Figure 75b - BM 1000 I/II Mine with AD 104 and BV 3

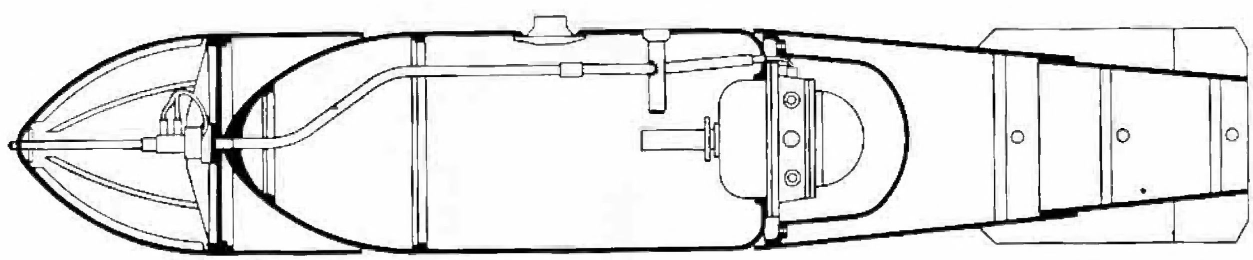


Figure 76a - BM 1000 M Mine with MA 102 and BV 2

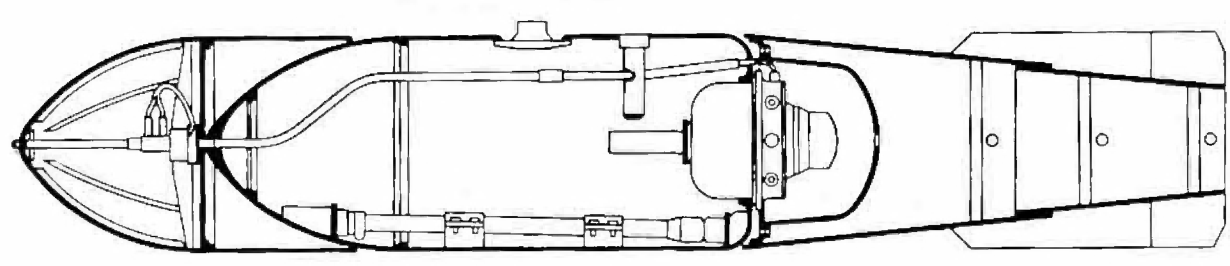


Figure 76b - BM 1000 J-II Mine with JDA 102/103 and BV 2 pointed time, the firing unit is put into the circuit and starts its arming cycle.

If the rate of deceleration is greater than 200g, as in the case of impact with a hard surface such as concrete or rock, the mine fires as an instantaneous bomb. No self-disarming devices are fitted.

BM 1000 II. The BM 1000 II is the same as the BM 1000 I, except for the unit-housing holding studs. These have been strengthened to withstand the shock of impact when the mine is dropped without a parachute.

BM 1000 C. The BM 1000 C was fabricated of Dynal, a resin-treated pressed paper, and produced in experimental quantity only. It was under development and had not been used operationally. It was fitted for conventional-type BM 1000 units and accessories.

Description

Length	69 in.
Diameter	26 in.
Material	Dynal
Weight of charge	1,500 lb.
Total weight	1,750 lb.

BM 1000 H. The BM 1000 H was developed in 1940 for the MA 101 and MA 102 Mine units, which required a larger unit opening than the BM 1000 I. The holding studs for the unit and the unit protective covering are arranged differently, and the mine case is slightly longer than the BM 1000 I.

Description

Length	64 in.
Diameter	26 in.
Weight of charge	1,[illegible]00 lb
Total weight	1,950 lb.

BM 1000 J. The BM 1000 J series was designed for use with induction mine-firing units. They are the same as the BM 1000 M, except for the addition of coil rods and case material. The ogive and tail sections of the "J" series are made of steel, and the cylindrical section is made on non-magnetic, 18% manganese steel.

The BM 1000 J mines differ in the following manner:

BM 1000 J-I has an 11-lb. nickel coil rod with copper winding.

BM 1000 J-II has a 3-1/2-lb. nickel coil rod with aluminum winding.

BM 1000 J-III has a coil rod similar to the one used with the BM 1000 J-II, but with a winding of higher resistance.

The BM 1000 J-I and II were designed for the JDA 105 mine unit, and the BM 1000 J-III was designed for the AJ 102 mine unit. None of these mines was used operationally in World War II.

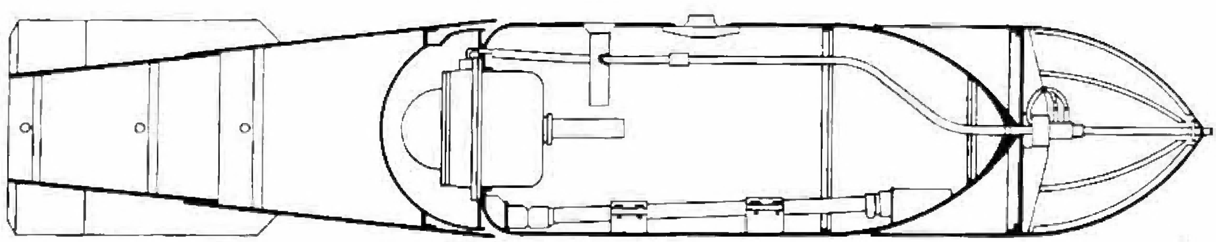


Figure 77a - BM 1000 J-I Mine with JDA 101 and BV 2

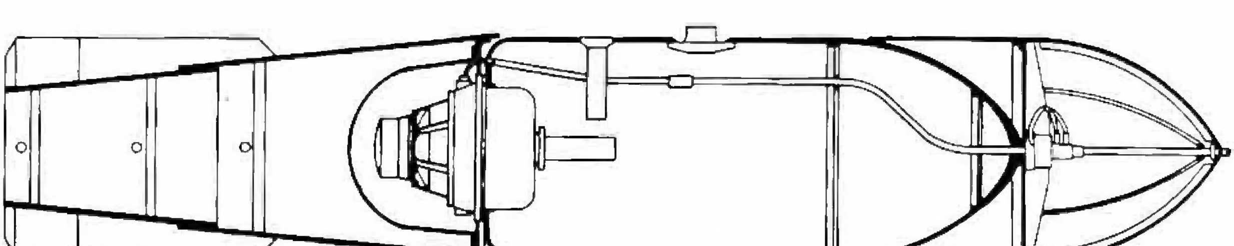


Figure 77b - BM 1000 M Mine with ADJ 101 and BV 2

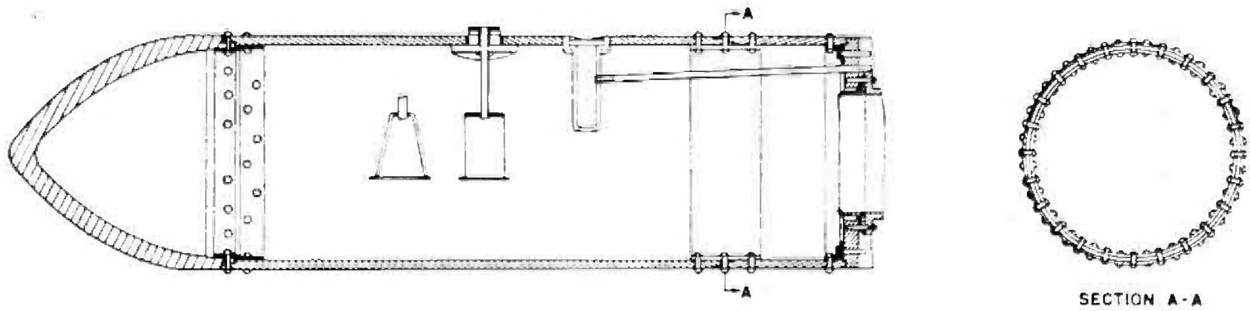


Figure 78 - BM 1000 C Mine - Cross Section

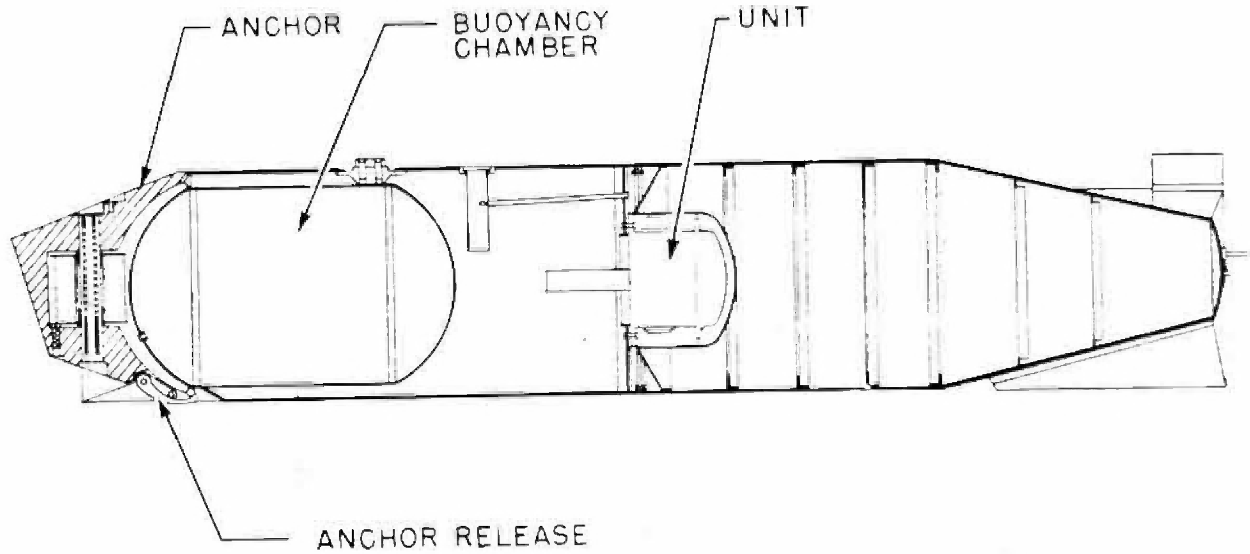


Figure 79 - BM 1000 T Mine - Cross Section

BM 1000 M. The BM 1000 M is the same as the BM 1000 H, except for two minor modifications.

A conduit runs from the fuze pocket to the nose, which holds the leads from the electric firing of the "Bugspiegle" releasing squibs.

The suspension lug is 1-1/8 in. lower.

BM 1000 T. The BM 1000 T was an attempt at making an aircraft-laid, moored mine with the same dropping characteristics as other mines of the BM 1000 series. It was designed to be fitted with an A 107 unit. Development on the mine was started in the fall of 1942 and abandoned in 1944 because the dropping test results were unsatisfactory.

Description

Length of case	122 in.
Length of anchor	20-1/2 in.
Diameter of case	[illegible] in.
Weight of charge	[illegible] lb.
Weight of anchor	[illegible] lb.
Total weight of assembly	2,420 lb.
Length of mooring cable	490 ft.
Diameter of mooring cable	1/4 in.

Permissible dropping heights. Without a parachute it can be dropped from heights of 165 to 1,000 feet in depths of water from 100 to 130 feet at speeds up to 220 m.p.h.

With an LS 3 parachute it can be dropped from heights of 165 to 1,650 feet in depths of water from 100 to 130 feet at speeds up to 220 m.p.h.

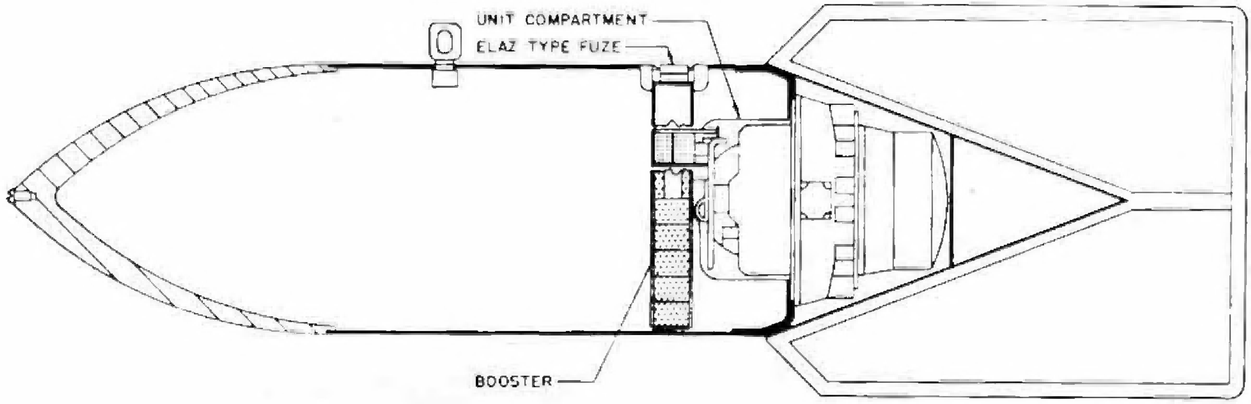


Figure 80 - BM 250 Mine - Cross Section

BM 500. The BM 500 mine is a modified SC 500 bomb designed to be fitted with the DA type mine units. This mine was in the early developmental stage, and no specimens were available. No tests had been made to determine permissible dropping heights, but it was believed that with an LS 3 parachute it could have been dropped from a height of 1,300 feet at speeds of 435 to 550 m.p.h in depths of water at least 50 feet.

Description

Length of case	57 in.
Diameter of case	18 in.
Weight of charge	660 lb.

BM 250. The BM 250 mine is a modified SC 250 E bomb designed to be fitted with the D 103, D 113, D 123, and D 133 mine units.

Description

Length	42 in.
Diameter	15 in.
Weight of charge	265 lb.
Total weight	550 lb.

Permissible dropping heights. With the tail assembly but without a guide parachute, it can be dropped from heights of 325 to 2,600 feet in depths of water from 10 to 50 feet at speeds up to 220 m.p.h.

With guide parachute LS 3, it can be dropped from heights of 325 to 2,600 feet in depths of water from 10 to 50 feet at speeds up to 400 m.p.h.

BUGSPIEGLES

The Bugspiegle is a flat-nosed, cylindrical cardboard fitting used on the nose of BM 1000 mine to break up the streamlining and decrease the speed of the mine in descent. The mine must be streamlined in transit before release from the plane: this is accomplished by a "Bugverkleidung" (streamlined false nose). This false nose is released from the mine assembly prior to the release of the mine from the plane.

The two types of Bugspiegles differ in the type of material used in their construction. The BS 1 is made of pressed paper, and the BS 2 is constructed of Dynal, a resin-treated pressed paper. These two types differ in the manner in which their releasing squibs are fired. The squibs in BV 2 are fired electrically by the bomb fuze, and the squibs of the BV 3 are fired mechanically by a lanyard attached to the plane.

BS 1 and 2. The fitting is a cylindrical, laminated-paper section, 20 inches long and 26 inches in diameter, open at its after end and drilled with a hole through the longitudinal axis of the forward end. This hole receives a securing rod, the after end of which is secured to a threaded recess in the charge case.

Bugverkleidung BV 2 and BV 3. A steel ogival section, 25 inches long and 26 inches in diameter consists of six overlapping, petal-shaped pieces held together at their forward and after ends respectively by a small nose cap and a steel ring. One petal is drilled with a 1 inch hole to allow passage of an arming wire to two small-delay detonators on the charge case. This section is secured to the plastic afterbody by six screws. The securing rod, which also passes through the longitudinal axis of this section, secures at its forward end to the small nose cap and serves to attach both the forward section and the afterbody to the charge case.

Operation. The Bugspiegle is assembled as shown in figures 75a and 75b and is held in place by a screw in the nose of the BM 1000 mine. The BV 2 and BV 3 consist of several petals which are held in place by the rod shown in the figures. Upon release of the mine from the plane, the squibs of the BV are fired, releasing the holding rod, and the petals that make up the BV fall off.

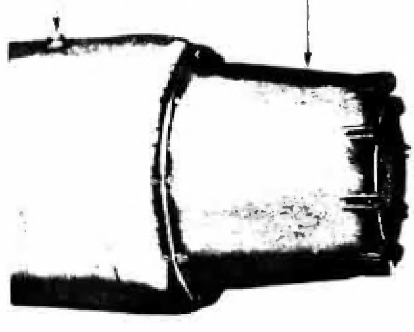


Figure 81 - BM 1000 Mine with SH 8 and 9

leaving only the Bugspiegle.

The Bugspiegle was abandoned because no appreciable increase in dropping height could be obtained. The maximum height from which a BM 1000 could be dropped with a Bugspiegle was 8000 feet.

SCHUTZHAUBES

Schutzhaubes are protective covers for mine units of the BM series mines. They are bolted on over the mine units to protect them from shock due to impact. The design of the covers differed according to the types of units used in the BM 1000 mines.

SH 1 and 2.

Type - a truncated cone, rounded at its after end and fitted with a flange at its forward end. It is 26 inches in diameter at the flange, 20 inches in maximum diameter on the conical section, and 16 inches long. It is secured to the charge case by 10 studs. Magnetic needle, acoustic, or acoustic-pressure units may be fitted.

SH 3 and 4.

Type - a truncated cone with a cylindrical base, rounded at its after end and fitted with a flange at its forward end. It is 26 inches in diameter at the flange, 19 inches in maximum diameter on the conical section, and 19 inches long. It is secured to the charge case by 10 studs. Ten equally-spaced drogue-securing lugs are fitted around the after end of the dome and a metal ring, 8 inches in diameter, is welded to this end. Magnetic needle, acoustic, or acoustic-pressure units may be fitted.

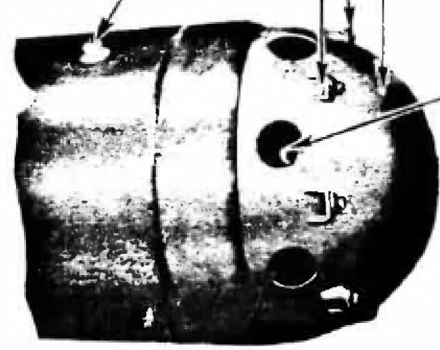


Figure 82 - BM 1000 Mine with SH 7

SH 7.

Type - hemisphere, 26 inches in diameter, fitted with eight holes, 3-1/5 inches in diameter, around its periphery. These holes give access to the eight studs which secure the dome to the charge case. It is fitted with eight equally-spaced brackets for securing the tail section. Only magnetic-acoustic units may be fitted.

SH 11.

Type - a truncated cone with a cylindrical base, rounded at its after end and fitted with a flange at its forward end. It is 26 inches in diameter at the flange, 19 inches in maximum diameter on the conical section, and 19 inches long. It is secured to the charge case by 10 studs. Magnetic needle, acoustic, or acoustic-pressure units may be fitted.

LEITWERKE (LW)

Leitwerkes are resin-treated, pressed paper, aerodynamic tails utilized with the BM 1000 mines except when the SH 8 and 9 are used in which case the LS 3 parachute is depended on to maintain ballistic stability. They consist of a truncated cone fitted with four radial fins enclosed in a shroud ring secured to the domes of the mines by rivets. These tails break off upon impact.

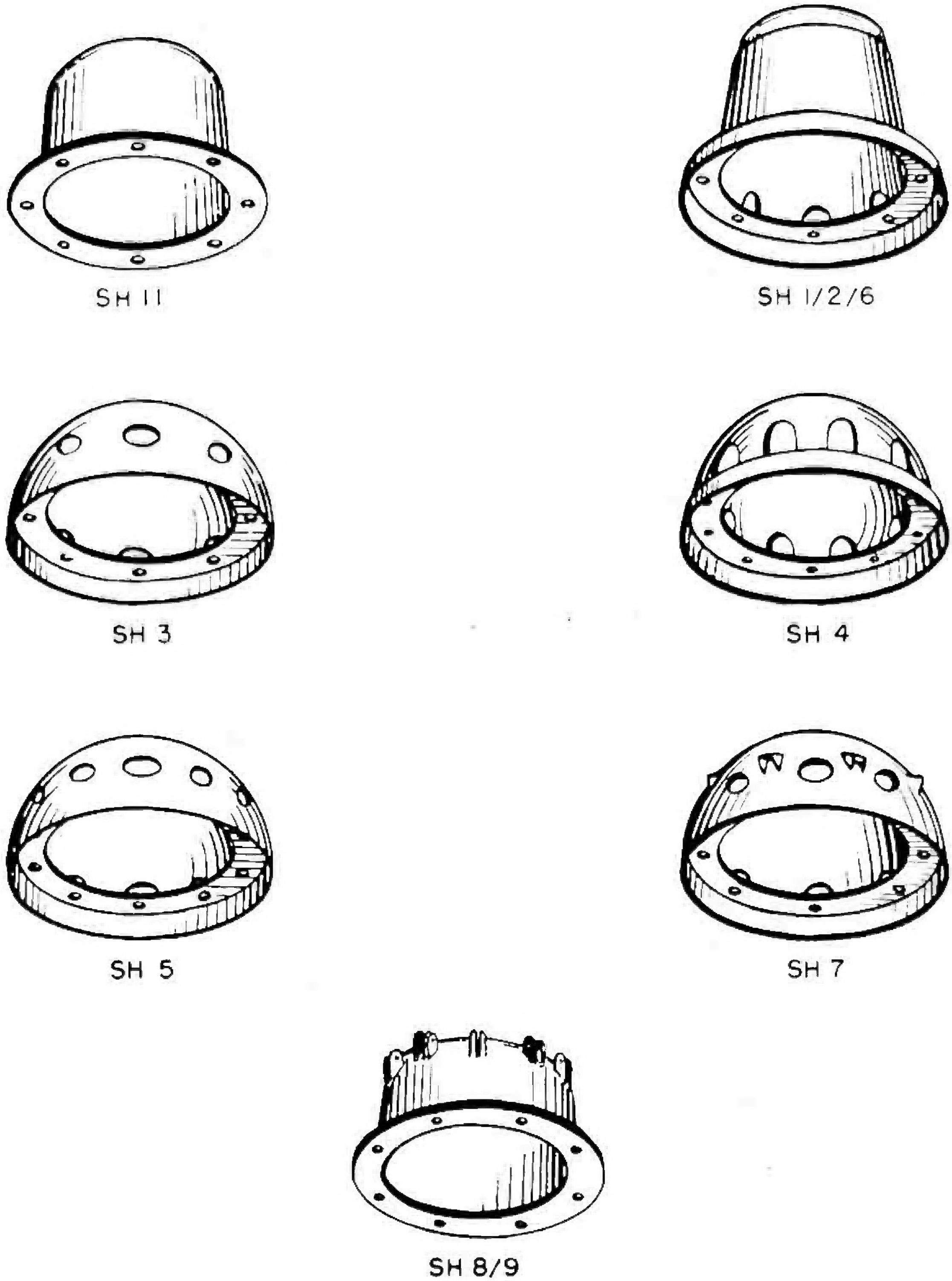
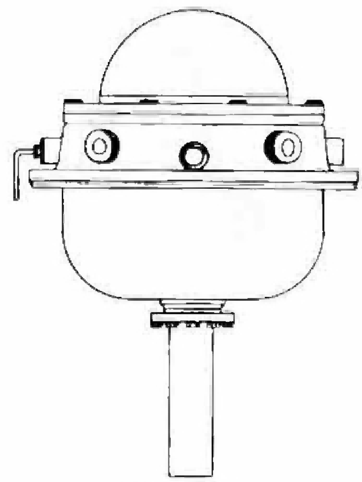
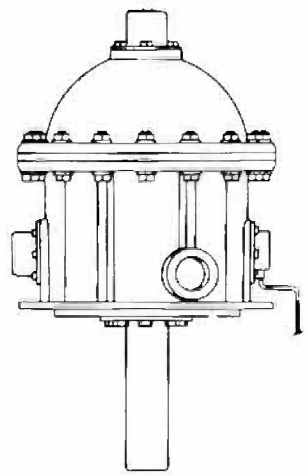


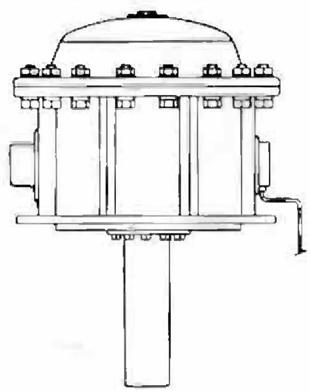
Figure 83 - Schutzhaubes



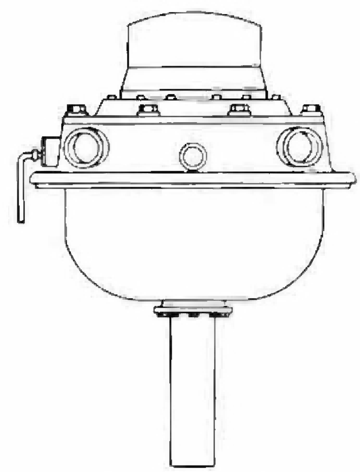
MA 101/102



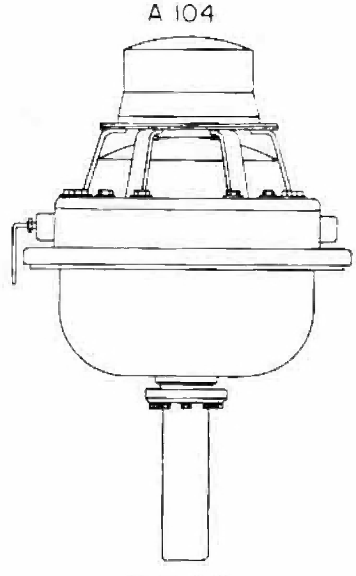
M 101/103



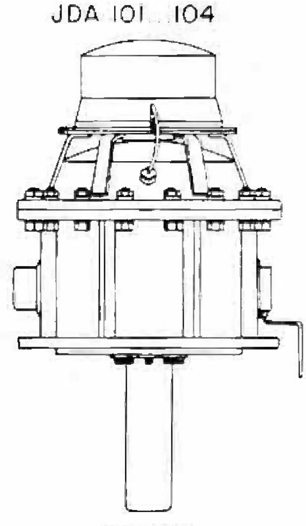
A 104



JDA 101...104



AJD 101



AD 104

Figure 84 - BM 1000 Mine Unit Housings

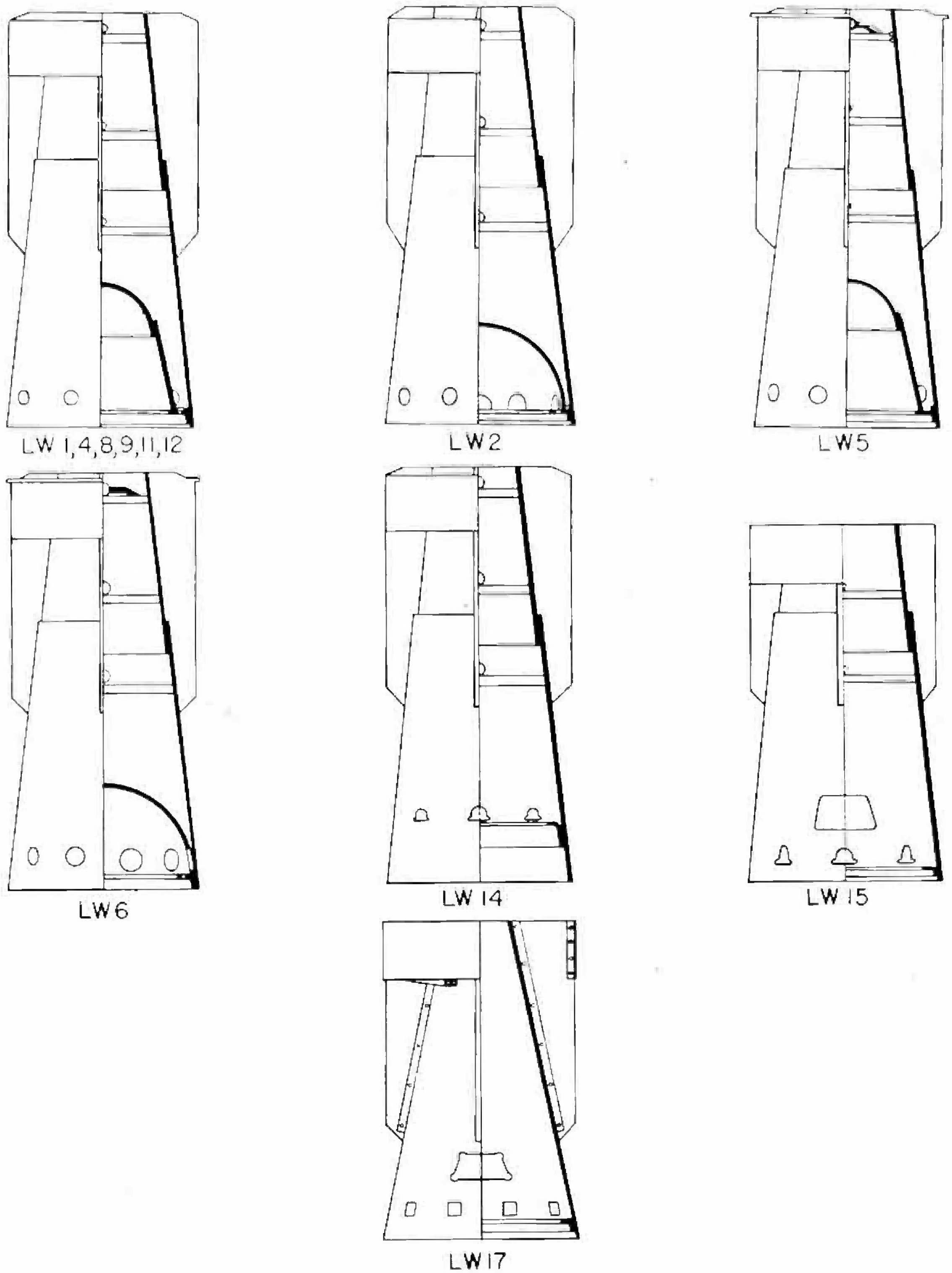


Figure 85 - Leitwerkes

ASSEMBLY PLAN - BM 1000 MINES

Unit ZUNDGERAT	Mine Case KORPER	Protective Cover SCHUTZHAUBE	Plastic Tail LEITWERK	Speed-Retarding Nose BUGSPIEGEL	Fuse AUFSCHLAGZUNDER	Extension Cap ZUNDERZWISCHENSTUCK	Streamlined False Nose BUGVERKLEIDUNG
1	2	3	4	5	6	7	8
M 101	BM 1000 I	In LW	LW 5 LW 8 LW 11	BS 1 BS 2	ElAz 56 AI 0.9	z 56 III	BV 1 or 3
	BM 1000 I	In LW	LW 9 LW 12				
M 103 M 104 AD 104	BM 1000 I	In LW	LW 5 LW 8 LW 11	BS 1	ElAz 56 AI 0.6	z 56 III	BV 1 or 3
	BM 1000 II	In LW	LW 9 LW 12	BS 2			
MA 101	BM 1000 H	SH 7	LW 14	BS 1 BS 2	ElAz 56 AI 0.6	z 56 III	BV 1 or 3
MA 102	BM 1000 H	SH 8	LW 15	BS 1 BS 2	ElAz 56 AI 0.6	z 56 III	BV 1 or 3
	BM 1000 H	SH 8	LW 15	BS 1 BS 2	ElAz 56 Zeit		BV 2 (BV 1 or 3)
J(D)A 101	BM 1000 J-I	SH 7	LW 14	BS 1 BS 2	ElAz 56 Zeit		BV 2 (BV 1 or 3)
JDA 102 JDA 103 JDA 104	BM 1000 J-II	SH 9	LW 15	BS 1 BS 2	ElAz 56 Zeit		BV 2 (BV 1 or 3)
AJD 101	BM 1000 M	SH 8	LW 15	BS 1 BS 2	ElAz 56 Zeit		BV 2 (BV 1 or 3)
	(BM 1000 H)	(In LW)	(LW 13)	(BS 1)	(ElAz 56 AI 0.6)	(z 56 III)	(BV 1 or 3)

Note: The types in parenthesis are possible combinations that were not used.

Figure 86 - Assembly Plan - BM 1000 Mines

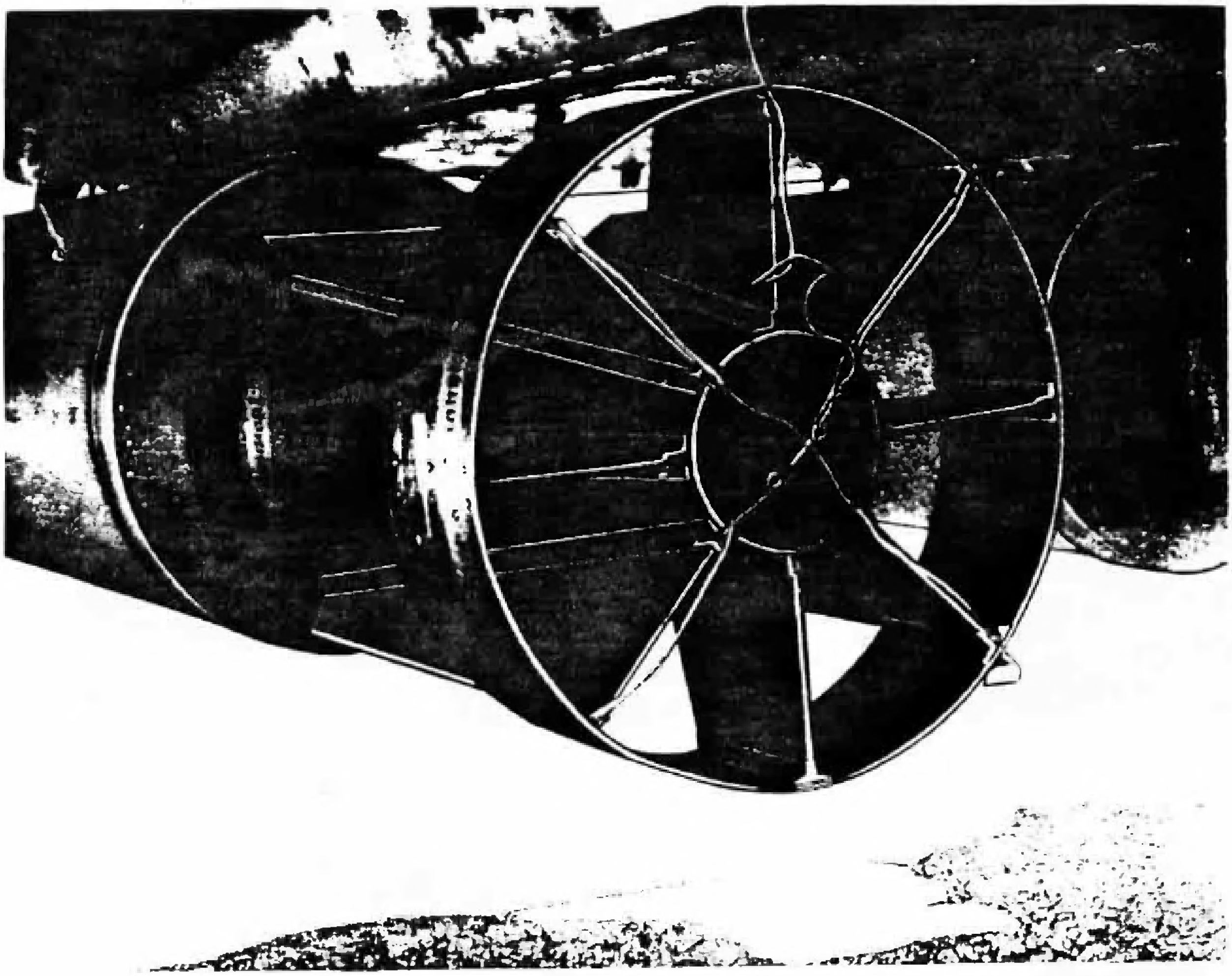


Figure 87 - LS 1 on Plane in Flight

BM 1000 PARACHUTES

The Luftwaffe experimented considerably with mine parachutes to improve ballistic stability and accuracy, and to increase the dropping heights of mines and laying speeds of planes. Most of the experimentation was carried on at the Forschungsanstalt Graf Zeppelin in Stuttgart-Ruit. Finally, after much experimentation, three types of small parachutes were developed and accepted for use with the BM 1000 mines. These three types were known as the LS 1, LS 3, and LFS-08. The LS 1 and LS 3 were used operationally. The LFS-08 was ready for operational use.

LS 1. The LS 1 is a small pack parachute fitted into the after end of the LW 17. The parachute (30 in.diam.) is made from loosely woven, reinforced rayon. It is camouflaged with 12 green, woven, rayon shrouds approximately five feet long. It is packed in a light brown, cloth pack which fits loosely in the tail section of the mine and is secured to the shroud ring with four steel wire leaders by four clamps. The 12 shroud lines are, in turn, secured to the four wire leaders, and the static line is secured to the plane.

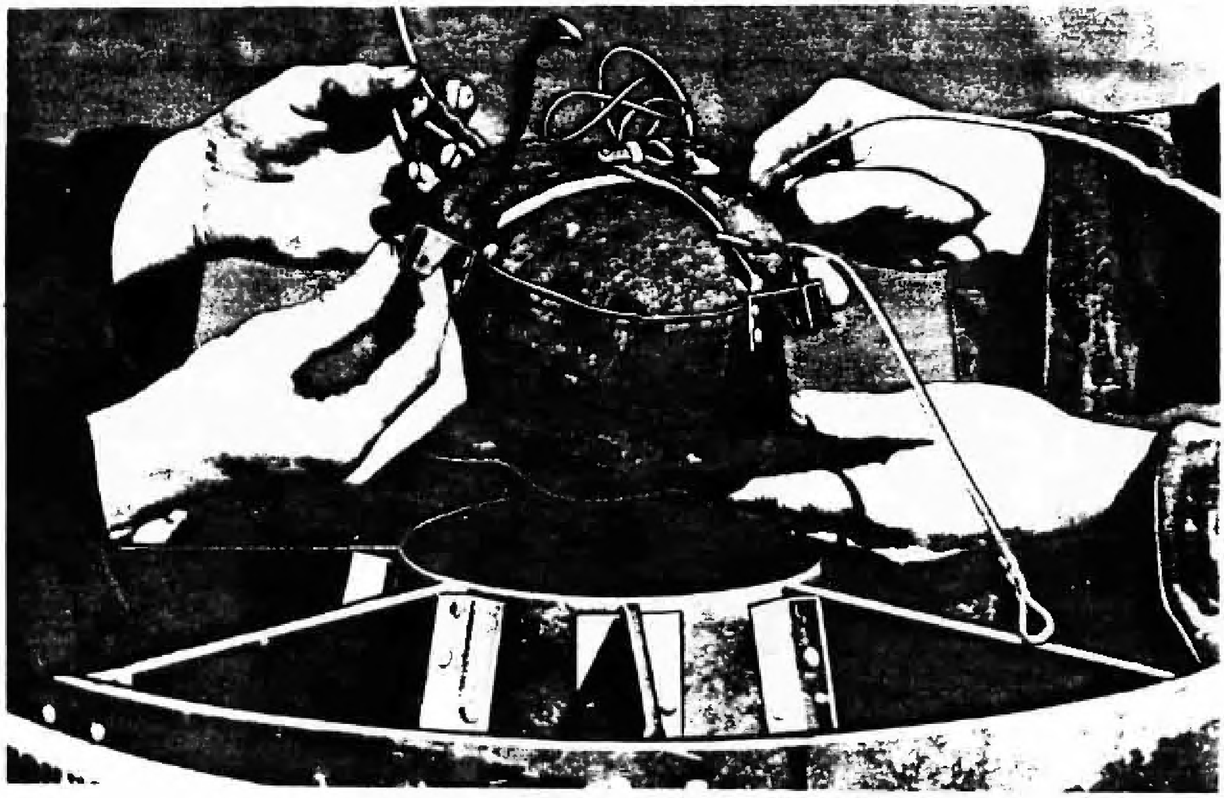


Figure 88 - Fitting LS 1 to LW

Figure 89 - LS 3 on BM 1000 Mine

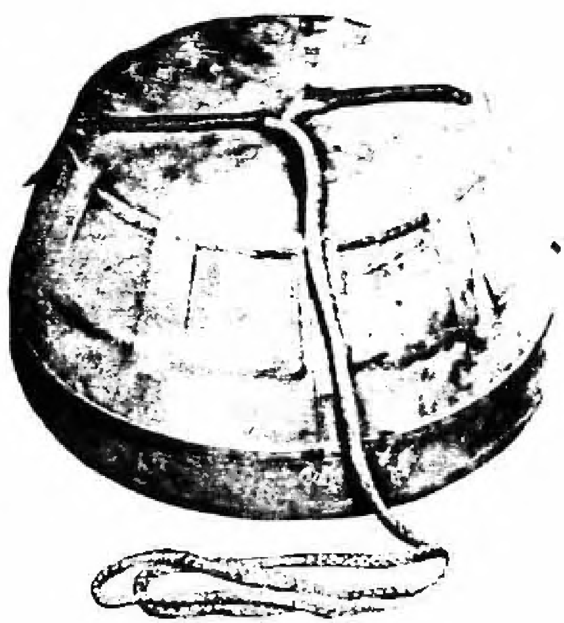


Figure 90 - LF S 08 Parachute

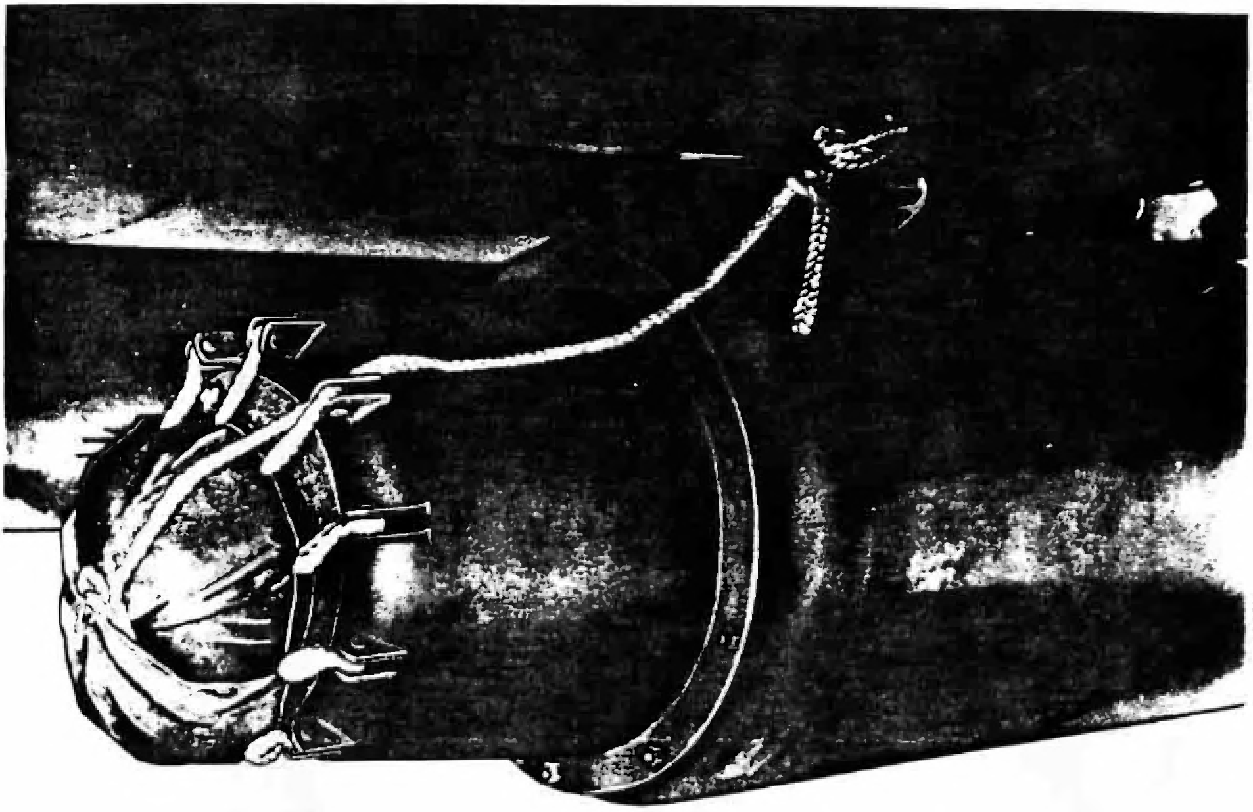
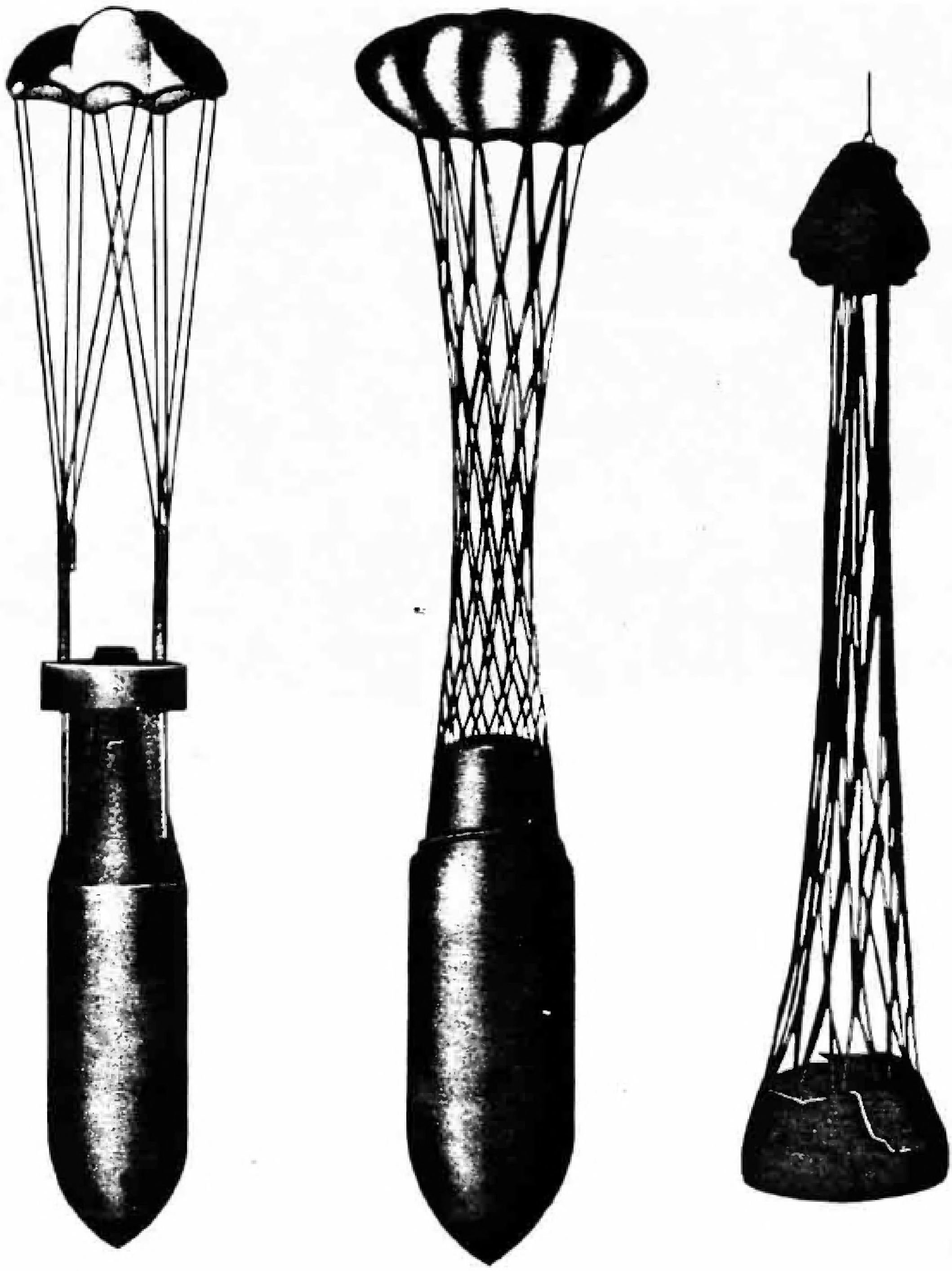


Figure 91 - LS 3 on Plane in Flight

LS 3. The LS 3 is a small parachute used on the BM 1000 mines with the SH 7, 8, and 9 and without the LW. The parachute (40 in. diam.) is made from loosely woven reinforced rayon. It is green, with 10 white, woven rayon shrouds approximately eight feet long. It is packed in a reinforced brown canvas bag 12 inches in diameter. The 10 shrouds are attached to the shroud lugs of the SH, and the 20-foot static line is flemished atop the pack and partially covered by four canvas petal flaps. The loose end of the static line is attached to a lug on the plane.

LFS-08. The mine parachute (32 in. diam.) is made from loosely woven, reinforced rayon. It is colored green with 20 white, woven, rayon shrouds approximately seven feet long. The parachute housing is a truncated ogive (22 in. base diam., 16-1/2 in. top diam., 11-1/2 in. height), the bottom half of which is constructed of cast steel and the top half of wood. The parachute and shrouds are contained within a cavity, 3-1/2 inches deep, in the top of the housing and covered with blimp cloth, which is torn apart to release the parachute when the mine is dropped. The parachute was housed on an experimental-type SH, and the 10-foot static line was faked on top of the pack. This parachute was still under development at the end of the war.



LS I IN FLIGHT

LS 3 IN FLIGHT

LFS-08

Figure 92 - Parachutes in Flight

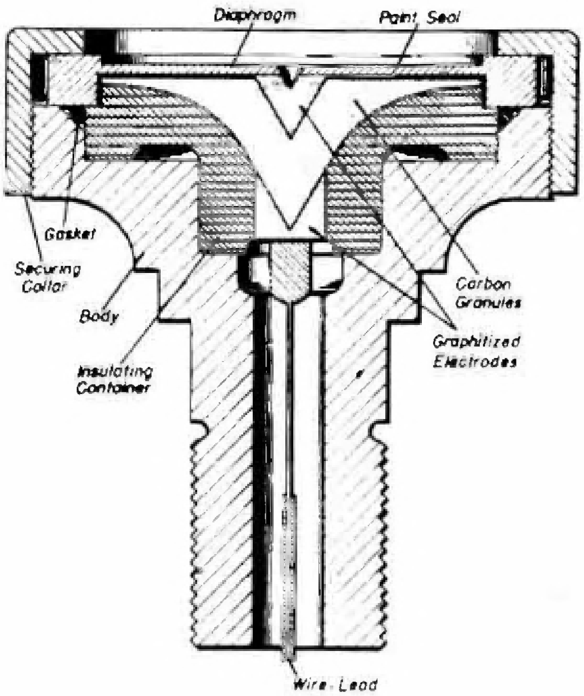


Figure 93 - Diaphragm Microphone

SPECIAL ACCESSORIES USED WITH BM 1000

Rheinmetall Bomb Fuze - Type 157/3. While the mine is being carried by the laying aircraft, the two spring-loaded charging plungers are depressed. As the mine is released and starts to drop, a potential of 180 volts is applied to the plungers, which act as a positive terminal, the fuze body being the negative terminal. When the mine clears the plane, the plungers spring up and arm the fuze firing circuit.

The fuze has two functions, as follows:

1. If the mine strikes a hard surface producing a deceleration of over 200g, an inertia bolt switch closes, firing the instantaneous detonator.

2. If the mine strikes a surface producing a deceleration of between 20 and 200g, one or both of two vibrating "trembler" switches closes, discharging the condenser through an electric igniter in the master switch.

Master Switch. The master switch is a positive-locking, single-pole, single-throw type, the body of which contains two spring-loaded contact plungers which bear against a contact block inside the firing device. Each of these plungers in turn is connected to an additional spring-loaded contact plunger

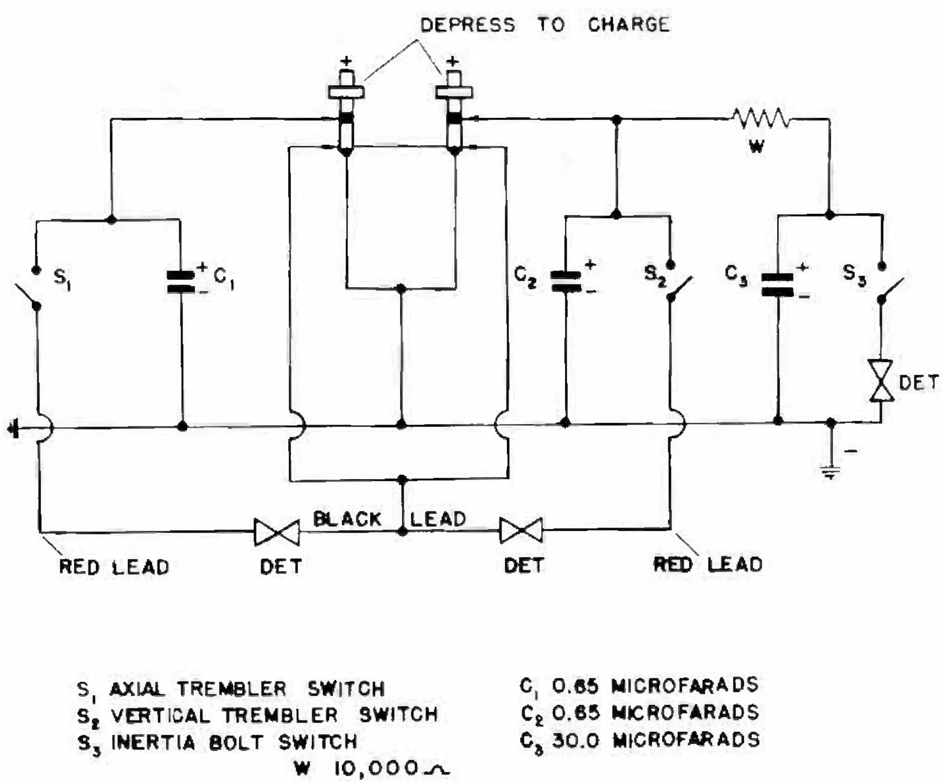


Figure 94 - Rheinmetall Fuze Circuit

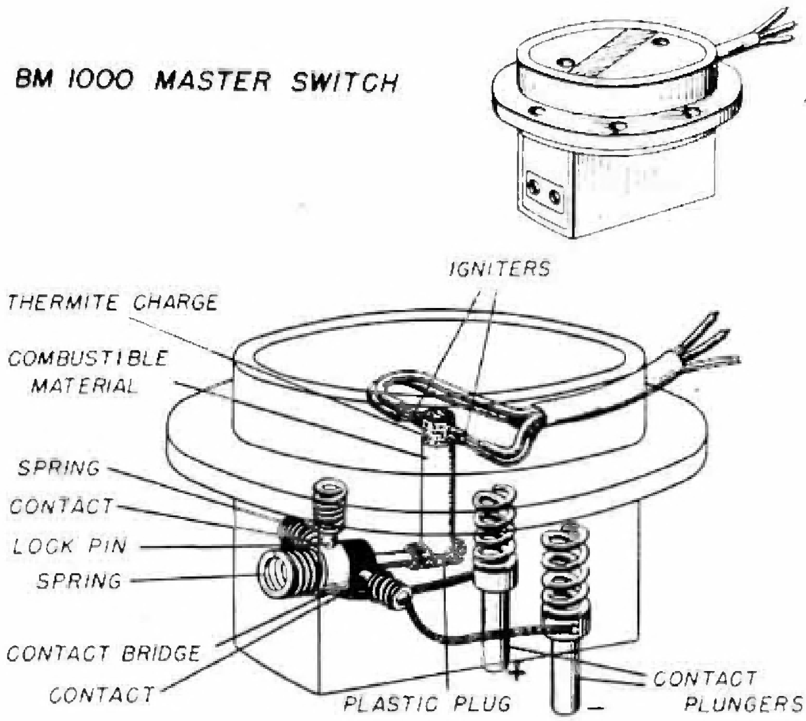


Figure 95 - BM 1000 Master Switch

which bears against an insulated portion of the contact bridge plunger.

When the Rheinmetall fuze discharges through one or both of the switch igniters, a thermit cartridge ignites. This in turn ignites combustible material inside the switch, and the resulting heat melts a plastic plug which holds the contact bridge open. Spring tension then forces the contact bridge plunger into the molten plug, thereby bridging the two side contact plungers and closing a switch in the firing circuit. A spring-loaded detent holds the contact bridge plunger in the closed position.

<u>Fuse Delay Switch (Figure 96)</u>. This switch is an electrically-operated delay type used in conjunction with delay bomb firing and period delay mechanism operation in this mine. It consists of a small cylindrical shell, D, mounted in a fuze clip, L, on an insulating board, I. A circuit is made from H to K through the spring copper strip, G, down the spring-loaded spindle, F, which is held in place by the adhesive action of a soft solder

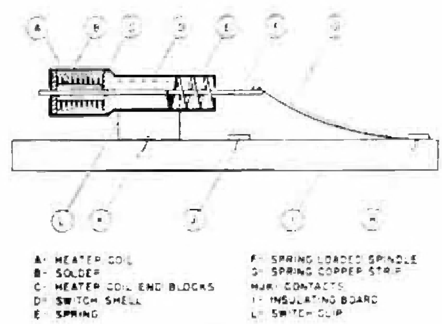


Figure 96 - Fuse Delay Switch

plug, B. The circuit continues from the spindle into the heater coil, A, and out through the shell, D. At the end of a heating period predetermined by the basic switch design, the solder melts and spring, E, forces spindle, F, to the left, thus breaking the circuit from H to K and making a circuit from H to J through the conducting strip, G.

Chapter 7

SUBMARINE-LAID MINES

THE SM MINES

The German Schact Minen (SM) mine series consisted of three types, SMA, SMB, and SMC. The SMA was the only mine of this series that was used operationally.

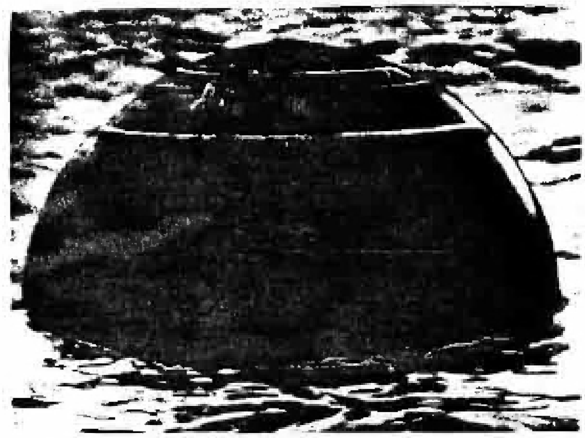


Figure 97 - SMA Mine Afloat

<u>The SMA Mine.</u> The SM moored, influence mine series was designed for laying by the type VII-D and X-B submarines. These submarines were fitted with special shafts to accomodate this type of mine. The design of the SMB was undertaken in 1937 at low priority. This mine was primarily intended for use in American waters. The SMC was completed in 1944 and was ready for operational use prior to the end of World War II.

Possible Units

1. M 3, A 7
2. M 4, AE 1

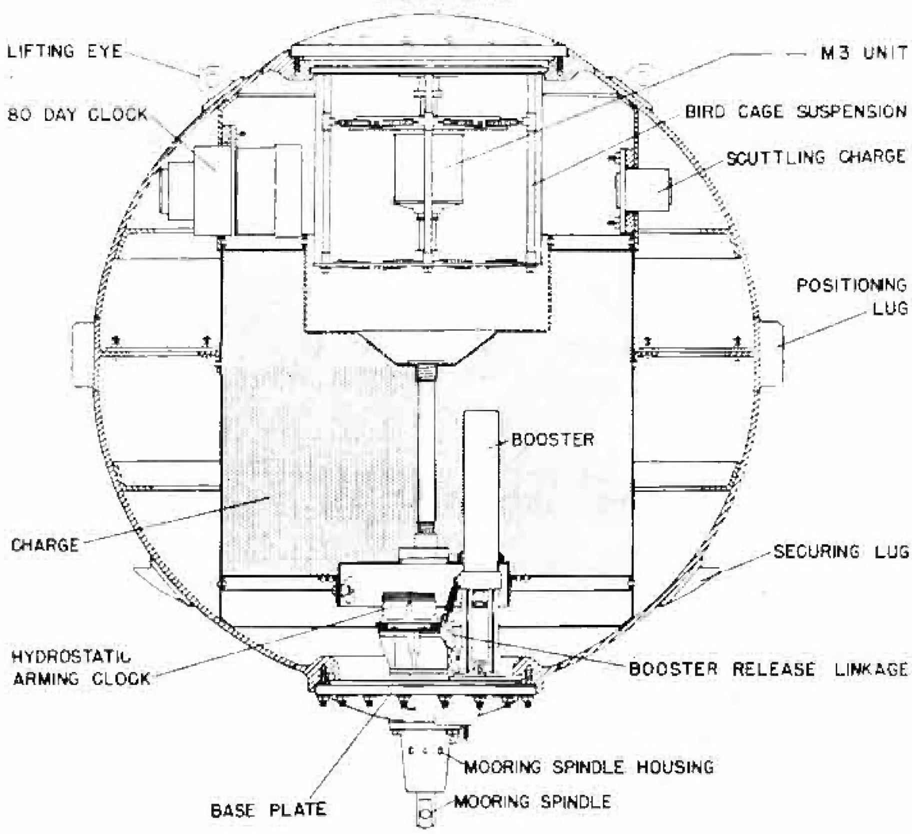


Figure 98 - SMA Mine - Cross Section

Figure 99 - SMA Mine with Anchor

Description of Case

Shape	Two hemispheres, joined by a 5-in. cylindrical midsection
Material	Aluminum (KSS)
Diameter	46 in.
Length	56 in.
Charge	750 lb. block-fitted hexanite

Description of External Fittings

Cover plate	19-in. diam., in center of upper hemisphere, flush type, secured by 18 bolts
Base plate	15-in. diam., in center of lower hemisphere, lap-fitted, secured by 18 studs; fitted with straight-shank mooring spindle and detonator strongback
Lifting eyes	Two, 180° apart on upper hemisphere, 24-1/2 in. from center
Anchor-securing lugs	Three, angular-shaped, 120° apart on lower hemisphere, 29-1/2 in. from center.
Positioning lugs	Two, fin-shaped, 180° apart on cylindrical mid-section

Operation. The mine took depth by a loose-bight hydrostat system. Mooring tension pulled out the mooring spindle, tripped the booster-release lever, and released the locking balls from the clock-starting spindle. Water pressure depressed the clock spindle at a depth of 15 feet, starting the clock. The clock ran off its delay period, and the unit started its testing cycle.

The only self-disarming device was the 80-day clock which was designed to scuttle the mine if the clock stopped at any time prior to completion of its set period or upon completion of its set period.

The SMB Mine. In 1937 the SMB mine was in development at low priority for use in depths of 6,750 to 10,000 feet. It was designed to use a large steel case, and it was to employ a new-type anchor to be designed. The SMB mine case was of the same diameter as the SMA, but was approximately double the length. It was to be laid by the same type submarine as the SMA mine.

The SMC Mine. The SMC was identical to the SMA, except for a few modifications to the anchor. These consisted of the removal of the anchor doughnut and the substitution of a 60-day clock to obtain delay in rising.

THE TM MINES

The German Torpedo Minen (TM) mine series consisted of four types of influence mines, all of which could be laid from the torpedo tubes of submarines. These four types were designated TMA, TMB, TMC, and MTA. Each type was used operationally during World War II.

The Germans commenced the development of the TM mine series in about 1928, when the design of the TMA was begun. While the TMA was in development, the TMB I, TMB II, and TMC I were also under development. As a result of this early start, the TMB and TMC cases, using the M 1 unit, were ready for operational use at the outbreak of the war. The TMA case was ready at the same time, but its magnetic unit, the M 2, was not ready until 1940. The other mines of this series, which were all late developments, were the TMB III, TMB (S), TMB (mit Auftriebskorper), "with flotation chambers," TMC II and MTA. All of these mines were used operationally during the war.

The TMA I Mine. This mine was the only moored mine of the series. Prior to the completion of the M 2 magnetic unit, a contact pistol was designed for the mine. This pistol was a pendulum type styled after the Russian 1906 pistol used in the Russian mines M 12, M 26, and PLT. The evidence as to whether this pistol was used operationally is conflicting, the prisoners of war interrogated having voiced different opinions on the subject. Since no documents were available, a

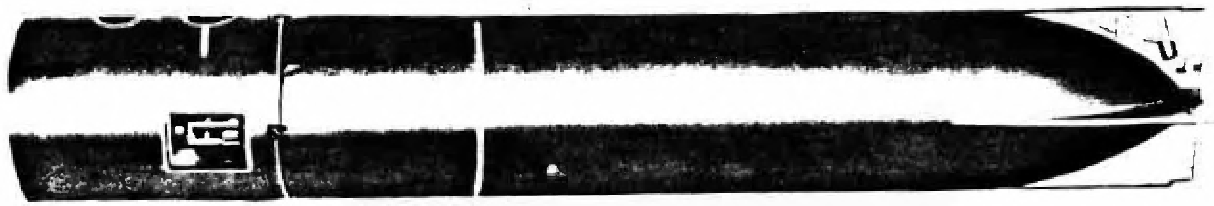


Figure 100 - TMA Mine with Anchor, Ready for Laying

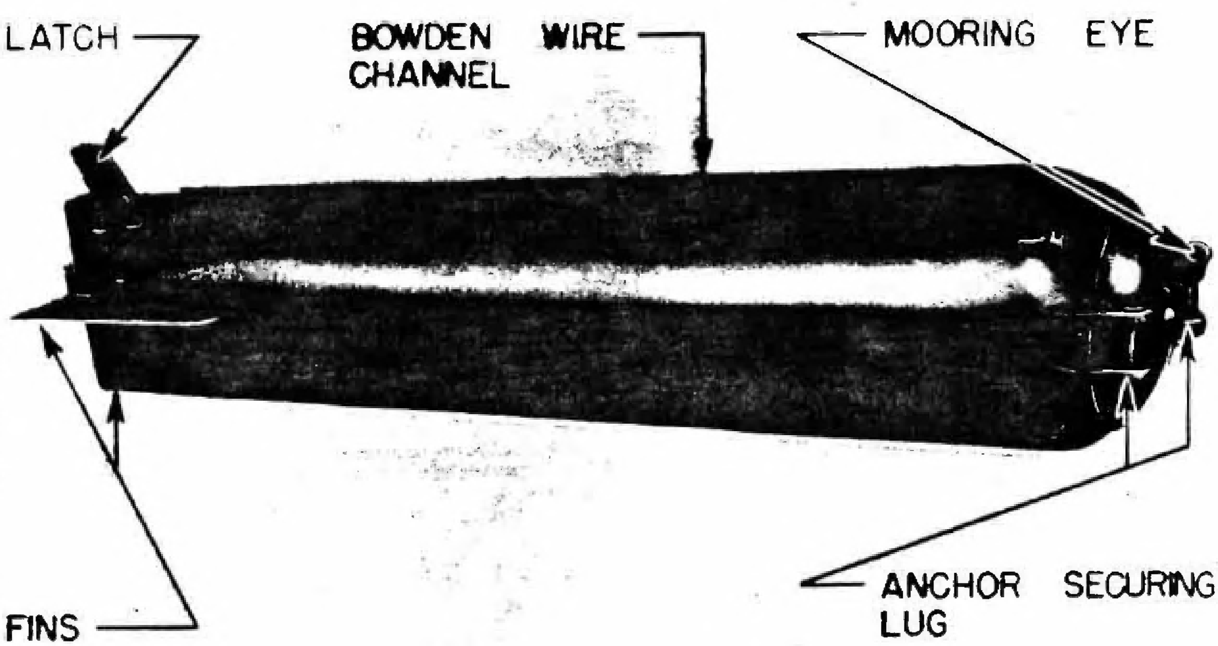


Figure 101 - TMA 1 Mine

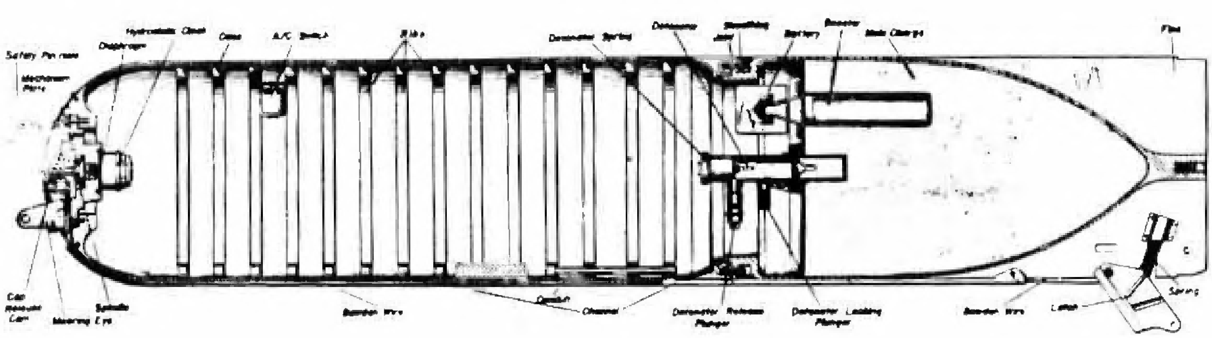


Figure 102 - TMA Mine - Cross Section

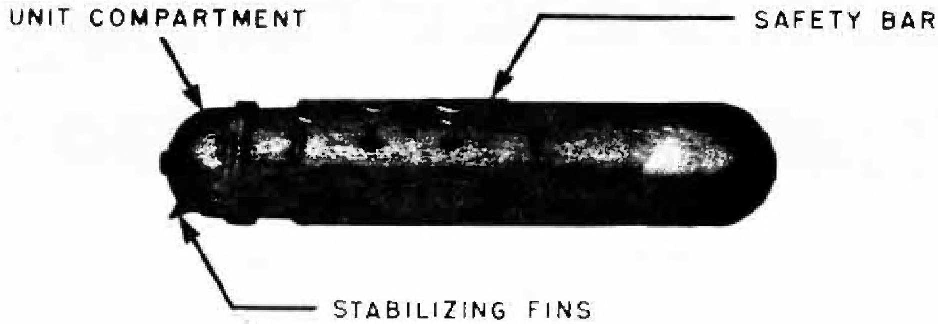


Figure 103 - TMB (S) Mine

definite answer to this question cannot be given.

The M 2 magnetic unit which was designed for the TMA proved unsatisfactory. Consequently, only a small quantity of TMA mines were laid. Toward the close of the war, the M 3 was adapted for use with this mine, so that existing stocks could be utilized.

Description of Case

Shape	Cylindrical, with hemispherical nose and tapered, finned tail
Material	Aluminum (KSS)
Diameter	21 in.
Length	9 ft. 3-1/2 in.
Charge	475 lb. cast hexanite

External Fittings

Bowden wire channel	180° from top center line, extends full length of case
Positioning lugs	Five, on nose, 30°, 120°, 210°, 270°, and 300° respectively from top center line; 7 in. from center
Securing lugs	Two, on nose, 90° and 270° respectively from top center line; 7 in. from center
Mechanism plate	11 in. diam., on nose, secured by 15 studs; covered by fairing, 16 in. diam., which is cut away to permit access to the mooring eye and securing lugs
Safety latch	On lower fin, in line with bowden wire channel, spring-loaded, controls bowden wire
Joining flange	5 ft. 6 in. abaft the nose, covered by two sections of semicircular sheathing, 2 in. wide
Fins	Four, 0°, 90°, 180°, and 270° from top center line, at after end; 2 ft. 4 in. long, 9 in. wide

Operation. When the mine is launched, the safety latch springs out, pulling the bowden wire. This unlocks the spindle of a hydrostatic clock. Water pressure depresses the clock spindle at a depth of 15 feet, starting the clock. The clock spindle, once depressed, is locked in. The clock runs off its delay setting, allowing the detonator to house in the booster, and the firing unit begins its arming cycle.

No self-disarming devices are fitted.

The TMB Mine. There are five models of this mine, TMB I, TMB II, TMB III, TMB (S) and TMB (mit Aufstriebskorper). These cases differ from each other as follows:

Description of Case

	TMB I-II	TMB III	TMB(S)
Material	KSS	KSS	KSS
Weight (lb.)	1,625	1,475	1,600
Main charge (lb.)	1,230	925	1,230
Length (overall)	92 in.	92 in.	103 in.
Shape	Cylindrical, with hemispherical ends. Deflecting fin on tail door.		

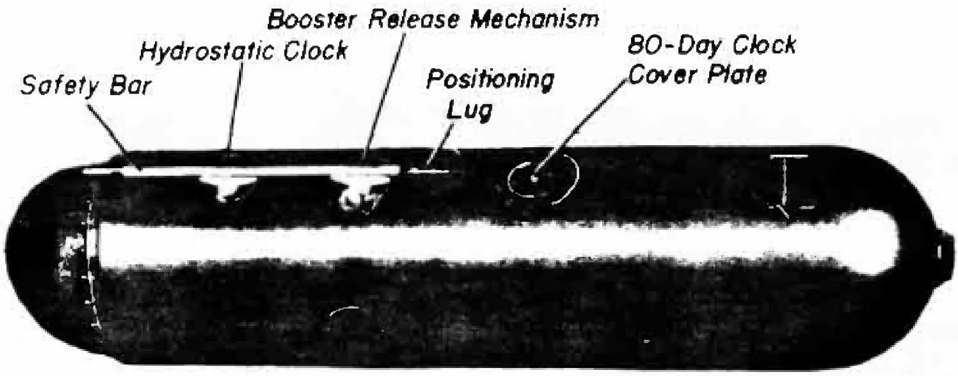


Figure 104 - TMB Mine

Description of External Fittings

Positioning lug	On top center line, 3 ft. 9-1/2 in. abaft the nose
Hydrostatic clock	6-in. diam., on top center line, 5 ft. 6-1/2 in. abaft the nose, secured by keep ring
Booster-release mechanism	4-in. diam., on top center line, 4 ft. 5 in. abaft the nose, secured by keep ring
80-day-clock cover plate	8-in. diam., on top center line, 3 ft. 2 in. abaft the nose, secured by keep ring
Detonator cover plate	4-3/4-in. diam., 180° from top center line, 4 ft. 6-1/2 in. abaft the nose, secured by keep ring
Filling holes	Two: one, 5-in. diam., threaded to nose; one, 6-in. diam., 90° from top center line, 4 ft. 6-1/2 in. abaft the nose; secured by four screws
Safety-bar clamp	On top center line at after end

The TMB I differs from the TMB II only in the method of constructing and securing the unit compartment. Whereas in the TMB I the unit compartment was cast aluminum (KSS) bolted into position, the compartment in the TMB II was all welded. The TMB III had a larger unit compartment than the TMB II, which accounts for the differences in weight. The TMB II and TMB III may be identified externally by the annular rabbet on the after end of each case. The widths of these rabbets are 3-1/2 in. and 11-1/4 in. respectively. Their purpose is to facilitate expulsion of the mines from the compressed-air discharge type torpedo tubes used by the Germans. The TMB (mit Aufstriebskorper) utilizes either the TMB II or the TMB III mine case with buoyancy floats bolted to each end. It was designed for demolition of enemy bridges, docks, etc.; and was laid by specially trained swimmers.

These mine cases were fitted with the following mine influence units:

TMB I-II	TMB III-S
M 1	DM I
A 2, A 2st	MA 2/3
AT 3	

The TMB (mit Aufstriebskorper) employed only a delay clock for firing, although influence units could be fitted if desired.

Operation. When the mine is launched, a spring-loaded safety bar is released from the top center line of the case, thereby unlocking the hydrostatic clock and booster-release mechanism. Water pressure depresses the clock spindle and operates the booster-release mechanism, respectively, at a depth of 15 feet, starting the clock and allowing the booster to house over the detonator. The clock runs off its delay setting, and the firing unit begins its arming cycle.

The only self-disarming device is the 80-day clock, which may be fitted to sterilize the mine at the end of its set period by shorting out the battery.

<u>The TMC Mine</u>. This mine was an enlarged TMB which was designed to meet the request of German field commands for a torpedo mine with a greater target area than the TMB. It existed in two models, TMC I and TMC II. The only differences between the two models was the size of the unit compartment, the weight of the charge and the total weight of the mine. The external appearance of the case is the same.

Figure 105 - TMC I Mine

Figure 106 - TMA Mine Afloat

Description

	TMC I	TMC II (Larger unit compartment)
Total weight lb.	2,450	2,200
Charge - lb.	2,050	1,760
Neg. buoyancy lb.	860	700 (600 when DM 1 used)
Length	134 in.	134 in.
Units fitted	M 1, A 2, A 2st, AT 3	DM 1, MA 2/3

Operation. When the mine is launched, a spring-loaded safety bar is released from the top center line of the case, thereby unlocking the hydrostatic clock and booster-release mechanism. Water pressure depresses the clock spindle and operates the booster-release mechanism, respectively, at a depth of 15 feet, starting the clock and allowing the booster to house over the detonator. The clock runs off its delay setting and the firing unit begins its arming cycle.

The only self-disarming device is the 80-day clock, which may be fitted to sterilize the mine at the end of its set period by shorting out the battery.

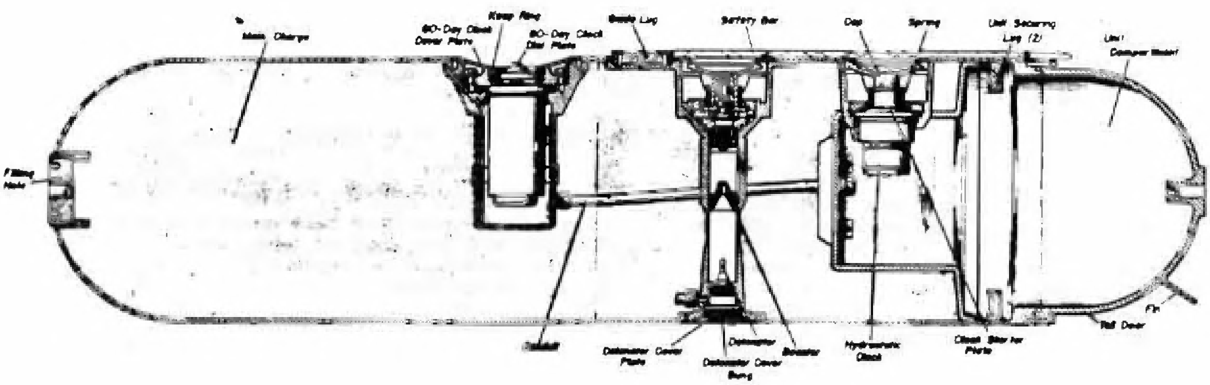


Figure 107 - TMB Mine - Cross Section

CONTROLLED MINES

THE KMB MINE

The KMB is a very simple controlled mine made of wood and concrete. It can be used as a normal controlled mine for firing by observation, as a magnetically monitored mine using the M 1 unit for night control, or as a combination of the two. It was designed early in 1944 to be used against landing craft and to be controlled from an observation point on shore.

Characteristics of the mine are as follows:

Height	31 in.
Diameter	41 in.
Weight of charge	220 or 440 lb. of cast hexanite
Total weight of mine	1,760 or 1,980 lb.
Safety distance	165 to 260 ft.
Maximum effective depth	100 ft.
Minimum effective depth	Unlimited
Method of laying	By crane from deck of surface vessel with no way on

THE RM MINES

The German Regulare Minen (RM) mine series consisted of six types, RMA, RMB, RMC, RMD, RME, and RMH. The RMC and RMD were completed but were never used operationally.

The RM mines were ground-influence and/or controlled types used defensively in harbors, harbor entrances and rivers. The RMA and RMB were the earliest influence-mine cases designed for a magnetic unit by the German Navy. Their design was undertaken simultaneously with the M 1 mine unit in approximately 1923. Several thousand were manufactured until production on this type mine was stopped in 1938 in favor of the LM mine series. At the outbreak of war, a number of these mines were laid by surface craft as ground magnetic mines. Their use as controlled mines came later in the war as the strategic picture changed.

Other mines of the series were war developments to protect Germany's extended coastline. These also were designed for the M 1 magnetic firing unit for use as a surface-laid, magnetic ground mine. No evidence of the existence of a German moored controlled mine was found.

THE RMA MINE. The RMA and its float are shown in figure 109. The purpose of the

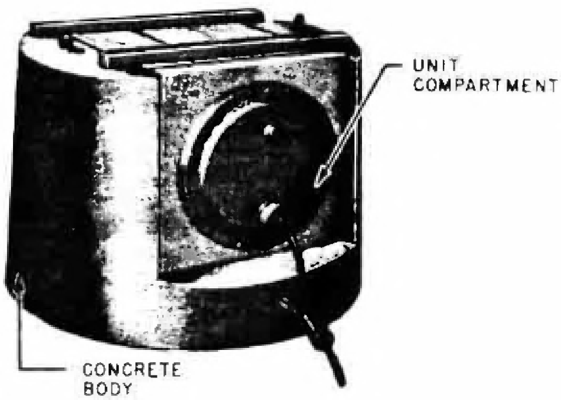


Figure 108 - KMB Mine

Figure 109 - RMA Mine

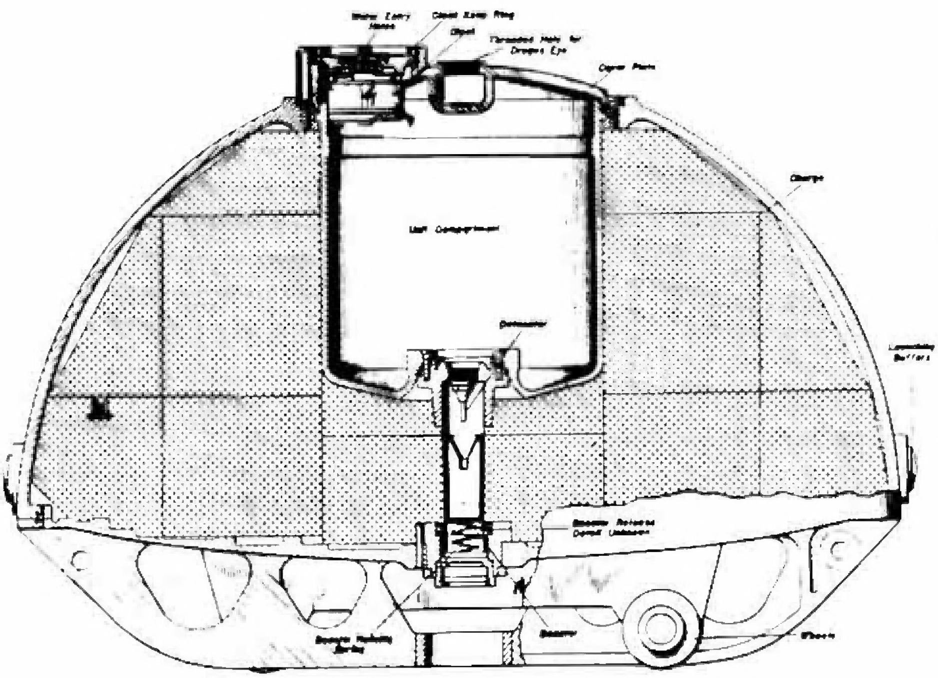


Figure 110 - RMA Mine - Cross Section

float was to assure proper planting of the mine by slowing its descent and causing the mine to plant in an upright position. The float incorporated a valve of novel design which allowed water to fill and sink it after the mine reached the bottom and tension on the float cable was released.

The RMA mine could operate in any one of the following ways:

1. Normal control mine for firing by observation
2. Normal ground-magnetic mine with the M 1 unit
3. Magnetically monitored by the M 1 unit for night control
4. Remote arming from an observation post by a cable through which the M 1 unit is rendered active at any desired time

Description of Case

Shape	Hemispherical; supported by four-wheeled truck
Diameter	50 in.
Height	39 in.
Charge	1,750 lb. block-fitted hexanite

Description of External Fittings

Cover plate	15-3/4-in. diam., on top center of case, flush type, secured by 18 screws
Drogue eye	Screwed into center of cover plate
Hydrostatic clock	6-in. diam., 4 in. from drogue eye, secured by keep ring
Inspection plug	1-in. diam., 13 in. from center of cover plate, screwed into case
Launching buffers	Two pairs on bottom edge of hemisphere, 180° apart. The buffers in each pair are 18 in. apart.
Booster cover plate	4-1/4-in. diam. screwed into bottom center of case

The RMB Mine

Description

Shape	Hemispherical; supported by four-wheeled truck
Diameter	36 in.
Height	20 in.

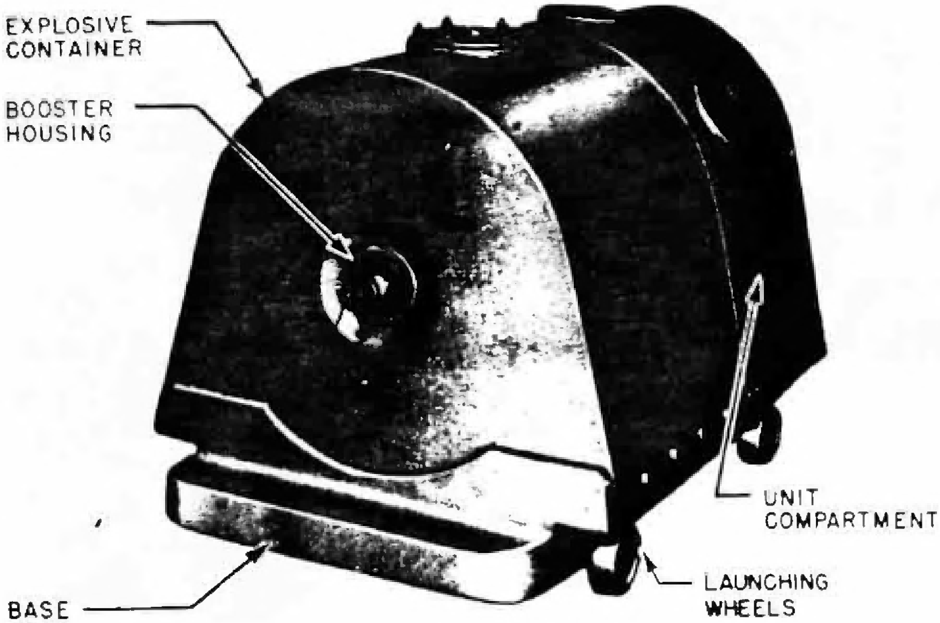


Figure 111 - RMD Mine

Charge 1000 lb. block-fitted hexanite

The RMB mine was a smaller version of the RMA. Its operation and method of employment were the same as for the RMA.

The RMC Mine. The RMC mine was, in turn, a smaller version than the RMB. Although completed, it was never used operationally, and the small number of mine cases on hand were used for experimental purposes only.

RM Mines Used as Influence Mines. When the mine was launched, water pressure operated the booster-release mechanism and, at a depth of 15 feet, depressed the clock spindle, starting the clock. The clock ran off its delay setting, and the firing unit began its arming cycle.

No self-disarming devices were fitted.

RM Mines Used as Controlled Mines. A firing cable was led into the case through a stuffing box which replaced the clock pocket in the influence-fired model of each mine. The cable used was a four-conductor type with the two black and two white wires twisted together to make a double-conductor cable.

The two conductors were attached to two upper terminals on the mine terminal board, and the detonator leads, to the corresponding lower terminals. Two detonators and boosters were sometimes used, in which case the detonators were wired in parallel. A galvanized cable connector was used to stop the firing cable to a drogue eye on the cover plate.

Operation

1. Mine was armed manually prior to launching.

2. Mine was fired electrically by an observer.

3. No self-disarming devices were fitted.

The RMD Mine. The RMD, figure 111, was designed for use as a controlled and/or influence firing mine. Its construction began at the end of 1944 and continued until March, 1945. During this period only five shells were completed, none of which were shipped from the plant.

Shortly before the end of the war in Europe, several improved models were completed and sent to SVK in Kiel for experimentation. This mine was not used operationally. It was designed for use with all the units fitted in the LMB mine. Section A of the mine housed the detonator, booster, and main charge; section B housed the firing unit. The outer end of section B was covered by an LMB type AA2 or type 4DK-1 tail door.

The mine assembly is semi-cylindrical with flattened sides, and consists of three main parts:

1. Base plate with launching wheels made of concrete

2. Charge container with booster made of sheet aluminum

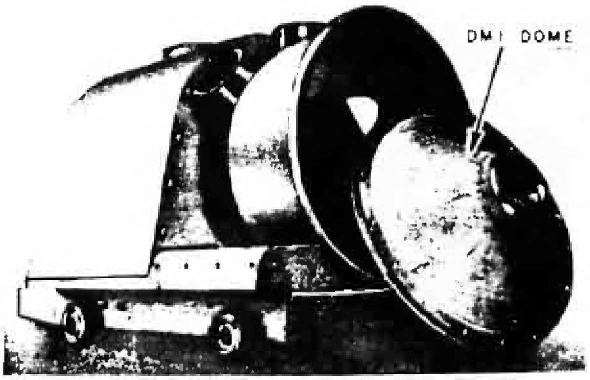


Figure 112 - RMD Mine - First Model

3. Unit compartment of aluminum housed in a pressed paper section

Dimensions

Base	50 in. x 32 in. concrete 8 in. thick at center
Charge and unit assembly	40 in. x 20 in.
Charge	750 lb. cast hexanite

The RME Mine. The RME was a small influence-ground mine designed for use in rivers and lakes. It was cuboidal, made of pressed paper reinforced with aluminum strips and loaded with cast hexanite.

Description

Type of firing unit	M 1
Weight of charge	88 lb. (approx.)
Total weight	286 lb.
Height	20 in.
Width	19 in.
Length	17 in.
Minimum depth	10 ft.
Maximum depth	30 ft.
Safety distances	130 ft
Case material	Wood or Prestoff

The RMH Mine. The RMH mine was a ground influence and/or controlled mine. It was started in 1935 and completed shortly thereafter. It was intended to replace influence ground mines in the event of a metal shortage. This mine was used extensively in all German

Figure 113 - RME Mine

controlled coastal waters, both as an influence mine, and as a controlled mine. It could operate in any of the four ways that the RMA operated.

Description of Case

Shape	Cuboidal; supported by a four-wheeled truck
Material	Wood
Length	3 ft. 5 in.
Width	3 ft. 2 in.
Height	3 ft. 10 in.
Charge	2,000 lb. cast hexanite

Description of External Fittings

Cover plate	19-3/4-in. diam., flush type on side of case, secured by 18 screws
Drogue eye	Screwed to center of cover plate; consists of eye bolt, housing, and space for soluble plug

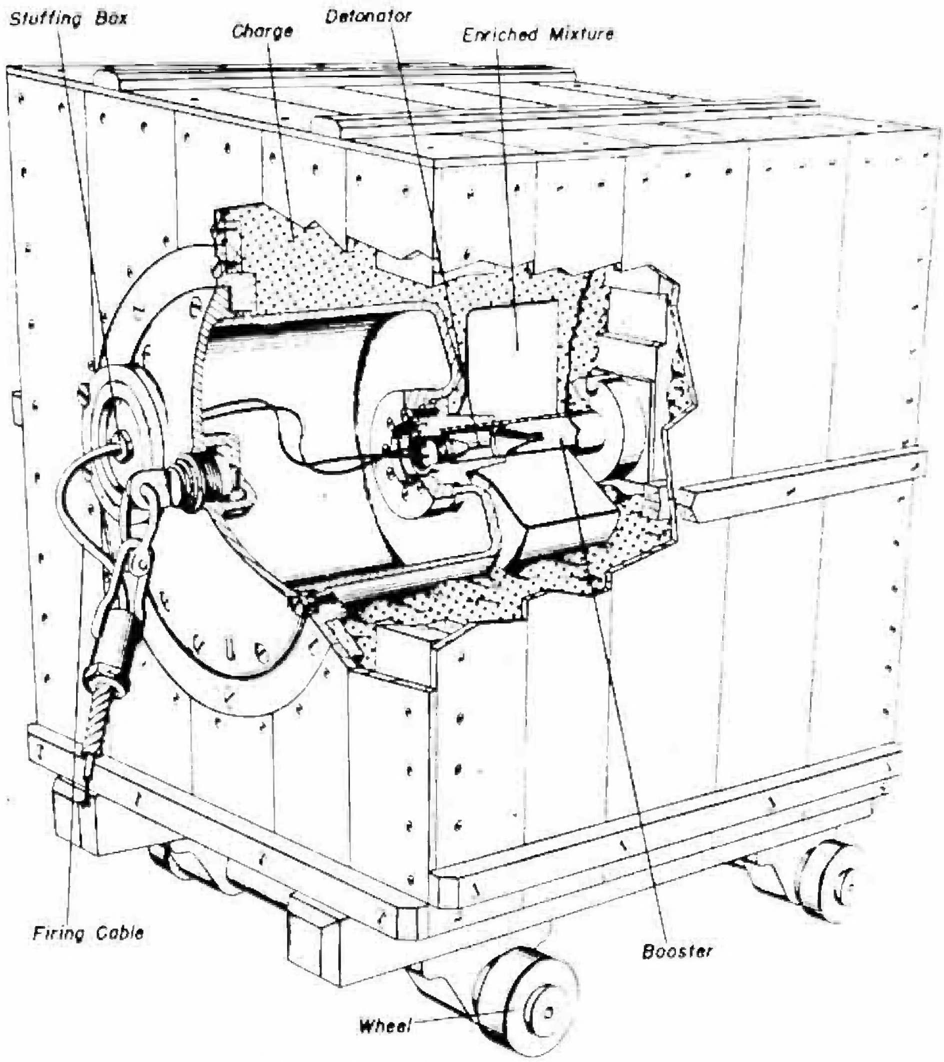


Figure 114 - RMH Mine - Sectional View

Booster cover plate	3-in. diam., aluminum, in center of side of case opposite cover plate
Hydrostatic clock	6-in. diam., 4 in. from drogue eye, secured by keep ring

RMH Used as an Influence Mine. When the mine is launched, it is oriented by a canvas drogue during descent. Water pressure operates the booster-release mechanism and, at a depth of 15 feet, depresses the clock spindle, starting the clock. The clock runs off its delay setting, and the firing unit begins its arming cycle.

No self-disarming devices were fitted.

RMH Used as a Controlled Mine. A firing cable was led into the case through a stuffing box which replaced the clock pocket in the influence-fired model of each mine. The cable used was a four-conductor type with the two black and two white conductors twisted together, making the cable a double-conductor type.

The two conductors were attached to two upper terminals on the mine terminal board, and the detonator leads, to the corresponding lower terminals. Two detonators and boosters were sometimes used, in which case the detonators were wired in parallel. A galvanized cable connector was used to stop the firing cable to a drogue eye on the cover plate.

Operation

1. Mine was armed manually prior to launching.

2. No self-disarming devices are fitted.

Designation	Stage of Development	Type	Method of Laying	Possible Units	Wt. of Charge	Case Material	Dimensions Diam.	Length
BMA I	Operational	Ground	Aircraft	J 1	1,425 lb.	Steel	26"	69"
BMA II	Operational	Ground	Aircraft or surface	J 1	1,425	Steel	26	69
BMA III	Abandoned	Ground	Aircraft or surface	J 1	1,425	Steel	26	69
BM 1000 I	Operational	Ground	Aircraft	M 101-A 104 M 103-A 105 A 107-AD 104	1,500	Manganese steel	26	64
BM 1000 II	Operational	Ground	Aircraft	M 101-A 104 M 103-A 105 A 107-AD 104	1,500	Manganese steel	26	64
BM 1000 F	Completed but not used operationally	Ground	Aircraft	S 101	660	Manganese steel	26	64
BM 1000 L	Idea stage only	Drifting	Aircraft	A 107	660	Manganese steel	26	64
BM 1000 H	Operational	Ground	Aircraft	MA 101-DA 132 MA 102-DA 142 DA 102-DA 152 DA 112-DA 162 AA 106-MA 105 AE 101-MDA 106	1,500	Manganese steel	26	64
BM 1000 M	Operational	Ground	Aircraft	MA 101-DA 132 MA 102-DA 142 DA 102-DA 152 DA 112-DA 162 AA 106-MA 105 AE 101-MDA 106	1,500	Manganese steel	26	66
BM 1000 J I	Completed but not used operationally	Ground	Aircraft	JDA 105	1,500	Steel	26	66
BM 1000 J II	Completed but not used operationally	Ground	Aircraft	JDA 105	1,500	Steel	26	66
BM 1000 J III	Completed but not used operationally	Ground	Aircraft	AJ 102	1,500	Steel	26	66
BM 1000 T	Abandoned	Moored	Aircraft	A 107	880	Steel	26	122
Winterballoon	Completed but not used operationally	Drifting	Aircraft	17 B Fuze pre-set	660	Steel	26	64
BM 500	Early development	Ground	Aircraft	DA 102 Series	660	Steel	18	57
BM 250	Early development	Ground	Aircraft	D 103 Series	265	Steel	15	42
Wasserballoon	Operational	Drifting	Aircraft	S 102, S 103	88	Steel	15	41

Figure 115 - Table of Influence Mines

Shape	Total Wt. in Air	Bomb Fuze	Type Clock	Case Min.	Depths Max.	Remarks
Bomb	2,200 lb.	--	--	--	120	Abandoned in early stages of war after a few had been laid.
Bomb	2,200	--	--	--	120	Abandoned in early stages of war after a few had been laid.
Bomb	2,200	--	--	—	120	Abandoned in developmental stage.
Bomb	1,920	157/3 56	80-hr.	24	120	Earliest of the Luftwaffe's bomb-mine series.
Bomb	1,920	157/3 56	80-hr.	24	120	Identical to BM 1000 I except that unit housing studs were altered to provide greater strength.
Bomb	1,200	17 A	72 hr.	2	6	Identical to BM 1000 I except that a transverse channel with water flap and housing for S 101 unit were added.
Bomb	1,080			5	10	It was contemplated that this mine would utilize a BM 1000 mine case with a special dome and float.
Bomb	1,950	157/3 56	80-hr.	24	120	Same as BM 1000 I except that unit port enlarged to permit housing of larger sized units.
Bomb	1,950	157/3 56	80-hr.	24	120	Same as BM 1000 H except for height of suspension lug and conduit leading from fuze pocket to nose.
Bomb	1,950	157/3 56	80-hr.	24	120	First Luftwaffe induction mine. Used one coil rod with nickel core and copper winding
Bomb	1,950	157/3 56	80-hr.	24	120	Same as BM 1000 J I except for amount of NI and substitution of AL windings for CU.
Bomb	1,950	157/3 56	80-hr.	24	120	Coil same as that of BM 1000 J II but with winding of higher resistance.
Bomb	2,420	157/3 56	80-hr.			First attempt to develop a Luftwaffe moored bomb-mine.
Bomb	1,200		72-hr.	5	10	Designed as an anti-power plant mine for use in the winter time. It uses a modified BM 1000 L case fitted with an anti-ricochet plate for penetrating ice as well as a rubber bag and CO_2 bottle in the tail to allow it to float under ice.
Bomb	1,100	56	--	—	—	Never progressed beyond experimentation.
Bomb	550	56	--	--	--	In experiment for use in rivers.
Bomb	550	—	--	--	—	Intended for use against river bridges.

(Continued on Next Page)

Designation	Stage of Development	Type	Method of Laying	Possible Units	Wt. of Charge	Case Material	Dimensions Diam.	Length
EMF	Operational	Moored	Surface	M 3, A 7, M 4 AE 1	750	KSS	45	50
EMH	Abandoned	Moored	Surface	Acoustic	750	Steel	45	50
EMI	Abandoned	Moored	Surface	Induction	Unknown	Steel	46	48½
EMR	Development	Moored	Surface	A 7, AE 1	660	Steel	45	50
EMU	Development	Moored	Surface	A 7, AE 1	220	Steel	40	45
BMB	Completed but not used operationally	Ground	Submarine	M 1, A 2 MA 2/3 AT 3	1,760	KSS	45	56
KMB	Operational	Ground	Surface	M 1	220 or 440	Concrete and wood	42	32
LMA I/II/III	Operational	Ground	Aircraft	M 1, M 1r, M 1s M 3, M 4, A 1, A 4, MA 1/2/3, MA 1a/1r/1ar, AT 1/2, AMT 2, DM 1	660	KSS	26	81½
LMA/S	Operational	Ground	Surface	Same as LMA I	660	KSS	26	52
LMA/P	Ready for operation	Ground	Aircraft	Same as LMA I	660	Pressed paper	26	52
LMB I/II/III	Operational	Ground	Aircraft	Same as LMA I	1,500	KSS	26	117½
LMB/P	Ready for operation	Ground	Aircraft	Same as LMA I	1,500	Pressed paper	26	117½
LMB/S	Operational	Ground	Surface	Same as LMA I	1,500	KSS	26	88
LMF	Operational	Moored	Aircraft	M 3, M 4, M 2, A 7, AE 1	610	KSS	26	92
LMF/S	Operational	Moored	Surface	M 3, M 4, M 2, A 7, AE 1	610	KSS	26	92
MTA	Operational	Ground	Submarine	M 1	1,000	KSS	21	23

Figure 115 - Table of Influence Mines (Continued)

Shape	Total Wt. in Air	Bomb Fuze	Type Clock	Case Min.	Depths Max.	Remarks
Sphere	2,450	—	UES II UES IIa ZE I, EW	15	120	First of the German surface-laid, moored, influence mines.
Sphere	--	--	—	--	--	To be same as EMF except that case was to be of steel.
Sphere	--	—	--	—	—	Was to utilize EMC case modified for induction unit.
Oval	--	--	--	—	—	Could be used as influence and/or contact mine.
Oval	--	—	—	--	--	Could be used as influence and/or contact mine.
Cylin-drical	2,200	—	UES II, UES IIa ZE	15	120	To be laid by specially designed Hecht midget sub.
Cylin-drical	1,760 or 1,980	--	UES II		100	Designed for use as an influence and/or controlled mine.
Cylin-drical	1,100	34A 34A* 34B	UES II/ UES IIa ZK, VW	15	120	The three models differed very slightly in manner of construction and change in parachute assembly.
Cylin-drical	1,100	--	Same as LMA I	15	120	Bomb fuze eliminated and tail changed to permit laying by E-boat.
Cylin-drical	1,100	Same as LMA I	Same as LMA I	15	120	A number of these mines were made but it is not known whether they were used. This type was a hedge against a possible aluminum shortage and intended to lower the expense entailed in AL cases.
Cylin-drical	2,175	Same as LMA I	UES II UES IIa ZK, VW, ZE III	15	120	Succeeded the LMA and was used more extensively because of its larger charge.
Cylin-drical	2,175	Same as LMA I	UES II UES IIa ZK, VW, ZE III	15	120	Developed for same reasons as LMA/P.
Cylin-drical	2,175	—	UES II UES IIa ZK, VW, ZE III	15	120	Same changes as for LMA/S.
Torpedo shaped	2,300	—	UES IIa, ZK, EW	54	120	First aircraft-laid, moored, influence mine. Case plants horizontally.
Torpedo shaped	2,300	--	UES IIa, ZK, EW	54	120	This model is the same as LMF except that the parachute is removed so that the mine may be laid by E-boat.
Torpedo	3,600	—	ZE III		120	Normal G 7e torpedo with special head fitted in place of warhead. Range 7,000 meters, speed 18 kts.

(Continued on Next Page)

Designation	Stage of Development	Type	Method of Laying	Possible Units	Wt. of Charge	Case Material	Dimensions Diam.	Dimensions Length
RMA	Operational	Ground	Surface	M 1	1,750	KSS	50	39
RMB	Operational	Ground	Surface	M 1	1,000	KSS	37	20
RMD	Ready for Operation	Ground	Surface	Same as LMB	750	KSS, plastic, concrete	32	50
RME	Ready for operation	Ground	Surface	M 1	88	Wood or pressed paper	20x19x17"	
RMH	Operational	Ground	Surface	M 1	2,000	Wood	46x41x38"	
SMA	Operational	Moored	Submarine	M 3, A 7 M 4, AE 1	750	KSS	46	56
SMB	Early development	Moored	Submarine	A 7, AE 1	Unknown	Steel	46	80 (approx.)
SMC	Ready for operation	Moored	Submarine	M 3, A 7, M 4, AE 1	750	KSS	46	50
TMA	Operational	Moored	Submarine	M 2, M 3 M 4, A 7	475	KSS	21	111
TMB I/II	Operational	Ground	Submarine	M 1, A 2 AT 3	1,230	KSS	21	92
TMB III	Operational	Ground	Submarine	M 1, A 2, AT 3, DM 1 MA 2/3	925	KSS	21	92
TMB (S)	Operational	Ground	Surface	M 1, A 2, AT 3, DM 1 MA 2/3	1,230	KSS	21	103
TMB(KTMB)	Operational	Sabotage	Swimmers	M 1, A 2, AT 3, DM 1, MA 2/3	1,230	KSS	21	172
TMC I	Operational	Ground	Submarine	M 1, A 2, AT 3	2,050	KSS	21	133
TMC II	Operational	Ground	Submarine	M 1, A 2, AT 3, DM 1 MA 2/3	1,760	KSS	21	133

Figure 115 - Table of Influence Mines (Concluded)

Shape	Total Wt. in Air	Bomb Fuse	Type Clock	Case Min.	Depths Max.	Remarks
Hemi-spher-ical	2,350	—	UES II, UES IIa, ZE, TW	15	120	This was the earliest of the German influence mine cases. Also adaptable for use as controlled mine.
Hemi-spher-ical	1,600	—	UES II UES IIa, ZE, TW	15	120	Smaller version of EMA.
Hemi-cylin-drical with flat sides	1,500	--	UES II UES IIa, ZE, TW	15	120	Developed for use as an influence and/or controlled mine.
Cube	286	—	UES II	15	60	Developed for use in rivers.
Cube	2,300	—	UES II UES IIa ZE, TW	15	120	Earliest of the German influence mines. Also adaptable for use as controlled mine.
Sphere	3,475	--	UES II UES IIa ZE, EW	15	120	Very similar to the EMG mine except for type anchor used. Laid from specially built minelaying subs fitted with vertical shafts.
Oval	--					Intended for use in depths up to 9,000 feet - primarily in American waters.
Sphere	3,475	—	UES II UES IIa ZE, EW	15	120	Same as SMA except that doughnut in anchor removed and 60-day delay-rising clock substituted.
Cylin-drical	1,760	—	UES II UES IIa	50	120	Laid from torpedo tubes of submarines. This mine was not used widely because the M 2 unit which was designed for it proved unsatisfactory.
Cylin-drical	1,625	--	UES II UES IIa ZE I/III	15	120	Same method of laying as TMA. Models I and II differ only in method of constructing unit compartment.
Cylin-drical	1,480	--	UES II UES IIa ZE I/III	15	120	Differs from Models I and II only in size of unit compartment.
Cylin-drical	1,600	—	UES II UES IIa ZE I/III	15	120	Altered for laying by E-boat.
Cylin-drical	2,000	—	UES II UES IIa ZE I/III	15	120	This mine utilised either the Model II or the Model III case and two floats - one fore and one aft - to enable swimmers to plant the mine in the desired position. Firing was usually by delay clock, but influence units could be utilised.
Cylin-drical	2,450	—	UES II UES IIa ZE I/III	15	120	A larger version of the TMB.
Cylin-drical	2,200	—	UES II UES IIa ZE I/III	15	120	Differs from TMC I in size of unit compartment.

Chapter 9

SPECIAL PURPOSE MINES

THE HM MINES

The German Haft Minen (HM) mine series consisted of three types, HMA, HMB, and HMC. The HMA and HMB were completed but were never used operationally; the HMC was abandoned after preliminary design work had been completed.

General. After the British had achieved their successful "human torpedo" attack against the Tirpitz, the German Navy undertook the development of a series of mines that could be used in the same manner by their midget-submarine group, KdK (Kommando der Kleinkampfverbande). By the end of 1943 they had completed the HMA, which was a copy of the warhead used by the British on their "human torpedo." The HMA was then followed by a type which was capable, in addition, of being used as an influence mine - The HMB.

Both HMA and HMB were intended for use with the Hecht submarine, which was in development simultaneously with the mines. It was intended that the mines be carried by this submarine as a false bow that could be released mechanically whenever the operator so desired. However, since the German Navy favored midget submarines that could fire torpedoes, the Hecht submarine project was dropped in 1944, and, consequently, the HMA and HMB mines were never used.

When work on the Hecht submarine was discontinued, the German Navy requested the development of a self-propelled mine that could be guided to its target by a swimmer. To meet these requirements the design of the HMC mine was begun. After preliminary design work had been completed, the HMC mine fell into disfavor and was discontinued.

The HMA Mine. The HMA mine is similar in appearance to the HMB mine, with the exception that it has two rows of permanent magnets on its upper side. Its characteristics are as follows: (Specifications are approximate.)

Description

Case material	Iron
Length of case	56 in.
Diameter of case	45 in.
Weight of charge	1200 lb.
Maximum depth	165 ft.
Holding strength of magnets	440 lb.
Positive buoyancy	22 lb.
Method of firing	UES II 6-day clock which is started by a hand-operated mechanical clock starter

The Germans felt that this mine presented the following operational difficulties:

1. It would be difficult for the operator of the submarine to penetrate British defensive installations.

2. It would be difficult for the operator of the submarine to affix the mine to the bottom of the target ship.

The HMB Mine. The HMB had no magnets and was not intended to adhere to the bottom of the target ship. On the contrary, it was designed for laying beneath a specific target ship or in other chosen areas as a ground influence mine. Its characteristics are as follows: (Specifications are approximate.)

Description

Case material	KSS
Length of case	56 in.
Diameter of case	45 in.
Weight of charge	1760 lb.
Maximum depths	80-115 ft., depending on the influence unit used
Method of firing	MA 2, MA 3, and DM 1

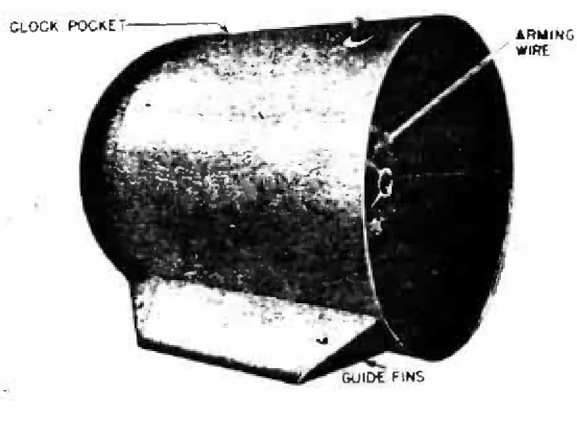


Figure 116 - HMB Mine

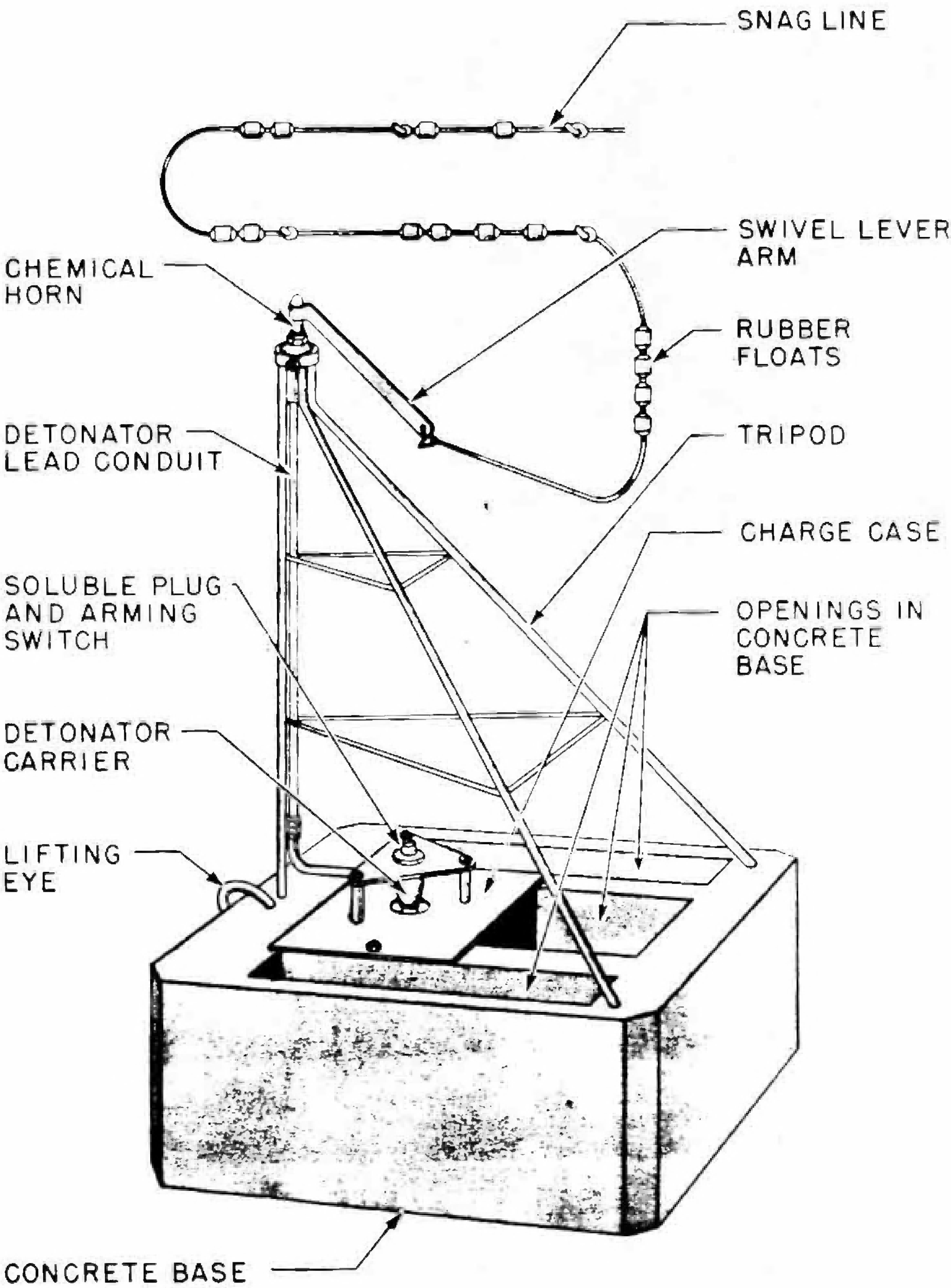


Figure 117 - KMA Mine - Elevation View

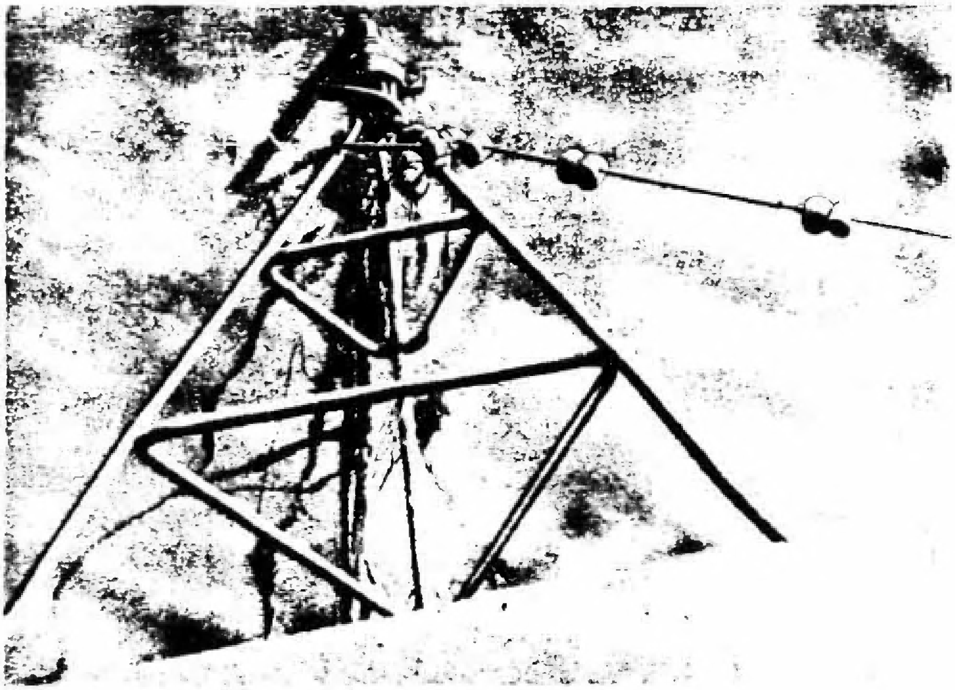


Figure 118 - KMA Mine

The HMC Mine. This mine was to be a torpedo-shaped HMA equipped with an electric propulsion system and electromagnets. It was contemplated that the mine would be guided and affixed to the target ship by a swimmer who would be towed by it.

Description

Case material	Iron
Length of case	144 in.
Diameter of case	24 in.
Weight of charge	220 lb.
Method of propulsion	Electric motor powered by U-boat type wet-cell batteries
Range	12 miles
Speed	3 knots
Method of firing	Same as HMA

THE KM MINES

The German Kuste Minen (KM) mine series consisted of two types of surface-laid coastal defense mines. These were the KMA and KMB. Each type was used operationally during World War II. (The KMB is described in Chapter 8.)

The KMA was a very simple contact mine, and the KMB was a control mine made of concrete. The KMA was used operationally by the Germans off the invasion coast of France, and the KMB was laid in great numbers off the Danish coast. Both mines were so designed that they could be fabricated locally by the various field commands from readily available materials. By this method a considerable saving of critical transportation space was realized.

The KMA Mine. The KMA was a concrete-base, ground, contact mine with a tripod attachment which was fitted with either a chemical horn and snag line or a chemical horn with extender and snag line. It was a surface-laid anti-invasion type for use in maximum depth of water of 30 feet. It was designed in November 1943 and completed in one month's time.

Description

Height	Base 20 in.; Over-all 88 in.
Length	47 in.
Width	47 in.
Shape	Rectangular, recessed concrete block, fitted with steel tripod on top
Weight of charge	165 lb. of cast hexanite
Total weight of mine	2,200 lb.
Safety distance	120 ft.
Maximum effective depth	Up to 30 ft.

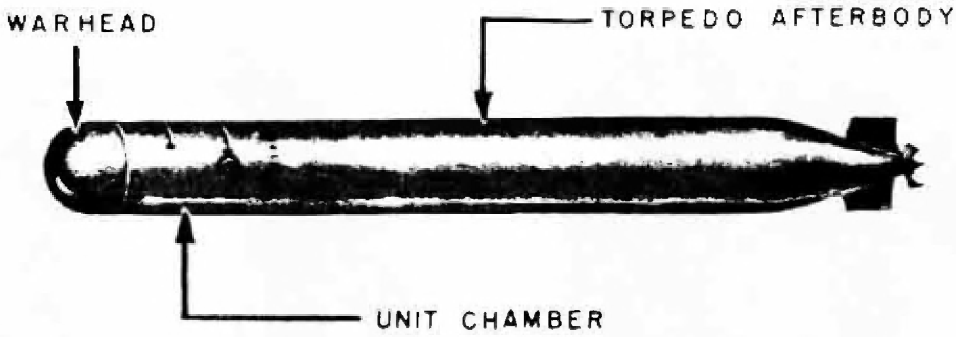


Figure 119 - MTA Mine

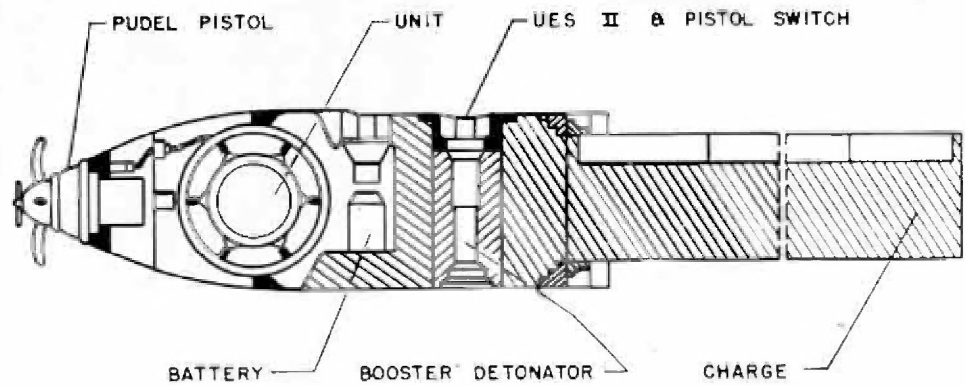


Figure 120 - MTA Mine - Cross Section

Minimum effective depth	Unlimited

The MTA Mine. The MTA Mine consists of a specially designed warhead secured to a modified G 7e torpedo in the manner shown in figure 119.

The mine is launched from the torpedo tubes of E-/or U-boats, which must be stopped at the time of firing. After running its preset course, the mine sinks to the bottom by virtue of its negative buoyancy and acts as a magnetic mine, using the M 1 firing unit. (Although the MTA could be made to accommodate units suitable for TMB II, only the M 1 firing unit was used.)

Description

Range	23,000 ft
Speed	18.5 ± 1 knots
Accuracy	± 1300 ft. meters in range ± 1.5% lateral deviation at 18 knots
Running depths	20 ft.
Maximum and minimum depth at target	Max. 100 ft. - Min. 25 ft.
Weight of charge	1,000 lb.
Total weight	3,600 lb.
Clock used	ZE III

Experiments were conducted with MTA to extend its range to 46,000 yards at a speed of 3.5 knots and to fit a pistol to the mine head. These experiments were not completed, and the experimental torpedo was designated "T IId Pudel," while the pistol was designated "Pudel Pistol." The development of an MTB warhead which was to have a larger unit compartment capable of housing later types of influence units was undertaken toward the close of the war, but was never completed.

The BM 1000 F Mine. The BM 1000 F was designed as an anti-power-plant mine for use against the Russians. It is similar to the BM 1000 II, but has a thinner case and is slightly longer.

The BM 1000 F is modified as follows:

1. A second bomb fuze is added just before the lifting lug on the top center line of the mine. This fuze is added

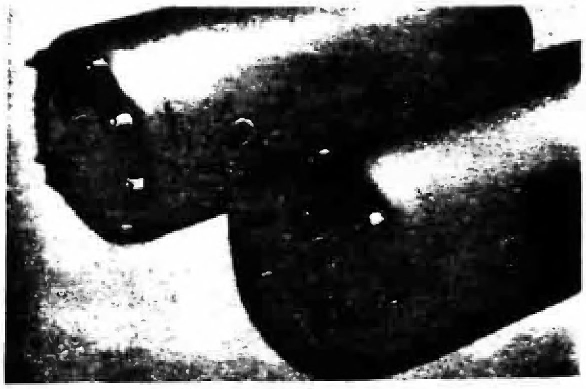


Figure 121 - BM 1000 F with SH 14

to ensure detonation if the mine is dropped on land.

2. A transverse channel containing a water flap is added.

3. The main explosive charge is loaded in such a manner that the mine has slight negative buoyancy and is carried downstream with only its nose touching the bottom. This also keeps the transverse channel perpendicular to the direction of the current.

4. The S 101 mine firing unit is fitted.

Operation. The BM 1000 F is dropped by aircraft upstream from the target. A current of 0.75 knots or stronger is sufficient to carry the mine to the target. When the mine reaches the power-plant inlets, it is rotated by the force of the current against the gate, allowing water to flow through the transverse channel. This moves the water flap, closing the battery switch and starting the clock of the S 101 unit. When the clock runs off its preset time, a matter of several minutes, the mine explodes.

Description

Length	64 in.
Diameter	26 in.
Weight of charge	660 lb.
Total weight in air	1,200 lb.

Permissible dropping heights with the LS 3 parachute at speeds of 150 - 285 m.p.h. are as follows:

Water Depth	Dropping Height
10 feet	325 feet
17 feet	1650 feet
24 feet	3300 feet
35 feet	23,000 feet

Figure 122 - Winterballoon Tail Section

The BM 1000 L Mine. This mine was still in the idea stage. It was to be a BM 1000 I and II modified to be used as a drifting mine against convoys. The charge was to be reduced to 660 pounds, and a buoy was to be added to give the mine proper buoyancy. The A 107 mine unit was to be used with this mine. The project was abandoned because of lack of confidence in the effectiveness of an aircraft-laid, drifting mine, and difficulties encountered in proper release of the buoy.

Winterballoon. The Winterballoon was designed as an anti-power-plant mine for use in the winter time. It is an SC 1000 L bomb modified as follows:

1. An anti-ricochet plate is welded to the nose section to aid the mine in penetrating the ice.

2. A rubber bag and a CO_2 bottle are installed in the tail compartment.

3. A 17B bomb fuze is used.

Operation. On impact, the bomb fuze starts to run, firing the explosive coupling of the retaining latch, releasing the rubber bag. At the same time a squib is fired, allowing the CO_2 to inflate the rubber bag. The added buoyancy due to the inflation of the bag causes the mine to float and be carried under the ice to the power plant by the force of the current.

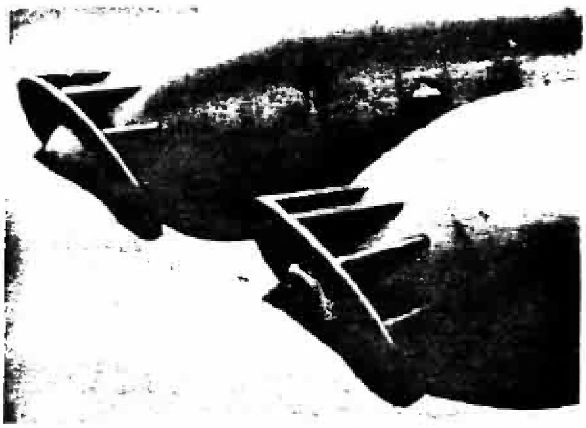


Figure 123 - Winterballoon Anti-Ricochet Plate

The mine is detonated, after the preset time of the 17B fuze has run off. This mine was never used operationally.

Wasserballoon. In the summer of 1944 the German Luftwaffe was ordered to develop a mine that would destroy bridges on the Rhine and other main rivers. The Wasserballoon was an attempt to meet this requirement. This was a modified Flam C 250 bomb designed to be fitted with optical units, S 102 and S 103.

Operation. The Wasserballoon was loaded with explosive to give it slight positive buoyancy and to permit it to float vertically downstream. The top of the bomb was modified to take an optical unit. One coil of primer cord was affixed on the inside around the top of the mine. When the mine floated under a bridge, the optic unit was actuated, firing the coil of primer cord. The resulting explosion split the case at the top of the buoyant section and allowed the mine to fill with water and sink. At the same time a time delay fuse was ignited, which prevented the mine from firing for several seconds until it sank. When the safety fuse burned out, a detonator fired the main charge and the column of water resulting from the explosion destroyed the bridge.

Description

Length	41 in.
Diameter	15 in.
Weight of charge	88 lb.
Units used	S 102 and S 103

Permissible Dropping Heights. With an LS 3 parachute it can be dropped from heights of 325 to 3,250 ft., in depths of water from 5 to 50 ft., at speeds up to 400 m.p.h.

Chapter 10

SWEEP OBSTRUCTORS

INTRODUCTION

German sweep obstructors, laid in and around moored mine fields, are designed to cut sweep cables and prevent or hinder sweeping of the mine field. They may contain explosives or merely support mechanical cutters on their mooring cables. The various types of conical floats may be indistinguishable when found afloat.

EXPLOSIVE CONICAL FLOATS

Sprengboje C and Sprengboje D. These are moored, conical floats used as sweep obstructors, laid by surface craft. They are defensive, anti-sweep devices laid in and around moored-mine fields. The maximum length of their mooring cables is 360 feet.

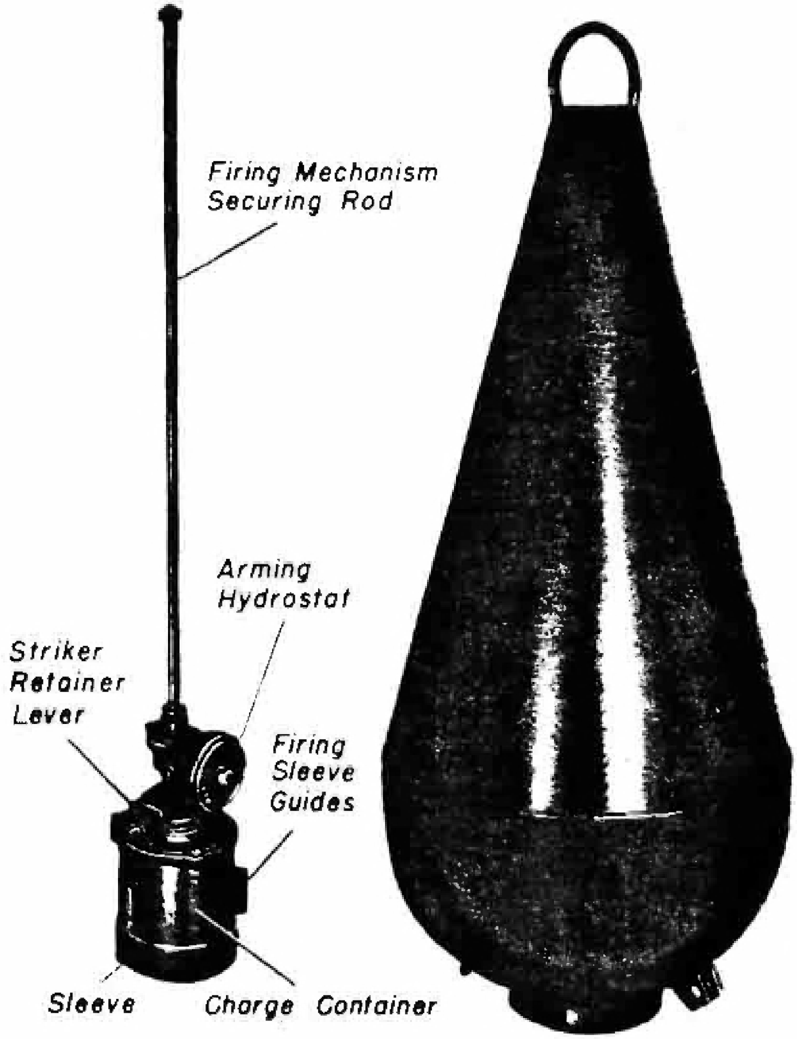


Figure 124 - Sprengboje C

Description of Case

Shape	Conical upper section welded to hemispherical lower section
Material	Steel
Diameter	15 in.
Length	37 in.
Charge	1 lb. 13 oz.
Total weight in air	50 lb. (approx.)

Description of External Fittings

Lifting eye	At top of conical section
Securing lugs	Two, 180° apart on lower hemisphere
Soluble plug fitting	Threaded into side of flange on lower hemisphere
Firing assembly	In pocket in base, secured by vertical rod and nut at top of float. Firing sleeve contains hole for safety pin.

Type D differs from Type C as follows:

1. The base of the float contains no soluble plug fitting on the flange.

2. The arming hydrostat locks in the armed position.

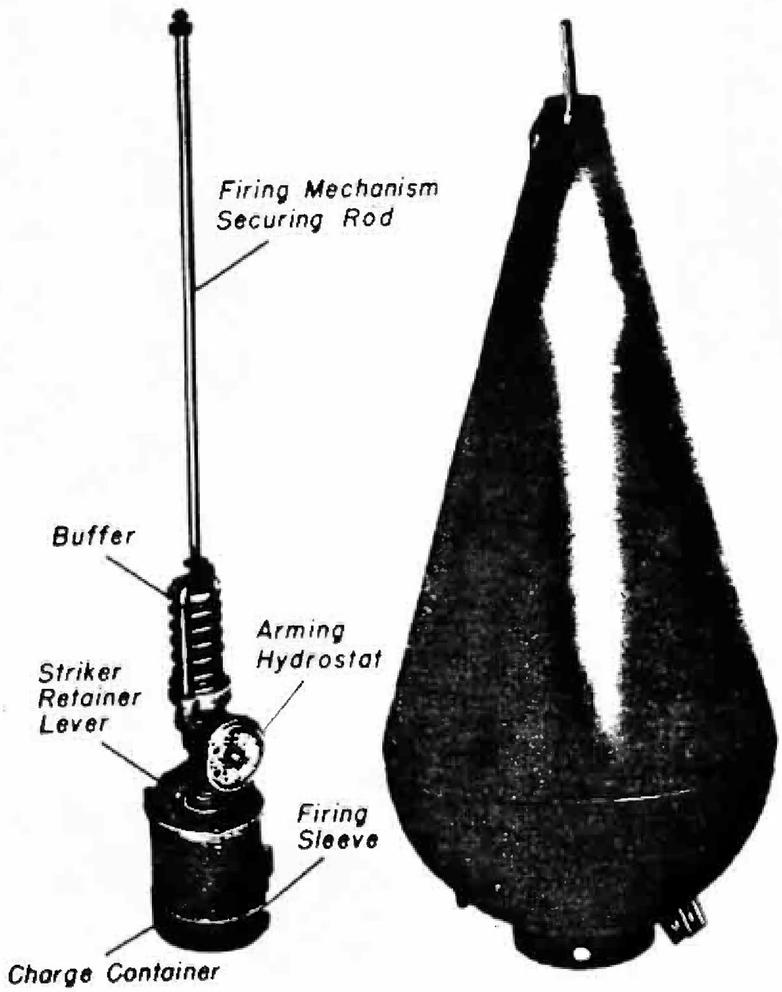


Figure 125 - Sprengboje D

Description of Case

Shape	Conical upper section welded to hemispherical lower section
Material	Steel
Diameter	15 in.
Length	37 in.
Charge	1 lb. 13 oz.
Total weight in air	50 lb. (approx.)

Description of External Fittings

Lifting eye	At top of conical section
Securing lugs	Two, 180° apart on lower hemisphere
Soluble plug fitting	Threaded into side of flange on lower hemisphere
Firing assembly	In pocket in base, secured by vertical rod and nut at top of float. Firing sleeve contains hole for safety pin.

Type D differs from Type C as follows:

1. The base of the float contains no soluble plug fitting on the flange.
2. The arming hydrostat locks in the armed position.

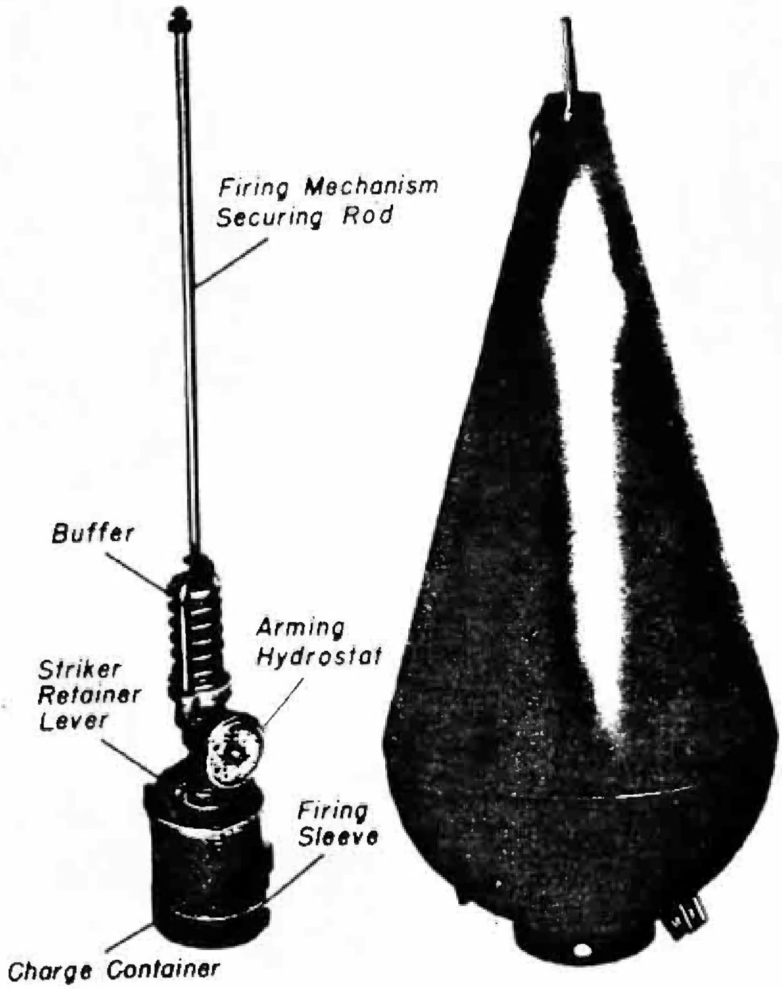


Figure 125 - Sprengboje D

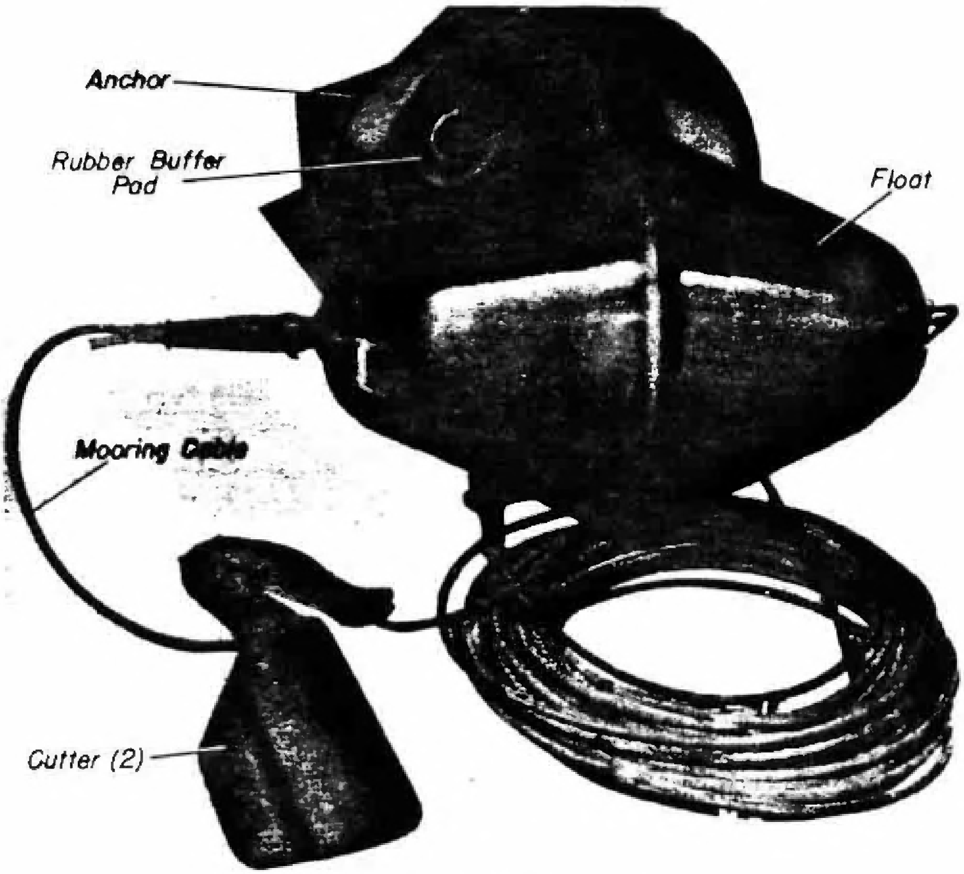


Figure 123 - Anti-Sweep Device

leases, dropping the mooring with charge still attached and freeing the float only.

The only self-disarming feature is a device which locks the firing pin when the float surfaces. This is extremely unreliable.

STATIC CONICAL SWEEP OBSTRUCTOR

Reisboje. . This is a moored, conical float, laid by surface craft, fitted with mechanical cutters on its mooring cable. It is a non-explosive, anti-sweep device, laid in and around moored-mine fields.

Description

Shape	Conical; resembles explosive conical floats, Types C and D.
Material	Steel
Diameter (base)	19 in.
Length	44 in.

The float is moored to a concrete block, 33 in. by 28 in. by 27 in., which is surmounted by a steel drum, 33 in. high and 25 in. in diameter. The mooring cable (300 ft. max.) is fitted with four mechanical cutters. The uppermost cutter is attached two feet below the float, and the others at 4 ft. 3 in. intervals. Seven cone-shaped, steel beads are woven into the mooring cable between the float and the uppermost cutter.

Operation. A stop pin is inserted in the anchor prior to laying to adjust the depth setting. The float therefore takes depth by fixed mooring-cable setting. Dissolution of a soluble plug releases the float from its anchor. The float then rises, pulling the cutters from brackets inside the drum and unreeling the cable.

AIRCRAFT-LAID SWEEP OBSTRUCTORS (BRA - BR2)

BRA. The BRA was the first aircraft-laid sweep obstructor developed by SVK. It consisted of a case similar to the BM 1000 mine cases, 60 inches long and 24 inches in diameter. A reel was located in the center of the case containing 350 feet of mooring cable.

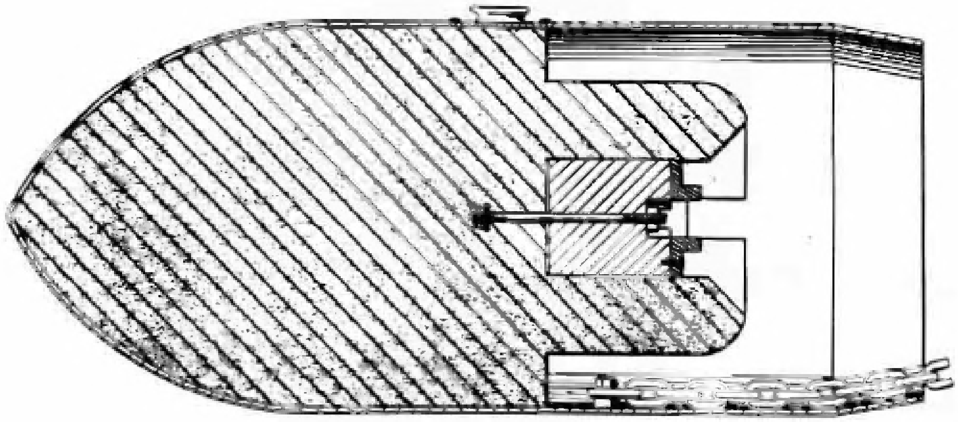


Figure 129 - BRP Anti-Sweep Device - Cross Section

The nose was filled with 500 pounds of concrete, and the cutters and float were placed in the after end. A stabilizing tail section was attached in the same way as on the BM mines. These obstructors were first manufactured by a French firm and were tested at Lake Constance. They were never used operationally, because the case and reel assembly were too weak to withstand the shock of impact. These assemblies were abandoned and replaced by the BRB type obstructor.

BRB. The BRB sweep obstructor is 8 feet 5-1/2 inches long, 25-1/2 inches in maximum diameter, and weighs 2,020 pounds. When assembled for laying, it resembles very closely a BM 1000 with tail fairings attached.

Component parts are as follows:

The Anchor. This is a steel cylinder with an ogival nose, resembling the case of a BM 1000. It is 62 inches long and weighs about 1,000 pounds. Approximately 865 pounds of cement are cast into the forward part, the after end of the casting being formed to provide (1) positioning seats for two cutters and (2) a mooring-cable drum.

The following fittings are bolted to the after end of the casting:

1. A wooden block which serves as a float seat
2. A circular, cut-away rubber buffer pad which is believed to serve as a shock absorber upon impact

The Float. This component has the appearance of two cones welded together at their bases. It is 32 inches long over-all, 21 inches in maximum diameter, and has a positive buoyancy of about 65 pounds. The mooring cable is attached to a lug at one end.

The Tail. This consists of a truncated cone fitted with four radial fins which are enclosed by a shroud ring, 8 inches long and 25-1/2 inches in diameter. The conical section is 43-1/2 inches long, 25-1/2 inches in diameter at its forward end and 8 inches in diameter at its after end. The tail is attached to the after end of the anchor by eight bolts.

The Cutters. These are standard mechanical cutters, two in number, secured to the mooring cable three feet and nine feet respectively, below the float.

The Mooring Cable. This consists of a 125-foot length of 5/8-inch steel wire. One end is attached to the float and the other end, to a short length of chain which, in turn, is attached to a bolt on the anchor case. The chain serves to prevent the mooring cable from parting as a result of chafing on the anchor. Prior to laying, the cable is wound around the cement casting in the anchor.

Operation. Impact with the water shears the tail. The buoyancy of its case and the expelling effect of the rubber buffer pad cause the float to rise toward the surface as the anchor sinks. As the anchor continues to sink, the entire length of mooring cable pays off the mooring drum and the float and cutters take depth according to the depth of the water.

MINE ANCHORS

Type	Date	Mooring Cable	Total Weight	Mines Used With	Remarks
EMC	1924	750'x3/8" diam. 325'x1/2" diam.	990 lb.	EMC I	Improvement of original EMA model. Laid from mine tracks of surface ships.
EMD I EMD II EMD III	1937	750'x3/8" diam. 325'x1/2" diam.	990 lb.	EMC II EMD I/II EMD I/II EMC II	Slight improvement over EMC anchor. Only differences in this series are slight modifications in design. Laid from mine tracks of surface ships.
EMD III	1937/38	490'x7/16" diam. 650'x7/16" diam. 750'x3/8" diam.	1,100 lb.	EMC II-with tombac tubing EMC II - without tombac tubing	Only changes are in cable sizes and lengths.
		425'x3/8" diam.	1,100 lb.	EMC II - (with upper and lower antenna)	EMC II upper antenna 130 ft., lower antenna 100 ft.
EMD IV	1940	650'x7/16" diam.	1,200 lb. with cable and plummet	EMC II - with tombac tubing - 100'	Construction heavier for use in greater depths. This anchor standard for EMC and EMF Mines. Laid from mine tracks of surface ships.
		985'x3/8" diam.	1,320 lb. with cable, chain and plummet		
		650'x7/16" diam. 1,150'x5/16" diam.		EMC II - with lower antenna - 100'	
		325'x1/2" diam. 650'x7/16" diam. 985'x3/8" diam.		EMC II - with cork-floated antenna	
		1,640'x5/16" diam.		EMC II - with chain (20' 5/8" diam.) and buffer	
				EMC II - with chain (20' 5/8" diam.) and snag line	
				EMF	
EMG	1940	600'x1/4" diam.	1,100 lb. with 120 lb. ballast ring	EMG with float	Slight modification of EMD III in order to accommodate ballast ring.
FMB	1928	25'x1/2" diam. 50'x1/2" diam.	350 lb.	FMB	Mooring cable wrapped around steel drum which is mounted on solid steel slab.

Figure 130a - Table of Mine Anchors

MINE ANCHORS (Concluded)

Type	Date	Mooring Cable	Total Weight	Mines Used With	Remarks
FMC	1928	165'x7/16" diam. 475'x5/16" diam.	640 lb.	FMC	Very simple anchor using plummet for taking depth.
UMA	1928	165'x7/16" diam.	1,430 lb.	UMA I/II/III	Similar to the FMB anchor except that the drum is longer.
UMB	1941	490'x7/16" diam. 650'x3/8" diam. 985'x5/16" diam.	525 lb.	UMB with lower antenna (65')	This anchor is similar in appearance and operates in the same manner as the EM series anchor.
		325'x7/16" diam. 490'x3/8" diam. 650'x5/16" diam.	925 lb.	UMB with chain (5' 5/8" diam.) and 1 cutter UMB with chain (5' 5/8" diam.) 1 cutter and snag line UMB with chain (5' 5/8" diam.) 2 mechanical cutters	
UMA	1942	245'x1/2" diam.	900 lb.	UMA/K with 120-lb. ballast ring	A very simple anchor consisting of a slab steel base with the mooring cable coiled on top of it.
OMA	1943	Chain mooring 35'x 3/4" diam. wire leader 35' 1/2" diam.	1,650 lb.	OMA I	Similar to the FMB mine anchor, but chain and mooring coiled inside the drum mounted on the slab.
OMA	1944	Double chain 35'x 3/4" diam. chain leader 35' 1/2" diam.	2,035 lb.	OMA/K	Similar to OMA for OMA I with modified drum to accommodate double chain mooring.
TMA	1939	490'x5/16" diam. 885'x1/4" diam.	880 lb.	TMA	Designed for submarine laying from torpedo tubes.
SMA	1941	1310'x7/16" diam. 1965'x3/8" diam. 2625'x5/16" diam.	1,900 lb.	SMA SMB SMC	These mines were laid from vertical shafts of submarines.
LMF	1940	490'x7/16" diam. 820'x3/8" diam. 985'x5/16" diam.	1,100 lb.	LMF	This anchor had parachute attachment for aircraft laying. With the LMF/S Mine the parachute was removed.

Figure 130a (continued) - Table of Mine Anchors

ANTI-SWEEP DEVICE ANCHORS

Type	Date	Mooring Cable	Total Weight	Mines Used With	Remarks
Sprengboje C	1926	165'x5/16" diam.	275 lb.	Sprengboje C	This anchor is similar to the FMB mine anchor. A soluble plug attachment is utilized for delay rising.
Sprengboje D	1929	215-360'x5/16" diam.	360 lb.	Sprengboje D	The drum of this anchor is larger to accommodate more mooring cable.
Reisboje	1935	165'x7/16" diam. 325'x3/8" diam.	1750 lb.	Reisboje	Box-type anchor with drum to accommodate mooring cable built on top of the main anchor assembly.
EMR	1943	165'x5/8" chain with 650'x1/2", 985'x7/16", or 1400'x3/8" cable	2,300 lb.	EMR	This is a modified EMD IV anchor.
EMR/X	1943	Double chain 65'x5/8" diam. and 115'x5/8" diam. Double cable 165'x1/2" diam. and 85'x 1/2" diam.	1,100 lb.	EMR/X	Similar to EMR with attachments for double moorings.

Figure 130b - Table of Anti-Sweep Device Anchors

Chapter 11

INFLUENCE MINE [illegible]ITS - SVK AND LUFTWAFFE

Section 1

INFLUENCE FIRING DEVICES - TABLES

In connection with the description of German influence units and circuits, it should be borne in mind that these units existed in a large number of slightly varying forms. One of the most common variations was in the delay arming clocks fitted, resulting in minor variations in the delay arming cycle but having no effect on the basic operation of the unit. The following descriptions will present typical assemblies of all known influence units, and all of the variations. German influence firing devices (units) were designated by the Allies with a letter prefix and a mark number. The prefix indicated the type of firing influence or influences employed as: M-magnetic, A-acoustic, AM-magnetic-acoustic, AP-acoustic-pressure and MP-magnetic-pressure. The mark number indicated the individual unit, the numbers being assigned in sequence of recovery, with little attention paid to the design of the particular unit. A detailed description of the operation of each unit circuit, together with various unit accessories, follows in chronological order, using German designations.

INFLUENCE MINE UNITS - NAVY

Unit	Principle	Originating Firm	Development Start	Development 1st Sample	Firm	Case	Use	Remarks
M 1	Magnetic	Hartmann & Braun, SVK	1923	1925	H & B SVK	RM, LM, TM	Sub. A/C Sur-face	Magnetic balance for vertical component. Self-setting since 1938. 30-mg until 1941, then 10-mg. 5-mg. for combination.
M 2	Magnetic	Askania	1933	1935	Ask-ania	EMF, SMA, TMA	Sub. Sur-face	Magnetic balance for vertical component. Self-setting since 1938. Counterbalance against motion. 30-mg.
M 3	Magnetic	SVK	1935	1936-1937	SVK H & B	EMF, SMA, TMA, LMF, LMB	Sub. Sur-face, A/C	Soft NI-FE antenna system. Self-setting since 1938. 20-mg. Cheaper than M 1.
M 4 (15-mg)	Magnetic	SVK, Eumig, Baermann	1941-1942	1943	Eumig H & B	EMF, SMA, TMA, LMF	Not laid	Soft NI-FE antenna system. Self-setting 15-mg. Little NI used. Cheaper than M 3.
M 4 (2.5-mg)	Magnetic	SVK, Eumig, Baermann	1944	1944	Eumig	EMF, SMA, TMA, LMF	Not laid	Same as above - used in combination capable of resetting.
M 5	Magnetic	Hagenuk	1942	1943	Hage-nuk	Gnd. mines	Not laid	Same as M 1; 2.5-mg Miniature M 1
A 1	Acoustic	SVK Hell	Sum-mer 1940	In Two Weeks	Hell	LM	A/C	Carbon microphone, Two-relay circuit, 200-cps cut-off after 2 months' use, Shock-blocking - 30-sec. period in 1st models; duration of shock in later models.

Figure 131 - Table of Influence Mine Units - Navy

INFLUENCE MINE UNITS - NAVY (Continued)

Unit	Principle	Originating Firm	Development Start	1st Sample	Firm	Case	Use	Remarks
A 1st	Acoustic	SVK Hell	1941	In Three Weeks	Hell	LM	A/C	Same as A 1 but with "stumpf" microphone.
A 2	Acoustic	SVK Hell	Fall 1940	Short Time	Hell	TMB TMC	Sub.	Same as A 1.
A 2st	Acoustic	SVK Hell	1941	Short Time	Hell	TMB TMC	Sub.	Same as A 1st.
A 3	Acoustic	SVK Hell	Fall 1940	Short Time	Hell	EMF SMA	Sub. Sur-face	Same as A 1. Abandoned after large number of EMF/A 3's blew up spontaneously in bad weather.
A 4	Acoustic	SVK Hell	1942	Four Weeks	Hell	LM TM	Not laid	Same microphone as A 1. Minimum rate-of-change fixed. Also shock-blocking.
A 4st	Acoustic	SVK Hell	1944	Short Time	Hell	LM TM	A/C Sub.	Same as A 4 but with "stumpf" microphone.
A 7	Acoustic	SVK Hell	1944	Short Time	Hell	EMF SMA	Sub. Sur-face	Same as A 4 but with series condenser for determining mean sound level.
MA 1	Magnetic-Acoustic	SVK Hell	1941-1942	Four Weeks	Hell	LM	A/C	5-mg M 1 triggers; 1-tube circuit.
MA 1a	Magnetic-Acoustic	SVK Hell	1942	Short Time	Hell	LM	A/C	Same as MA 1 but no shock-blocking.
MA 2	Magnetic-Acoustic	SVK Hell	1942	3 Weeks	Hell	LM TM	Sub. A/C	5-mg. M 1 triggers 3-tube A circuit with rate-of-change circuit. 30-40 sec. active period of A.

Figure 131 - Table of Influence Mine Units - Navy (Continued)

INFLUENCE MINE UNITS - NAVY (Continued)

Unit	Principle	Originating Firm	Development Start	Development 1st Sample	Firm	Case	Use	Remarks
MA 3	Magnetic-Acoustic	SVK Hell	1944	Short Time	Hell	LM	A/C	Same as MA 2 but 15-sec. active period of A.
AT 1 (AA 1)	Acoustic-Subsonic	SVK	1942	6 Months	Elac	LM	Not laid	Acoustic triggers subsonic. Dynamic microphone 25 cps. 3-tube amplifier 60-sec. active period of T.
AT 2 (AA 2)	Acoustic-Subsonic	SVK Elac	1943	3 Months	Elac	LM	A/C	Same as AT 1, but improved protection against detonations. 3-4-sec. active period of T.
AT 3 (AA 3)	Acoustic-Subsonic	SVK Eumig	1943	5 Months	Eumig	TMB TMC	Not laid	Same as AT 2, but with longer life and for TM use.
D 1	Pressure	SVK	1942	6 Months	Hasag	LM TM	---	Pressure component only. Suction contact. Circuit normally set to 8-sec. delay.
D 2	Pressure	Hasag	1944	Short Time	Hasag	LM TM	---	Pressure component only. Smaller than D 1. Pressure contact added and detonation protecting valve.
DM 1	Pressure-Magnetic	SVK Hasag	1942	Summer 1942	Hasag	LM TM	A/C Sub.	5-mg M 1 combined with D 1; 8-sec. delay in D 1 circuit at 15-25-mm suction D 1 ready for action 15-40 sec. after M 1.

Figure 131 - Table of Influence Mine Units - Navy (Continued)

INFLUENCE MINE UNITS - NAVY (Continued)

Unit	Principle	Originating Firm	Development Start	Development 1st Sample	Firm	Case	Use	Remarks
M 1s	Magnetic	SVK	1943	1944	Hage-nuk	LM	Not laid	Improved M 1 to save battery on pendulum action.
M 1r	Magnetic	SVK	1943	1944	Hage-nuk	LM	Not laid	Sea electrodes detect current from LL-sweep and block; otherwise normal M 1.
MA 1ar	Magnetic-Acoustic	SVK	1944	Short Time	Hage-nuk	LM	Not laid	MA 1a with sea current blocking device for M 1 component.
S	Low-Frequency "Seismik"	SVK	1944-1945	1945	SVK Hage-nuk	LM	Not laid	Carbon microphone in D 1 unit. Fires on 5-8 cps.
DS 1	Pressure-Seismik	SVK	1945	Short Time	SVK	LM	Not laid	Combination of D 1 or D 2 with S.
AE 1	Acoustic-Echo	ELAC	1943	6 Months	ELAC	EMF SMA	Not laid	Acoustic triggers echo-sounder. Fires when water depth decreases - sensitivity 2 meters.
O	Optic	Ley-boldt	1941-1942	1942	Ley-boldt	--	Abandoned in '43	Selenium cell operates relay if light intensity decreases.
WS	Electro-Magnetic	Hell	(1932) 1942	3 Months	Hell	LM	A-ban-doned in '43	Two antennae for transmitter and receiver with no mutual induction. Acoustically-triggered. Xmtr 5 kc. Distortion of field fires.

Figure 131 - Table of Influence Mine Units - Navy (Continued)

INFLUENCE MINE UNITS - NAVY (Continued)

Unit	Principle	Originating Firm	Development Start	Development 1st Sample	Firm	Case	Use	Remarks
AA 4	Acoustic-Supersonic	Siemens	1943-1944	6 Months	Siemens		Abandoned in '44	Acoustic triggers two sets magnetistrictive receivers 25 kc. Output of two sets compared.
AMT 1	Acoustic-Magnetic-Subsonic	SVK	1944-1945	1945	SVK	TM	Not laid	Combination of M 4 with AT 3.
AMT 2	Acoustic-Magnetic-Subsonic	SVK	1944-1945	1945	SVK	LM	Not laid	Combination of M 4 with AT 2.
	Cosmic Ray	SVK	1942	--	Inst. of Prof. Regener	LM	Not laid	24 Geiger counters with 1000-1500 v fed to amplifier. Change in cosmic ray background level, when ship passes over, fires mine; rate-of-change circuit.

Figure 131 - Table of Influence Mine Units - Navy (Concluded)

INFLUENCE MINE UNITS - LUFTWAFFE

Unit	Principle	Mfr.	Development Start	Development End	Case	Remarks
M 101/	Magnetic	A.E.G.	Winter 1939	Fall 1940	BM 1000 I/II	Magnetic balance for vertical component.
M 103/	Magnetic	A.E.G.	Summer 1940	Spring 1941	BM 1000 I/II	Same as M 101, except that it responds to either a red or a blue field.
MA 101/	Magnetic-Acoustic	A.E.G.	Winter 1940	Fall 1941	BM 1000 H/M	Magnetic section like M 103 acoustic section consists of four microphones, transformer, and an amplifier. Magnetic triggers acoustic. Fires when sound reaches a certain intensity.
MA 102/	Magnetic-Acoustic	A.E.G.	1941	1942	BM 1000	Further development of the MA 101 with a more sensitive magnetic section.
A 104/	Acoustic	Hell	Spring 1941	Spring 1942	BM 1000 I/II	Sound must reach a certain intensity before firing. Shockblocking. Has a frequency response of 50 to 300 cps.
A 105/	Acoustic	Hell	Spring 1942	Fall 1943	BM 1000 I/II	Same as A 104 except that sound must reach certain level within a definite time to fire.
A 105/	Acoustic	Hell	Spring 1942	Fall 1943	BM 1000 I/II	Same as A 105 but with "stumpf" microphone.
A 107	Acoustic	Hell & Goeple	Spring	---	BM 1000 I/II/T	Further development of the A 105, with a rate-of-change circuit.
AD 104/	Acoustic-Pressure	Hell	Fall 1942	Fall 1943	BM 1000 I/II	A 104 plus a D 101 unit 4-6 or 6-8 sec. delay in D 101 circuit at 20-30 mm suction.
DA 102	Pressure-Acoustic	Hasag	Summer 1943	Summer 1944	BM 1000	Combination of D 102 and "Permissive" A circuit. A circuit uses a Hasag microphone. Must have a sustained suction of 5-9 seconds.
DA 112	Pressure Acoustic	---	---	---	BM 1000 H/M	Further development of the DA 102.

/ Used operationally

Figure 132 - Table of Influence Mine Units - Luftwaffe

INFLUENCE MINE UNITS - LUFTWAFFE (Continued)

Unit	Principle	Mfr.	Development Start	Development End	Case	Remarks
DA 122	Pressure Acoustic	---	---	---	BM 1000 H/M	Development of the DA 102, with "stumpf" microphone.
DA 132	Pressure-Acoustic	---	---	---	BM 1000 H/M	Development of the DA 102 with normal acoustic and "stumpf" D 102 unit.
DA 142	Pressure-Acoustic	---	---	---	BM 1000 H/M	Development of the DA 102 with normal acoustic and normal pressure but must have sustained suction of about 18 seconds.
DA 152	Pressure-Acoustic	---	---	---	BM 1000 H/M	Development of the DA 102; the acoustic unit works on a rate-of-change principle similar to the A 105; normal pressure unit.
DA 162	Pressure-Acoustic	---	---	---	BM 1000 H/M	Development of the DA 102, but no other information available.
D 103	Pressure	Hasag	Fall 1942	Summer 1943	BM 250	Fires on pressure actuation only. Requires a continuous suction of 3 seconds; sensitivity of 15 to 30 mm of water.
D 113	Pressure	Hasag	---	---	BM 250	Development of the D 103. Must have a sustained suction of 6-7 sec. and a sustained pressure of 2-3 sec.; sensitivity of 10 to 20 mm of water.
D 123	Pressure	Hasag	---	---	BM 250	Development of the D 103. Must have a sustained suction of 4-5 sec.; sensitivity of 10-20 mm of water.
D 133	Pressure	Hasag	---	---	BM 250	Development of the D 103. Must have a sustained suction of 2-3 sec.; sensitivity of 80-100 mm of water (stumpf).
AA 106	Acoustic-Supersonic combination	A.E.G. Atlas	Spring 1943	Winter 1944	BM 1000 H/M	Acoustic triggers directional supersonic. Two supersonic receivers (magnetstrictive), one vertical and one horizontal. Amplitude received by horizontal controls sensitivity of vertical. Frequency of 25 Kc.

Figure 132 - Table of Influence Mine Units - Luftwaffe (Continued)

INFLUENCE MINE UNITS - LUFTWAFFE (Concluded)

Unit	Principle	Mfr.	Development Start	Development End	Case	Remarks
AE 101	Acoustic-Echo combination	ELAC	Summer 1942	Summer 1944	BM 1000 H/M	Acoustic triggers vertical echo unit. Fires when 10-foot depth decrease occurs at proper minimum rate.
AJ 102	Acoustic-Induction	Hell	Spring 1944	Summer 1944	BM 1000 J III	British-type vibrator and coil-rod in parallel produce high frequency transients.
JDA 105	Induction-Pressure-Acoustic	A.E.G.	Spring 1943	Autumn 1944	BM 1000	Induction triggers pressure, and the pressure triggers the acoustic.
MA 105	Magnetic-Acoustic	A.E.G.	Spring 1943	Winter 1944	BM 1000 H/M	Improvement of the MA 101; acoustic amplifier improved and the magnetic part more sensitive (5-mg).
MDA 106	Magnetic-Pressure-Acoustic	A.E.G.	Fall 1944	Not complete	BM 1000 H/M	MA 105 plus pressure unit.
S 101	Clock-work	A.E.G.	Fall 1944	Winter 1944	BM 1000	Water flap must be closed for 30 sec. continuously. Mine will fire when present time (72-hour max.) has run off.
S 102✓	Optical	A.E.G. Hell	Fall 1944	Winter 1945	Wasser-balloon	Passive optical unit designed for use against bridges.
S 103	Optical	D.V.L.	Fall 1944	Not complete	Wasser-balloon	Similar to S 102; passive optical unit with 6 photo-electric cells.
S 104 S 105	Optical	A.E.G.	Fall 1944	Not complete	Wasser-balloon	Active acoustic unit with transmitter and receiver; light flashing method (13 flashes/sec.)

✓ Used operationally

Figure 132 - Table of Influence Mine Units - Luftwaffe (Concluded)

OPERATIONAL GROUND INFLUENCE MINES - NAVY

Designation	Weight, Pounds	Possible Units	Max. Depth for Unit*	Max. Depth for Charge	Maximum Laying Speeds	Minimum Mine Spacing
RMA RMB RMH	1,820 770 1,935	M 1 M 1 M 1	100 ft. 100 100	165-200 ft. 100 165-200	25 knots 25 25	525 ft. 325 525
KMB	220 440	M 1	100	100	12	165 260
TMB I/II	1,230	M 1 A 2 A 2st	100 115 115	130	25	425
TMB(S)	1,230	DM 1	80	130	25	425
TMB III	925	MA 2,3 DM 1	115 80	115	25	425
TMC I	1,960	M 1 A 2 A 2st	100 115 115	200-230	25	660
TMC II	1,760	MA 2,3 DM 1	115 80	165-200	25	660
LMA/S	770	M 1 M 3 A 1, 4 A 1st A 4st AT 2 MA 1, 2 MA 1st DM 1	100 65 115 115 115 115 115 115 80	100	25	325
LMB/S	1,540	Same as LMA/S	-	165	25	425
MTA	1,010	M 1	100	115	0	380

*Depths given are calculated on the basis of average targets.

Figure 133 - Table of Operational Ground Influence Mines - Navy

OPERATIONAL MOORED INFLUENCE MINES - NAVY

Designation	EMF	SMA/SMC≠	TMA	LMF
Case Material and Diameter	KSS 45 in.	KSS 47 in.	KSS 22 in.	KSS 26 in.
Method of Laying	Surface ship	Submarine	Submarine or Surface ship	Aircraft or Surface ship
Type of Unit	M 3	M 3	M 3	M 3
Other Possible Types of Units	M 4 A 7 AE 1	M 4 A 7 AE 1	M 4	M 4
Maximum Planting Depths	1,650 ft.	1,970-2,625 ft.	885 ft.	985 ft.
Minimum Planting Depths	130 ft.	165 ft.	165 ft.	165 ft.

≠ Same as SMA except that clock is fitted to anchor, permitting up to 60-day delay in separation of mine and anchor.

Figure 134 - Operational Moored Influence Mines - Navy

Chapter 11 - Section 2

MAGNETIC UNITS

M 1 UNIT AND MODIFICATIONS

The M 1 (Allied Designation M Mk II) unit falls into a general class of early magnetic firing devices known as BIK. BIK is an abbreviation of the OKM designation of the device which is "Ballon Inklinatorium", and is a cover name for all firing devices coming under this heading. Later, experiments with these units became more specialized to adapt them to special purposes, and separate designations were applied to the different variations. The modifications described herein are developmental modifications, some of which were on the verge of becoming operational.

<u>M 1 Unit.</u> The original type of hand-set BIK, designed for use in ground mines, was designated E-BIK for "Einer nadel BIK" (single-needle BIK), and the multiple-needle type for moored mines designated M-BIK for "Mehrer nadel BIK" (Multiple-needle BIK). Later the automatic latitude adjuster was applied to both. They were then called EE-BIK for "Selbst einstell E-BIK" and SM-BIK. The E-BIK was laid in 1939 and was designated M Mk I by the Allies. The EE-BIK was laid in 1940, and was similarly designated M Mk II. When the German nomenclature was systematized, the EE-BIK was designated M 1 by the Germans. This device went through some small improvements known as M Mk III and M Mk II (revised) to the Allies, but retained its original German designation. In 1941 the Germans laid the SM-BIK in the TMA mine. They considered this unit unsuccessful and experimental, and it was withdrawn from service. However, it was designated M 2 (Allied designation M Mk VII). Captured material examined indicates that the Germans conducted considerable experimental work on the movement of ground mines in mud. As a result, they felt that too much battery energy was being expended by excessive pendulum action in the normal M 1 unit. The first attempt to save the battery was by the use of two pendulums; one sensitive and one insensitive. This device was never used operationally.

<u>M 1s Unit.</u> The M 1s (s equals sparschaltung) is merely an improvement over the normal M 1 by the use of a different anti-countermining circuit. The magnetic brake of the latitude adjustment arrangement is fitted with a single-pole-single-throw normally-closed switch, which converts it to a normally-closed relay. In the normal M 1 an anti-countermin-

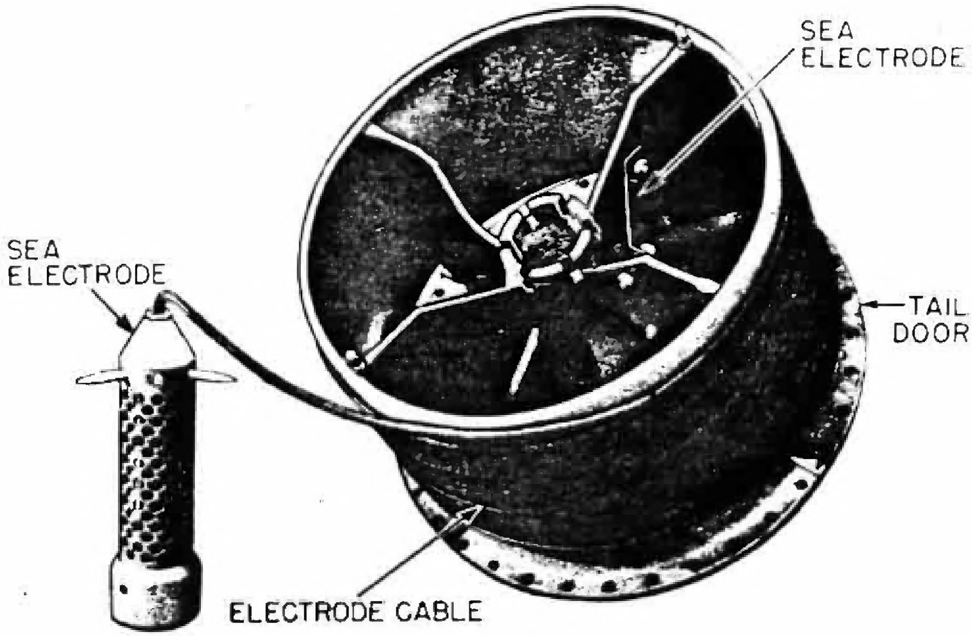
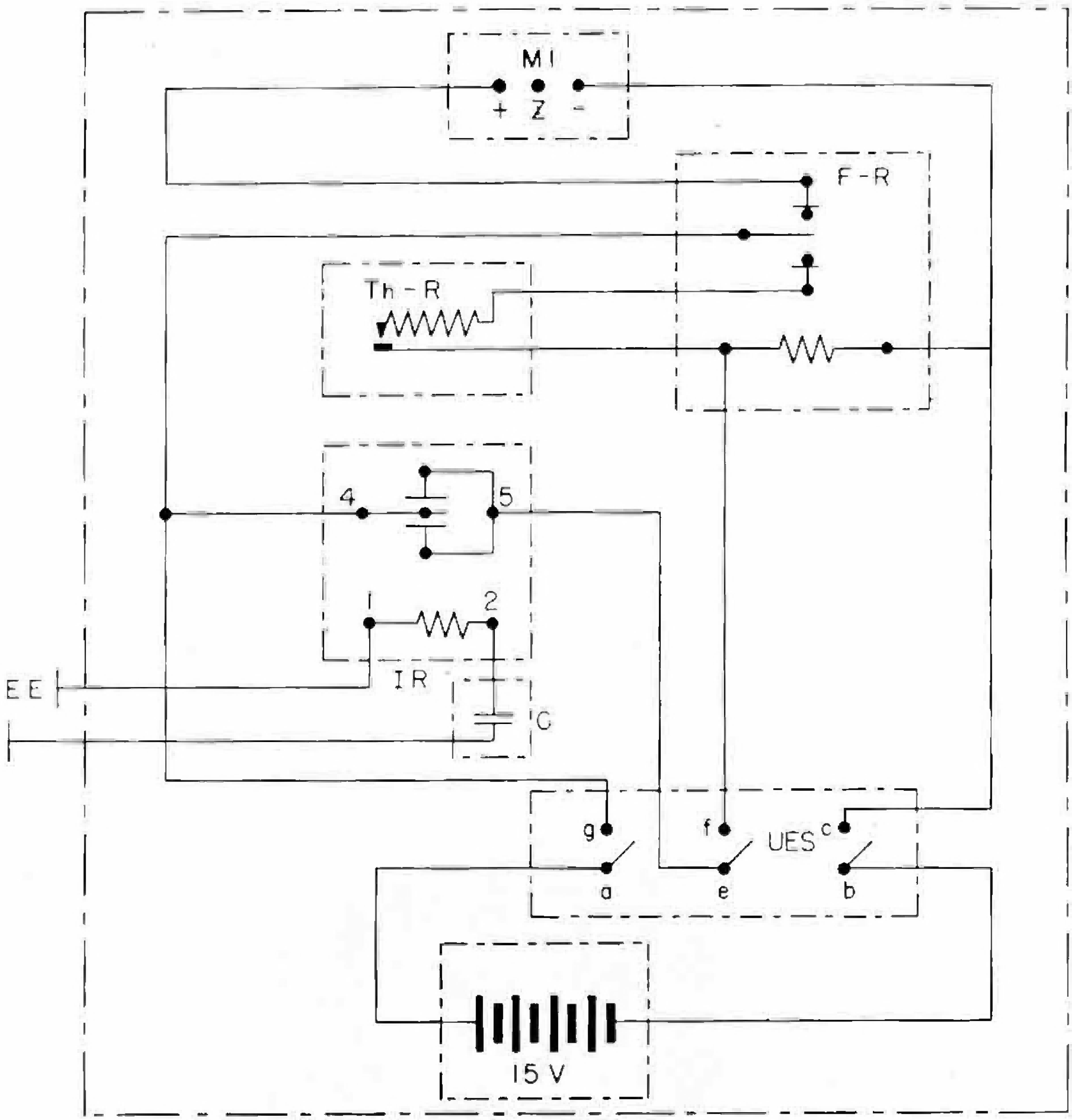


Figure 135 - Raumschutz for LMB Mine



MI - MI UNIT
Z - DETONATOR SWITCH
F-R - HOLDING COIL
Th-R - THERMAL DELAY SWITCH
a-g - HYDROSTATIC CLOCK CONTACTS
C - CONDENSER
UES - HYDROSTATIC CLOCK
EE - SEA ELECTRODES
IR - OPERATING COIL

Figure 136 - M IrUnit Circuit

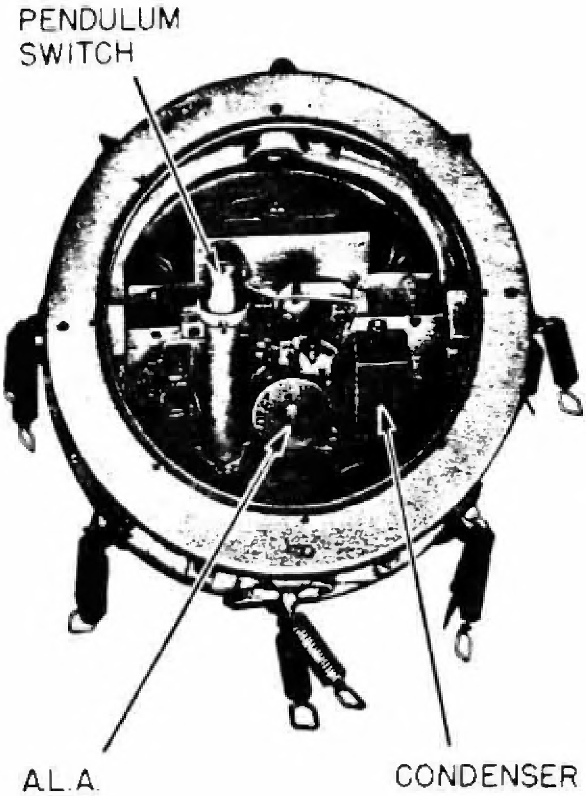


Figure 137 - M 1 Unit Housing

ing reaction was caused by movement of the gimbals which operated the pendulum switch; thus the hold-off coil and air-core relay were energized. The hold-off coil assured that the needle did not make contact, and the air-core relay closed the electromagnet switch, thus stopping the escapement of the latitude adjuster. The current which flowed in these two parallel circuits was approximately 0.5 amperes. This was considered excessive. In the M 1s, the hold-off coil is energized only during the latitude adjustment process if the needle sticks to its contact. Closing of the pendulum switch energizes the electromagnet directly, stopping the escapement and opening the ALA switch. Thus, until the hold-off is de-energized, no closing of needle contacts can fire the mine. One coil of the air-core relay and its corresponding contact are unused. In this circuit, the battery drain is approximately [illegible]0 ma. instead of 500 ma.

M 1r, MA 1r, and MA 1ar. The "r" (raumschutz) modification has been applied to M 1, MA 1 and MA 1a, in which case the "r" is appended to its designation. In MA 1r and MA 1ar the modification lies primarily in the M 1 component fitted, and this may be considered a modification of the M 1 unit. The "raumschutz" feature is a system designed to defeat magnetic sweeps of the sea-current type, such as the British LL. Although it is not definitely known to have been used operationally, it was in the advanced limited-production stage.

In principle, the "raumschutz" device consisted of a rubber-covered cable 165 feet long with a copper electrode at the end of the cable and another on the mine-case and insulated from it. When a magnetic sweep of the open-end sea-current type passes over, a small current would be induced into the cable, a sensitive relay in the mine would react, and the unit would be rendered passive for the duration of the sea current plus a predetermined period. This system was designed for mounting on the LMB mine when laid by S-boat. The mine electrode was mounted between the fins of a special tail-door, and its lead was led through the fins of a special compartment. The cable was wrapped around the fins of the tail door, and the tail electrode stowed inside the winding. Some experimentation has been carried on with nickel electrodes; but, for some reason unknown to the Germans, the nickel electrodes were destroyed by galvanic action after a few weeks in sea water, so copper electrodes were adopted.

The circuit of the "raumschutz" device of M 1r is shown in figure 138. When a sea current is detected by the sea electrodes EE, the current is fed to the operating coil of IR through condenser C, which is designed to eliminate spurious currents. When IR operates, the operating coil of F-R is energized, switches over, and breaks the + lead to the M 1 unit. This condition persists as long as sea current is detected by IR. When IR is de-energized, self-holding of F-R is maintained through thermal delay switch Th-R which now heats. When Th-R heats sufficiently (approximately 30 seconds), self-holding F-R is broken and the mechanism returns to normal.

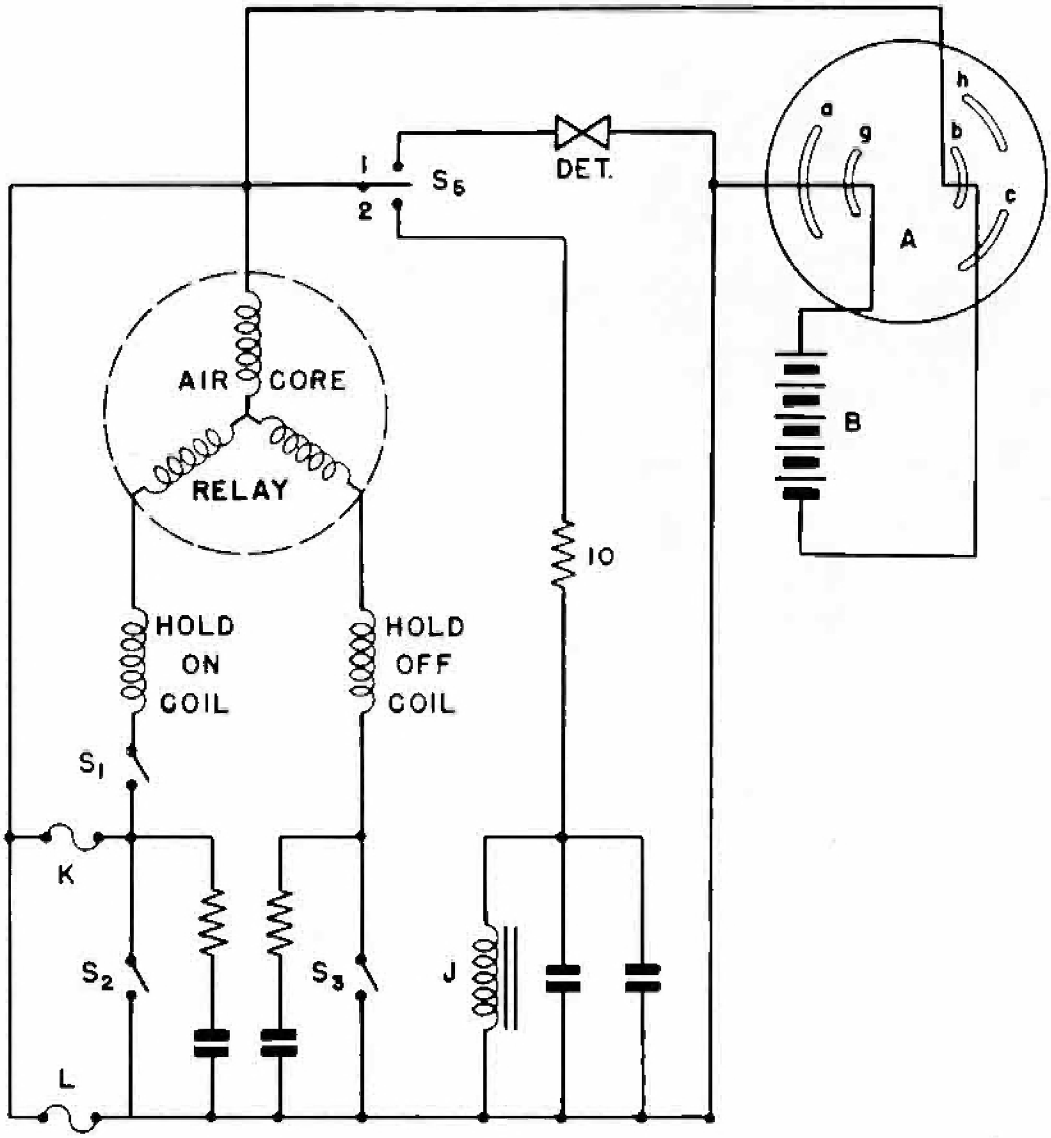
A few samples of M 1 have been found with a small clockwork fitted to the top of the needle box. This clockwork, when started by a normal actuation, drives five small gear wheels fitted with switch cams. These cams switch in various bias coils in the unit according to fixed time constants and thus transform the normal M 1 unit into a rate of change needle-type firing mechanism.

M 1 Unit Circuit - Operation (Figure 138)

Arming. 5 1/2 minutes after the six-day clock starts, a-g closes, and b-c closes 11 1/2 minutes later. B then blows L, unlocking the needle and starting A.L.A. Upon completion of A.L.A., S_2 closes and B blows K, allowing the preset sensitivity to be applied to the unit. As the preset sensitivity is applied, S_2 opens and, upon completion of this operation, S_1 closes. The unit is now alive.

Normal Firing. A firing actuation closes S_2. This energizes the hold-on coil and the relay, closing S_5 to contact No. 1 and completing the circuit through the detonator.

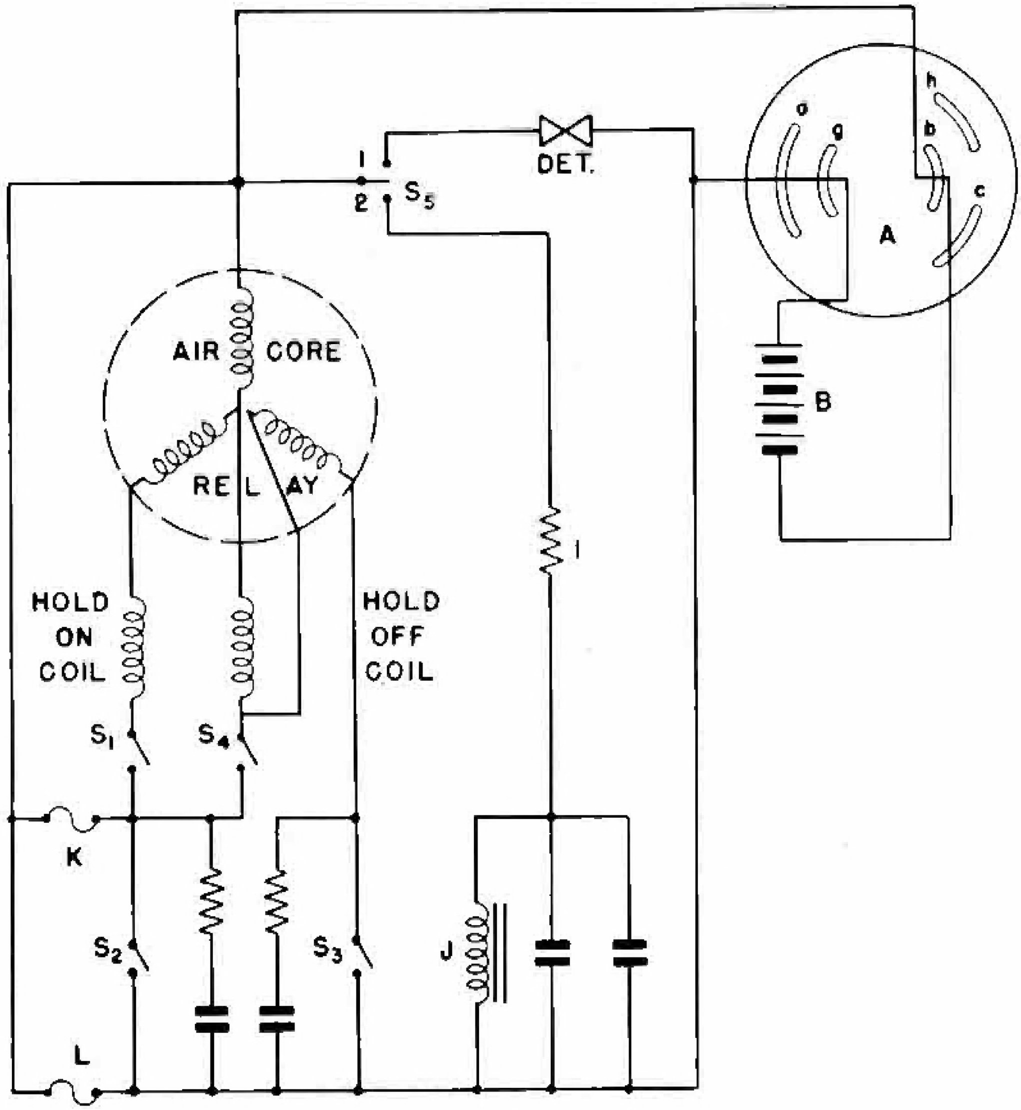
Normal Anti-Countermining. A counter-mining shock closes S_3. This energizes the hold-off coil and the relay, closing S_6 to contact No. 2. The unit remains passive until S_3 settles down.



A CLOCK(HYDROSTATIC)
B BATTERY-15 VOLTS
K AUTOMATIC SETTING FUSE(ALA)
L MAGNET RELEASE FUSE(ALA)
J ELECTROMAGNET

S_1 SENSITIVITY SETTING SWITCH
S_2 NEEDLE SWITCH
S_3 PENDULUM SWITCH
S_5 AIR CORE RELAY SWITCH

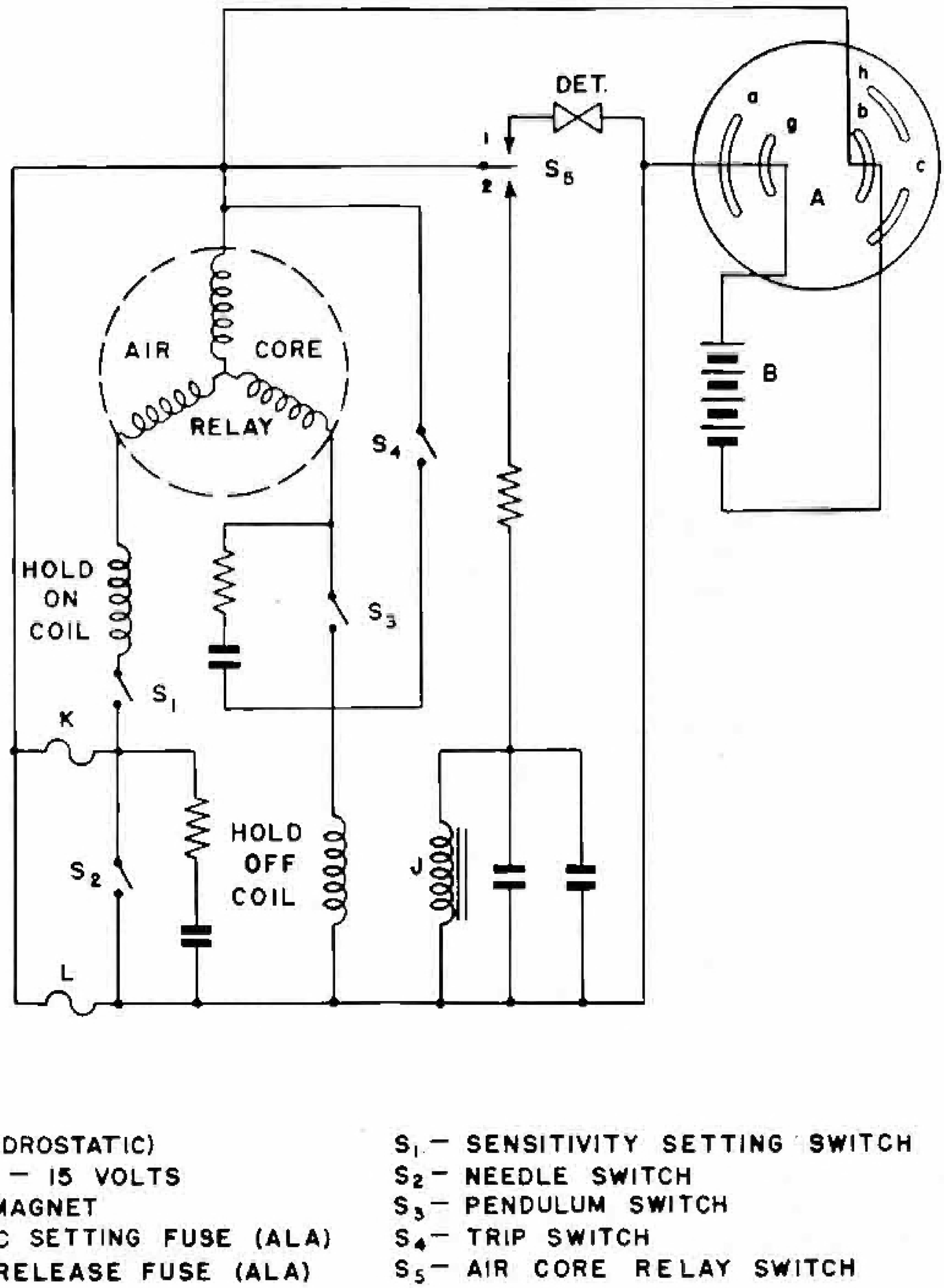
Figure 138 - M 1 Unit Circuit



A CLOCK (HYDROSTATIC)
B BATTERY-15 VOLTS
K AUTOMATIC SETTING FUSE (ALA)
L MAGNET RELEASE FUSE (ALA)
J ELECTROMAGNET

S_1 SENSITIVITY SETTING SWITCH
S_2 NEEDLE SWITCH
S_3 PENDULUM SWITCH
S_4 TRIP SWITCH
S_5 AIR CORE RELAY SWITCH

Figure 139 - M 1 Unit (First Revision) Circuit



A — CLOCK (HYDROSTATIC)
B — BATTERY — 15 VOLTS
J — ELECTROMAGNET
K — AUTOMATIC SETTING FUSE (ALA)
L — MAGNET RELEASE FUSE (ALA)

S_1 — SENSITIVITY SETTING SWITCH
S_2 — NEEDLE SWITCH
S_3 — PENDULUM SWITCH
S_4 — TRIP SWITCH
S_5 — AIR CORE RELAY SWITCH

Figure 140 - M 1 Unit (Second Revision) Circuit

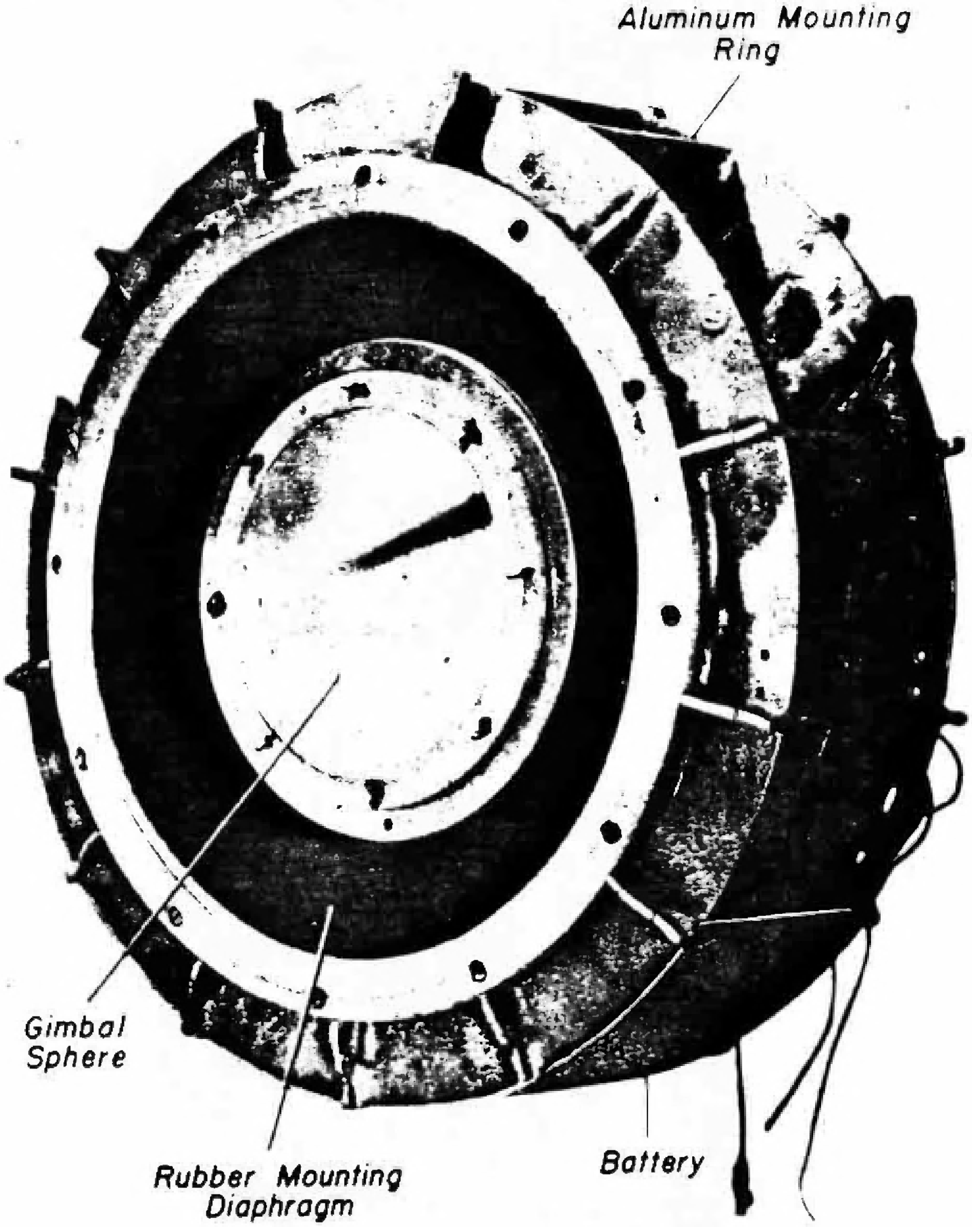


Figure 141 - M 1 Unit for LMA/LMB Mines

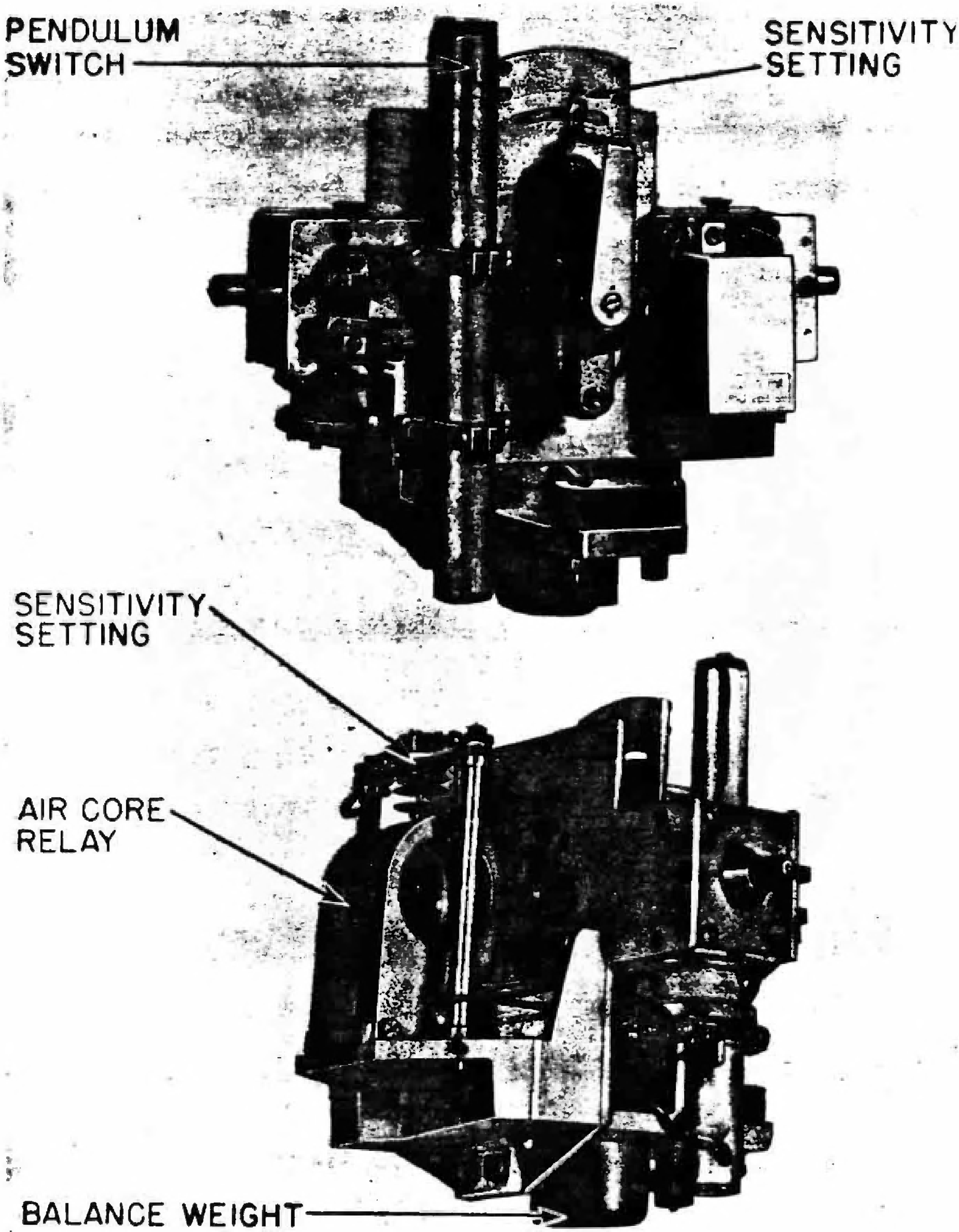


Figure 142 - M 1 Unit - Hand-Set - Front and Side

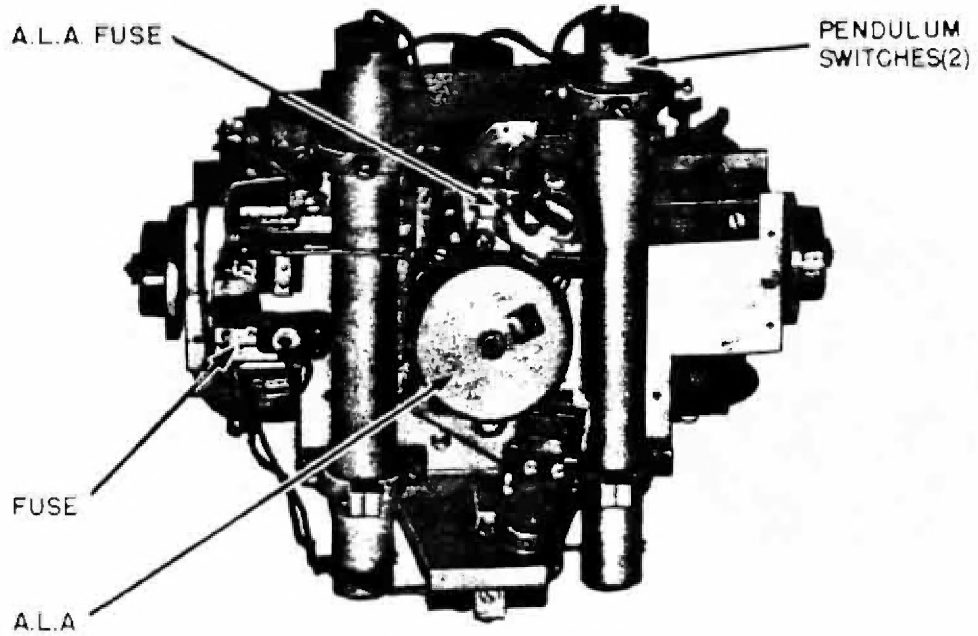
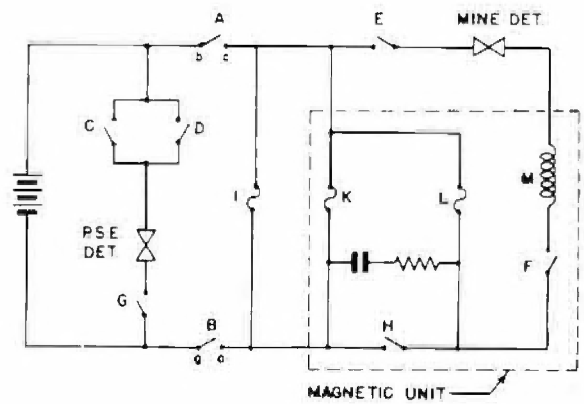


Figure 143 - M 1 Unit - Two-Pendulum



A CLOCK SWITCH
B " "
C P.S.E. SWITCH
D " "
E A/C SWITCH
F SENSITIVITY CONTACT
G SAFETY PIN
H NEEDLE SWITCH
I DET. RELEASE FUSE
K UNIT RELEASE FUSE
L LATITUDE FUSE
M HOLD ON COIL

Figure 144 - M 2 Unit Circuit

A countermining shock during A.L.A. closes S_3. The hold-off coil and relay operate as above, energizing J, which holds the A.L.A. arm inoperative until S_3 settles down.

M 1 (1st Revision) Unit Circuit - Operation (Figure 139).

Arming. Same as original unit except that if S_2 does not open properly as the preset sensitivity is applied, the A.L.A. arm momentarily closes S_4, completing the circuit through the hold-off coil and S_2, opening S_2.

Normal Firing and Anti-Countermining. Same as the original M 1.

M 1 (2nd Revision) Unit Circuit - Operation (Figure 140)

Arming. Same as the M 1, except that, as the preset sensitivity is applied, S_4 closes momentarily even if S_2 has opened properly; the purpose being to make doubly sure that S_2 is open at the completion of the operation.

Normal Firing and Anti-Countermining. Same as M 1.

M 2 UNIT

M 2 Unit Circuit - Operation (Figure 144). The M 2 (SM-BIK) unit was a dip-needle type unit designed for and laid in the TMA mine. It was considered unsuccessful and experimental, and was withdrawn from service.

Arming. When the hydrostatic clock runs

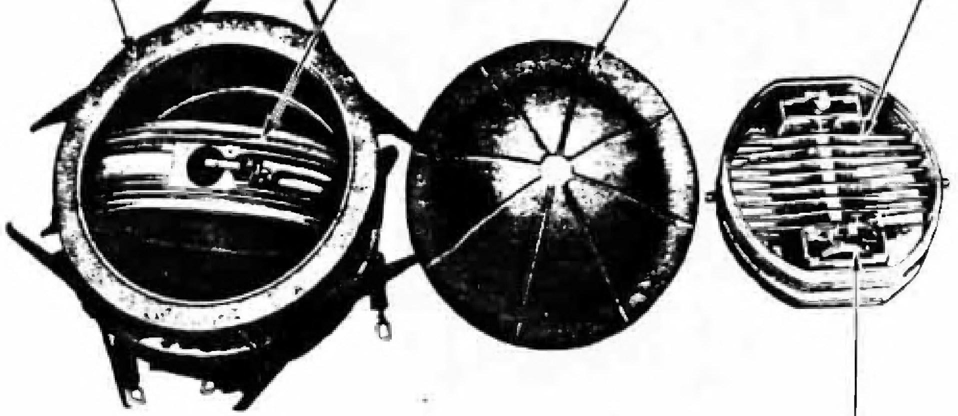


Figure 145 - M 2 Unit Breakdown

Figure 146 - M 2 Unit In TMA Mine

off its delay setting, a-g and b-c close, blowing the detonator release fuse and starting A.L.A. which is performed as in M 1. The M 2 differs from M 1 as follows:

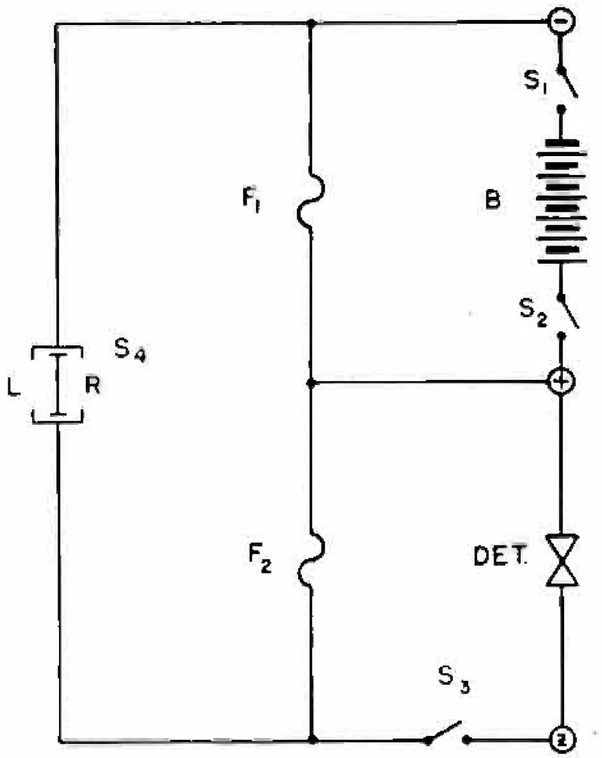
1. The firing current passes directly through the needle switch.

2. The anti-countermining device is of a different type.

3. The needle switch consists of eight flat needles mounted on a horizontal shaft with the needle edges in the vertical plane. The shaft is reverse-geared to a counterbalance system of weights and lever arms, so that the moments of inertia of the needles and counterbalance system are equal and opposite. The above change in construction permits the unit to tilt as much as 45° from the vertical without closing the needle switch. The net result of this modification, then, is that the opposing inertia moments prevent the unit from firing from shock or tilting, whereas the needles may depress and close the needle switch upon receipt of a firing actuation without affecting the counterbalance system.

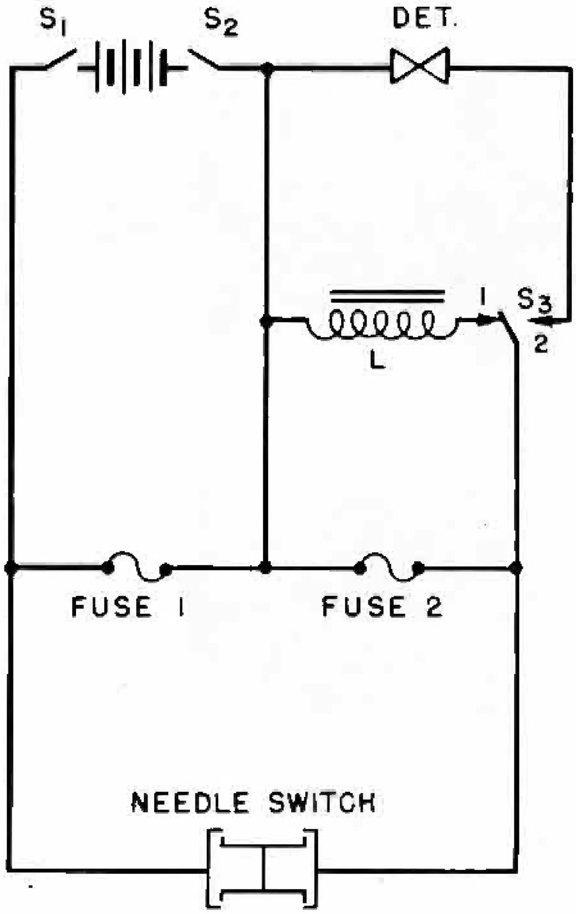
Normal Firing. A firing actuation closes the needle switch, operating the hold-on coil and completing the circuit through the detonator.

Normal Anti-Countermining. A countermining shock opens the inertia-operated clockwork-type anti-countermining switch, which is normally closed. When the switch opens, it winds a small clockwork escapement, and the circuit is broken until the escapement



B- BATTERY 9 VOLTS
F_1 FUSE
F_2 FUSE
S_1 HYDROSTATIC CLOCK SWITCH
S_2 HYDROSTATIC CLOCK SWITCH
S_3 CAM SWITCH
S_4 NEEDLE SWITCH

Figure 147 - M 3 Unit Circuit



S_1 S_2-CLOCK SWITCHES
S_3- P.D.M. SWITCH
L - P.D.M. SOLENOID

Figure 148 - M 3 Unit Circuit (Revised)

runs down in 3 to 10 seconds, varying directly with the intensity of the shock.

M 3 UNIT

M 3 Unit Circuit - Operation (Figure 147). The M 3 (Allied designation M IV and M IVa) bi-polar unit was designed primarily for moored influence mines EMF, LMF, SMA, and TMA.

This unit contains an armature-type, vertically-pivoted needle and represents an improvement over the M 1 group in that it is more compact, incorporates bi-polar firing, and can be made in mass production. No anti-countermining device is fitted, and the unit fires more readily because of motion. Nevertheless, this unit has been used with considerable success in moored and ground mines laid by submarines, surface craft, and aircraft with parachute. An improvement of the M 3 incorporates a special, 15-place mechanical P.D.M. as an integral part of the unit.

Arming. When the hydrostatic clock runs off its delay period, S_1 and S_2 close, blowing fuse No. 1. This releases a clock escapement and starts A.L.A. S_4 makes and breaks during A.L.A., blowing fuse No. 2. Upon completion of A.L.A., S_3 closes and the unit is alive.

Normal Firing. A RED or BLUE actuation closes S_4 to the proper contact, completing the circuit through the detonator.

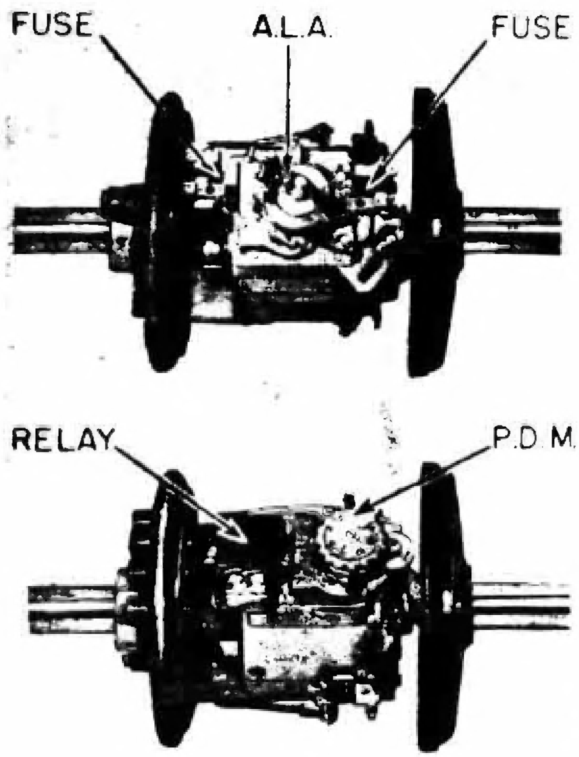


Figure 149 - M 3 Unit - Front and Rear Views

M 3 (Revision) Unit Circuit - Operation (Figure 148).

Arming. When the hydrostatic clock runs off its delay period, S_1 and S_2 close, blowing fuse No. 1. This releases a clock escapement and starts A.L.A. During A.L.A. the needle switch closes, blowing fuse No.2 and energizing L. When fuse No. 2 blows, the Needle switch reopens and L is de-energized. Upon completion of the P.D.M. cycle, the unit returns to normal. After a maximum of 14 "blind" actuations, S_3 changes from contact No. 1 to contact No. 2, cutting out the P.D.M. and putting the detonator in the circuit.

Normal Firing. An additional RED or BLUE actuation closes the needle switch, completing the circuit through the detonator.

THE M 4 UNIT

The M 4 unit is a bi-polar, dip-needle, magnetic unit. It is of the same basic type as the M 3, but it is smaller and more compact. It is capable of dependable setting at a 2.5 mg sensitivity, and was used operationally in 1945.

The M 4 may be used alone in moored or ground mines, or as a magnetic trigger in a combination unit. In the former case, the sensitivity is adjusted to 20 mg; in the latter case, sensitivity settings may be as high as 2.5 mg. When used in combination, the M 4 is capable of repeated resetting to compensate for magnetic variations or faulty original adjustments.

The major differences between the M 4 and M 3 units are as follows:

1. The M 4 is capable of higher sensitivity settings.

2. The M 4 has a more dependable latitude adjustment system.

3. The orientation of the M 4 need not be vertical.

4. The M 4 is capable of re-setting when used in combination.

5. The M 4 is much smaller, of more rugged construction, with fewer moving parts.

The M 4 was developed to meet the need for a bi-polar unit of high sensitivity which would not fire prematurely as a result of mine motion. When used as a straight magnetic unit, the M 4 is mounted in gimbals for vertical orientation.

The use of M 4 on a fixed-axial orientation in the LM or TM type mines in combination with AT 2 and AT 3 was in development. These combinations were designated AMT 2 and AMT 3.

Unit Construction. A cross section and circuit representation of the M 4 is shown schematically in figure 152. Two mu-metal cylinders lead the magnetic field to two pole pieces which are adjacent to the needle. The needle is a cylindrical drum magnet mounted on a horizontal axis with its poles normally fixed at right angles to the axis of the pole pieces. The drum magnet consists of a quantity of steel powder within a bakelite matrix. In constructing the magnet, the steel powder is pressed into the matrix, and, in that form, is magnetized. The top pole piece has two coils (R and H-1) with adjusting resistors (W 1 and W 2) mounted next to them. Mounted on the lower pole piece is a single coil (H 2). A small d-c motor is mounted on the pole piece. This motor has a permanent magnetic field and a reduction gear train. Since the motor is rigidly fixed on the pole piece, it maintains a constant orientation with respect to the needle magnet. The magnetic effect of the motor is compensated for in latitude adjustment.

Latitude Adjustment and Arming Process. Two hairsprings are connected to the needle shaft. One is so adjusted that it has no tension when the needle is in equilibrium. The other hairspring is connected to a motor-driven gear wheel with a 1 : 64,500 ratio. The latitude adjustment is accomplished by the rotation of this wheel. Before latitude adjustment commences, this

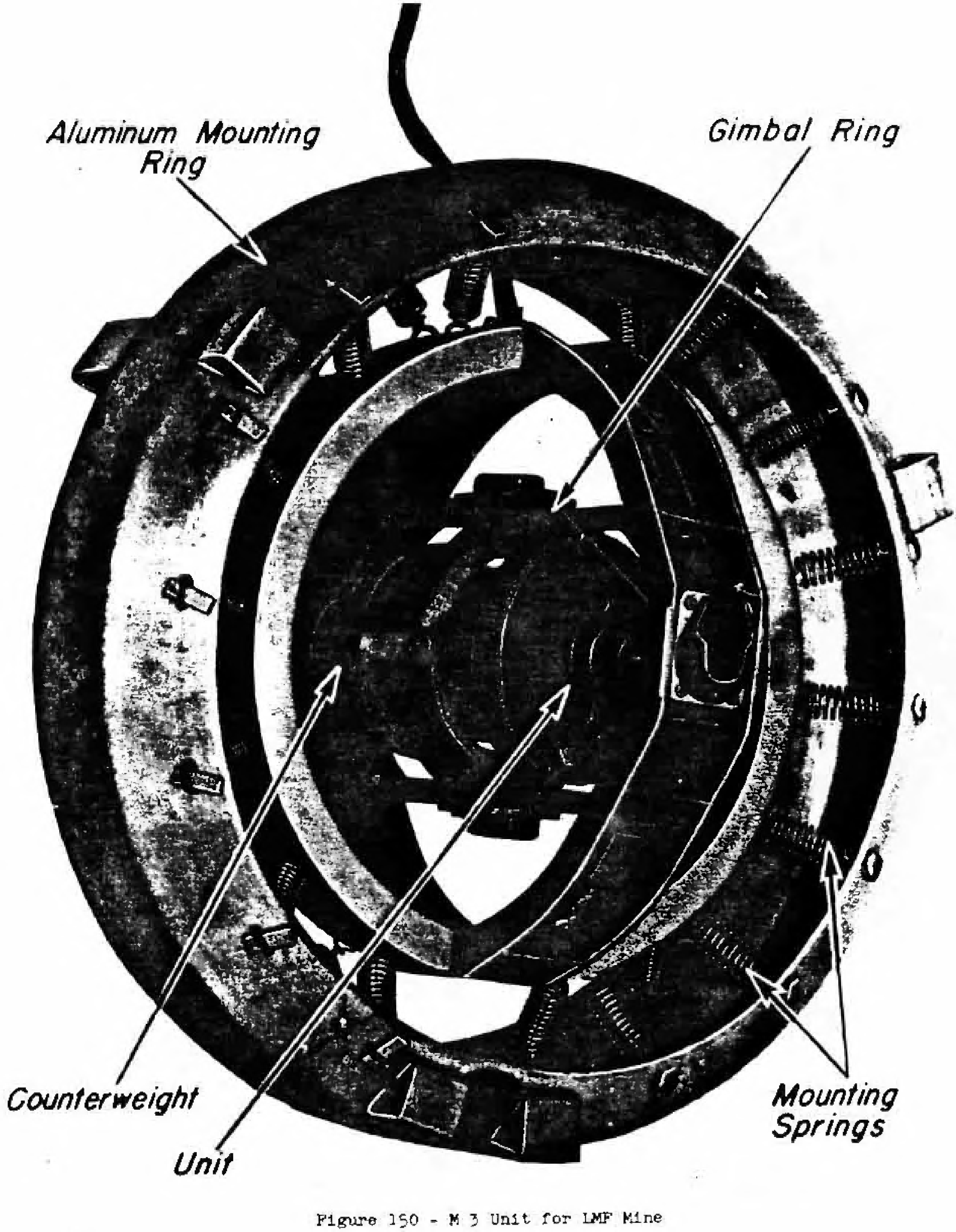


Figure 150 - M 3 Unit for LMF Mine

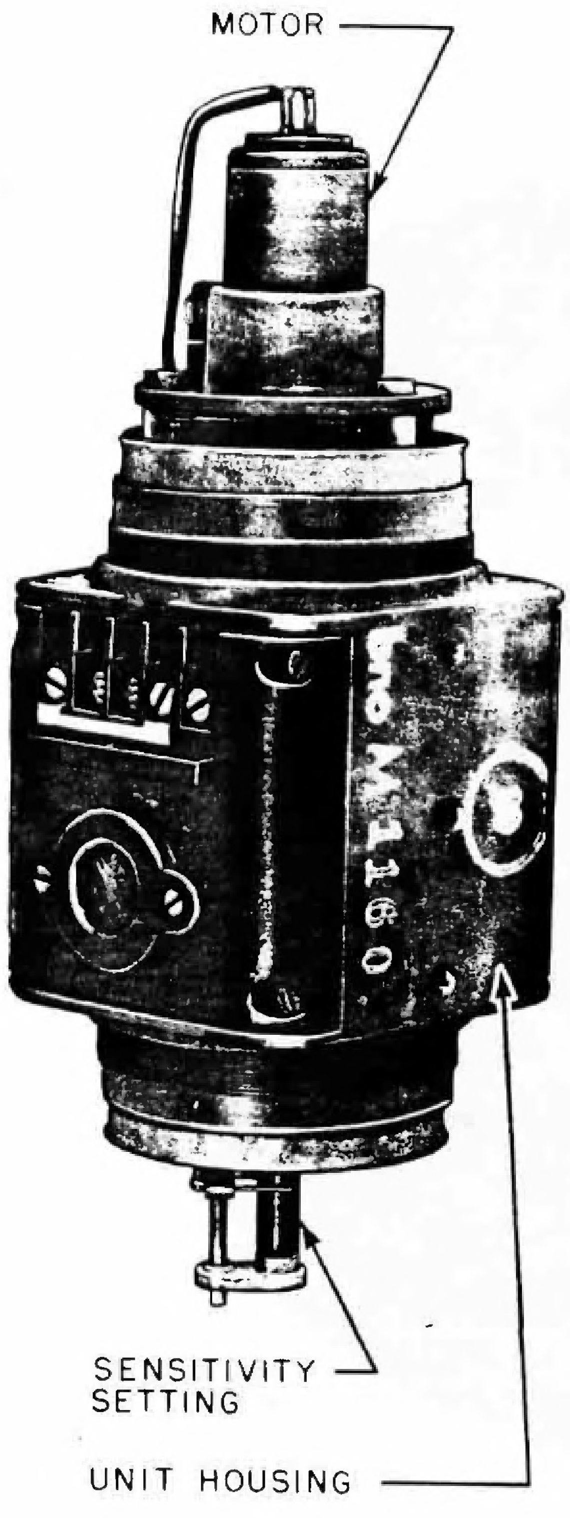


Figure 151 - M 4 Unit

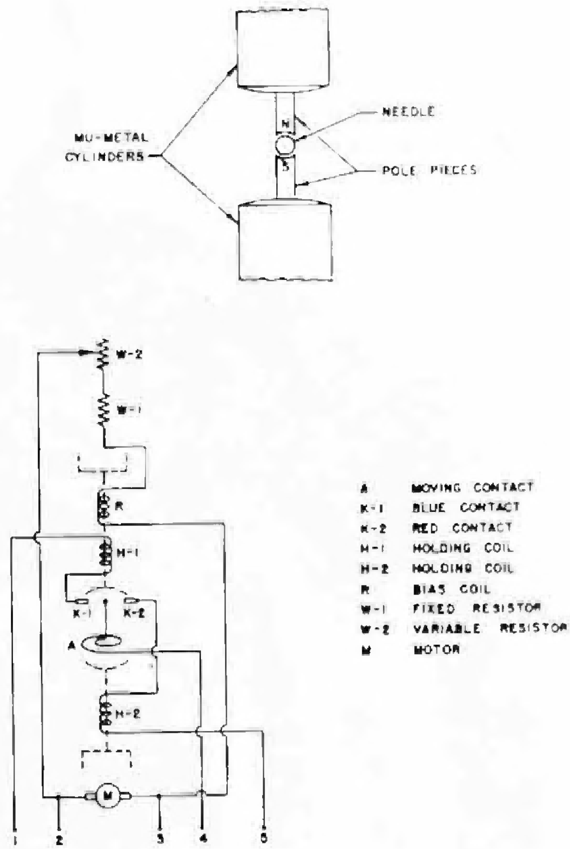


Figure 152 - M 4 Unit Circuit

hairspring has a tension capable of equalizing a magnetic field up to 800 mg RED. However, in this condition, the moving needle contact is held fixed in an equilibrium position by a cam-operated clamp switch. The cam releases the needle, and the spring tension is equal to approximately 700 mg RED. The adjustable range of the mechanism is from 700 mg RED to 400 mg BLUE.

The latitude adjustment and arming process for magnetic actuation is as follows, when the ZR Ia mechanism is used (See figure 154).

When the battery and detonator are connected into the circuit, the motor (M2) is energized and begins to run. Its ratio gear train drives the main gear wheel, which reduces tension on the hairspring. When the tension has been decreased to a point equal and opposite to a field of 700 mg RED, switch T + opens, releasing the needle. The needle then closes to the BLUE contact K_1. The current continues to flow to the motor and to the biasing coil R on the hairspring. The bias-coil-adjusting resistor W is adjusted to exert a RED bias on the unit equal to the RED sensitivity.

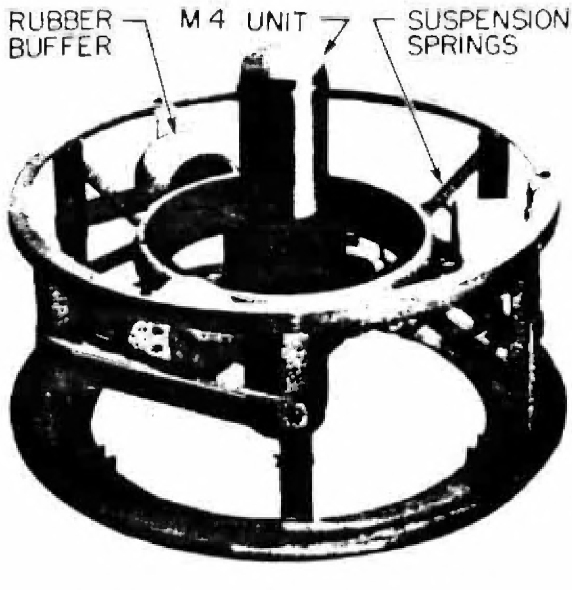


Figure 153 - M 4 Unit in Housing

When tension on the hairspring has been decreased sufficiently, the needle moves from BLUE contact K_1 to RED K_2, permitting current to flow to relay A through III, IV, H_2 and K_2. When A is energized, contacts a_1 and a_2 operate. Contact a_2 provides self-holding for A and short circuits H_2. Contact a_1 breaks the circuit to the motor and de-energizes the bias coil, permitting the needle to resume equilibrium. This is accomplished by the switching over of a_1, at which time the fuse (S) blows.

When fuse (S) blows, the switching escapement starts contacts III and IV open. (A) is de-energized, allowing a_1 and a_2 to return to normal, and, after approximately four seconds, contacts I and II close and IV recloses. At this point, the arming process is complete.

Firing. If the unit is actuated by a RED field, the needle moves to the RED contact K_2,—the needle being held on by H_2—and the battery fires the detonator through II. If a BLUE actuation occurs, the needle moves to the BLUE contact K_1,—the needle being held on in this case by H_1 — and the battery fires the detonator through II, IV, and I.

+ T is the needle clamp switch which is fitted to all M 4 units, when M 4 is employed as a straight magnetic unit. T is used for clamping only.

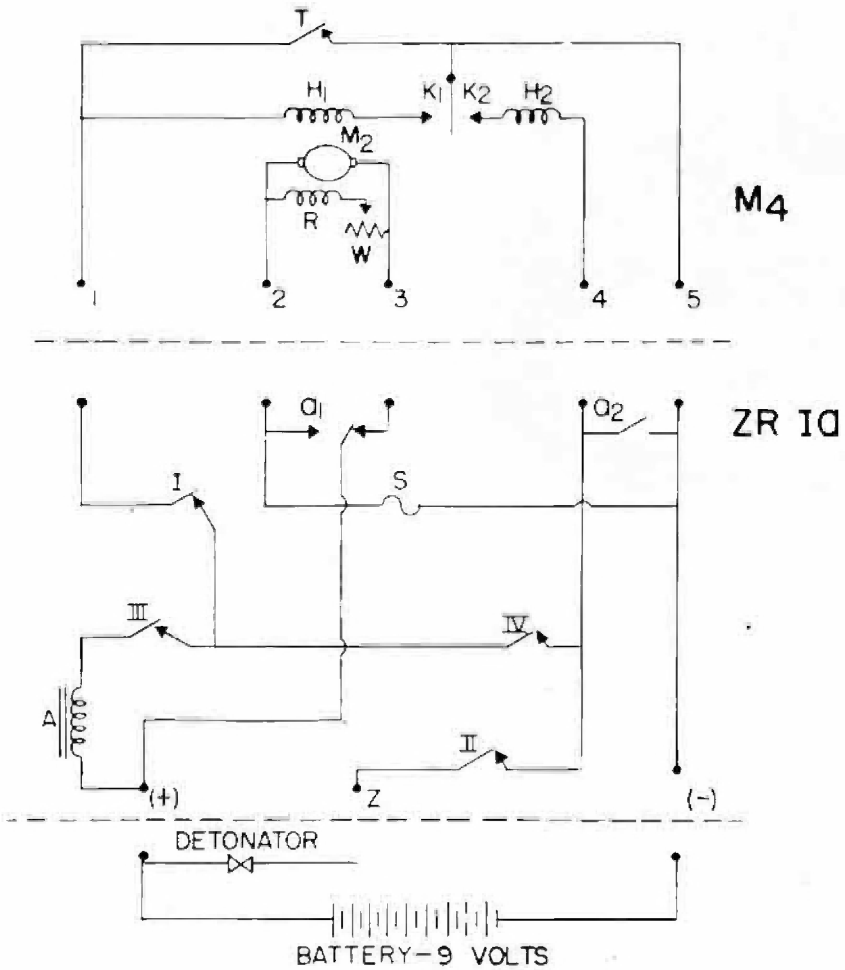
M 4 Used in Combination with Another Unit. When the M 4 is used as a straight magnetic unit, it may premature, because of faulty settings or variations in the earth's magnetic field. On the other hand, when used in combination with other units, the M 4 will reset itself when actuated to compensate for the agnetic influences exerted. The mechanism designed to accomplish this resetting is called ZR IIb, and is used only when M 4 is combined with AT 2 or AT 3 (these combinations are designated AMT 2 and AMT 3).

The circuit of M 4 with ZR IIb is shown in figure 155. The switch cam of ZR IIb is actually fitted with six contacts, but for simplicity, only four are indicated. When the battery is connected into the circuit, relay A is energized through contact T. When T opens, A remains energized through BLUE contact K_1. Current passing through A causes a_1, a_2, and a_3 to operate. Contact a_3 maintains self-holding of A, a_2 starts motor M_1 and a_1 switches over. At this point, it is necessary for contact II to be closed in order for latitude adjustment to take place. Thus, approximately 30 seconds of each two-minute cycle is available for magnetic adjustment. With the above exceptions, latitude adjustment occurs in the normal manner.

When latitude adjustment is complete, the unit is ready for actuation. If a RED magnetic actuation occurs, K_2 is made and relay B energized through III and H_2. When B is energized, b_1, b_2 and b_3 operate. Contact b_3 maintains self-holding of B; b_2 starts the cam-switching motor, and b_1 switches over, but does not energize M_2, since II is open. A few seconds later, I closes and maintains motor current until the end of the cycle. Thereafter, IV closes, energizing the associated combination units. If the mine does not fire, IV reopens after a set interval and II closes. If, at this point a different magnetic field prevails, the motor M_2 readjusts the M 4 unit accordingly. If the unit is still properly adjusted, A is energized, and the adjusting current through R and M_2 is broken. If a new adjustment has been necessary, the same series of events will occur after the adjustment. At a point near the end of the switching cycle, II and III open. The opening of II limits the period during which readjustment may take place. The opening of II breaks the holding circuit to A and B, after which III recloses. When I closes, the switching cycle ceases. If the closure period of II is insufficient to permit proper readjustment, the needle switch remains on contact and a new cycle is started. This process continues until proper adjustment has taken place.

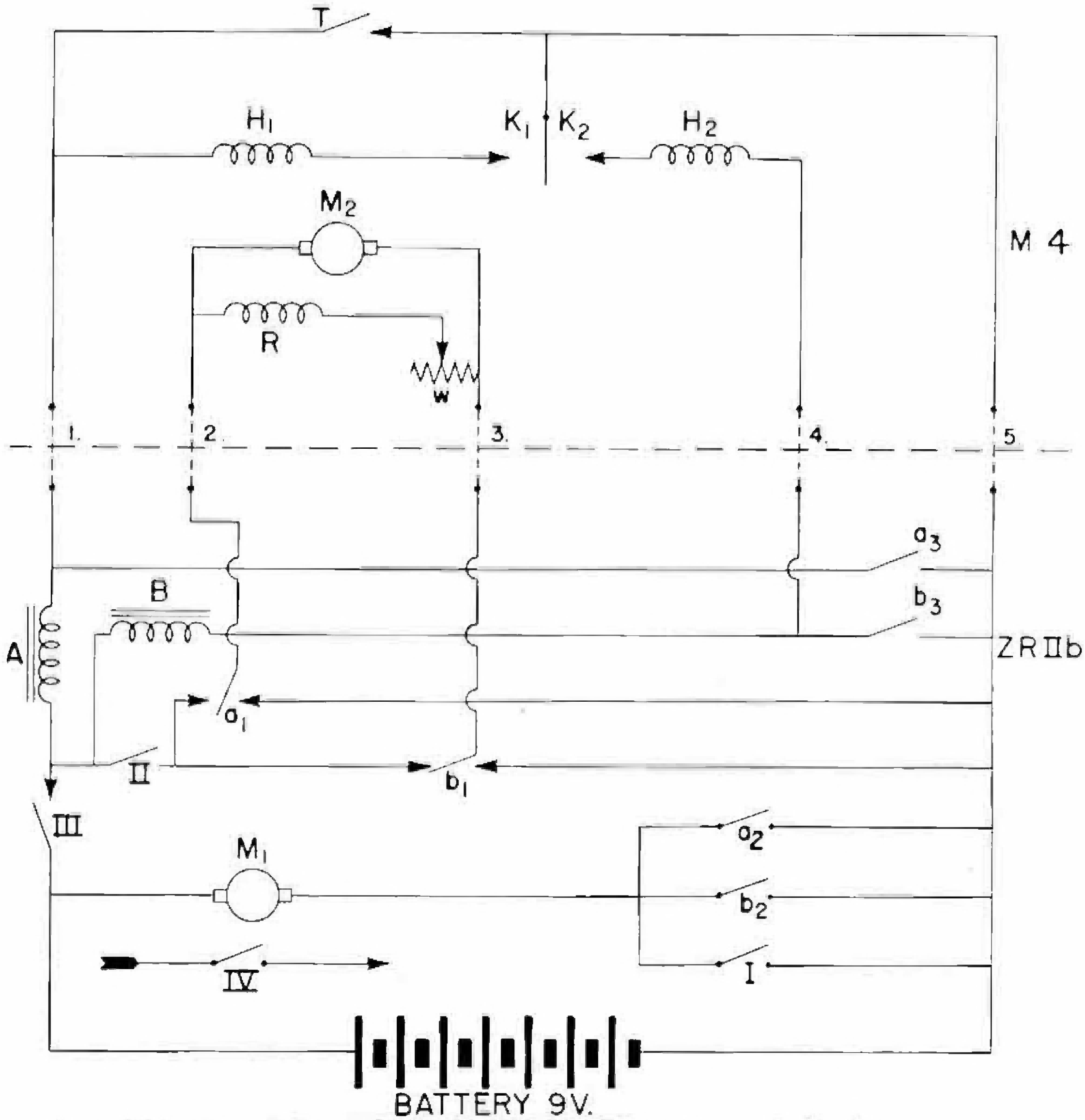
M 5 UNIT

The M 5 is a relatively small and simplified dip-needle type unit of the same basic construction as the M 1, and is suitable for mass production. It is fitted with a pendulum-type anti-countermining switch, and was designed for use in ground mines. Its operational characteristics are similar to those of the M 1, except that it is reported to be capable of dependable setting at a 2.5-mg sensitivity. Its development was undertaken in parallel with that of the M 4, the intention being that the unit which proved more satisfactory would be adopted. The M 4 development was completed first. Since the



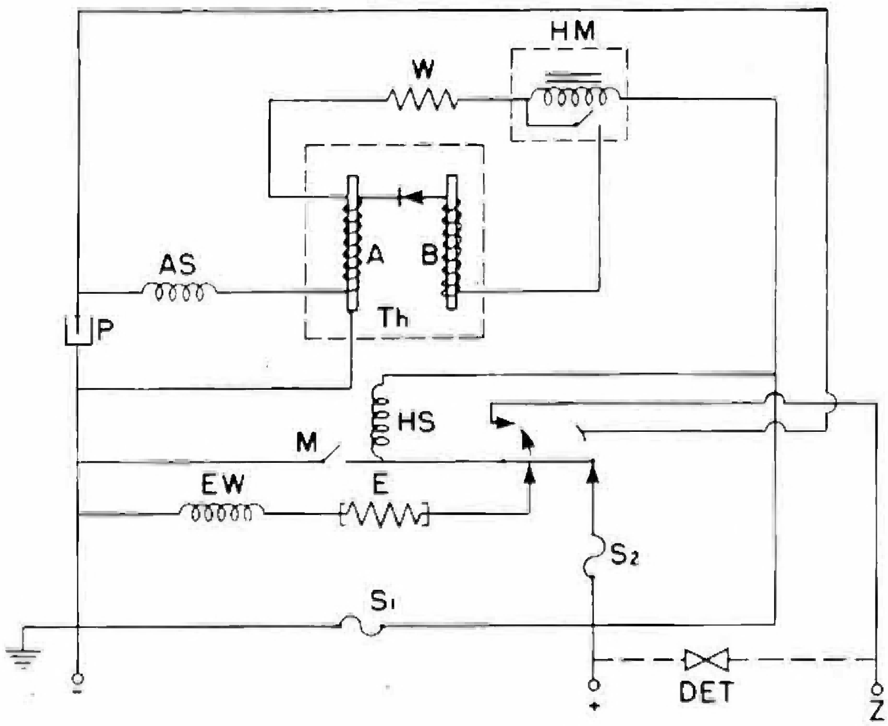
M_2	MOTOR OF M4 UNIT
R	BIAS COIL (RUCKSTELLSPULE)
H_1, H_2	HOLDING COILS (HALTESPULEN)
W	BIAS-ADJUSTING RESISTOR
A	RELAY (a_1 AND a_2 CONTACTS OF A)
S	FUZE (SCHMELZDRAHT)
I, II, III, IV	CONTACTS OF ZR Ia
T	NEEDLE CLAMPING SWITCH
K_1 (BLUE) K_2 (RED)	CONTACTS
1, 2, 3, 4, 5	TAP-IN FOR USE IN COMBINATION WITH OTHER UNITS

Figure 154 - M 4 Unit Circuit (with ZR Ia)



A, B - CONTROL RELAYS WITH CONTACTS $a_1, a_2, a_3, b_1, b_2, b_3$.
I, II, III, IV CONTACTS OF CAM-SWITCHING MECHANISM ZR II b.
M_1 - MOTOR OF ZR IIb
M_2 - MOTOR OF M 4
T - NEEDLE CLAMPING SWITCH
K_1 - BLUE CONTACT
K_2 - RED CONTACT
H_1 - H_2 - HOLDING COILS
R - BIAS COIL
W - BIAS ADJUSTING RESISTOR
S - FUSE
IV - ZR II b CONTACT FOR ASSOCIATED COMBINATION UNITS
1, 2, 3, 4, 5 TAP-IN FOR USE IN COMBINATION WITH OTHER UNITS.

Figure 155 - M 4 Unit Circuit (with ZR IIb)



Th THERMAL DELAY SWITCH
(COIL A-CLOSING-4Ω)
(COIL B-OPENING-75Ω)
S_1 =MAGNET-RELEASE FUSE
S_2 =LATITUDE-SETTING FUSE
AS=HOLD-OFF COIL (0.4Ω)

HS=HOLD-ON COIL (0.6Ω)
W =RESISTOR (5Ω)
M =NEEDLE SWITCH
P =PENDULUM SWITCH
HM=ELECTROMAGNET (15Ω)
E =SENSITIVITY-SETTING COIL 0.2Ω

EW=SENSITIVITY-SETTING RESISTOR-PLUG IN

TYPE	SENSITIVITY	RESISTANCE
a	5 mg	2000Ω
b	10 mg	1000Ω
c	20 mg	500Ω
d	30 mg	335Ω

Figure 156 - M 5 Unit Circuit

M 5 unit had the advantage of bi-polarity and repeated latitude setting, and was suitable for use in moored mines, the work on the M 5 was curtailed.

The Unit Frame. The unit frame is a single casting mounted on gimbal rings inside a spherical container approximately eight inches in diameter. The container is fitted with rubber ties that serve as shock absorbers. The unit is so balanced that it assumes a vertical position rapidly. All the electrical and magnetic components are mounted on the unit frame except the setting coil (einstellwicklung) and the setting resistor (einstellwiderstand). The components mounted on the frame are:

1. The needle switch and damping assembly
2. The hold-on coil (Haltespule)
3. The pendulum switch (Pendel)
4. The hold-off coil (Abreisspule)
5. The anti-countermining device (Haltemagnet)
6. The thermal delay switch (bi-metal Relais)
7. The five-ohm resistor
8. The clockwork escapement
9. Magnet-release fuse
10. The latitude-setting fuse and switch

The Needle Switch. This switch is a single-pole single-throw type, mounted on knife edges and fitted with four cylindrical permanent magnets. These magnets are approximately 3/8 inch long and are mounted in the same plane on two parallel axes. There are two magnets approximately 1/2 inch apart and parallel to each other at each end of the needle switch casting, and they are so arranged that the parallel axes of the magnets at each end are the same. This arrangement gives the appearance of two parallel magnets 1/2 inch apart, broken in the middle by a gap of about 1/4 inch. The needle axis is fitted with a moving contact outside the magnet housing. Two hairsprings are mounted on the needle axis, one of which is a stabilizer and has no tension when the plane of the magnet is horizontal (switch closed). The other is an adjusting spring which has a large initial tension that serves to hold the needle switch off contact until proper clockwork adjustment takes place. Each end of the switch casting is fitted with a wire to which a disc of 1/2 inch diameter is attached. These two discs move in cylindrical wells within the main unit frame, and by means of a loosely fitted "dash-pot" action, provide the needle damping. The needle housing is protected from dust by two small transaparent plastic covers. The magnetic moment of the system is the same as for the M 1.

The Hold-On Coil. This coil is mounted on a form on the bottom of one end of the unit frame. It is 5/8 inch in diameter and 1/2 inch long, and has a resistance of 0.06 ohms.

The Pendulum Switch. This pendulum is of the same type as that used with the M 1 unit, but is much smaller. (1/2 inch in diameter, 2 3/4 inches long).

The Hold-Off Coil. This coil is mounted on a form on the bottom center of the unit frame. It is 3/4 inch in diameter and 1/4 inch long, and has a resistance of 0.3 ohms.

The Anti-Countermining Relay. This relay is a small two-coil type with a single-pole single-throw contact that is normally open, and is mounted on one side of the unit frame. When energized, this relay stops the clockwork escapement by blocking the motion of the escapement arm. The resistance of the relay magnet is 15 ohms.

The Thermal Delay Switch. This switch consists of two bi-metal strips with a normally closed contact between them, each strip being wound with a heater coil, and this switch is a part of the anti-countermining circuit. One of the strips has a four-ohm heater coil and acts as a contact in another part of the circuit. When heated, this strip tends to keep the switch closed. The other strip has a 75-ohm heater coil which, when heated, tends to open the switch

The Clockwork Escapement. This device is similar to the one used in the M 1 unit with the normal type oscillating arm. When released by the blowing of the magnet-release fuse, this device slowly decreases the tension in the needle hairspring, this process continuing until the clockwork is stopped by the blowing of the latitude setting fuse.

The Magnet-Release Fuse. This fuse is the ordinary wire type, and, when blown, it performs two functions:

1. It unlocks the magnetic switch.
2. It releases the latitude adjustment clockwork escapement.

The Latitude-Setting Fuse. This fuse is the same type as the magnet-release fuse. When blown as a result of the first closing of the needle switch, it releases a spring-loaded arm which:

1. Breaks contact to the setting coil.
2. Makes transient contact to ensure that the needle does not stick.
3. Closes the final arming circuit to the detonator.

The Setting Coil. The sensitivity-setting coil is wrapped around the inner gimbal ring, and, in conjunction with the sensitivity-setting resistor, puts a RED magnetic bias field on the mechanism during the latitude-adjusting process. The resistance of this is 0.2 ohms.

The setting resistor is plugged into a receptacle on the inner gimbal ring. The value of this resistor determines the sensitivity of the unit when armed. The following are four resistance values for four different sensitivities:

5 mg - 2,000 ohms
10 mg - 1,000 ohms
20 mg - 500 ohms
70 mg = 335 ohms

Operation of the Unit. When the hydrostatic clock runs off, the battery is connected across the (+) and (-) terminals of the unit, and the magnet-release fuse S_1 blows, with the following results:

1. The needle switch is unlocked and is free to rotate on its knife edges.

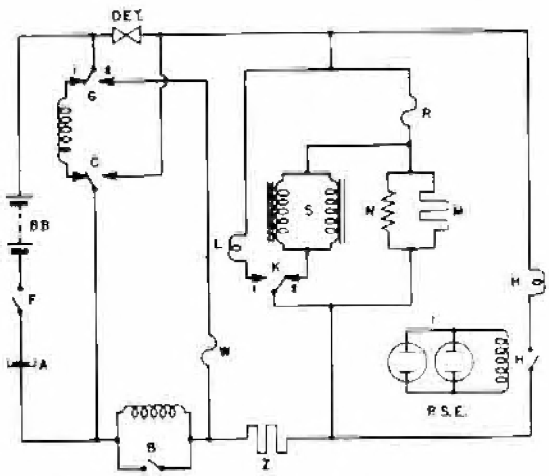
2. The latitude adjustment escapement is allowed to start.

Rotation of the latitude-adjustment escapement causes gradual decrease in the tension of the needle hairspring. During this process, the sensitivity-setting bias coil, EW, which is in series with the bias coil resistor E, is energized. This determines the amount of RED bias placed on the unit. When the hairspring tension has decreased to the point where the torque on the needle shaft caused by the hairspring is equal and opposite to the magnetic force of the earth's vertical field, the needle switch will be in equilibrium.

When the needle switch M closes, the reduction in resistance causes the latitude-setting fuse S_2 to blow and release a spring-loaded arm which, in rotating, breaks the circuit to the sensitivity-setting coil and stops the latitude-adjustment escapement. When the sensitivity-setting coil is de-energized, the RED bias is removed. However, since the hold-on coil HS is energized at this time, the needle switch does not reopen.

Rotation of the spring-loaded arm makes transient contact, energizing the hold-off coil AS through the relay HM. When energized AS removes the needle from its contact and de-energizes HS. Current through HM causes it to close contact, thereby energizing the self-holding circuit through the contact of the thermal delay switch. This condition persists until the 75-ohm heater opens the thermal delay switch, de-energizing HM. Further rotation of the arm carries it to its limit stop, closing the arming switch which connects terminal Z to the needle-switch circuit. The unit is now fully armed. At this time, a RED magnetic field, equal to or greater than the RED bias field imposed by EW in adjustment, will close M. The HS coil will hold the needle on contact, and the detonator will fire.

Disturbance of the mine unit actuates the pendulum switch. This switch energizes the hold-off coil, holding the needle off contact, and current is passed through the four-ohm heater, which tends to keep the thermal delay switch closed. If this disturbance



A CLAPPER SWITCH
B FUSE DELAY SWITCH
BB BATTERY 15 VOLT
C FUSE DELAY SWITCH
F MASTER SWITCH
G HYDROSTATIC SWITCH
H PHOTOCELL RELAY AND HOLD-ON
I PHOTOCELL
K NEEDLE SWITCH
L HOLD-ON COIL FOR K
M THERMISTOR
N RESISTOR
R FUSE
S LATITUDE ADJUSTMENT COILS
W FUSE
Z THERMISTOR

Figure 157 - M 101 Unit Circuit

occurs during latitude adjustment, the current passing through the HM coil will stop latitude adjustment, and close the HM self-holding circuit. The thermal delay switch is prevented from opening, while the pendulum is closed because the four-ohm coil is energized. For this reason, the duration of a protection period is at least equivalent to the duration of the disturbance.

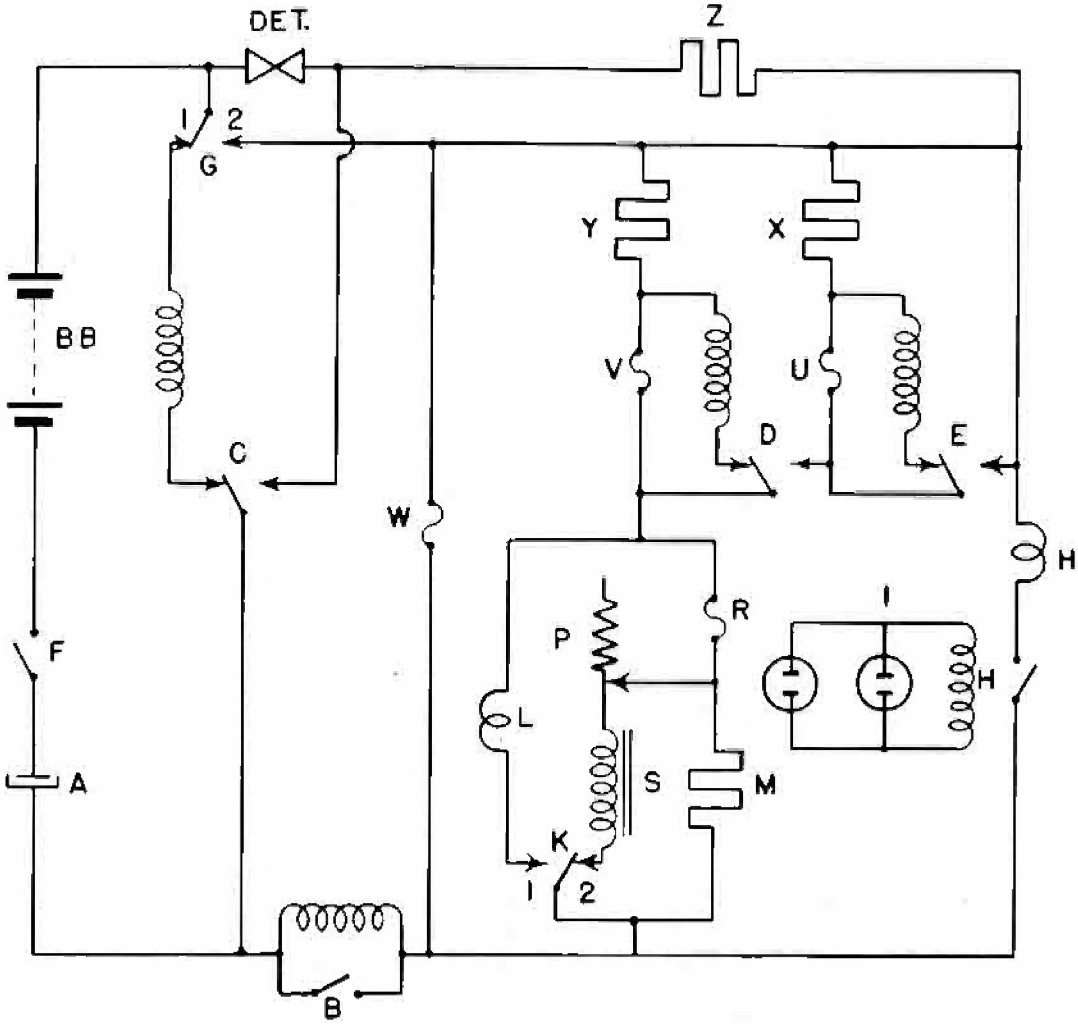
M 101 UNIT

The M 101 unit * (Allied designation, M Mk VI, M Mk VIII) was the first of the Luftwaffe mine unit series. It is a uni-polar unit, and it operates on the principle of magnetic balance for a vertical component. Work on this unit began in the winter of 1939, and it was completed and ready for operational use in the fall of 1940. It was used operationally as a magnetic unit, and in combination with acoustic and pressure components in the BM 1000 I/II mine cases.

M 101 Circuit - Operation (Figure 157).

Arming. When the mine is dropped, action of the Rheinmetall fuse closes the master

* The M 101 appears operationally with two modifications. The first was the addition of a specially designed, electrical, three-place, ship counter; the second, the addition of an electrical 10-place ship counter. In each instance, after recovery, the Allied designations changed; however, the modified units remained M 101 in the German system.

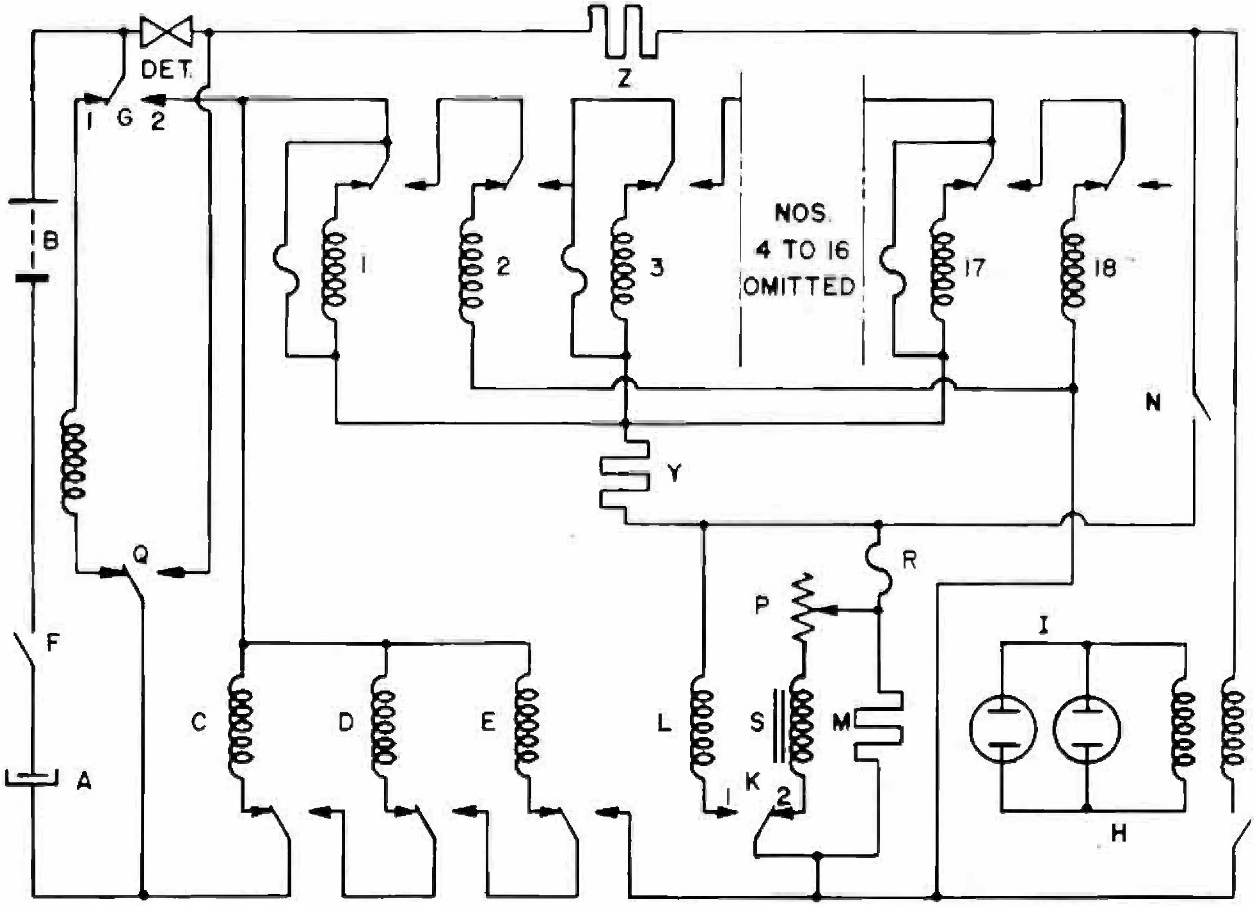


A	CLAPPER SWITCH	L	HOLD-ON COIL FOR K
B	FUSE DELAY SWITCH	M	THERMISTOR
BB	BATTERY 15 VOLT	P	RESISTOR
C	FUSE DELAY SWITCH	R	FUSE
D	" " "	S	LATITUDE ADJUSTMENT COILS
E	" " "	U	FUSE
F	MASTER SWITCH	V	"
G	HYDROSTATIC SWITCH	W	"
H	PHOTOCELL RELAY AND HOLD-ON	X	THERMISTOR
I	PHOTOCELL	Y	"
K	NEEDLE SWITCH	Z	"

Figure 158 - M 101 Unit Circuit (with Three-Place P.D.M.)

switch F. The thermostatic clapper Switch A is normally closed at temperatures above 32° Fahrenheit. If the mine reaches a depth of 24 feet or more, the hydrostatic switch G closes to contact No.2, and the battery BB energizes fuse delay switch E through fuse W. Upon completion of its delay period, E shorts its heater coil and W blows, as a result of the increased current in the circuit. Battery current is then applied to the magnetic firing circuit.

Switch K is normally closed to contact No. 2 because of the BLUE field of a local magnet. When current energizes coil S, this magnet is depermed by rapid making and breaking of contact No.2 until K no longer tends to close to contact No.2. Thermistor M then heats un-



A – CLAPPER SWITCH
B – BATTERY 15 VOLT
C – FUSE DELAY SWITCH
D – " " "
E – " " "
F – MASTER SWITCH
G – HYDROSTATIC SWITCH
H – PHOTOCELL RELAY AND HOLD-ON
I – PHOTOCELL
K – SWITCH-MAG. UNIT RELAY
L – HOLD-ON COIL FOR K
M – THERMISTOR
N – FUSE DELAY SWITCH
P – RESISTOR
Q – SWITCH 40 SEC. FUSE DELAY
R – FUSE
S – LATITUDE ADJUSTMENT COILS
Y – THERMISTOR 5 TO 8 SEC.
Z – " 2 TO 5 SEC.
1-3-5-7- SWITCHES 27 SEC. FUSE DELAY
2-4-6-8- " 7 " " "

Figure 159 - M 101 Unit Circuit (with Ten-Place P.D.M.)

til fuse R blows and isolates the A.L.A. circuit. The unit is now alive.

Delay-Action Bomb Firing. If the mine does not reach a depth of 24 feet, G remains on contact No. 1 and BB energizes C. Upon completion of its delay period, C switches over, completing the circuit through the detonator.

Normal Firing. A RED actuation closes K to contact No. 1, completing a circuit through the detonator, hold-on coil L, and thermistor Z. When Z has heated sufficiently, L holds K on contact No. 1 and a current increase to 1/4 ampere fires the detonator.

P.S.E. Firing. The unit is fitted with two photo-electric cells designed to be energized upon exposure to light. The resultant current operates relay H, completing a circuit through H, Z and the detonator. The detonator will fire as above when Z heats sufficiently.

M 101 With Three-Place P.D.M. (Figure 158).

Arming. Same as original unit.

Delay-Action Bomb Firing. Same as original unit

Normal Firing with Period-Delay Mechanism. A RED actuation closes K to contact No. 1, completing a circuit through thermistor Y, fuse V, and hold-on coil L. As Y heats, L holds K on its contact and V blows, energizing fuse-delay switch D. Upon completion of its delay period, D switches over, completing a circuit through thermistor X and fuse U. X, being cold, cannot pass enough current to operate L, and the circuit returns to normal.

A second RED actuation causes repetition of the above, with X heating, U blowing, and fuse-delay switch E switching in the detonator and thermistor Z. Z, being cold, cannot

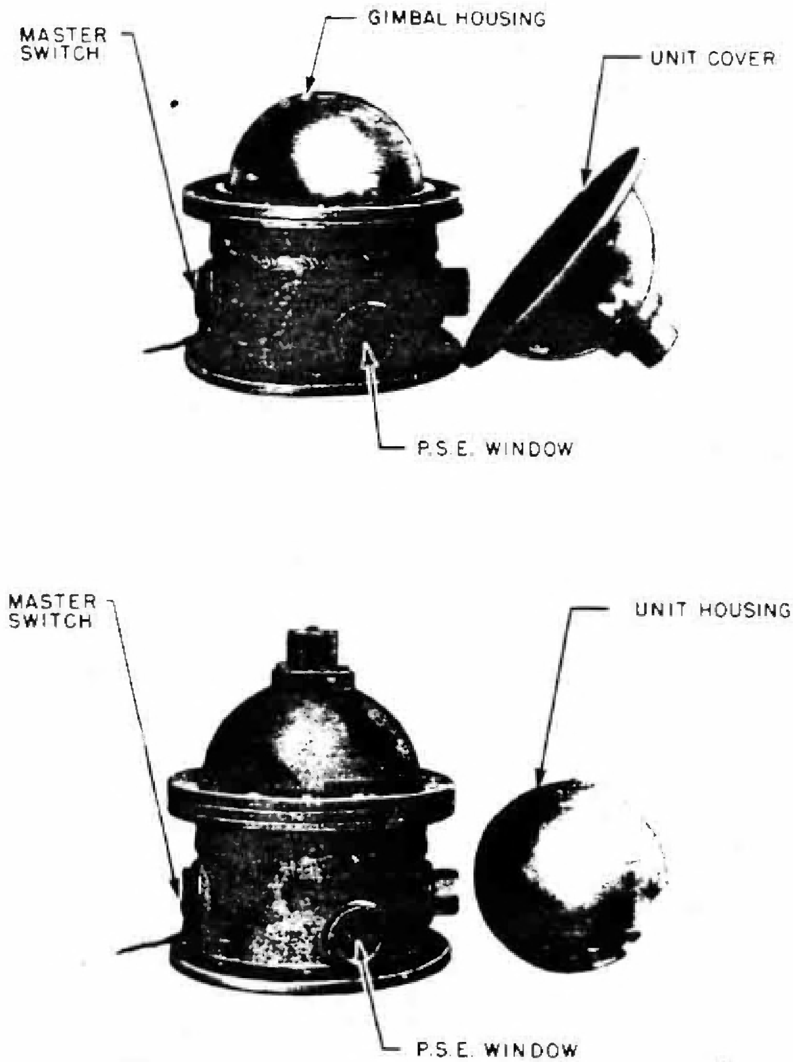
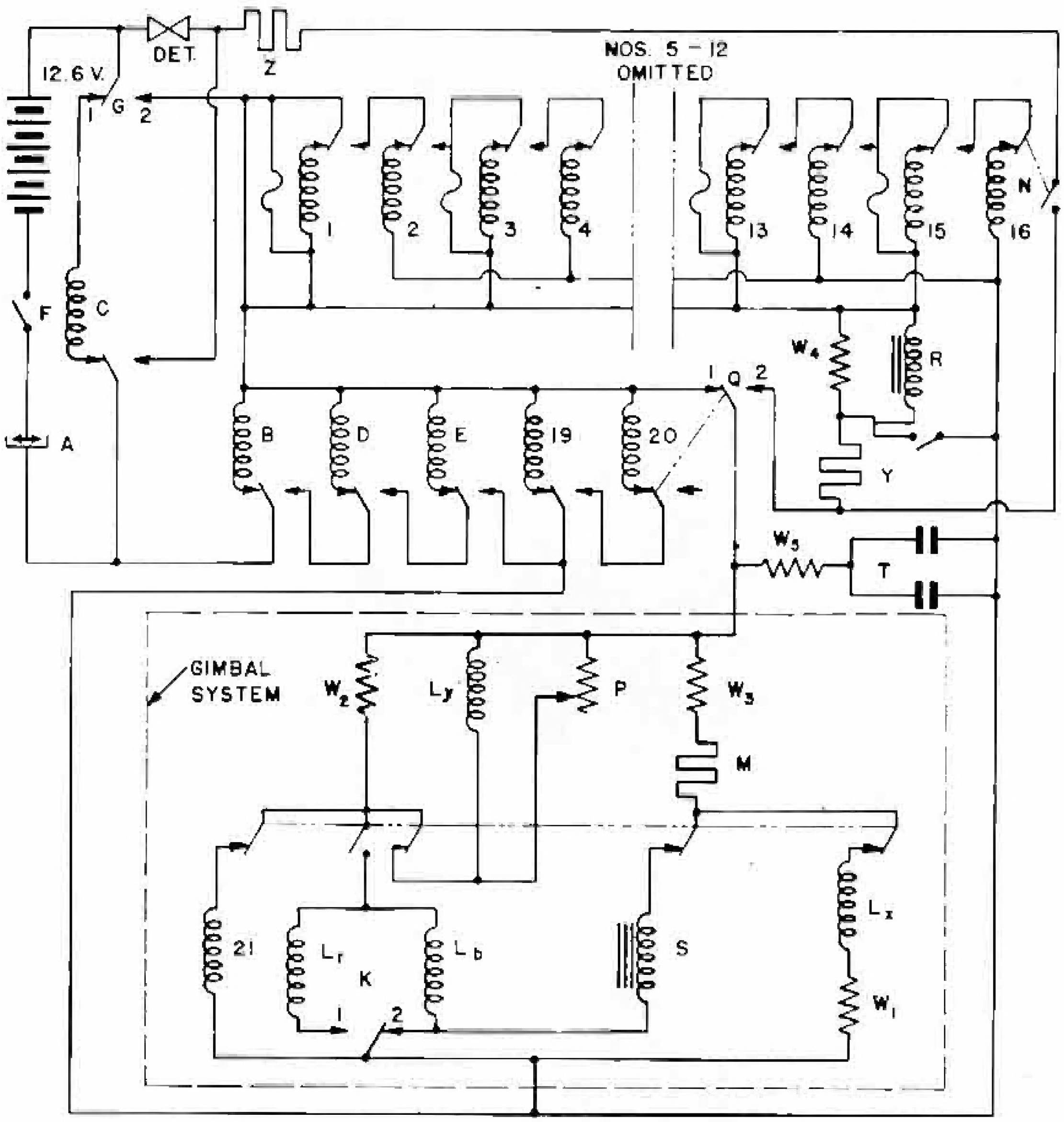


Figure 160 - M 101 Unit



A — CLAPPER SWITCH
B,C,D,E — FUSE DELAY SWITCH
F — MASTER SWITCH
G — HYDROSTATIC SWITCH
K — NEEDLE SWITCH
L — RED HOLD-ON COIL
L — BLUE HOLD-ON COIL
L — AUXILIARY COIL
L — COMPENSATING COIL
M,Y,Z — THERMISTORS

N — SW. OPERATED BY FUSE DELAY SW. #16
P — POTENTIOMETER
Q — SW. OPERATED BY FUSE DELAY SW. #20
R — SOLENOID RELAY
S — LATITUDE ADJUSTER COIL
T — CONDENSERS
W_1, W_2, W_3, W_4, W_5 — RESISTORS
#1 — #16 — P.D.M. FUSE DELAY SW.
#19, #20 — DELAY ARMING FUSE DELAY SW.
#21 — A.L.A. FUSE DELAY SWITCH

Figure 161 - M 103 Unit Circuit

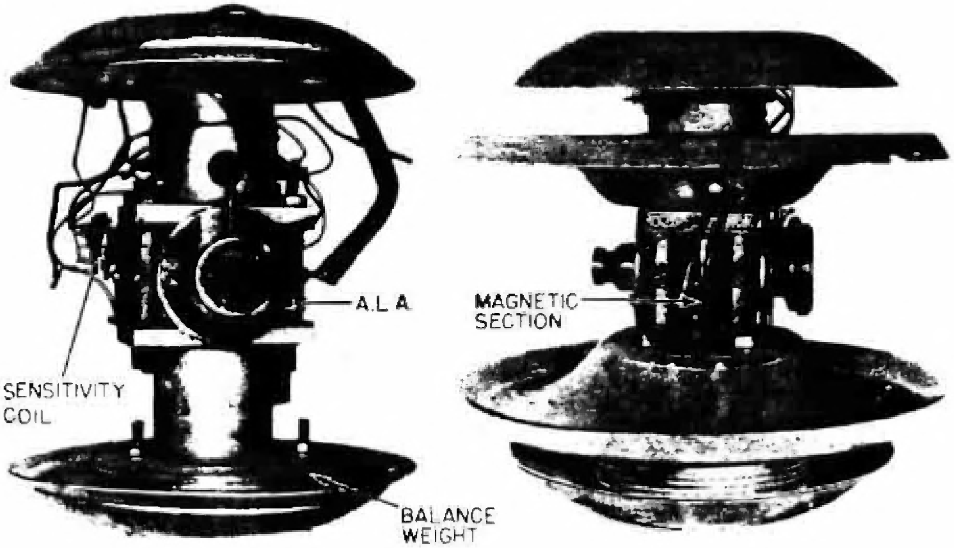


Figure 162 - M 103 Unit - Front and Side Views

pass enough current to operate L, and the circuit again returns to normal.

A third RED actuation completes the circuit through Z, L, and the detonator, which fires when the current rises to 1/4 ampere.

P.S.E. Firing. Same as original unit.

M 101 - with Ten-Place P.D.M. (Figure 159).

Arming. When the mine is dropped, action of the Rheinmetall fuze closes the master switch F. The thermostatic clapper switch A is normally closed at temperatures above 32° Fahrenheit. If the mine reaches a depth of 24 feet or more, the hydrostatic switch G closes to contact No. 2, and the battery energizes fuse-delay switches C, D, and E in that order. Upon completion of the delay period of E, battery current starts A.L.A., in the magnetic unit through the by-pass fuse, of fuse-delay switch No. 1, and thermistor Y. Upon completion of A.L.A., as in the original M 101, fuse F will have blown, and K will be just clear of contact No. 2.

Delay-Action Bomb Firing. Same as original unit.

Normal Firing with P.D.M. A RED actuation closes K to contact No. 1, completing a circuit from the battery through the by-pass fuse of fuse-delay switch No. 1, thermistor Y, and hold-on coil L. When Y heats sufficiently, L holds K on its contact, the by-pass fuse blows, and switch No. 1 is energized. Upon completion of its delay period, Switch No. 1 switches over, breaking the hold-on circuit, allowing L, Y, and K to return to normal, and cutting in switch No.2, which passes current through a by-pass. Upon completion of its delay period, switch No.2 switches over, cutting in switch No. 3. After a maximum of nine "blind" actuations, switches No. 17 and No. 18 will have operated, closing switch N and putting the detonator in the firing circuit.

A final RED actuation completes a circuit L, N, Thermistor Z, and the detonator. When Z has heated sufficiently, L holds K on its contact, and a current increase to 1/4 ampere fires the detonator.

P.S.E. Firing. Photo-electric cells may be fitted as in the original M 101.

M 103 UNIT

The M 103 unit (Allied designation M Mk IX) was the same as the M 101, except that it responded to either a RED or a BLUE field. Work on this unit began in the summer of 1940 and was completed and ready for operational use in the spring of 1941. It was used alone or in combination in the BM 1000 I/II mine cases. Like the M 101, the M 103 used an electrical, eight-place P.D.M.

M 103 Operation (Figure 161).

Arming. When the mine is dropped, action of the Rheinmetall fuze closes the Master Switch F. The thermostatic clapper switch A is normally closed at temperatures above 32° Fahrenheit. If the mine reaches a depth of 24 feet or more, the hydrostatic switch G closes to contact No. 2, and fuse-delay switches B, D, and F are energized in that order. Upon completion of the delay period of F:

1. The battery current energizes the gimbal system in which fuse-delay switch No. 21 controls four circuits in addition to its own. Battery current energizes coil S, which deperms its own magnetic core to a point where

switch K is just clear of contact No. 2. All the current in this parallel circuit now flows through L_x, which provides an increasing RED field due to heating of thermistor M. This assures that K does not remake contact No. 2, and further deperm S. During the above operation, L_y has been introducing a BLUE field roughly equivalent to the unit sensitivity. The strength of the L_y field is adjustable by varying P. When switch No. 21 switches over after completion of A.L.A., it breaks its own circuit, isolates S, breaks the circuit to L_x, and breaks the circuit to the compensating coil L_y and P, so that K goes to equilibrium between the two contacts.

2. The battery current energizes switches No. 19 and No. 20 in that order. Upon completion of its delay period, No. 20 switches over to a blank contact and mechanically switches Q from contact No. 1 to contact No.2, putting the bi-polar gimbal unit in the P.D.M. circuit.

Delay-Action Bomb Firing. Same as M 101.

Normal Firing with P.D.M. A RED or BLUE actuation closes K to the appropriate contact, and battery current heats thermistor Y until it passes sufficient current to operate hold-on coil L_r or L_b. When the current reaches 100 ma., the by-pass fuse on fuse-delay switch No. 1 blows, and the fuse-delay switch then carries the total current. The increasing current operates relay R, which provides its own holding current through a lead which by-passes the gimbal portion of the unit. Hold-on current for K is then reduced to a point where K opens. Upon completion of its delay period, switch No. 1 switches over, de-energizing R, which then returns to normal cutting in switch No. 2. Upon completion of its delay period, switch No. 2 switches over and the unit returns to normal.

After a maximum of eight "blind" actuations, switch No. 16 closes switch N, completing the circuit through the detonator and thermistor Z. A final actuation fires the detonator as in M 101 with 10-place P.D.M.

P.S.E. Firing. Photo-electric cells may be fitted as in M 101.

Chapter 11 - Section 3

ACOUSTIC MINE UNITS

The German Navy and Luftwaffe made considerable use of Sonic Acoustic Units in mining. Since the first sonic acoustic mine was laid in 1940, several different types of sonic acoustic units have been used, and several more were in advanced development just prior to being used operationally at the end of the war in Europe.

The German sonic acoustic mine units include the following:

A 1	Navy	TMA/TMB	Ground
A 1st			
A 2	Navy	TMB/TMC	Ground
A 2st			
A 3	Navy	EMF/SMA	Moored
A 4	Navy	TMB/TMB/TMC	Ground
A 4st			
A 7	Navy	EMF/SMA	Moored
A 104	Luftwaffe	BM1000	Ground
A 104st			
A 105	Luftwaffe	BM1000	Ground
A 105st			
A 107	Luftwaffe	BM1000 T	Moored
		BM1000	Ground

Any of the units specified may be altered by the introduction of a "stumpf" (insensitive microphone and other small modifications to make an anti-mine-sweeper unit. Its designation is changed accordingly, eg: A 4st (A 4-stumpf).

A 1 - UNIT

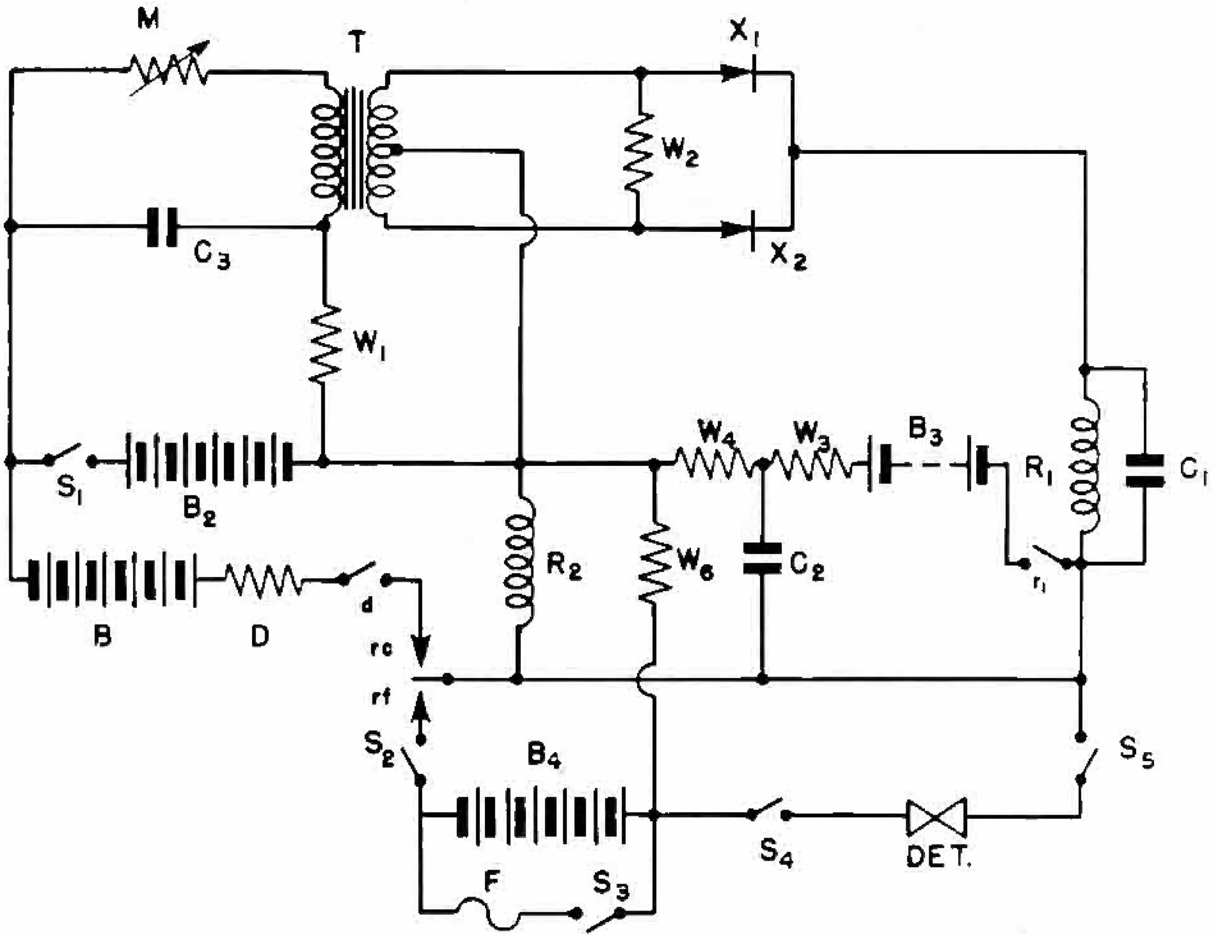
The A 1 unit (FAB 3) (Allied designation A Mk I) was the first attempt by the Germans to make an acoustically-fired mine unit. The development started in May, 1940, by the firm, "Dr. Ing. Rudolf Hell" (Berlin) and was completed in September 1940. It was immediately put into operation, and the first specimen was recovered by the Allies a month later. When the first unit was in development, the following requirements were laid down:

1. The mine must fire at the approach of a ship.
2. The mine must not fire as a result of detonation of other mines in the area.

A 1 Unit - Operation (Figure 163)

Arming. Two minutes after the hydrostatic clock starts, S_3 closes, blowing fuse F and starting the delay clock. When the hydrostatic clock runs off its delay period, (17 minutes) S_4 and S_5 close, putting the detonator in the circuit. When the delay clock runs off its period (six days maximum), S_1 and S_2 close and the unit is alive.

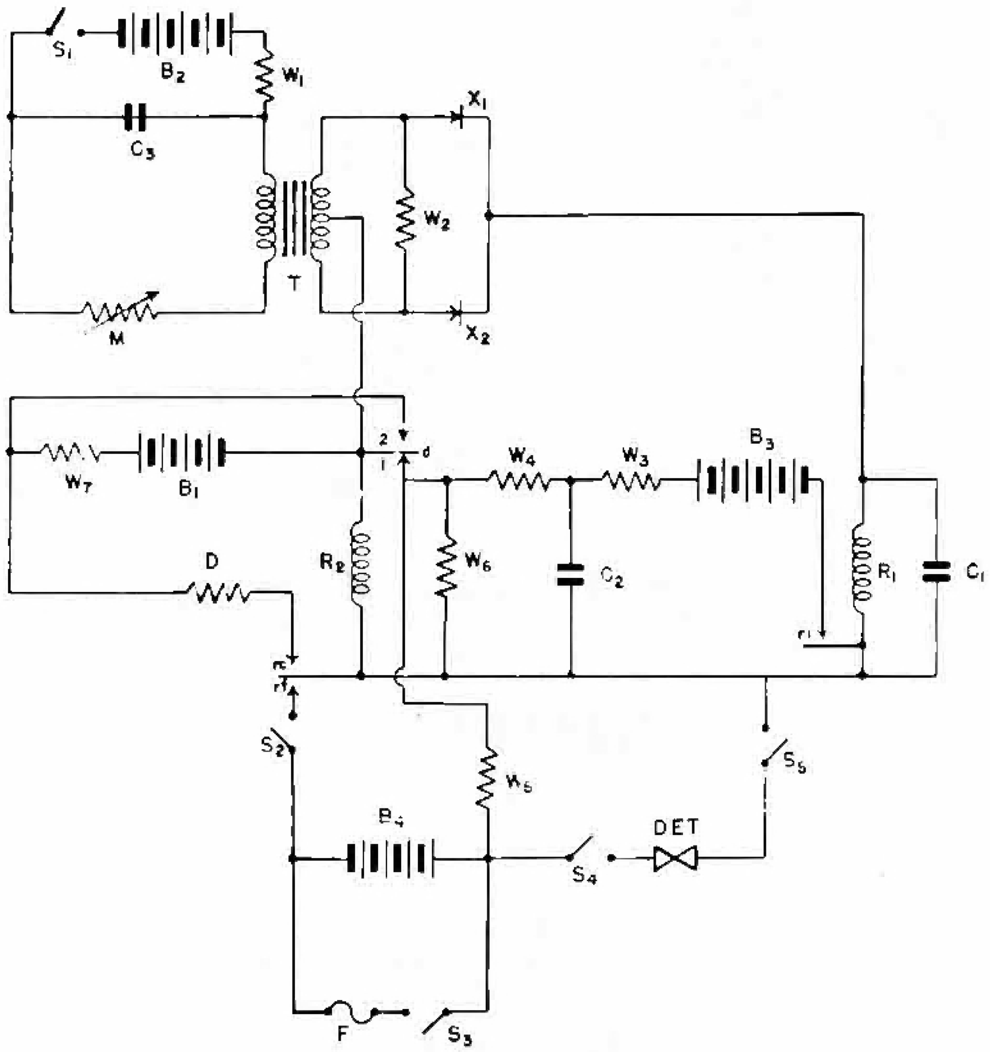
Normal Firing. When sound impinges on the microphone resistance will appear as current



B_1 9 VOLTS
B_2 9 VOLTS
B_3 15 VOLTS
B_4 9 VOLTS
C_1 280 MICROFARADS
C_2 330 "
C_3 10 "
W_1 25 OHMS
W_2 3000 "
W_3 5000 "
W_4 5000 "
W_6 1000 "
D THERMAL DELAY HEATER
d " " SWITCH

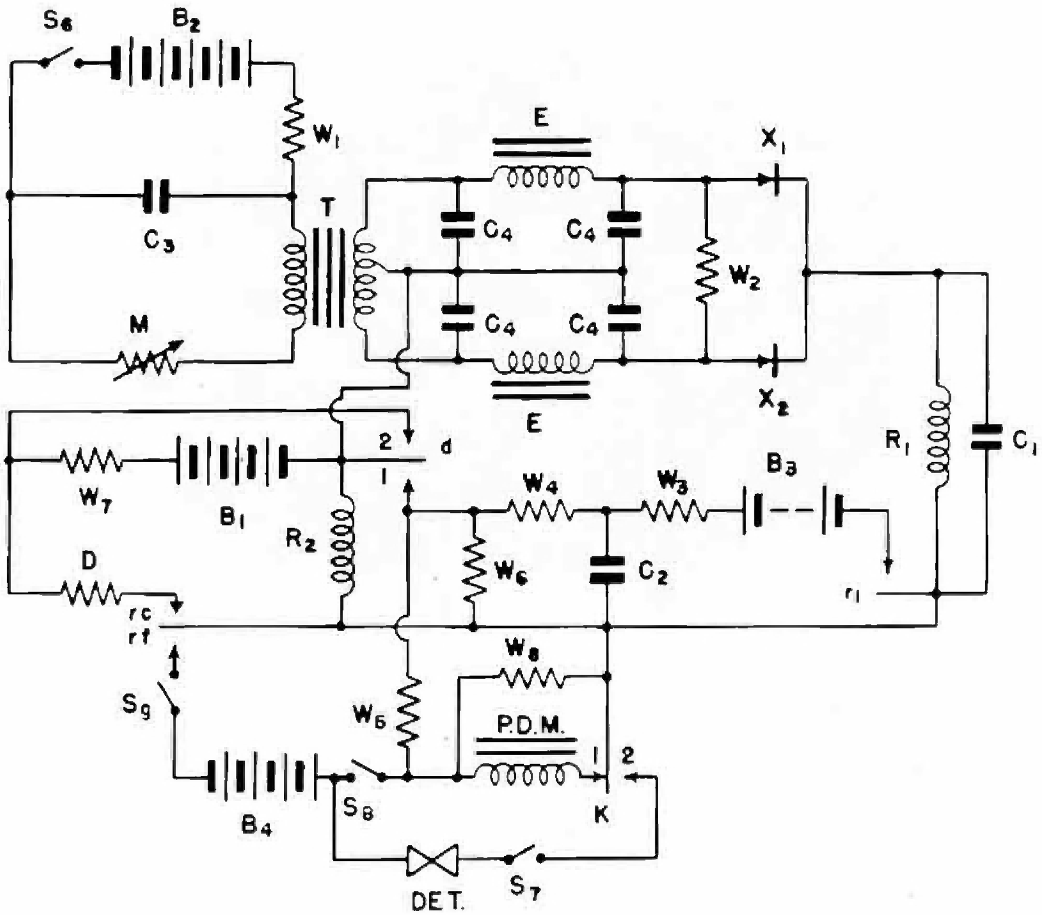
F FUSE TO START DELAY CLOCK
S_1S_2 SWITCHES CLOSED BY DELAY CLOCK
S_3 TRANSIENT CONTACT ON HYDR. CLOCK
S_4 HYDROSTATIC CLOCK SWITCH (a—g)
S_5 " " " (b—c)
T MICROPHONE TRANSFORMER
M "
X_1 COPPER OXIDE RECTIFIER
X_2 " " "
R_1 RELAY-SENSITIVITY 116 MICROAMPS TO r_1
R_2 " " 440 MICROAMPS TO rc
1110 MICROAMPS TO rf

Figure 163 - A 1 Unit Circuit



B_1	15 VOLTS	S_1.S_2	SWITCHES CLOSED BY DELAY CLOCK
B_2	9 VOLTS	S_3	TRANSIENT CONTACT ON HYDR. CLOCK
B_3	15 VOLTS	S_4	HYDROSTATIC CLOCK SWITCH (o-g)
B_4	9 VOLTS	S_5	HYDROSTATIC CLOCK SWITCH (b-c)
C_1	315 MICROFARADS	T	MICROPHONE TRANSFORMER
C_2	365 MICROFARADS	D	THERMAL DELAY HEATER-100 OHMS
C_3	10 MICROFARADS	F	FUSE
W_1	25 OHMS	R_1	RELAY- SENSITIVITY 123 MICROAMPS TO ri
W_2	5000 OHMS	R_2	RELAY- SENSITIVITY 700 MICROAMPS TO rc 975 MICROAMPS TO rf
W_3	5000 OHMS	M	MICROPHONE
W_4	5000 OHMS	X_1	COPPER OXIDE RECTIFIER
W_5	1000 OHMS	X_2	COPPER OXIDE RECTIFIER
W_6	5000 OHMS		
W_7	20 OHMS		

Figure 164 - A 1 Unit (First Revision) Circuit



B_1	15 VOLTS
B_2	9 VOLTS
B_3	15 VOLTS
B_4	9 VOLTS
C_1	315 MICROFARADS
C_2	365 MICROFARADS
C_3	10 MICROFARADS
C_4	0.6 MICROFARADS
W_1	25 OHMS
W_2	5000 OHMS
W_3	5000 OHMS
W_4	5000 OHMS
W_5	1000 OHMS
W_6	5000 OHMS
W_7	20 OHMS
W_8	100 OHMS

S_6	SWITCH-CLOSES AT END OF DELAY (a-g)
S_7	SWITCH-CLOSES AT END OF DELAY (b-c)
S_8	SWITCH-CLOSES SHORTLY AFTER S_6 AND S_7 (e-f)
S_9	SWITCH ON P.D.M.
K	SWITCH ON P.D.M. (STAYS ON 1 UNTIL RUN OFF)
D	THERMAL DELAY HEATER-100 OHMS
E	FILTER CHOKES
M	MICROPHONE
T	MICROPHONE TRANSFORMER
R_1	RELAY SENSITIVITY 123 MICROAMPS TO r_1
R_2	RELAY SENSITIVITY 700 MICROAMPS TO rc 975 MICROAMPS TO rf
X_1	COPPER OXIDE RECTIFIER
X_2	COPPER OXIDE RECTIFIER

Figure 165 - A 1 Unit (Second Revision) Circuit

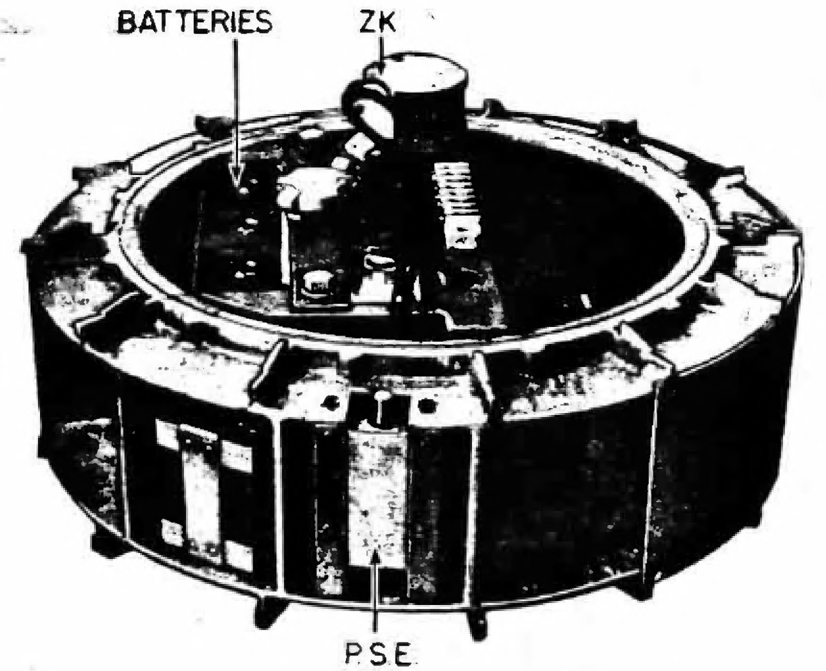


Figure 166 - A 1 Unit

variations on the primary of transformer T and as alternating signal current on the secondary of T. The signal current is then rectified by rectifiers X_1 and X_2, with direct current then flowing from the secondary through two relays in series, the first, R_1 being more sensitive than the second, R_2.

If the sound is of suitable intensity for normal firing, the current flowing through R_1 and R_2 will not be strong enough to operate R_2. If the sound persists long enough to charge C_1, R_1 closes to r_1. B_3 now sends current through R_2, which opposes and is stronger than the induced current from the secondary of T. The direction of this current is such that R_2 closes to contact r_f, putting the detonator across B_4.

Normal Anti-countermining. A loud sound which produces a strong current through R_1 and R_2 tends to operate both relays. Because of the delay in R_1 occasioned by C_1, R_2 operates first and, because of the direction of the actuating current, closes to rc.

B_1 and B_2 then apply a locking voltage, preventing R_1 from operating, blocking further current from the secondary of T and keeping R_2 closed to rc. This condition persists until thermal delay heater D heats and opens its switch, d, after about 12 seconds.

R_2 then opens, d closes, and the unit returns to normal. If frequent anti-countermining shocks are received, D will heat to the point where the unit's inert period may be as short as three seconds.

Intermediate State. A sound which builds up uniformly and rapidly to a point of considerable intensity may produce a current which is strong enough, after R_1 operates, to cancel out the current from B_3 which would ordinarily close R_2 to rf. R_2 would not then close to either contact, and the unit would neither fire nor be rendered passive. If such a signal ceased abruptly, R_1 would open, although the unit would probably fire as a result of discharge from C_2 through R_2 which would close to rf.

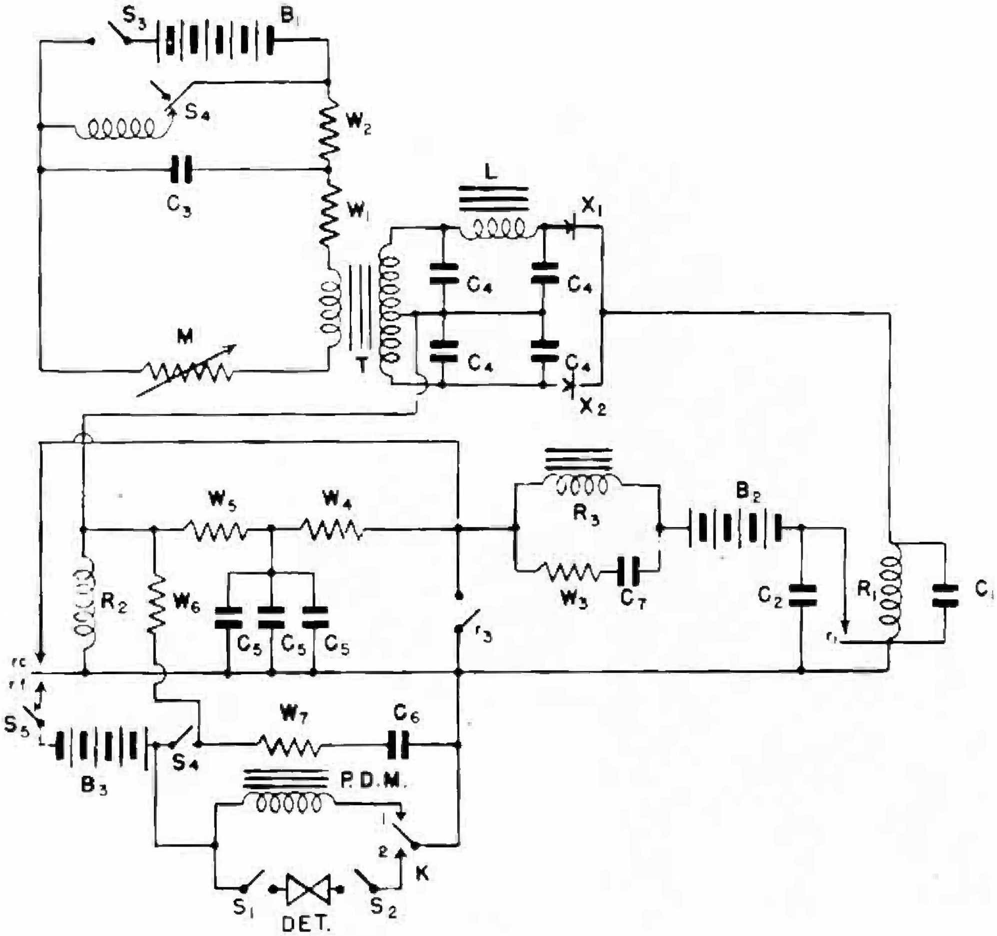
<u>A 1 (Allied - A Mk II)</u> (<u>Figure 164</u>)

Arming and Normal Firing. Same as original A 1.

Normal Anti-countermining. A loud sound which produces a strong current through both R_1 and R_2 tends to operate both relays. However, because of the delay in R_1 occasioned by C_1, R_2 will close to rc first, imposing a blocking potential from B_1 across the secondary, thereby holding R_1 open.

With R_2 closed to rc, the circuit from B_1 through D is completed and the thermal delay switch D starts to heat. After about 35 seconds, d_1 is broken and the contact starts to move toward d_2, which it makes in about 30 seconds.

When contact d_2 is closed, B_1 is shorted through W_7, hold-on current through R_2 is reduced to a small amount, and rc opens. Since the circuit from B_1 through D is then broken, D begins to cool and the thermal de-



B_1	9	VOLTS
B_2	15	VOLTS
B_3	9	VOLTS
C_1	300	MICROFARADS
C_2	365	MICROFARADS
C_3	10	MICROFARADS
C_4	.6	MICROFARADS (each)
C_5	240	MICROFARADS
C_6	100	MICROFARADS
C_7	100	MICROFARADS
W_1	20	OHMS
W_2	100	OHMS
W_3	3000	OHMS
W_4	5000	OHMS
W_5	6000	OHMS
W_6	1000	OHMS
W_7	20	OHMS

K	P.D.M. CHANGEOVER SWITCH
L	FILTER CHOKE
M	MICROPHONE (COARSE)
R_1	RELAY — 50 MICROAMPS SENSITIVITY r_1 — R_1 CONTACT
R_2	RELAY — 50 MICROAMPS SENSITIVITY r_c, r_f — R_2 CONTACTS
R_3	RELAY — 50 MICROAMPS SENSITIVITY r_3 — R_3 CONTACT
T	MICROPHONE TRANSFORMER
S_1, S_2	CLOCK SWITCHES (a-g, b-c)
S_3	CLOCK SWITCH (e-f)
S_4	FUSE DELAY SWITCH (30 SEC)
S_5	PDM SWITCH (NORMALLY CLOSED)
X_1, X_2	COPPER OXIDE RECTIFIERS

Figure 167 - A 1st and A 2st Unit Circuit

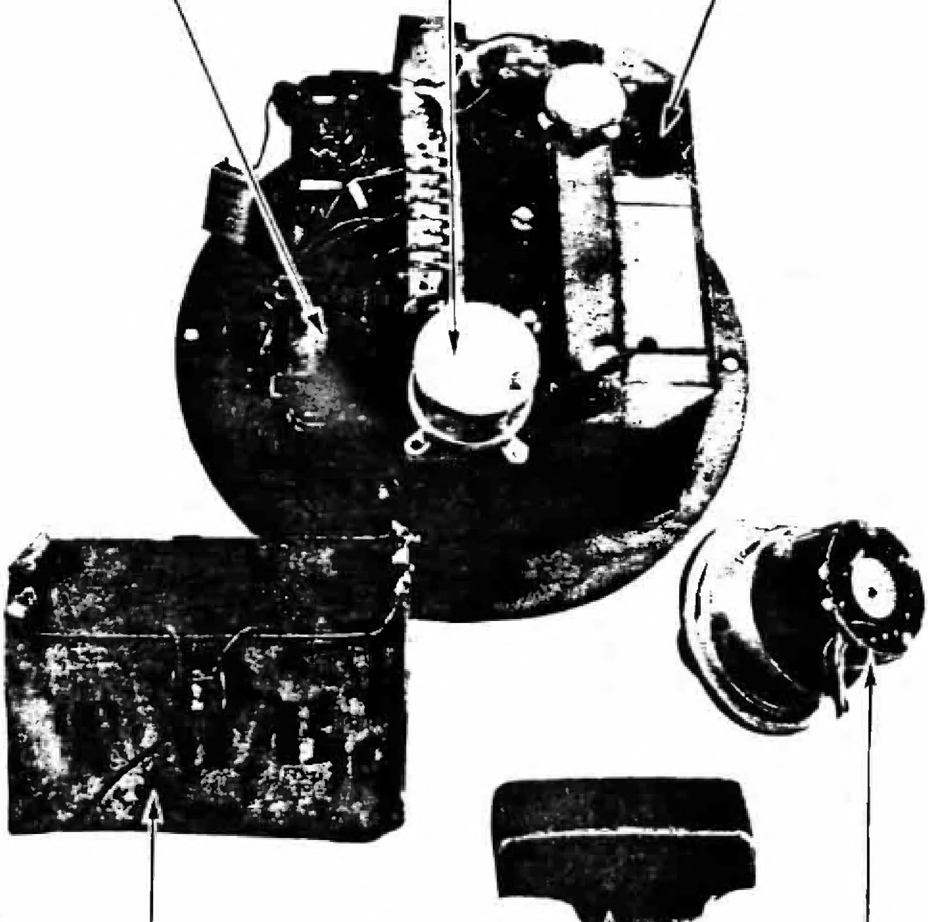


Figure 168 - A 2st Unit

lay switch starts moving back from d_2 to d_1, requiring about 15 seconds (total period of cycle is 80 seconds).

Note: The unit is not alive until the thermal delay switch returns to d_1 because, although the blocking potential is removed from the secondary upon opening of R_2, even if a signal causes R_1 to close, there is no circuit from B_3 through R_2, and R_2 cannot, therefore, be moved to its firing contact rf.

A 1 (Allied - A Mk III) (Figure 165)

At the end of its preset period, the hydrostatic clock closes switches S_6, S_7 and S_8.

Normal Firing. Same as A Mk I and Mk II, except that the incorporation of an extra choke condenser filter (E-C_4) eliminates signal currents of 700-1000 cps. frequency, thereby making the unit more selective as to the frequencies of sound which will cause firing or anticountermining.

Normal Anti-countermining. Same as A Mk I and Mk II, except as noted above.

P.D.M. Action. In addition, a twelve-place P.D.M. may be fitted which operates as follows:

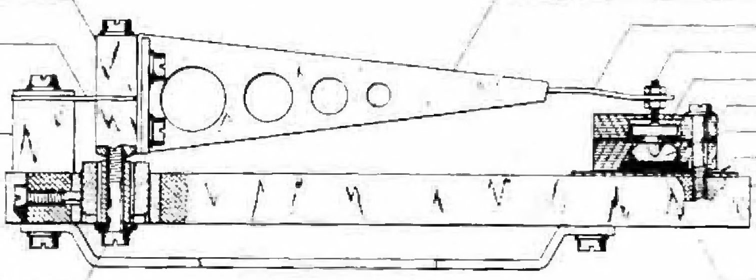


Figure 169 - German Acoustic Mine Microphone

1. When a firing impulse closes R_2 to rf, battery B_4 puts hold-on current through R_2 by means of W_5. The P.D.M. solenoid is also energized by B_4 through K_1, and the P.D.M. clockwork starts.

2. When S_Q breaks, R_2 hold-on current is broken and the P.D.M. solenoid is de-energized. The circuit then remains dormant until the P.D.M. interval is run off and S_Q recloses. When the final "blind" actuation is run off, K_1 breaks and K_2 makes, putting the detonator in the circuit.

3. Detailed operation of the P.D.M. is the same as that of the standard P.D.M. S_Q corresponds to P-Q, K_1 to R-S, and K_2 to S-T.

A 1st - A 2st (Allied - A Mk VI) Circuit Operation (Figure 167)

Arming. When the hydrostatic clock completes its delay period, S_1 and S_2 close, putting the detonator into the circuit. Eighteen minutes later, S_3 closes and B_1 energizes fuse-delay switch S_4 and the microphone M. Upon completion of its delay period, S_4 switches over, cutting out its heater, putting full battery current on the microphone and closing an extra contact of S_4 which arms the holding circuit of B_3 on R_2.

Normal Firing with P.D.M. When sound impinges upon the microphone, it causes resistance variations which appear as alternating current upon the secondary of transformer T. This current is filtered and rectified in a manner similar to that employed in the A 1 (Allied A Mk II), with the intensity of the rectified current directly variable with the intensity of the sound. An insensitive microphone is used so that the amount of current through the relay coils will be small compared to that produced in the A 1 (A Mk II).

Since R_1 is more sensitive than R_2, normal sound of the type produced by an approaching minesweeper will operate R_1, but R_2 will not operate until the sweeper is fairly close. When R_1 closes, it completes a circuit through R_3, W_4, W_5 and R_2. Because of the high resistance of the circuit, R_3 does not operate.

If the sound persists for 3 to 3½ seconds, however, C_5 charges sufficiently to let R_2 close to rf, whereupon B_3 energizes a holding circuit through W_6 and the P.D.M. solenoid. During the P.D.M. cycle S_5 breaks, de-energizing the holding circuit. After a maximum of 11 "blind" actuations, switch K breaks contact No. 1 and makes contact No. 2, and an additional firing actuation will fire the mine.

Normal Anti-countermining. If the sound impinging on the microphone is of a very high intensity, such as might be produced by an underwater explosion, both R_1 and R_2 operate. R_2, however, closes to rc, so that the circuit from B_2 through R_3 is one of very low resistance. R_3 operates, closing r_3 which provides a self-holding current for R_3 through r_1, thus preventing C_5 from charging and R_2 from closing to rf. This condition will persist until the sound level drops below that necessary to keep R_1 operative. At this point, R_3 is restored to normal and the unit is alive to normal actuation.

MICROPHONES

With one experimental exception, all German sonic acoustic mine systems (including combinations) used carbon-button microphones. All the units described herein, except A 107 (Goepel), used the cantilever-type microphone which existed in two basic forms. The "normal" microphone, as its name implies was used for acoustic units designed against normal target vessels. The "stumpf" microphone had somewhat different characteristics and was designed for use with acoustic units modified to be anti-mine-sweeper units. First attempts to make insensitive units were confined to putting low-resistance shunts in the microphone circuit, but unfavorable microphone characteristics caused this procedure to be abandoned. Both types of cantilever microphones were mounted securely on a base bolted inside the mine. Through a spring suspension, the assembly was mounted free to move due to mine-case vibrations. An arm amplified the motion of the resonant mass and transferred it to a carbon button. In the case of the normal microphone, figure 170a, arm motion was transferred directly to the upper electrode and vibrations thus caused direct compression and expansion of the carbon granules. In the "stumpf" microphone, figure 170b, arm motion was transferred to a block which caused compression and expansion of the large body of

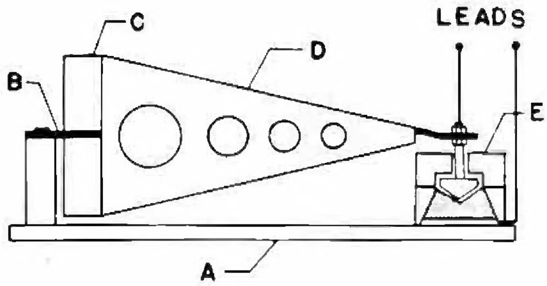


Figure 170a - Normal Microphone

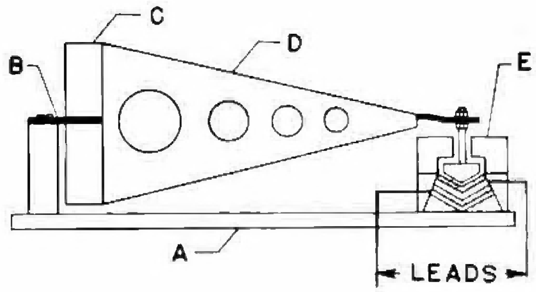


Figure 170b - Stumpf Microphone

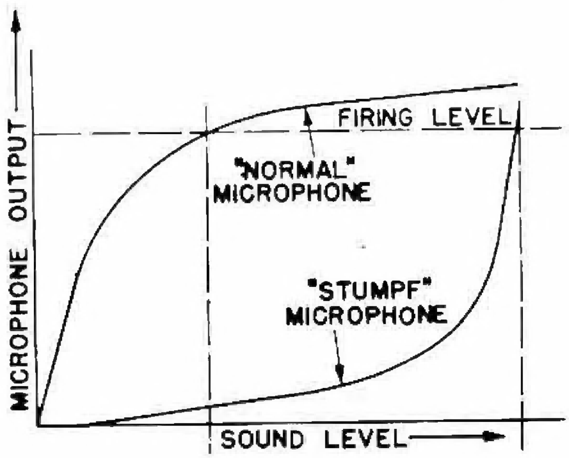


Figure 171 - Relative Characteristics of Microphones

carbon granules between two electrodes located in the carbon. These microphones were developed in 1943, and mass production was started early in 1944. They were used only in the A 1, A 2, A 4, A 104 and A 105.

Resistance output for the normal microphone was 50 cps.

Resistance output for the "stumpf" microphone was 100 cps.

The microphones VM 1, VM 2, VM 3 had no shock mounting; VM 4 had shock mounting; VM 5 Stu. had a very coarse setting.

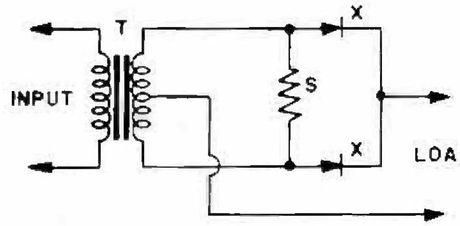
The relative characteristics of the two microphones are shown in figure 171. A normal microphone response is nearly flat, because of overloading after the point normally used for firing; thus, it was unsuitable for shunting and use in anti-mine-sweeper circuits. The "stumpf" microphone, however, had an entirely different characteristic that rendered it suitable for such systems. This was a principle of microphone construction known to the Germans as "Querstrom" (cross-current)

The cantilever type of microphone construction was known to the Germans as the "Vibrations Mess-systeme" or vibrations-measuring-system. It had the advantage that it was not exposed to the water and its operating point was not changed by depth. However, it was somewhat less sensitive than some later types developed by the Germans. Every cantilever microphone was received at the mine depot with a group of shunts designed for insertion into the circuit when the microphone was fitted in the mine. The normal microphone was received with four shunts, (for different sensitivities) and the "stumpf" microphone with one shunt.

The first German microphones had a peak resonance at approx. 200 cps., with a band width of approx. $\pm$ 75 cps. Because of constant effort and improved construction methods, the normal resonance was reduced to approximately 90 cps. with a band width of approx. $\pm$ 5 cps. The "stumpf" microphone, it was expected, would have very sharp resonances at several points in the spectrum. The improvements in the cantilever microphone resulted in smaller size, stronger construction, and lower frequency resonance to make sweeping more difficult.

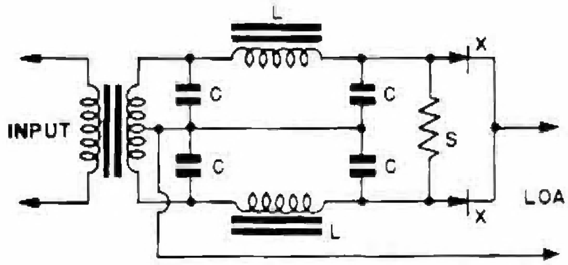
The two A 107 (Goepel) units, used the D 102 Mi microphone (Hasag-Mikrophon). This microphone was a converted D 102 pressure detector, fitted with an external diaphragm and a carbon-button microphone. The mounting was fitted with an equalizing channel which allowed pressure to be equalized on both sides of the external diaphragm. This was the same type of microphone used in the DA 102 series of units and had the advantage that, although its diaphragm was exposed to the water, hydrostatic pressure did not alter the operation point.

Microphone Circuit. The typical microphone circuit was very simple and consisted of a microphone battery, resistor, clock switch, and transformer. The circuit was activated by hydrostatic clock switch closure, and the mine remained alive until the battery was dead. The sensitivity of the mechanism depended on battery potential, and German figures on life indicate 3 - 6 months maximum. This circuit could be modified to suit the unit to which fitted, but it always remained basically the same.



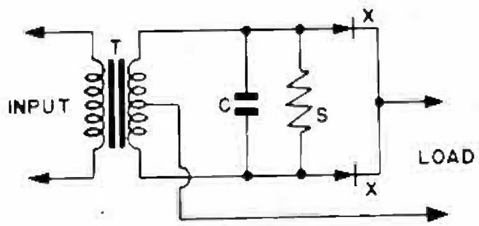
T = MICROPHONE TRANSFORMER
S = SHUNT
X = COPPER OXIDE RECTIFIERS

Figure 172a



L = CHOKES
C = CONDENSERS - 4 /UFD.

Figure 172b

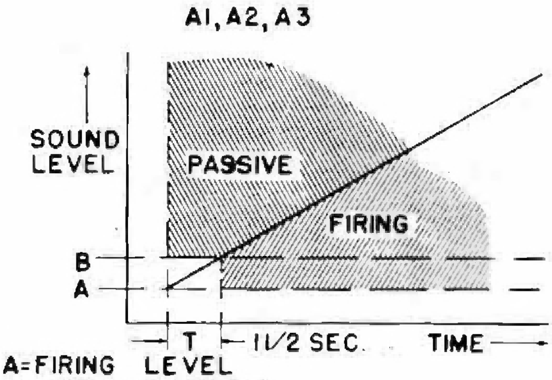


C = CONDENSER - 0.2 UFD.

Figure 172c

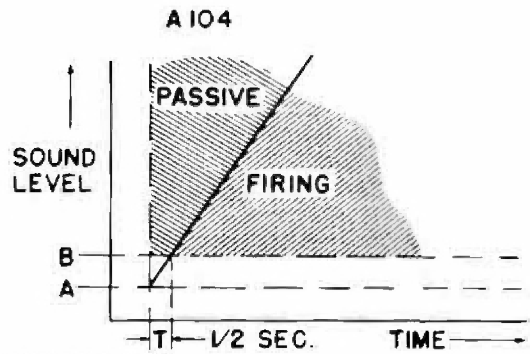
Figure 172 – Parts a, b, and c - Rectifier-Filter Circuits

Rectifier-Filler Circuit. The first acoustic unit was made with no attempt to limit the operation frequencies. The signal current was shunted (to determine sensitivity) and rectified full-wave to feed the unit relays, figure 172a: as a result, a secondary resonance at approximately one kc was present. It was found that, although a minor resonance, mines with this must be swept with underwater signalling apparatus which operated near one kc. A large number of such mines were fired in the vicinity of light-ships, etc. To counter this effect, some circuits were fitted with L/C filters of a low-pass type which caused cut-off at approximately 400 cps., figure 172b. As well, some of the later types were fitted with only a low-capacity condenser, figure 172c, when used with a microphone with a narrow band width.



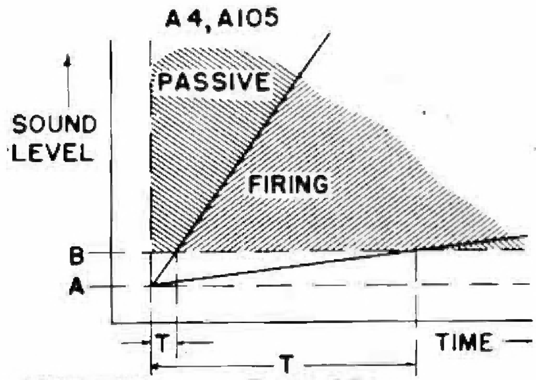
A = FIRING LEVEL
B = BLOCKING LEVEL

Figure 173a - System 1 - Initiating Level



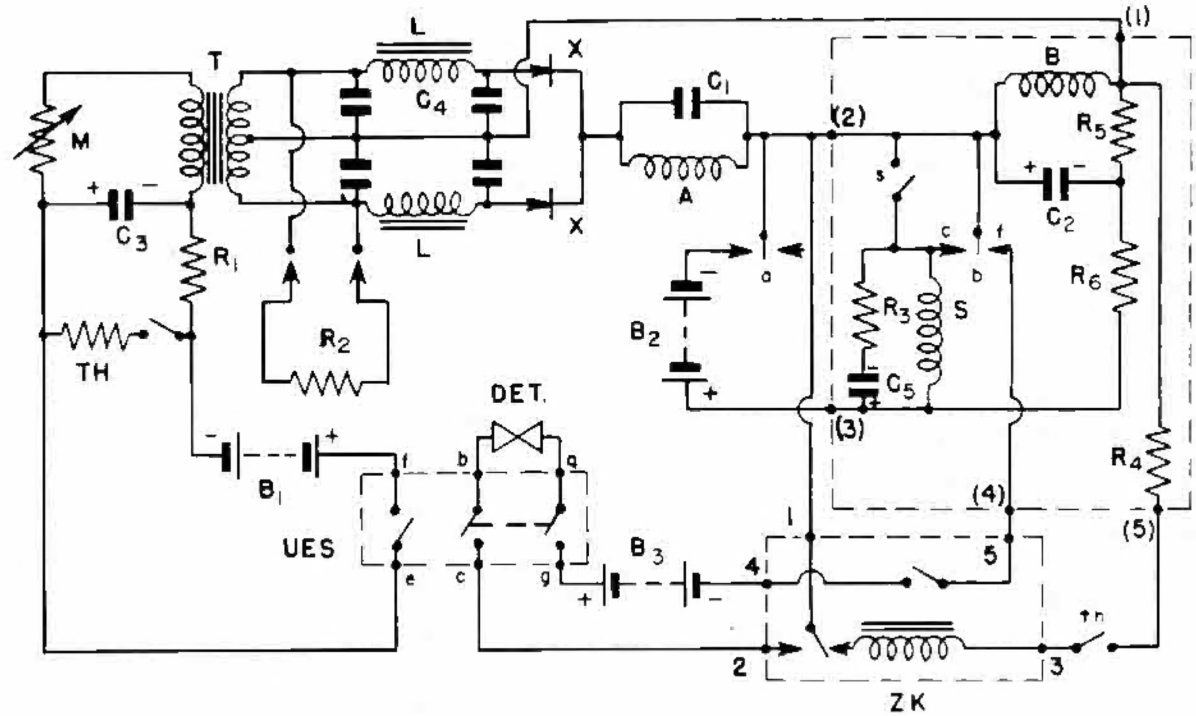
A = INITIATING
B = FIRING

Figure 173b - System 1 - Initiating Level



A = INITIATING
B = FIRING
T = 1/2 SEC.
T = 4 - 8 SEC.

Figure 173c - System 2 - Initiating Level



A RELAY a CONTACT OF A
B RELAY b CONTACT OF B
S RELAY s CONTACT OF S
B_1 BATTERY 9 V IN A1
6 V IN A2
B_2 BATTERY 15V
B_3 BATTERY 9 V
C_1 240 MFD.
C_2 240 MFD. IN A1, A2, A3,
720 MFD. IN A1-ST, A2-ST
C_3 10 MFD.
C_4 4 MFD.
C_5 100 MFD.

R_1 20 OHMS
100 OHMS IN A 1-ST, A 2-ST
R_2 SENSITIVITY-SETTING SHUNT
R_3 3 KOHMS
R_4 5 KOHMS
R_5 5 "
R_6 5 "
T MICROPHONE TRANSFORMER
X COPPER OXIDE RECTIFER
L FILTER CHOKES
UES HYDROSTATIC CLOCK (6-DAY)
ZK 12-PLACE P.D.M.
TH FUSE DELAY SWITCH (WHICH CLOSES CONTACT (th) AT END OF ITS PERIOD)

Figure 174 - Composite Circuit, A1, A1st, A2, A 2st, and A3

Basic Systems. There were three basic sonic systems:

1. Systems where the maximum rate-of-change of sound level was limited: A 1, A 2, A 3, A 104.

2. Systems where both maximum and minimum rate of change of sound level were limited: A 4, A 105.

3. Systems where both maximum and minimum rate of change of sound level were limited and determined from a reference point equal to the average background sound level: A 7, A 107.

System 1. In the first system, when the initiating level was reached, the rate of sound level increase did not exceed that shown in figures 173a, b, c; the unit fired 1 1/2 seconds after the sound reached the firing level in figure 173a and when the firing level was reached in figure 173b. If the rate ex-

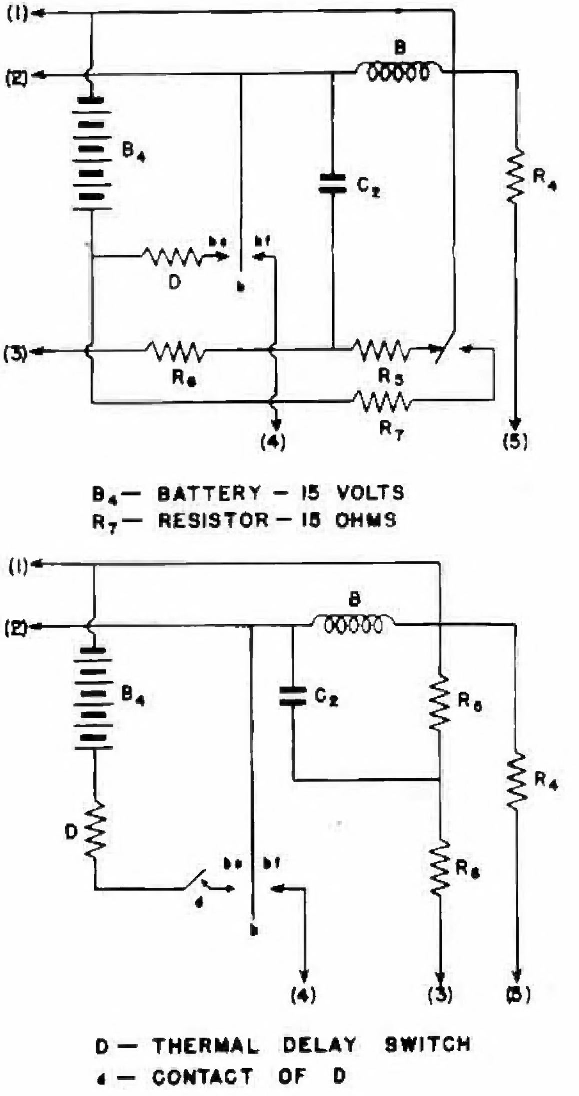


Figure 175 - Interchange Tap-Ins

ceeded that shown, the unit would be rendered passive for a period dependent upon the anti-counter-mining circuit.

System 2. In the second system, after the initiating level was reached, the rate of sound level increase had to be between the two points indicated in figure 173c, if the mine was to fire when the firing level was reached. Otherwise, the unit would be rendered passive for a period depending on the anti-counter-mining circuit.

System 3. In the third system the circuit was capable of determining average sound background level. This level was used as a reference point, and operation from this point was the same as in system 2.

System 1 - A 1, A 1st, A 2, A 2st, A 3. In the description of the circuits of this system, A 1, A 1st, A 2, A 2st and A 3 will be described jointly because of their similarity. A 1, A 1st, A 2, and A 2st were designed for ground mine use and were used extensively. A 3 was designed for moored mine use but was unsatisfactory because of high-background sound level and was never used operationally on account of its tendency to fire spontaneously. A composite circuit of A 1, A 1st, A 2, A 2st, and A 3 is shown on figure 174. Earlier units in this series had no L/C filter, ZK or fuse delay.

The sequence of operations is as follows:

1. Running of UES finally closes switches a-g and b-c, putting the detonator into the circuit. A few minutes later, e-f closes and B 1 energizes the microphone circuit and fuse delay switch TH. TH heats for several seconds before switching itself out and closing (th) thus preventing initial surge from firing the mine, since (th) breaks the holding circuit to Relay B. All sound impulses on the microphone produce alternating currents in the transformer circuit which are shunted by R_2, then filtered and rectified. The value of the direct current, led to relays A and B, is determined by the sound level.

2. Firing. When the sound level reaches the operating point of A, (a) closes after a short delay due to C_1, and places B_2 in the circuit of the B relay through R_5 and R_6 in opposition to the signal current. Since current from B_2 is greater than signal current (b) closes to (bf) and B_3 holds (b) on (bf) by a holding circuit through R_4. At the same time, B_3 energizes the trigger coil of the ZK (shift-counter), or, if on the last actuation, the detonator, and firing reaction is produced. In the case of a blind actuation, the interrupter contact (4-5) of the ZK breaks the holding circuit and the unit returns to normal.

3. Protection. If, when the sound level reaches the operating point of A, it rises too rapidly to the operating point of B for A to react (since A is delayed somewhat by C_1 and put B_2 in opposition to the signal current, (b) closes to (bc), S is energized by B_2 as soon as (a) closes, closing (s) which provides a self-holding circuit for S as long as (a) is closed and provides a short circuit across B and prevents firing. In the earlier circuits, the self-holding of (b) on (bc) was obtained by the use of an additional battery and a definite passive period set-up determined by the heating of a thermal delay switch D to break self-holding. These systems were found less positive in action.

4. Intermediate State. An additional phenomenon is possible. If, after A has acted, but before (b) has closed to (bf) the sound rises to a very high level, the resultant signal current may be strong enough to equalize and oppose the B_2 current. In this case, B acts as a galvanometer until the sound level determines the outcome. In most cases, the sound level drops and the B_2 current (or charge on C_2) closes (b) to (bf) and firing results.

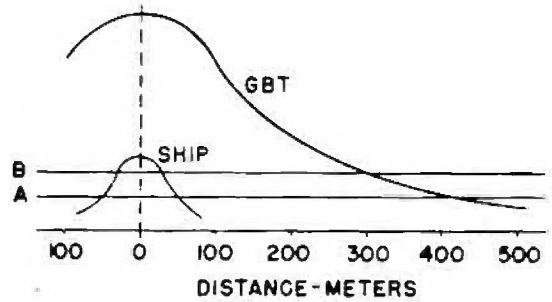


Figure 176a

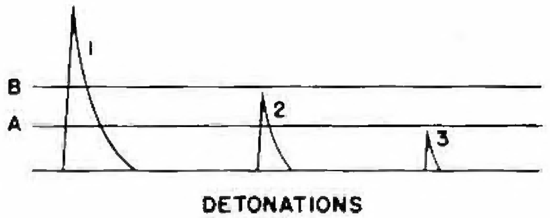


Figure 176b

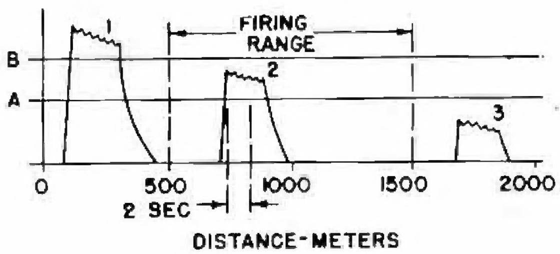


Figure 176c

Figure 176 - Parts a, b, and c - Reactions of A 1, A 2, and A 3

5. Schematic Representation of the reaction of A 1, A 2, and A 3 to different sound effects is shown in figures 176a, b, c. In figure 176a, it is shown that A 1, A 2 and A 3 will fire as a result of influence of a ship or GBT sweep. Firing occurs approximately two seconds after the sound level of A has been reached. Distances shown are approximate. In figure 176b, there are three cases which result from detonations:

Case 1 - Detonation Nearby - both A and B react simultaneously - protection.

Case 2 - Detonation at distance - only A reacts, but closed less than 2 seconds - no reaction.

Case 3 - Detonation at great distance - neither A nor B reacts.

In figure 176c, there are three cases which result from a detonation sweep. (Distances are approximate).

Case 1 - KKG 0-1650 ft. - both A and B react simultaneously - protection.

Case 2 - KKG 1650-5000 feet - only A reacts and closed more than 2 seconds - firing.

Case 3 - KKG greater than 5,000 ft. - neither A nor B reacts.

A 104

In A 104, figure 177, the sequence of operations is as follows:

1. Closing of the master switch (HS) puts battery B_1 into the circuit. KTSE will be closed if the temperature lies between -5° Centigrade and + 35° Centigrade. Thus, the microphone and fuse-delay switch S_1 are energized. After a short delay, S_1 operates, putting B_2 into the delay-bomb-firing circuit if the mine is in less than 24 feet of water. In this case, S_2 and S_3 are energized, and, after a delay, switch the detonators into the B_2 circuit and the mine fires. If the mine is in more than 24 feet or more of water, the hydrostatic switch (WDS) operates, cutting out S_2, S_3, and S_4, which, after a short delay, put the detonators into the acoustic circuit. Through the ship counter and through the detonators, B_2 charges C_4.

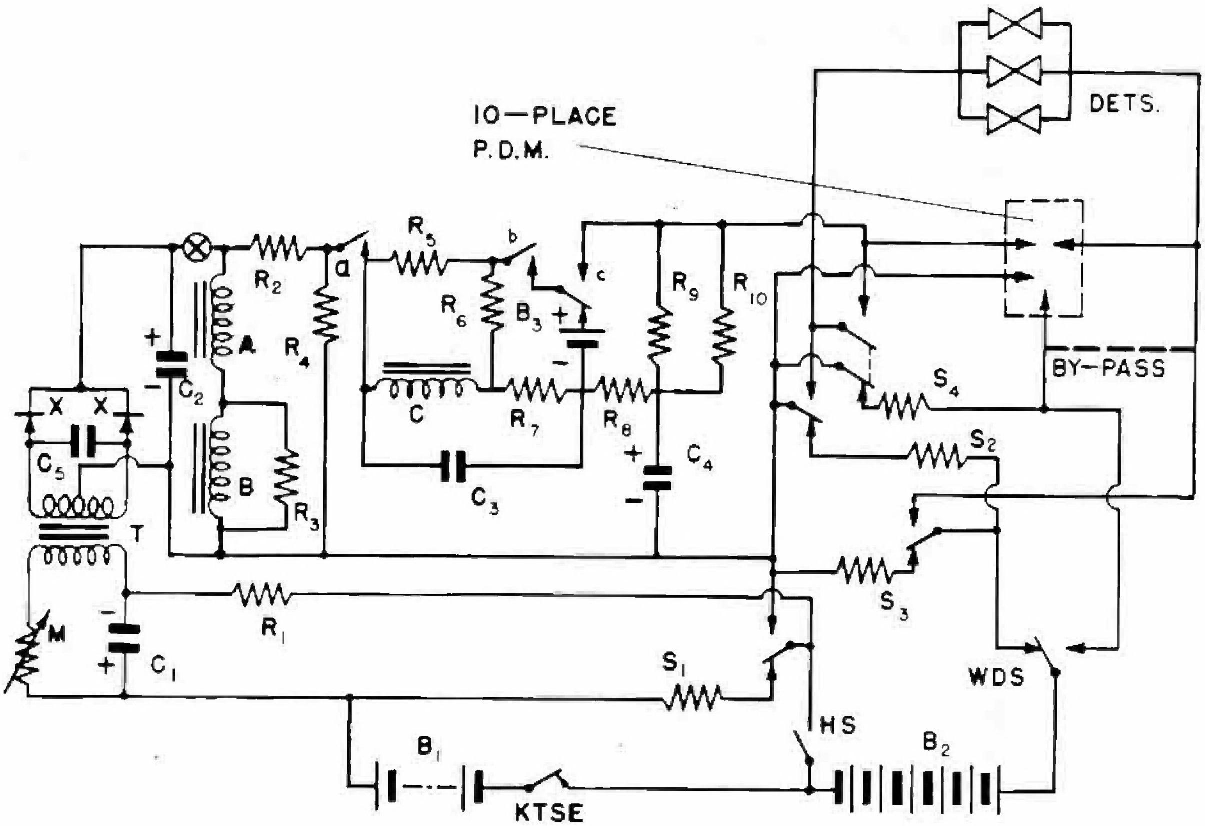
2. Firing. When the sound level reaches the operating point of A, (a) closes, allowing the charge on C_4 to operate relay C, with a delay of 1/2 second occasioned by R_3 and C_3, causing (c) to switch over. When the sound level reaches the operating point of B, (b) closes and B_2 fires the detonators with the current passing through: HS, R_4, (a), R_5, bc, detonators, by-pass, and WDS. Holding of A and B is accomplished by voltage drop through R_4, and since the resistance of the charging circuit for C_4 is low, C_4 keeps relay C in the operated position. Thereafter, C_4 keeps relay C operated as long as (a) is closed.

3. Protection. If, when the sound level reaches the operating point of A, it rises too rapidly to the operating point of B for C to react (less than 1/2 second), closure of (b) puts a short-circuit across C_3 through (c) and battery B_3 helps discharge any potential on C_3 and, at the same time, provides a weak current to hold (c) on its normal contact as long as (b) is closed. This condition persists as long as (b) is closed.

In figure 176a, A 104 will fire as a result of influence of a ship or GBT sweep. Firing occurs when the sound level reaches B.

In figures 176b and 176c, A 104 will react in the same manner as the A 1, A 2, and A 3 units. The original A 104 circuit used an additional battery for relay C instead of a charge on condenser C_4.

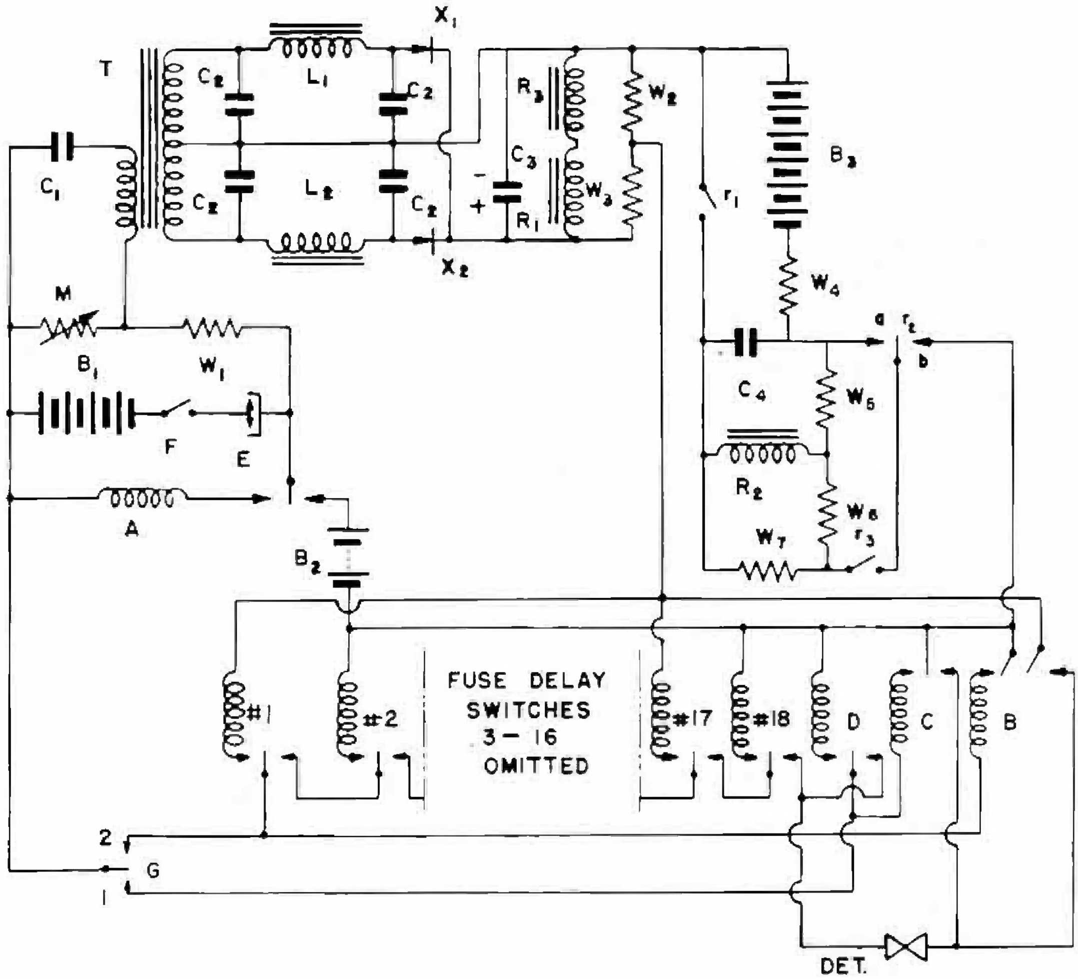
In figure 177, the heavy dotted line indicates 18 fuse-delay switches which make up the 10 place P.D.M.



HS — MASTER SWITCH (HAUPTSCHALTER)
KTSE — THERMOSTATIC SWITCH
WDS — HYDROSTATIC SWITCH
A — RELAY, a — CONTACT OF A
B — RELAY, b — CONTACT OF B
C — RELAY, c — CONTACT OF C
B_1 — BATTERY — 3 V
B_2 — BATTERY — 9.6 V
B_3 — BATTERY — 1.2 V
M — MICROPHONE
T — MICROPHONE TRANSFORMER
X — COPPER-OXIDE RECTIFIERS
⊗
C_1, C_4 — CONDENSER — 240 UFD.

C_2, C_3 — CONDENSERS — 100 UFD.
C_5 — CONDENSER — 0.2 UFD.
R_1 — RESISTOR — 10 OHMS
R_2, R_{10} — RESISTORS — 10 KOHMS
R_3 — RESISTOR — 3 KOHMS
R_4, R_5 — RESISTORS — 5 OHMS
R_6 — RESISTOR — 5 KOHMS
R_7, R_8 — RESISTORS — 15 KOHMS
R_9 — RESISTOR — 100 KOHMS
S_1, S_2, S_3, S_4 — FUSE DELAY SWITCHES (WHICH SWITCH OVER WHEN SOLDER MELTS AFTER PREDETERMINED HEATING PERIOD.)

Figure 177 - A 104, A 105, A 107 Unit Circuits - Condition before Launching



A,B,C,D – FUSE DELAY SWITCHES
B_1 – BATTERY – 3 VOLTS
B_2 – " – 7.5 VOLTS
C_1 – CONDENSER – 240. MFD. – ELECTROLYTIC
C_2 – " – 0.5 "
C_3 – " – 100. " – ELECTROLYTIC
C_4 – " – " " – "
E – THERMOSTATIC SWITCH (CLOSED AT > 23 F AND < 95 F)
F – MASTER SWITCH
G – HYDROSTATIC SWITCH (24 FT.)
L_1,L_2 – FILTER CHOKES
M – CARBON MICROPHONE
R_1 – RELAY (INITIATING) – 500Ω r_1 – R_1 CONTACT
R_2 – " (TIMING) – 50Ω r_2 – R_2 "
R_3 – " (FIRING) – 250Ω r_3 – R_3 "
T – MICROPHONE TRANSFORMER
X_1,X_2 – COPPER OXIDE RECTIFIERS
#1 – #18 – P.D.M. FUSE DELAY SWITCHES

W_1 – 10 Ω
W_2 – 5 Ω
W_3 – 2000 Ω
W_4 – 5000 Ω
W_5 – 5000 Ω
W_6 – 200 Ω
W_7 – 5 Ω

Figure 178 - A 104 Unit Circuit

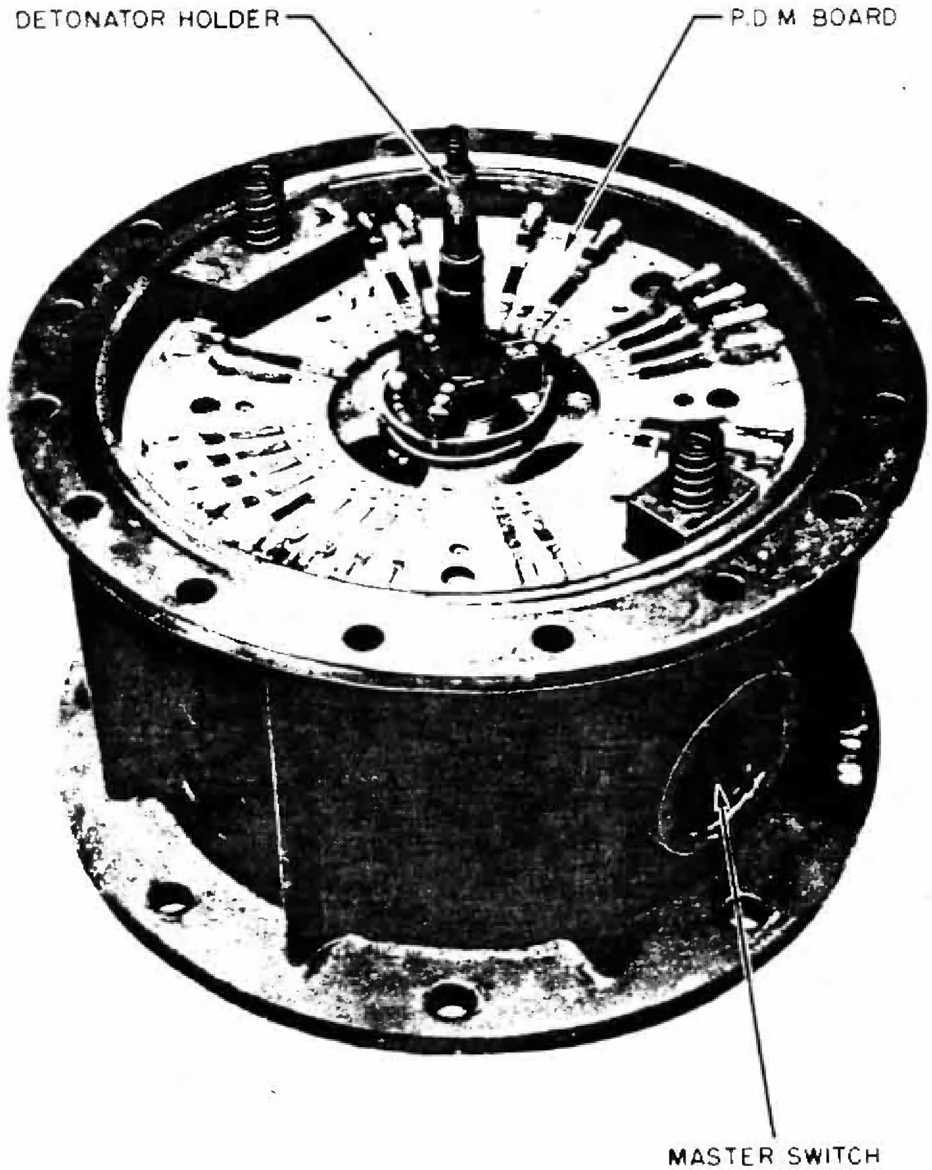


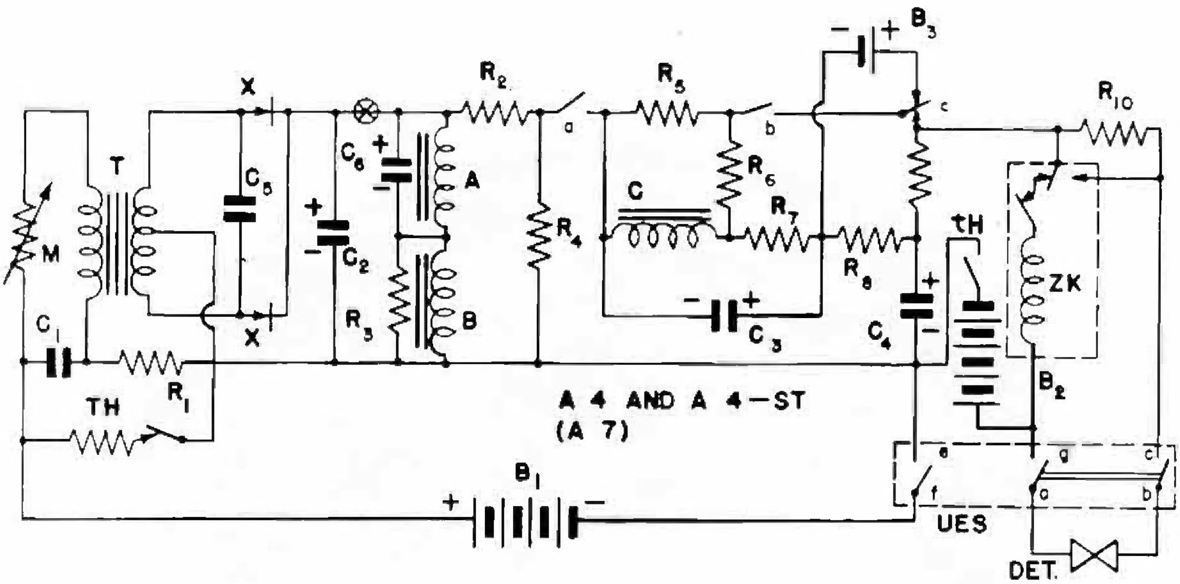
Figure 179 - A 104 Unit

A 104 Circuit - Operation (Figure 178)

Arming. When the mine is dropped, action of the Rheinmetall fuze closes Master Switch F. Since the thermostatic switch E is normally closed at temperatures between 23° and [illegible]° Fahrenheit, B_1 energizes the microphone through W_1 and fuse-delay switch A. Upon completion of its delay period, A switches over, putting B_2 in series with B_1 with respect to all parts of the circuit, except the microphone circuit.

If the mine reaches a depth of 24 feet or more, hydrostatic switch G closes to contact No. 2, and upon completion of the operations described in "Closing of the Master Switch" under A 104, Par. 1 above, B_1 and B_2 energize fuse-delay switch B. Upon completion of its delay period, B switches over, cuts itself out, and puts the detonator in the circuit.

Delay-Action Bomb Firing. If the mine does not reach a depth of 24 feet, the hydrostatic switch remains on contact No. 1, and upon completion of the operations described in "Closing of the Master Switch" Par. 1 above, B_1 and B_2 energize switches C and D in parallel. Upon completion of their respective delay periods, C and D switch over, putting the detonator across the batteries.



⊗ — SEE TEXT
UES — HYDROSTATIC CLOCK
ZK — 12-PLACE P.D.M.
M — MICROPHONE
X — COPPER-OXIDE RECTIFIERS
T — MICROPHONE TRANSFORMERS
TH — FUSE DELAY SWITCH
tH — CONTACT OF TH (CLOSES AFTER DELAY IN MELTING SOLDER OF TH)
A — RELAY; a CONTACT OF A
B — RELAY; b — CONTACT OF B
C — RELAY; c — CONTACT OF C
B_1 — BATTERY — 4.5 V
B_2 — BATTERY — 9 V
B_3 — BATTERY — 1.5 V
C_1 — CONDENSER — 240 UFD.
C_2 — CONDENSER — 240/UFD.
C_3 — CONDENSER — 100/UFD.
C_4 — CONDENSER — 240/UFD.
C_5 — CONDENSER — 0.5/UFD.
C_6 — CONDENSER — 100/UFD.
R_1 — RESISTOR — 50 OHMS
R_2 — RESISTOR — 10 KOHMS
R_3 — RESISTOR — 3 KOHMS
R_4 — RESISTOR — 5 OHMS
R_5 — RESISTOR — 5 OHMS
R_6 — RESISTOR — 5 KOHMS
R_7 — RESISTOR — 16 KOHMS
R_8 — RESISTOR — 16 KOHMS
R_9 — RESISTOR — 0.1 MOHMS
R_{10} — RESISTOR — 16 KOHMS

Figure 180 - A 4, A4st Unit Circuit - Condition before Launching

Normal Firing with P.D.M. When sound impinges on the microphone, the change in microphone resistance appears as current variations on the primary of transformer T, and as alternating signal current on the secondary of T. The signal current is filtered by L_1, L_2 and C_2, rectified by X_1 and X_2 with direct current then flowing through R_1 and R_3, charging C_3. R_1 is more sensitive than R_3, the sound level at which R_1 operates being the initiating level and the level at which R_3 operates being the firing level.

When the sound reaches the initiating level, R_1 closes r_1, causing B_3 to start charging C_4. After 1/2 second, C_4 will be sufficiently charged to operate R_2, thereby breaking r_2a, and making r_2b, completing a circuit from B_1 and B_2 through fuse delay switch No. 1, W_2, r_1, W_7, r_3 and r_2b. Potential drop through W_2 holds R_1 and R_3 operative, and since r_1 is half closed, B_3 holds R_2 operative.

Upon completion of its delay period, switch No. 1 switches over, cutting in switch No. 2 and by-passing the holding circuit which, if the sound has ceased, allows the circuit to return to normal. Upon completion of its delay period, switch No. 2 switches over, cutting in switch No. 3, and the circuit is normally alive again. After a maximum of nine "blind" actuations, switches No. 17 and No. 18 operate, putting the detonator in the

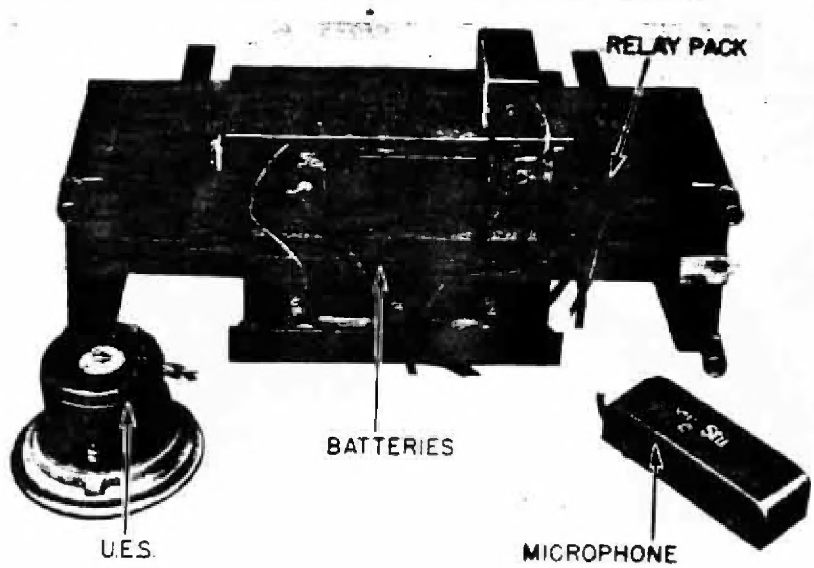


Figure 181 - A 4st Unit

firing circuit, and an additional firing actuation will fire the detonator.

Normal Anti-countermining. If, at any time during the life of the unit, the relays operate in such a sequence that R_3 operates before R_2, the unit is rendered passive for the duration of the sound which causes the condition. If the sound reaches the firing level within 1/2 second after r_1 closes, R_3 will close r_3, making an almost direct short across C_4 via r_2a. R_2 then cannot operate.

If the sound then drops below the initiating level, all relays return to normal. If the sound drops below the firing level, but not below the initiating level, and then rises to the firing level after a 1/2 second delay, the unit will fire normally.

P.S.E. Firing. Photo-electric cells may be fitted as in M 101.

System 2 - A 4, A 4st, A 105, A 105st (Figure 180) A 4, A 4st, A 105, A 105st, are all basically the same mechanism. All are designed for ground mines. A 4 and A 4st are designed for use in LMB, TMB, and TMC. A 105 and A 105st are designed for use in BM 1000. The requirements laid down for A 4 were as follows: firing at the approach of ship, recognition and thwarting of noise-buoys, recognition and thwarting of detonator-sweeps, and self blocking at the detonation of nearby mines. The circuit of A 105 is the same as that for A 104, except that R 10 is removed to prevent recharging of C_4 through a low-resistance circuit. Thus, A 105 operates as shown in figure 185, since the charge of C_4 leaks off through relay C in 4-8 seconds to the point where it will no longer keep C in the operated position. The circuit of A 4 and A 4st is shown in figure 180, and the sequence of operations is as follows:

1. Running of UES finally closes switches a-g and b-c, putting detonator into the circuit. A few minutes later, e-f closes and B_1 energizes the microphone circuit and fuse delay switch TH. TH heats for several seconds before switching itself out and closing (th), thus preventing initial surge from firing the mine, since (th) breaks charging circuit from B_2. When (th) closes, B_2 charges C_4 with a delay occasioned by R_0. All sound impulses on the microphone produce alternating currents in the transformer circuit which are then rectified. The value of direct current fed to relays A and B is determined by the sound level.

2. Firing. When the sound level reaches the operating point of A, (a) closes, allowing the charge on C_4 to operate relay C with a delay of 1/2 second occasioned by R_8 and C_3, causing (c) to switch over. When the sound level reaches the operating point of B, (b) closes and B_2 energizes the trigger coil of the ZK; or, if on the last actuation, the detonator and firing reaction is produced with the current passing through (th), R_4, (a), R_5, (b), (c), and the ZK (or detonators). Holding of A and B is accomplished by voltage drop through R_4 after the charge on C_4 is dissipated.

3. Protection. If, when the sound level reaches the operating point of A, it rises too rapidly to the operating point of B for C to react (less than 1/2 second), closure of (b) puts a short circuit across C_3 through (c), and battery B_3 helps discharge any potential on C_3 and, at the same time, provides a weak current to hold (c) on its normal contact as long as (b) is closed. This condition persists as long as (b) is closed. Protection is also provided in case after closure of (a), the sound level rises too slowly to the operating point of B. After closure of (a), C_4 is

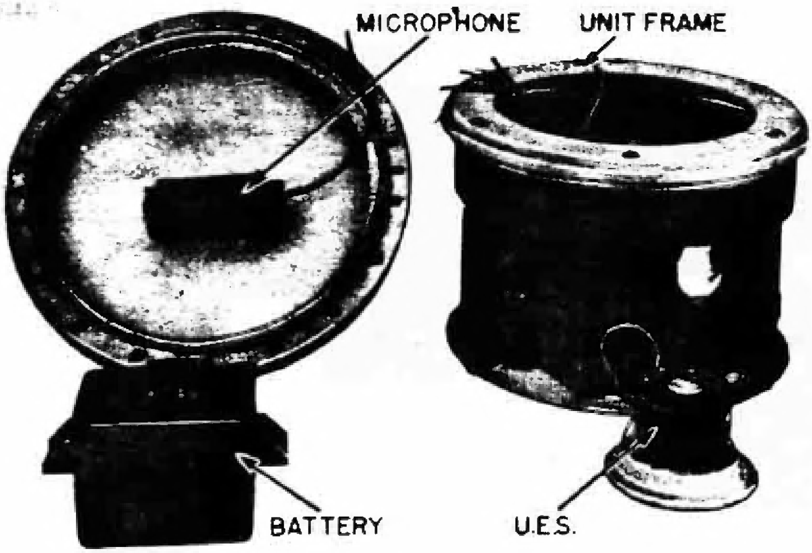


Figure 182 - A 7 Unit

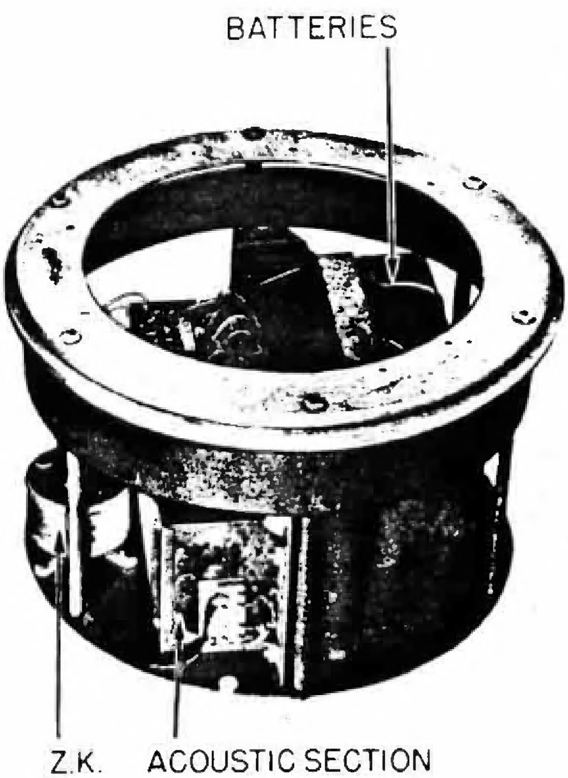


Figure 183 - A 7 Unit

subject to current drain, and, after 4-8 seconds, is no longer capable of holding C in the operated position. Thus, if the sound level does not rise to the operating point of B within the 4-8-second interval, the mechanism will react as though C had not operated and will remain passive until (a) opens and allows the recharging of C_4 through R_9, which requires approximately 15 seconds.

In figure 184a, it is shown that A 4 and A 105 will fire as a result of influence of a ship, but not as a result of GBT sweep. Since the ship's sound level reaches B within period T after C reacts, firing occurs when the B level is reached. In the case of the GBT, however, the B level is not reached until period T has expired and protection results. (Distances shown are approximate.)

In figure 184b, there are three cases which result from detonations:

Case 1 - Detonation nearby - both A and B react simultaneously - protection.

Case 2 - Detonation at distance - only A reacts - no reaction.

Case 3 - Detonation at great distance - neither A nor B reacts.

In figure 184c, there are three cases which result from a detonation sweep:

Case 1 - KKG nearby - both A and B react within 1/2 second - protection.

Case 2 - KKG at distance - only A reacts - no reaction.

Case 3 - KKG at distance - neither A nor B reacts.

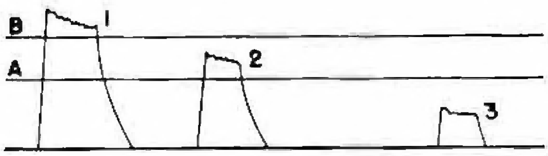


Figure 184a

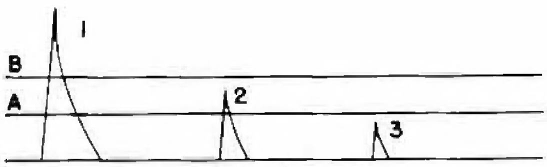


Figure 184b

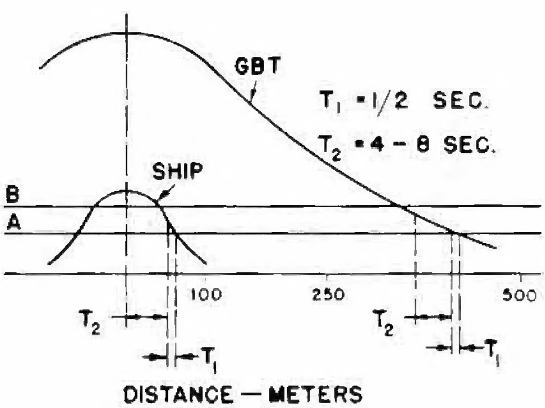


Figure 184c

Figure 184 — Parts a, b, and c - Reactions of A 4, A 105

A 105

A 105 Circuit Operation (Figure 185)

Arming. When the mine is dropped, action of the Rheinmetall fuze closes the master switch F. Since the thermostatic switch E is normally closed between temperatures of 23° and 95° Fahrenheit, B_1 energizes the microphone M through W_1 and fuse-delay switch A. Upon completion of its delay period, A switches over, putting B_2 in the circuit.

If the mine reaches a depth of 24 feet or more, hydrostatic switch G closes to contact No. 2, and, upon completion of the operations described above, B_2 energizes fuse-delay switch B. Upon completion of its delay period, B switches over, cuts itself out, and puts the detonator in the circuit. B_2 charges C_4 after a 15-second delay due to the resistance of W_6.

Delay-Action Bomb Firing. Same as A 104, except that all current is supplied by B_2.

Normal Firing with F.D.M. When sound impinges on the microphone, the change in microphone resistance appears as current variations on the primary of the transformer T, and as alternating signal current on the secondary of T. The signal current is rectified by X_1 and X_2 with direct current then flowing through R_1 and R_3, charging C_3. R_1 is more sensitive than R_3, the sound level at which R_1 operates being the initiating level and the level at which R_3 operates being the firing level.

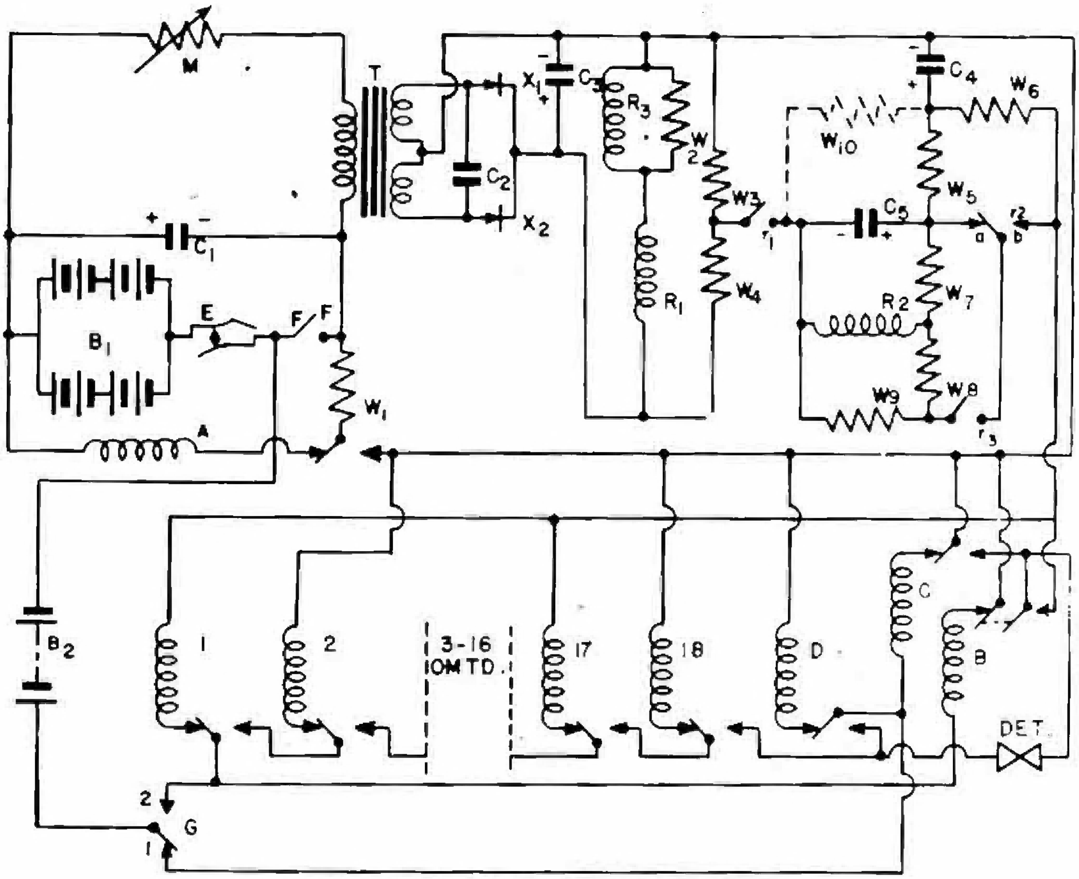
When the sound reaches the initiating level, R_1 closes r_1, causing C_4 to start charging C_5 in an attempt to operate R_2. After 1/2 second, C_5 will be sufficiently charged to operate R_2, thereby breaking r_2a, and making r_2b. If the sound then reaches the firing level before C_4 and C_5 discharge (10 seconds), R_3 closes r_3, completing a circuit through fuse-delay switch No. 1, r_2b, r_3, W_9, r_1, and W_3. Potential drop through W_3 holds R_1 and R_3 operative, and since r_1 is held closed, C_4 and C_5 hold R_2 operative.

Upon completion of its delay period, switch No. 1 switches over, cutting in switch No. 2 and by-passing the holding circuit which, if the sound has ceased, allows the circuit to return to normal. Upon completion of its delay period, switch No. 2 switches over, cutting in switch No. 3, and the circuit is normally alive again. After a maximum of nine "blind" actuations, switches No. 17 and No. 18 operate, putting the detonator in the firing circuit; and an additional actuation will fire the detonator.

Normal Anti-countermining. Normal anti-countermining may occur if the sound level rises too fast. The unit will be rendered passive in the same manner as the A 104, except that if the sound ceases or drops below the firing level, the unit will not again be normally alive for a period of 15 seconds maximum.

P.S.E. Firing. Photo-electric cells may be fitted as in M 101.

System 3. A 7 and A 107 are modifications of A 4 and A 105, respectively. A 7 and A 107 were originally intended as plain acoustic units to be used in moored mines. However, considerable difficulty with acoustic units in moored mines was encountered, due to the large background sound level. For some time the idea of using an acoustic unit in a moored mine was abandoned, since an experimental minefield of over 100 EMF mines fitted with A 3 units detonated almost simultaneously in the Kattegat. Since Dr. Hell had done most of the former work on Navy and Luftwaffe acoustic mines, he was charged with the task of designing one capable of being laid in a moored mine for both services. The



A, B, C, D - FUSE DELAY SWITCHES
E ------ THERMOSTATIC SWITCHES (CLOSED AT 23°F AND 95°F)
F ------ MASTER SWITCH
G ------- HYDROSTATIC SWITCH (24 FT)
B_1 ------- 3 VOLTS
B_2 ------- 10 "
C_1 ----- CONDENSER - 240 MFD. - ELECTROLYTIC
C_2 ----- " - 0.2 MFD
C_3 - C_4 - C_5 " - 100 MFD. - ELECTROLYTIC
M ----- CARBON MICROPHONE
R_1 ------ RELAY (INITIATING) r_1-R_1 CONTACT
R_2 ------ " (TIMING) r_2-R_2 "
R_3 ------ " (FIRING) r_3-R_3 "
T ------ MICROPHONE TRANSFORMER
X_1, X_2 -COPPER OXIDE RECTIFIERS
#1 - #18 P.D.M. FUSE DELAY SWITCHES

W_1 - 10 Ω	W_4 - 10,000 Ω	W_7 - 15,000 Ω
W_2 - 3,000 Ω	W_5 - 15,000 Ω	W_8 - 5,000 Ω
W_3 - 5 Ω	W_6 - 0.1 Ω	W_9 - 5. Ω

Figure 185 - A 105 Unit Circuit

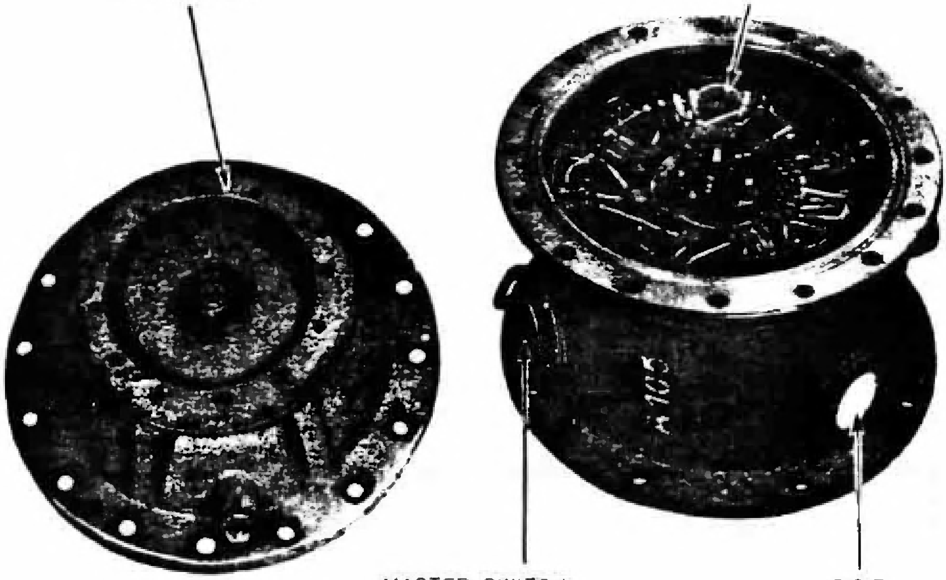


Figure 186 - A 105 Unit

result was the A 7 for the Navy and his own version of A 107 for the Luftwaffe. The A 7 was still in the final testing stage at SVK at the end of the war in Europe, but the Hell A 107 for the Luftwaffe was temporarily shelved in favor of a parallel development of Goepel of the Luftwaffe E-Stelle. Hell's system consists of either A 7 or A 105, modified by the introduction of a large condenser in the output of the rectifier circuit and remains a three-delay system.

A 7 is designed for use in EMF/SMA. A 107 (Hell) is designed for use in BM 1000 T. Outside of physical differences for mounting in moored mines, A 7 is the same as A 4, with the following differences.

1. In A 7 a 600/ufd condenser is inserted at the point indicated.

2. In A 7, condenser C 2 is 600/ufd instead of 240/ufd.

Conversion of A 105 to A 107 (Hell) is done by the same process.

Goepel System. The Goepel development is quite different from the Hell system, and is essentially a two-relay system. This development had two branches:

1. A 107 for moored mine BM 1000 T, and

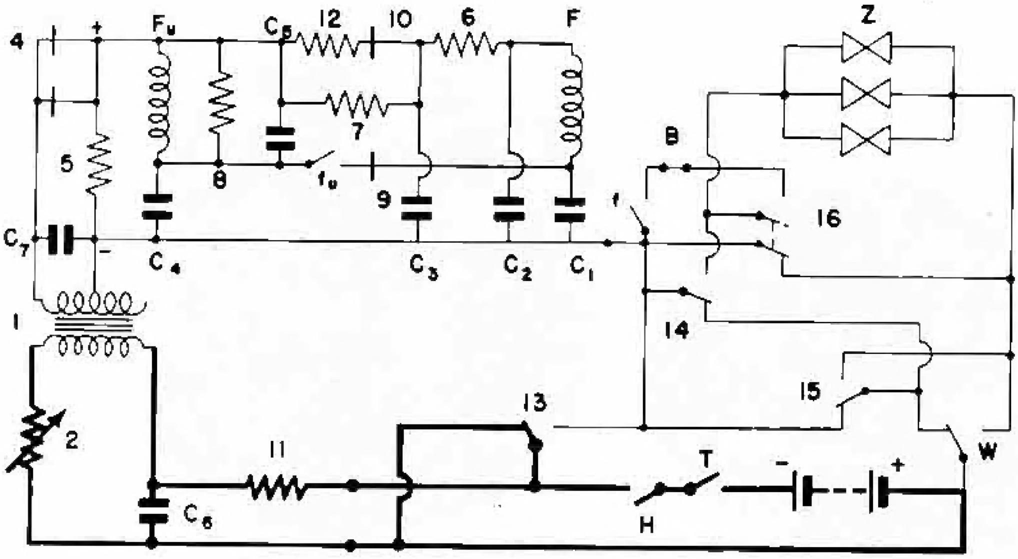
2. A 107 for ground mine BM 1000.

Both systems went through several stages of development and, in each case, the system is discussed in terms of the most recent development.

A 107 for Ground Mine BM 1000 (Goepel). In this circuit, when the master switch H closes, figure 187, the battery energizes fuze-delay switch No. 13. At the end of the delay on switch No. 13, it operates, producing the condition shown in figure 188 with fuse-delay switches No. 14 and No. 15 energized. At the end of the periods of No. 14 and No. 15, they operate and produce the condition shown in figure 189. The battery then fires the detonators Z. This is delay bomb firing, since the hydrostatic switch (W) has not switched over. A depth of 24 feet of water is necessary for W to operate. If sufficient depth is reached, W operates; No. 14 and No. 15 are not energized, but switch No. 16 is energized as shown in figure 190. At the end of the delay period of No. 16, it operates and opens, putting the detonator into the circuit. The carbon-button microphone (2) has been energized by the battery ever since the closure of H. Sound causes resistance variations in the microphone, which are transformed by transformer (1), to the half-wave rectifier circuit. As a result of the rectification produced by (3) and (4), a direct current directly proportional to the sound level appears across the terminals marked (+) and (-), as shown in figure 192.

Relay Reactions - (A 107 for Ground Mine - Goepel)

1. Firing. Relay F is the firing relay and is more sensitive than relay Fu, the protection relay. If the sound level rises too rapidly, Fu will operate as a result of long delays on F caused by the large condensers. If the sound level does not rise too rapidly, as in normal ship transits, Fu will not be



1 – MICROPHONE TRANSFORMER
2 – CARBON BUTTON MICROPHONE D 102MI
3,4 COPPER OXIDE RECTIFIERS
9,10 " " "
5 – RESISTOR 30 KOHMS 0.5 WATTS
6,8 " 3 " " "
7 – " 100 " " "
11 – " 10 " " "
12 – " 5 " " "
13,14,15,16 – FUSE DELAY SWITCHES
(5 OHMS ± 0.5 OHMS, 0.5 AMPS.)
B – TAP-IN FOR PRESSURE UNIT

C_1, C_2, C_3, C_5 – 240 MFD. 10 – 12 VOLTS
C_4 – 30 MFD. 120 VOLTS
C_6 – 50 MFD. 120 VOLTS
C_7 – 0.1 MFD. 20 – 250 VOLTS
F – J-RELAY f – SWITCH
F_u – J-RELAY f_u – SWITCH
H – DELAY MASTER SWITCH (72 HRS.)
T – THERMOSTATIC SWITCH
(KTSE –0.5° C TO +35° C)
W – HYDROSTATIC SWITCH (24 FT.)
Z – DETONATORS (3)

Figure 187 - A 107 Unit Circuit

actuated and C_4 will charge as shown in figure 193. The charging of C_5 quiets the action of Fu, and, when C_4 is fully charged, C_3 is charged, through rectifier No. 10, figure 194. When C_3 is fully charged, C_2 is charged through the additional resistance of resistor No. 6, figure 195. After the additional delay occasioned by charging of C_2, current may flow to C_1 and the firing relay F. If the charging current to C_1 due to sound level is large enough, relay F will be energized as shown in figure 196; contact (f) closes, and the firing circuit is shown in figure 191.

(D is an additional set of terminals which may be used to fit a pressure (Druck) unit to convert to an AD 107 unit. They are normally bridged in all A 107 circuit diagrams.)

2. Blocking. If, at any time before F operates, the sound level rises too rapidly, relay Fu will operate and close contact (fu). Closing of (fu) short-circuits all charging current to C_1 through rectifier No. 9 and maintains holding for relay Fu as long as such current flows, figure 197 and figure 198. In addition, as shown in figure 199, condenser C_2 discharges through the same circuit in addition to going through the coil of relay F in the opposite direction. Thus, (f) is prevented completely from closing, and blocking continues as long as charging current continues to flow in large volumes from the rectifier circuit. When the sound level drops off, C_2 and C_1 are substantially discharged. Note that blocking occurs if the sound level rises too rapidly due to the action of relay Fu; also, although not a locking action, if

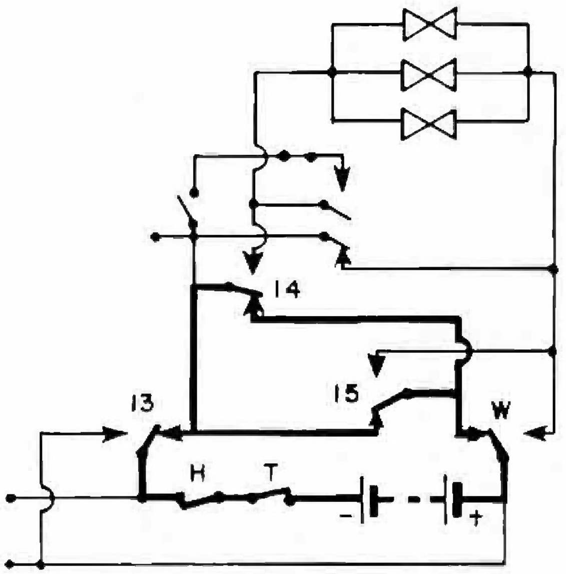


Figure 188

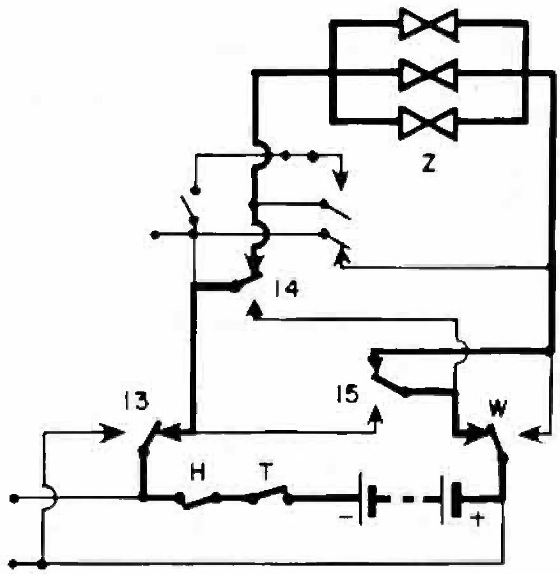


Figure 189

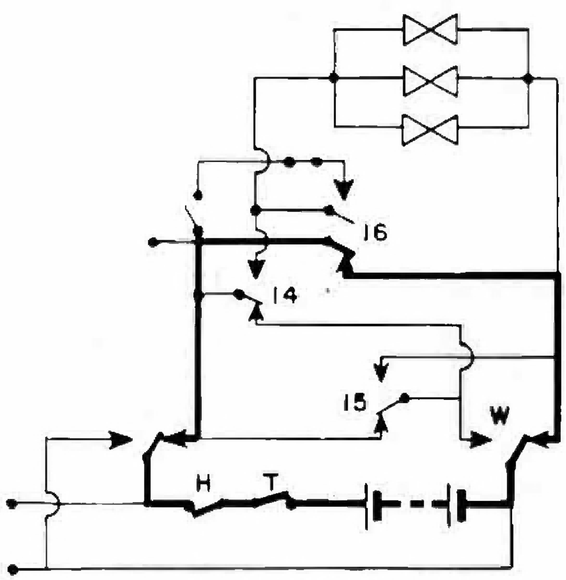


Figure 190

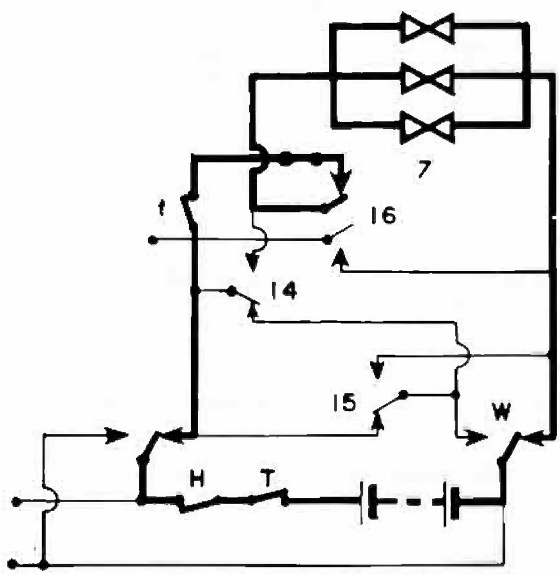


Figure 191

Figures 188-191 - Sequence of Operation, A 10? Unit

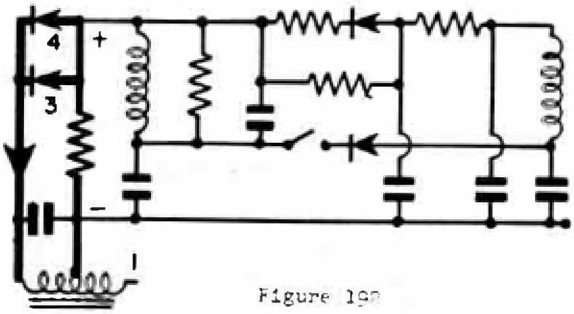


Figure 192

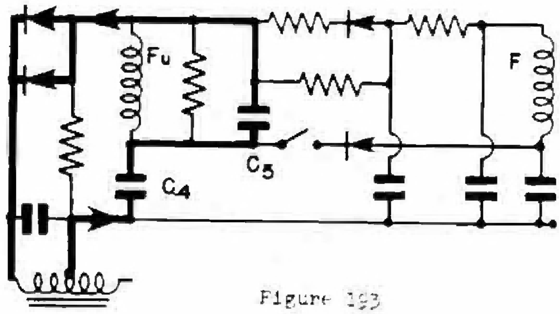


Figure 193

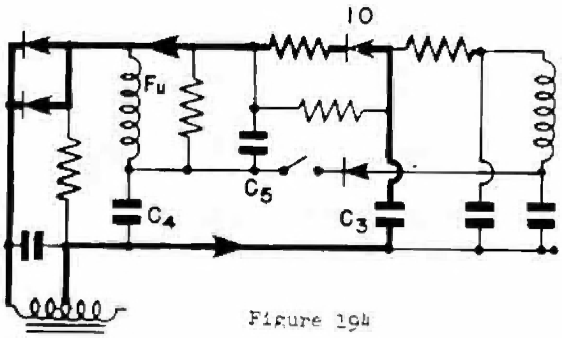


Figure 194

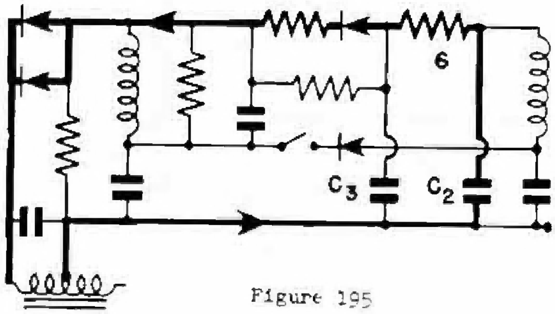


Figure 195

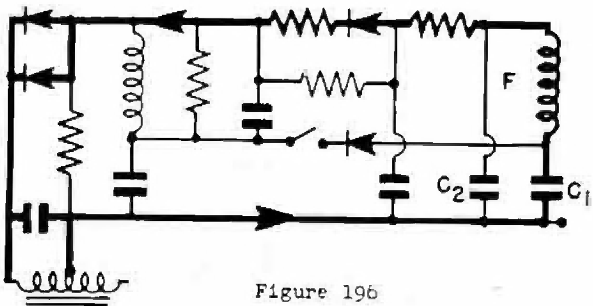


Figure 196

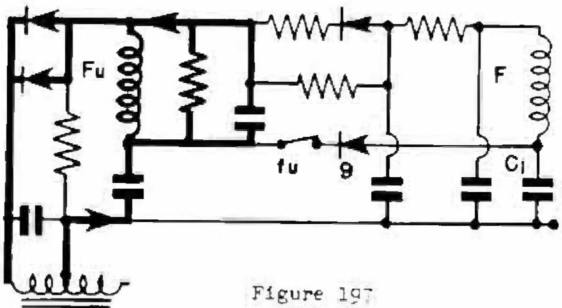


Figure 197

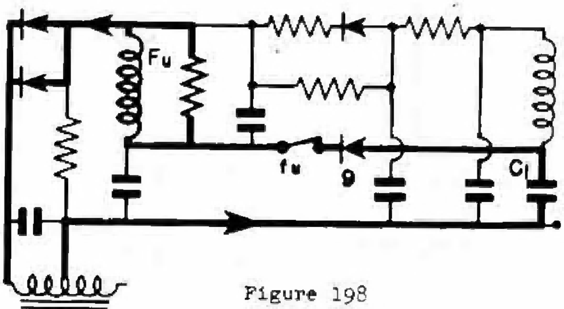


Figure 198

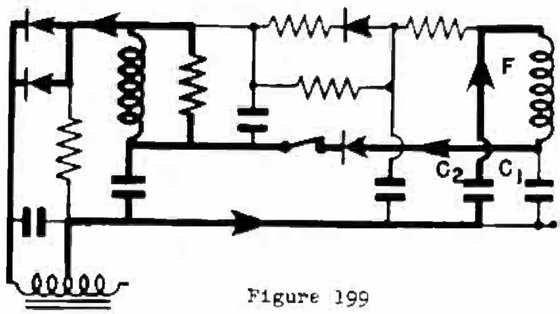


Figure 199

Figures 192-199 - Sequence of Operation, A 107 Unit the sound level rises too slowly and is not of sufficient magnitude when charging current runs to C_1, relay F will not be operated. Therefore, if firing is to occur, the sound level must rise at a rate between the two described.

A 107tc

Reactions in A 107tc are very similar to those in the ground mine version of A 107. Among the differences between the two circuits are the following:

1. Full-wave rectification of the signal current issued in A 107tc.

2. The rectifiers of the blocking circuit are placed differently.

Circuit Components for A 107

1 Microphone transformer

2. Carbon button microphone D 102 M1

3. 4. Copper oxide rectifiers

9. 10. " " "

5. Resistor 30 K Ohms 0 5 watt

6. 8. " 3 K Ohms "

7. " 100 K Ohms "

11. " 10 K Ohms "

12. " 5 K Ohms "

13. 16. Fuse-delay switches 5 Ohms 0.5 ohm; 0.5 amp.

C_1, C_2, C_3, C_6	Electrolytic condenser 240/ufd. 10/12 volt
C_4	Becherkondersator - 30/ufd. 120 volt
C_5	Electrolytic condenser 50/ufd. 120 volt
C_7	Paper condenser 0.1/ufd. 20/250 volt
F	J-relay
Fu	J-relay
H	Delay master switch (72 hours)
T	Thermostatic switch KTSE - 0.5°C. to + 35°C.
W	Hydrostatic switch (24 feet)
Z	Detonators (3)

The constants of the A 107tc circuit are not known at present, and it is not known what characteristics that unit has which make it particularly desirable for moored mine application.

Chapter 11 - Section 4

MAGNETIC-ACOUSTIC COMBINATION UNITS

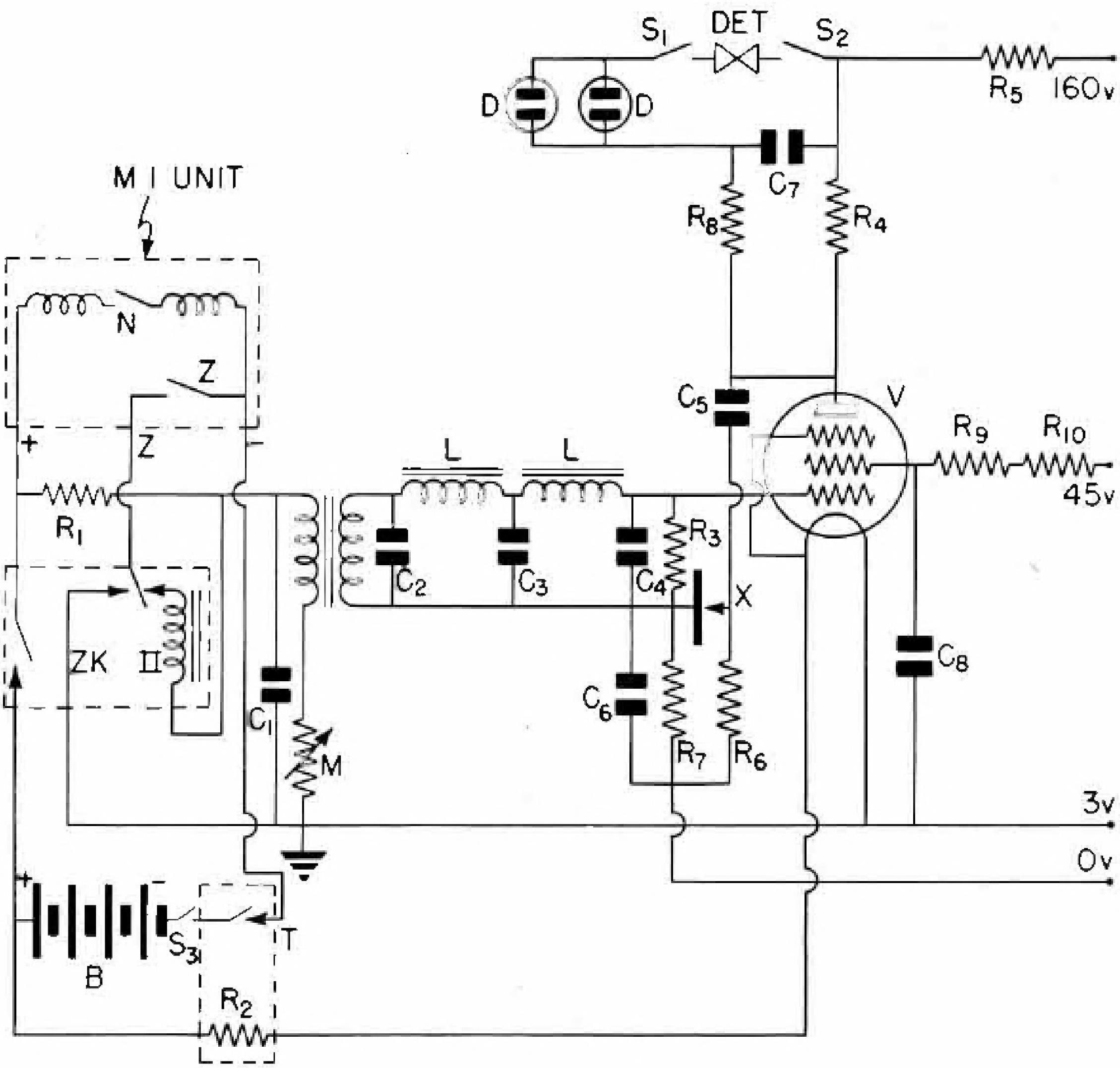
MA 1, MA 1a, MA 1st, MA 2, and MA 3 MINE UNITS

The first German magnetic-acoustic combination mine unit was recovered in September 1941 This was the MA 1 and MA 1a type, which were nearly identical and laid in equal quantity. Later, the MA 2 and MA 3 units were developed. Both of these later units incorporate a rate-of-change acoustic system, and are nearly identical; but small variations result in a substantial difference in the operational characteristics. The MA 1st is a further modification of the MA 1 type, but it was not used operationally.

The German MA 1, MA 1a, MA 1st, MA 2, and MA 3 units are magnetic-acoustic combination mine-firing devices. In each case, a special acoustic firing unit with vacuum-tube amplification is triggered by the standard magnetic-unit type M 1 or one of its modifications. The principal modification used is M 1r. When MA 1a is used with M 1r, it is designated MA 1ar. Because of the use of the M 1 system, all these units are restricted to ground-mine use, because of the pendulum-type anti-countermining feature.

MA 1. The MA 1 unit circuit is shown in figure 200. The acoustic component is triggered by the magnetic component for a period determined by the time interval set by the heating of a thermal delay switch. The acoustic component contains a single pentode vacuum-tube, which, in its output circuit, fires the detonator without use of a relay system. The operation of the circuit is as described below.

Arming. Arming is accomplished by closure of the hydrostatic clock switches which are indicated in the circuit diagram as S_1, S_2, and S_3. Closure of S_1 and S_2 puts the detonator into the circuit. Closure of S_3 connects battery B into the circuit. When B is connected by S_3, the magnetic M 1 component goes



B-BATTERY-15 v
C_1-CONDENSER-100 μfd.
C_2-CONDENSER-0.02 μfd.
C_3-CONDENSER-0.05 μfd.
C_4-CONDENSER-0.02 μfd.
C_5-CONDENSER-0.01 μfd.
C_6-CONDENSER-0.5 μfd.
C_7-CONDENSER-0.25 μfd.
C_8-CONDENSER-4.0 μfd.
N-NEEDLE SWITCH (OF M1)
M-CARBON-BUTTON MICROPHONE

V-PENTODE
LL-FILTER CHOKES
DD-NEON TUBES
X-COPPER OXIDE RECTIFIER
T-THERMAL DELAY SWITCH
S_1-a-g) HYDRO
S_2-b-c) CLOCK
S_3-e-f) SWITCHES
Z-"Z" SW. (M1)

R_1-300 OHMS
R_2-200 OHMS (HEATER)
R_3-0.1 MOHMS
R_4-0.06 MOHMS
R_5-5.5 KOHMS
R_6-0.3 MOHMS
R_7-1.5 MOHMS
R_8-1.5 MOHMS
R_9-1.0 MOHMS
R_{10}-6000 OHMS
ZK II-12-PLACE P.D.M.

Figure 200 - MA 1, MA 1a, M1A 1st Circuit

through latitude adjustment in the usual manner through the normally-closed contact of thermal delay switch T. When latitude adjustment is complete the unit is ready for actuation.

Triggering. Triggering is accomplished by the magnetic component, which is normally alive. If a F.D.M. (ZK II) is fitted, the "blind" actuations (11 maximum) need only be magnetic, in which closure of the Z switch of the M 1 unit allows battery B to energize the trigger coil of the ZK II and advance the F.D.M. one stage. During the cycle of 120 seconds, the normally-closed switch of the ZK II breaks holding current to the M 1 unit and restores the original condition of the circuit. When the "blind" actuations are run off on the ZK II, the next magnetic actuation will trigger the acoustic component. The M 1 component is modified slightly when used in this combination to produce a higher magnetic sensitivity averaging approximately 5 mg. This is done by weakening the latitude-adjusting hairspring and slowing down the latitude-adjustment clockwork. When a magnetic actuation now takes place, closure of the Z switch:

1. Energizes microphone M through resistor R_1

2. Energizes the heater of pentode V

3. Energizes the heater R_2 of thermal delay switch T.

Acoustic Actuation. Sound falling on the microphone is transformed into electrical impulses in the secondary of the microphone transformer and fed to a low-pass L/C filter. The filtered output is loaded across R_3. Vacuum tube V is biased as a linear amplifier, and the amplified signal appears in the output circuit of V. Some of the amplified signal is fed back to the grid circuit by condenser C_5 to rectifier X. This rectifier is connected to R_6 and R_7, in such a manner that a rectified signal potential appears across R_7, thus making the grid potential of V more positive. This results in greater conductivity of V and a greater plate current through resistor R_4. The potential drop across R_4 is loaded across C_7 through R_8, which provides a short charging delay. When C_7 charges to a potential of approximately 110 volts, the neon tubes (DD) break down and C_7 discharges through the detonator, firing the mine.

De-Energizing. If, after triggering and energizing of the acoustic component, no acoustic actuation occurs, heating of the thermal delay switch T due to heater R_2 causes the contact of T to break. When this contact breaks, all components of the acoustic component energized by magnetic actuation are de-energized, since the return of battery B is thereby broken. Also, the holding current to the magnetic component is broken, and all components of the circuit are restored to normal. Since R_2 is also de-energized, the thermal delay switch recloses shortly after opening. Approximately 45 seconds is necessary for the T contact to open from an originally cold conditinn. However, if repeated magnetic actuation takes place, the period

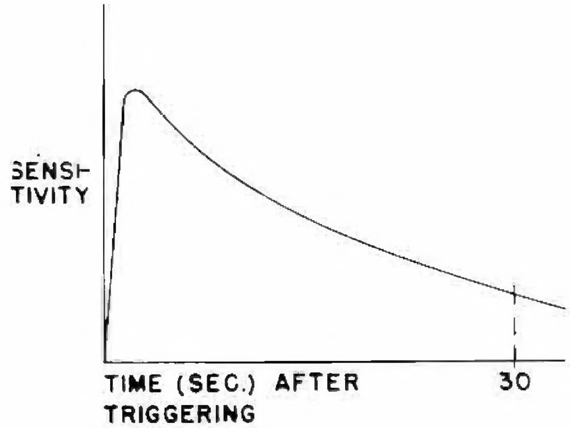


Figure 201a

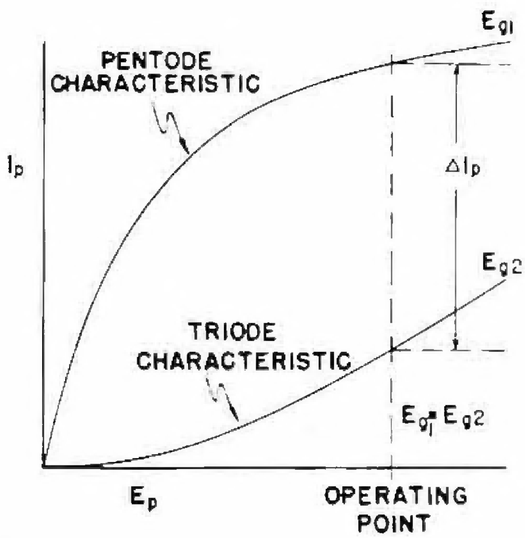


Figure 201b

Figure 201- Parts a and b - MA 1a Characteristics

will be accordingly shortened.

MA 1a. MA 1a is the designation of a slight modification of MA 1 which has a slightly different operational characteristic. The MA 1a circuit is identical with that of MA 1, as shown in figure 200, with the exception that in MA 1a, R_9 has a value of 10 M Ohms instead of 1 M Ohm. The result is that during the live cycle (45 seconds) of the acoustic component after triggering, the acoustic sensitivity falls off quite rapidly after reaching its peak within 1 to 2 seconds after triggering, figure 201a. Thus, if the acoustic influence does not occur immediately after triggering, considerably more than ordinary acoustic influence is necessary to fire the mine. This is designed to make sweeping more difficult. Increasing the value of R_9 to 10 M Ohms has the effect of isoleting the screen grid of V from its battery connection.

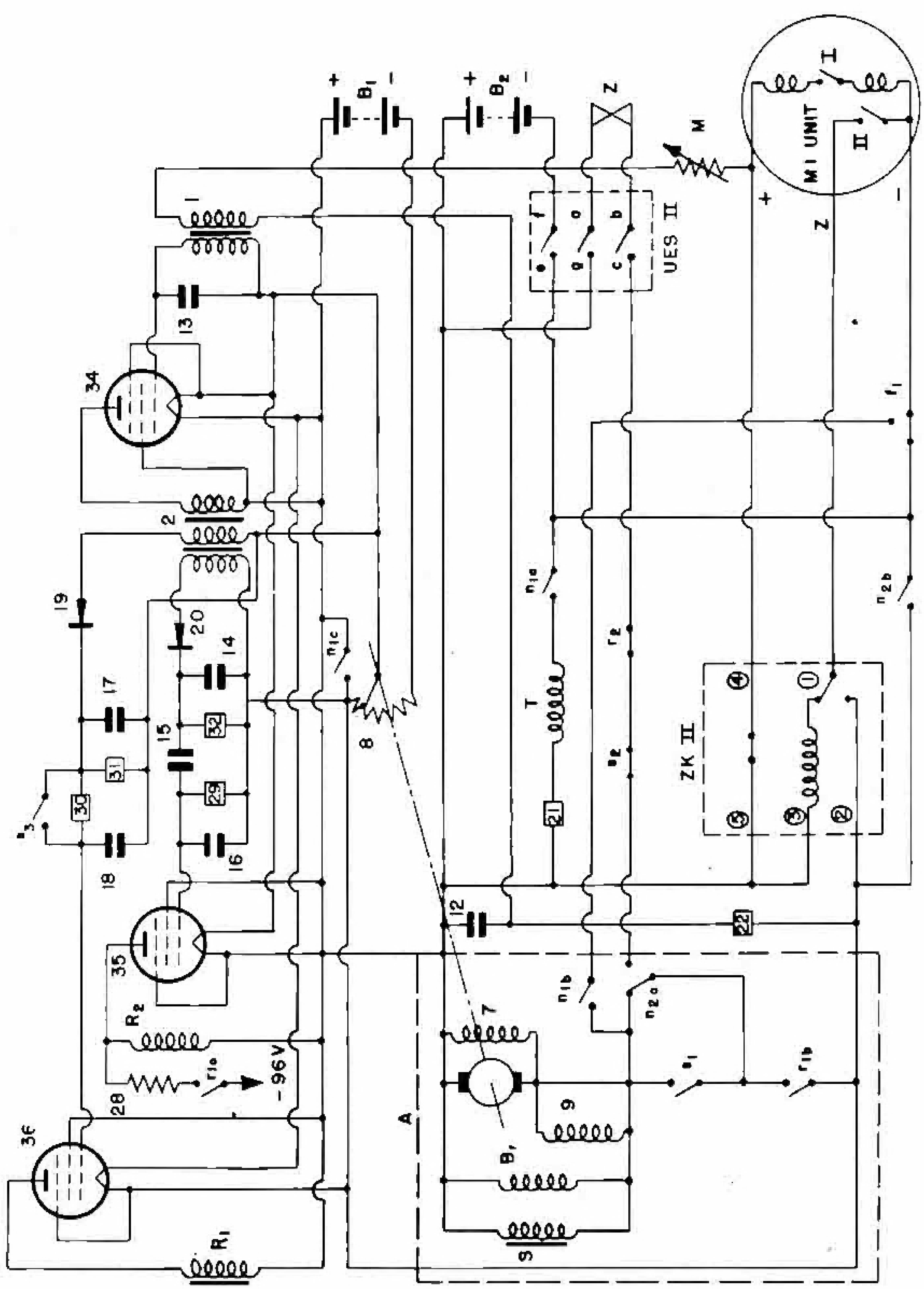
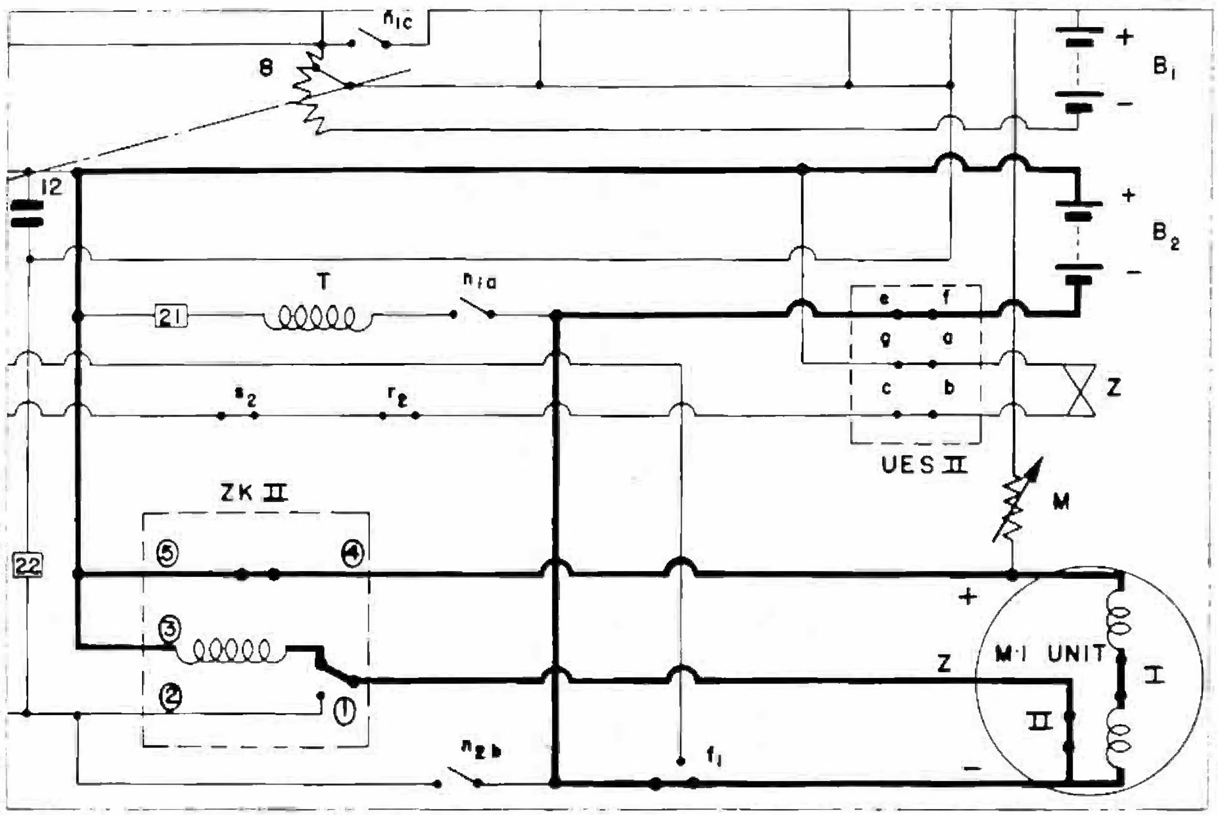


Figure 202 - MA 2/MA 3 Unit Circuit



1 — TRANSFORMER
2 — COUPLING TRANSFORMER
7 — MOTOR ARMATURE
8 — POTENTIOMETER
9 — FIELD COIL
12 – 18 — CONDENSERS
19,20 — RECTIFIERS
21,22 — HEATER SWITCHES
28 — RESISTOR
29 – 32 — FUSE DELAY SWITCHES
34 – 36 — PENTODES
① - ⑤ — ZK II SWITCHES
I, II — SWITCHES OF M-I UNIT
A — MOTOR
B_r — MAGNETIC BRAKE
B_1 — BATTERY 96 VOLTS
B_2 — BATTERY 15 VOLTS
M — MICROPHONE
R_1, R_2 — RELAYS
S — BLOCKING RELAY
T — THERMAL DELAY COIL
UES II — HYDROSTATIC CLOCK
Z — DETONATOR SWITCH OF M-I UNIT
ZK II — P.D.M. SWITCHES
a,b,c,e,f,g, — HYDROSTATIC CLOCK CONTACTS
n_{1a}, n_{1b}, n_{2a}, n_{2b} — CAM SWITCHING ASSEM.
r_{1a}, r_{1b} — RELAY CONTACTS FOR R_1, R_2
r_2 — RELAY SWITCH
s_1, s_2 — HYDROSTATIC ARMING SWITCH
s_3 — BLOCKING RELAY SWITCH
t_1 — THERMAL DELAY SWITCH
n_{1c} — CAM SWITCHING ASSEMBLY

Figure 203 - MA 2/MA 3 Unit Circuit

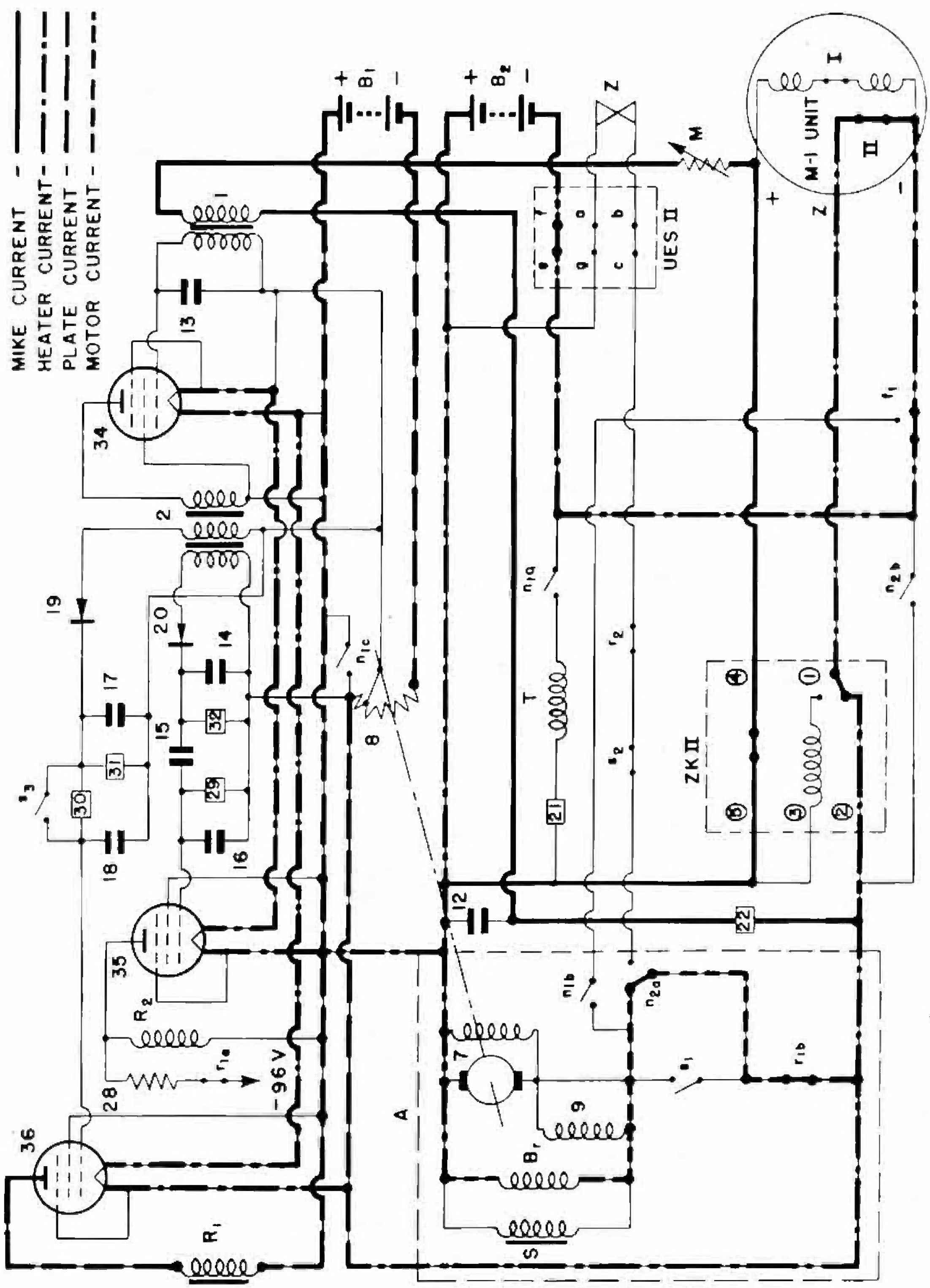


Figure 204 - [illegible] Unit Circuit

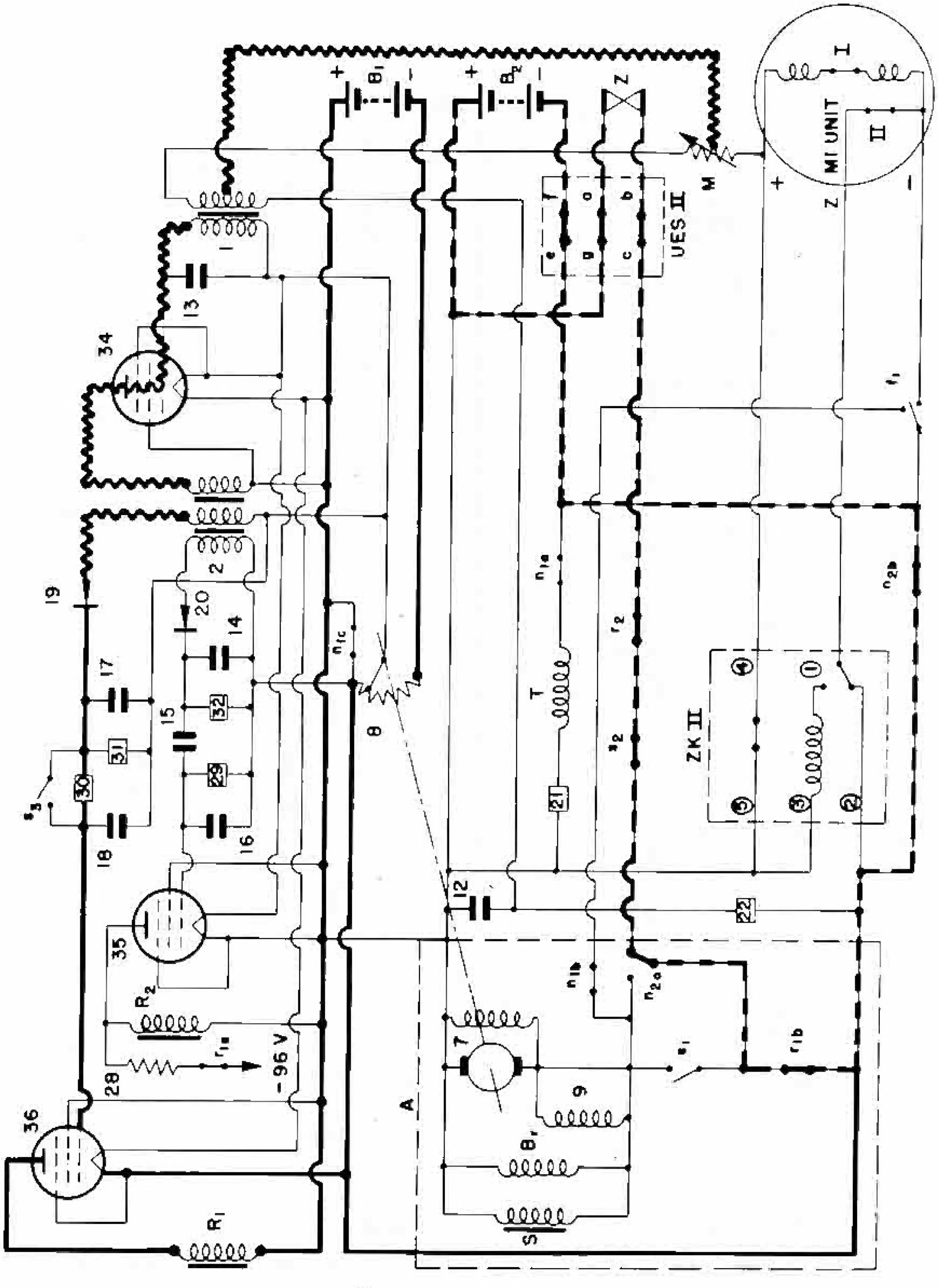


Figure 205 - MA 2/MA 3 Unit Circuit

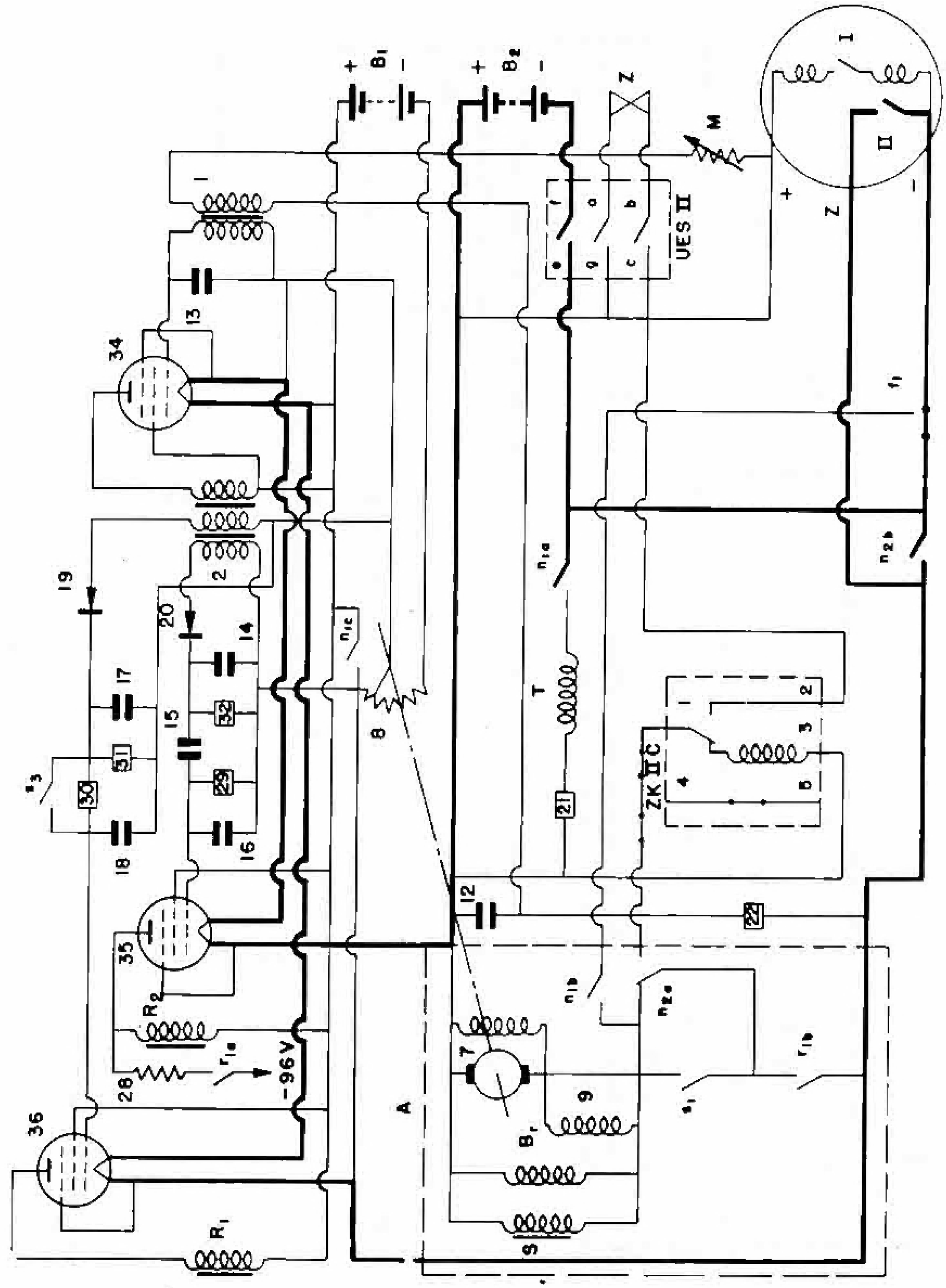


Figure 206 - MA 2/MA 3 Unit Circuit

At the start of the cycle, C_8 is fully charged to 45 volts. However, when V is energized, the screen grid as well as the plate start drawing current, with the result that C_8 is at least partially discharged. The resultant lowering of the screen potential inhibits the pentode characteristic of V, and it tends to approach a triode characteristic. Thus, for the same F and Eg the plate current Ip is lower and a much higher sound level is necessary to fire the mine, figure 201b. The MA 1 circuit has a tendency to show this characteristic, but it is not as marked as in MA 1a and does not seriously affect its sweepability

MA 1st. MA 1st is a further modification of MA I. The modification did not reach the operational stage and was being tested at the end of the war in Europe. It consists essentially, of the substitution of a "stumpf" (coarse) microphone in the circuit, making the overall system very insensitive and suitable as an anti-mine-sweeper unit.

The ZK IIe mechanism is used in this unit. The ZK IIe mechanism has a cam-operated switch which is closed for 15 seconds after a magnetic actuation and then open for 120 seconds in parallel with another cam-operated switch which is closed only after 84 cycles of the mechanism. Through this system, acoustic actuation must take place within 15 seconds after triggering or result in triggering only with an interval of 120 seconds, for a maximum of 84 times. After the 84th cycle, the circuit is made normal. This system would require that a mine-sweeper make sufficient acoustic influence on the mine within 15 seconds after magnetic triggering to fire the unit when fitted with the "stumpf" system.

MA 2. The MA 2 circuit is shown in figure 202. The amplifier consists of three pentodes types RV 2.4 P 700, which make up two channels: the firing channel and the protecting channel. The output of the microphone is fed to an amplifer pentode (34). The output of this amplifier is fed, through coupling transformer (2) to the two channels. Pentode (34) and its associated circuits make up the firing channel. Pentode (35) and its associated circuits make up the protective channel. The input circuit to (34) has a time-delay circuit of 1 to 2 seconds. The input circuit to (35) has a very short time-constant and is designed to handle steep fronts.

MA 2 Cam Switching System. The rate-of-change feature of the unit is provided by means of a motor-driven potentiometer on which is mounted a group of cam-switches. The potentiometer (8) is driven through an arc of 280 degrees by the armature (7) of the motor. In this arc the resistance of the potentiometer increases arithmetically from 150 to 2,000 Ohms. When the motor armature is energized, its field coil (9), its magnetic brake (Br) and the blocking relay (S) are also energized. The magnetic brake is designed to stop the motor instantly when de-energized, and the blocking relay (S) breaks the circuit to the detonator during motor running. The cam-switching assembly consists of two groups, labelled "n_1" and "n_2" respectively. The switches labelled "n_1" are closed immediately after the motor starts, and open immediately when the motor has driven the potentiometer back to the zero-position. The switches labelled "n_2" are closed immediately when the motor has driven the potentiometer back to the zero-position. The switches labelled "n_2" are closed immediately after the motor starts, but re-open again when the potentiometer has been driven to the 280 degree position.

MA 2 Operation. When the hydrostatic clock (UES II) runs off, switches a-g and b-c close, putting the detonator (Z) into the circuit. A short time later, e-f closes and puts the 15-volt battery across the (+) and (-) terminals of the M 1 component through f_1 and (4-5) of the ZK II mechanism. The M 1 runs through latitude adjustment and becomes normally alive. A magnetic actuation closes switch I(needle switch), and switch II (Z switch) is closed due to relay action. Closure of switch II allows the battery to energize the trigger coil of the ZK II, figure 203. All "blind" actuations on the ZK II mechanism are run off on magnetic actuation alone (11 maximum). After the last "blind" actuation, the ZK II breaks 3-1 and makes 1-2, putting the acoustic-triggering system into the circuit.

Triggering. When the magnetic actuation occurs, closure of switch II allows the 15-volt battery to energize the microphone, and the heaters of the three pentodes. The acoustic component is now alive for the first acoustic impulse, figure 204.

Automatic Adjustment. If sound is at this point incident upon the microphone and it is of the proper frequency (100-200 cps.) the output of the amplifier stage (34) is fed through the coupling transformer (2) to the two channels. If the signal is of firing level, it is rectified by rectifier (19), passed through the time-delay circuit to the grid of pentode (36). The resultant increases in plate current of (36) will operate relay R_1. Operation of R_1 closes contacts r_{1a} and r_{1b}. Closure of r_{1a} connects the plate of (35) to +96 volts through 100 K Ohm resistor (28). This current does not operate R_2, but is designed to replace blocking-signal current which, by this time, would normally have been dissipated. Closure of r_{1b} allows the 15-volt battery to energize the motor (7), its magnetic brake (Br) and the operating coil of relay (S), through n_{2a}. Closure of s_1 makes a maintaining circuit for the motor through r_{1b}. Opening of s_2 breaks the detonator lead to the battery. Closure of s_3 bridges the time-delay circuit in the input circuit to the firing tube. Thus, the motor drives the potentiometer (8) as long as the circuit to the motor is maintained. The variation of the potentiometer resistance varies the grid potential of the grids of pentodes (34) and (36). When the plate current of (36) is reduced below the maintaining point of R_1, r_{1b} breaks the motor circuit and the braking coil brings it to a stop immediately. The system is capable of compensating for an initial sound level of 150 mv. or less.

Cam-switching. As soon as the motor starts, all switches "n" are switched over, figure 205.

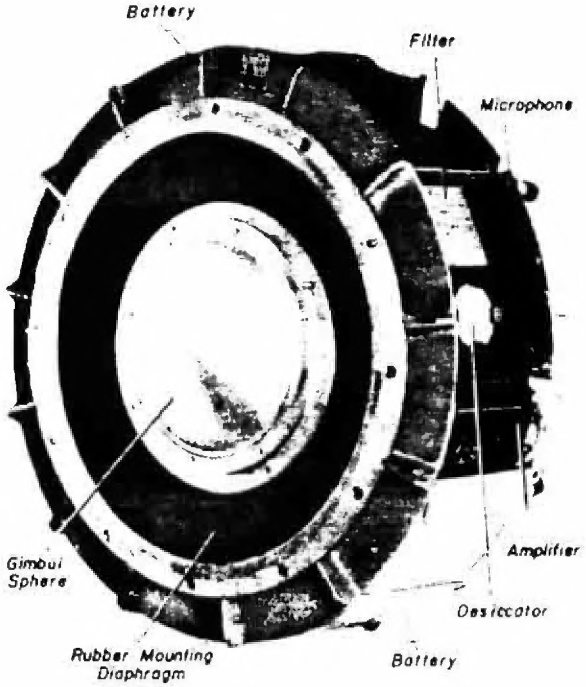


Figure 207 - MA 1 Unit

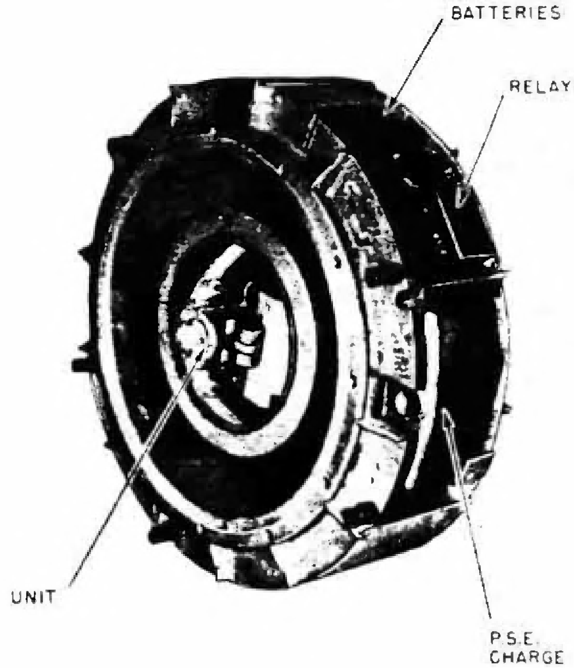


Figure 208 - MA 1 Unit

n_{1a} puts the 15-volt battery across the heater coil of the thermal delay switch T.

n_{1b} arms the motor-resetting circuit which comes into play when f_1 operates.

n_{1c} connects the potentiometer to the (+) side of the 96-volt battery, thus causing battery drain only when the unit is live to acoustic actuation.

n_{2a} arms the firing circuit, but, since s_2 is open during this process, the mine cannot fire.

n_{2b} shuts switch II of the M 1 unit.

Firing. If, after the adjustment has taken place, the sound level arises so that the plate current of (36) reaches the operating point of R_1, R_1 operates, closing r_{1b} and since n_{2a}, s_2 and r_2 are closed, the 15-volt battery fires the detonator Z, figure 205.

Blocking. If at any time during the acoustically active period, the sound level rises too rapidly and actuates the blocking circuit of pentode (35), operation of R_2 opens r_2 and breaks the firing circuit.

Re-setting. If satisfactory acoustic actuation does not take place after acoustic adjustment occurs, heating of the thermal delay switch T causes its contact f_1 to switch over and allow the 15-volt battery to energize the motor and associated gear through n_{1b}. This will continue until the motor reaches the 0° setting, at which point the cam switches return to normal and the motor is de-energized. In addition, this will occur if the initial sound level incident on the microphone is higher than 150 mv. In this case, rotation of the potentiometer is incapable of reducing the plate current of pentode (36) below the maintaining point of R_1. Therefore, the motor current will be maintained through r_{1b} until the poteniometer is returned to normal. At this point it will stop unless the magnetic component is still in an actuated condition. If this is the case, the triggering will go through another cycle.

MA 2 with ZK IIc. Figure 206 shows the modification of the MA 2 circuit when fitted with ZK IIc instead of ZK II. The ZK IIc mechanism is designed to require only a very short pulse on its trigger coil to go through a complete cycle. Thus, with a ZK IIc fitted, both magnetic and rate-of-change acoustic actuations are required for "blind" as well as firing actuations. This system is known as MA 2/ZK IIc.

MA 3. The MA 3 unit is electrically and mechanically the same as the MA 2 unit with two exceptions: the speed of the motor, and the time-interval provided by the thermal delay switch T. The exact figures on relative speed of the motor in MA 2 and MA 3 are not known. The differences between MA 2 and MA 3 with respect to the thermal delay switch have to do with the time required for its contact f_1 to break its normal contact and make its "hot" contact.

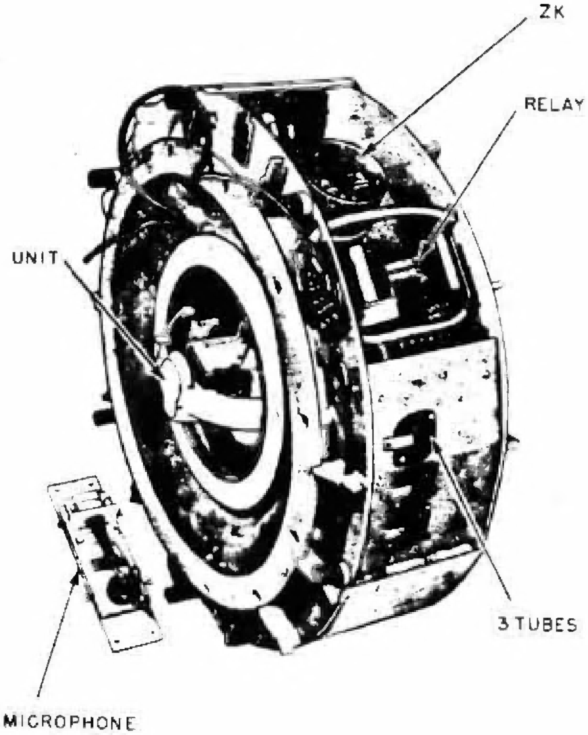


Figure 209 - MA 1 Unit

	MA 2	MA 3
Break normal contact	10-16 sec.	7-14 sec.
Make "hot" contact	20-32 sec.	14-20 sec.

MA 101 UNIT

The MA 101 unit consists of a constantly active magnetic, bi-polar component, an acoustic component, a nine-place P.D.M. and a galvanic P.S.E. Its operation differs from that of the MA 1 in that the P.D.M. "blind" actuations are run off by actuation of both the acoustic and the magnetic components together rather than by actuation of the magnetic component alone; i.e., when the magnetic component is actuated, it immediately puts the acoustic component in the circuit, and when sound impinges on the microphone, he P.D.M. advances one step. If acoustic actuation does not occur within 40 seconds after magnetic actuation, the "T" switch returns the entire unit to normal as in MA 1. Excessive moisture or humidity in the unit will operate a galvanic P.S.E. and fire the detonator after a short delay.

MA 101 - Operation (Figure 211)

Arming. When the mine is dropped, action of the Rheinmetall fuze closes the master switch F, making one contact and breaking two. Thermostatic switch A is normally closed at temperatures between 23° and 95° F. B_1 energizes fuse delay-switch No. 17 which, upon completion of its delay period, cuts in fuse delay switches No. 18 and No. 22. Hydrostatic switches H_1 and H_2 open when the mine reaches a depth of 15 feet or more. Upon completion of its delay period, switch No. 18 switches over, cutting in switch No. 19 which, upon completion of its delay period, connects the battery to the main positive and negative terminals of the unit.

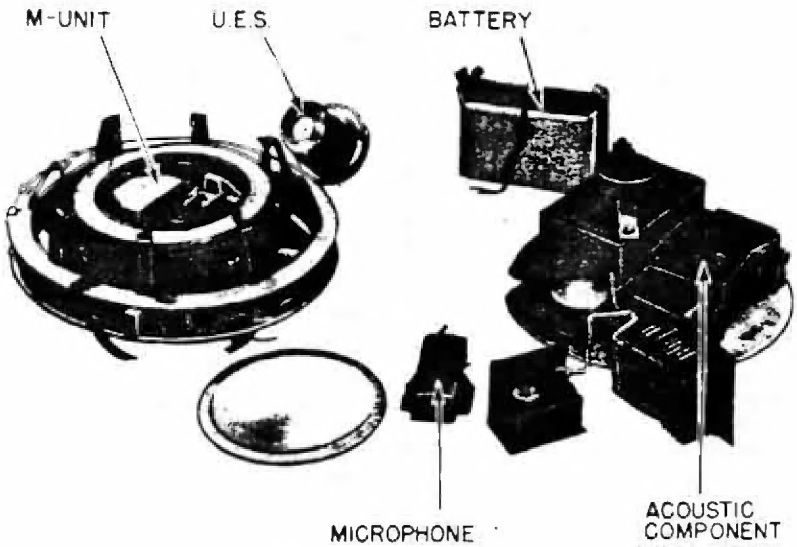
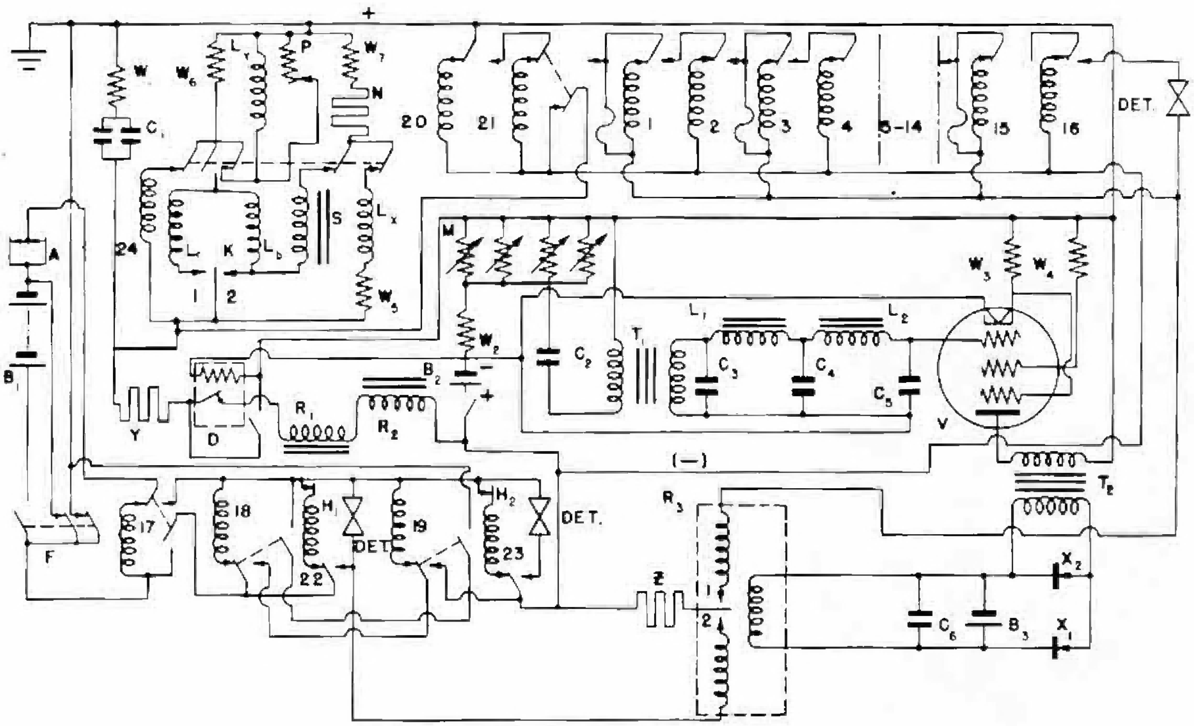


Figure 210 - MA 2 Unit for TMB



A - THERMOSTATIC SWITCH (CLOSED AT >23°F & <95°F)
B_1 - BATTERY - 13.5 VOLTS
B_2 " - 1.5 "
B_3 - SEA BATTERY - (PSE MARK IV) FORMED BY MOISTURE IN UNIT.
C_1 - CONDENSER - MFD.
C_2 - " - "
C_3 - " - "
C_4 - " - "
C_5 - " - "
C_6 - " - "
D - THERMAL DELAY SWITCH & HEATER (40 SEC.)
F - MASTER SWITCH
H_1 H_2 - HYDROSTATIC SWITCH - (CLOSED AT <15 FT.)
K - NEEDLE SWITCH
L_1 L_2 - FILTER CHOKES
L_X - AUXILIARY COIL
L_Y - COMPENSATING COIL
M - MICROPHONES (4)
N, Y, Z, - THERMISTORS

P - POTENTIOMETER
R_1 R_2 - SOLENOID RELAY
R_3 - SENSITIVE RELAY
S - LATITUDE ADJUSTER COIL
T_1 - MICROPHONE TRANSFORMER
T_2 - OUTPUT TRANSFORMER
V - VACUUM TUBE (PENTODE)
W_1 - RESISTOR
W_2 - "
W_3 - "
W_4 - "
W_5 - "
W_6 - "
W_7 - "
X_1 - COPPER OXIDE RECTIFIER
X_2 - COPPER OXIDE RECTIFIER (INEFFICIENT)
#1 - #16 - P.D.M. FUSE DELAY SWITCHES
#17 - #21 - DELAY ARMING FUSE DELAY SWITCHES
#22, #23 - DELAY BOMB FIRING FUSE DELAY SWITCHES

Figure 211 - MA 101 Unit Circuit

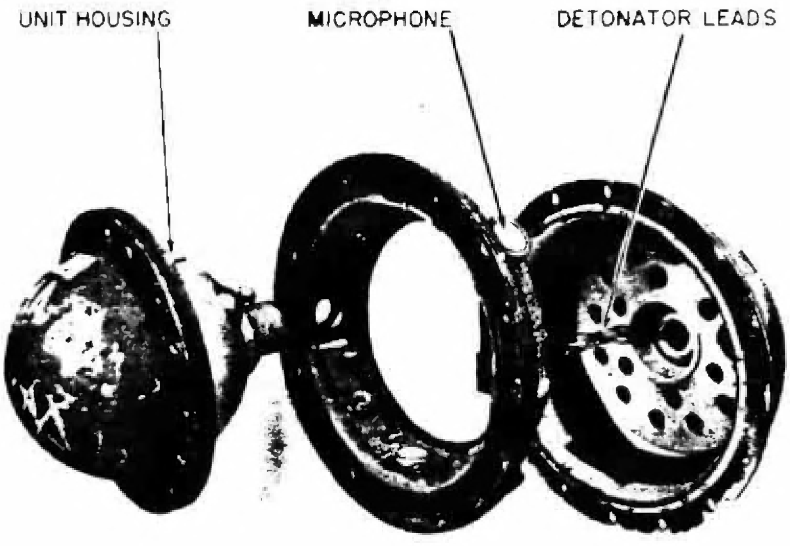


Figure 212 - MA 101 Unit

The magnetic component (M 103 unit slightly modified) then goes through A.L.A., upon the completion of which the only parts of the magnetic component remaining in the circuit are W_6, L_T or L_b, and K. During A.L.A., switches No. 20 and No. 21 operate, switching in the P.D.M. fuse-delay switches and breaking the negative return contact to the magnetic component.

Delay-Action Bomb Firing. Two different methods of accomplishing delay action bomb firing may be employed as follows:

1. If the mine does not reach a depth of 15 feet, H_1 remains closed and, when fuse-delay switch No. 22 switches over, a detonator is put across the battery and the mine fires.

2. If the mine does not reach a depth of 15 feet, H_2 also remains closed. When fuse delay switch No. 19 switches over and connects the battery to the positive and negative leads of the unit, switch No. 23 will operate and fire the mine if H_2 has not opened. (H_2 is provided to allow an alternative method of delay bomb firing in case H_1 does not operate properly.)

Normal Firing with P.D.M. A RED or BLUE actuation will close K to contact No. 1 or No. 2, respectively, and current will then pass from the main positive lead through W_6, L_T or L_b, K, thermistor Y, and the normally-closed contact of thermal delay switch D; and the operating coils of relays R_1 and R_2 close. Closing of R_1 provides a self-holding circuit for R_1 and R_2 through the contact of D. Closing of R_2 energizes the heater of D, energizes the four microphones M through W_2 and energizes the vacuum tube filament through W_3. The self-holding circuit of R_1 and R_2 shunts out the needle system, reducing the hold-on current to such a low level that K breaks its contacts and Y cools. The main circuit through R_1 and R_2 will persist until D breaks its contact due to heating action.

If sound impinges on the microphone before D breaks its contact, the change in microphone resistance appears as current variations in transformer T_1 and passes through the filter circuit to the control grid of pentode V. This vacuum tube amplifies the signal, which then appears as current variations on transformer T_2. The output of T_2 is fed to the operating coil of sensitive relay R_3. Since the rectifier X_1 allows current to pass only in the direction of its arrow and since the current output from T_2 is alternating, X_1 passes current half the time to the operating coil of R_3 with a slight delay due to C_6. Rectifier X_2 acts as an overload feature to by-pass heavy currents. The signal current from T_2 and X_1 closes R_3 to contact No. 1.

When R_3 closes to contact No. 1, a circuit is completed from (+) through the by-passing fuse of fuse-delay switch No. 1, the holding coil of R_3, and thermistor Z to (-). If the sound persists long enough, Z heats and passes enough current to operate the holding coil, the by-pass fuse blows, and fuse-delay switch No. 1 carries the total load until completion of its delay period, when it switches over to switch No. 2, thereby cutting out the holding circuit and allowing R_3 and Z to return to normal. Before switch No. 2 completes its delay period, D breaks its contact, cutting out R_1 and R_2 holding circuit, its own heater current, the microphone current, and the vacuum-tube current. When switch No. 2 switches over to No. 3, the entire unit is again normal and ready for re-actuation. A maximum of eight "blind" actuations operates switches No. 15 and No. 16, putting the detonator in the circuit, and an additional magnetic-acoustic actuation fires the mine.

P.S.E. Firing. If water or excessive moisture enters the unit, a cell is formed between two dissimilar metals. Current will flow through the operating coil of R_3 in such a direction that R_3 closes to contact No. 2, making a complete circuit from (+) through the closed contacts of switches No. 18 and No. 19, a detonator, the R_3 holding coil and 2 to (-). When 2 has heated sufficiently, the current holds the relay closed and the mine fires.

MA 105 UNIT

The MA 105 unit is a further Luftwaffe development of the MA 101 unit. Although many samples of MA 105 were captured in the Mediterranean area in 1943, it is not definitely known to have been used operationally. The magnetic component is a new bi-polar magnetic needle device capable of repeated resetting to assure proper latitude adjustment and to accommodate small changes in the prevailing magnetic field. It is similar in operation to the M 4 unit developed by SVK embodying the usual Luftwaffe magnetic-unit construction. The acoustic component is a new type which uses two pentode amplification stages.

The MA 105 unit is a combined magnetic-acoustic mine firing mechanism of the same basic design and appearance as the obsolete MA 101 (Allied designation AM Mk II) with several improvements. However, the unit uses the same type of microphones (four in number) as the MA 101 unit. The microphone is very insensitive and decreases in sensitivity with the depth of water. Final investigation may show unique characteristics of the acoustic component, but preliminary examination of the available information tends to indicate that the magnetic component is the primary firing device with the acoustic component introduced to make sweeping more difficult. The MA 105 unit is designed for laying in the BM 1000 H mine. There is some evidence to indicate the existence of an MA 105r unit ("r" equals raumschutz). It is not known how the "raumschutz" anti-sweeping device could be handled in the laying of a bomb-mine.

Chapter 11 - Section 5

SUBSONIC UNITS

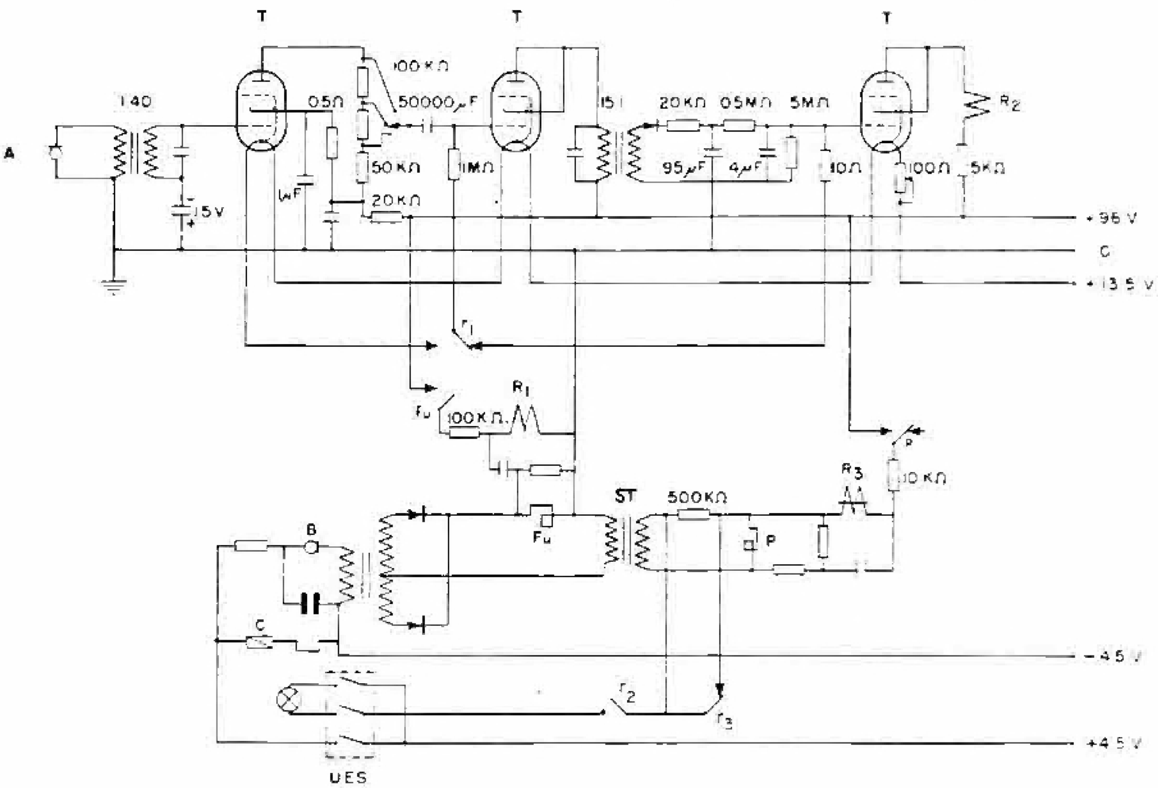
AT 1 - AT 2 - AT 3 UNITS

The Germans had attempted since 1941 to produce a mine embodying subsonic firing, with only partial success. The result was the AT group of units, which includes the AT 1, AT 2, and AT 3 units. These units were formerly designated AA 1, AA 2, and AA 3; but AT is a more recent official German designation (T-Tieftone). It is claimed that units of this type had been laid since 1942, but, until the war in Europe was over, only small parts of the units had been captured and none had ever been recovered.

The German AT units are subsonic mine-firing units for ground mines. The subsonic firing feature has some vertical directional characteristics, but, since the mines in which it is used are cylindrical, the Germans assumed that any position in whch the mine might lie would not inhibit its proper operation. Each AT unit is fitted with a sonic-acoustic triggering system designed to save the amplifier batteries of the subsonic component. The subsonic component is designed to operate in the range between 20 and 25 cps. The different units are likely to have slightly different resonances, with quite sharp resonance peaks, but this is considered a good operational property by the Germans.

Magnetopnone. A magnetophone ("Klotz") is the detecting device for the subsonic component of the AT units. This device is sometimes known as a "doppelschwinger" or "double oscillator" by the Germans. A sectional drawing of the magnetophone appears in figures 215, 217. The device is suspended from a supporting arm which is threaded into the mine-case tail door on the axis of the mine. This supporting arm is fitted with a guard cylinder to prevent excessive motion on impact. The magnetophone is connected to the supporting arm by a type of bearing in such a way that it is free to rotate in a plane perpendicular to the axis of the mine. To prevent damage on laying, the magnetophone is held in a fixed position by an arm mounted on the tail door, and the magnetophone is released by the blowing of a fuse when the mine becomes armed. It is expected that the mine will lie horizontally or nearly so, and the weight of the magnetophone will cause it to swing to a hanging position.

Magnetophone Construction. As shown in figure 215, the magnetopone consists of a magnet and the assembly for the coil. The magnet is cylindrical, and has two concentric poles with a small gap between. The magnetic field in this gap is 9,000 gauss. The coil assembly is a group of zinc fittings bolted onto the gap end of the magnet. Inside the assembly, the coil is mounted on an aluminum block supported by two flat bronze springs. The coil is wound on a cylindrical paper form and held to it by shellac. Two springs are used to assure that motion of the coil between the magnet poles will be along the



R_1 - RELAY

R_2 - RELAY

r_1 - GRID CONTACT

P - ANTI-COUNTERMINING RELAY

Fu - OUTPUT RELAY

fu - OUTPUT RELAY CONTACT

UES-HYDROSTATIC CLOCK

r_2 - FIRING CONTACT

r_3 - CONTACT FOR R_3

R_3 - DELAY RELAY

p - ANTI-COUNTERMINING CONTACT

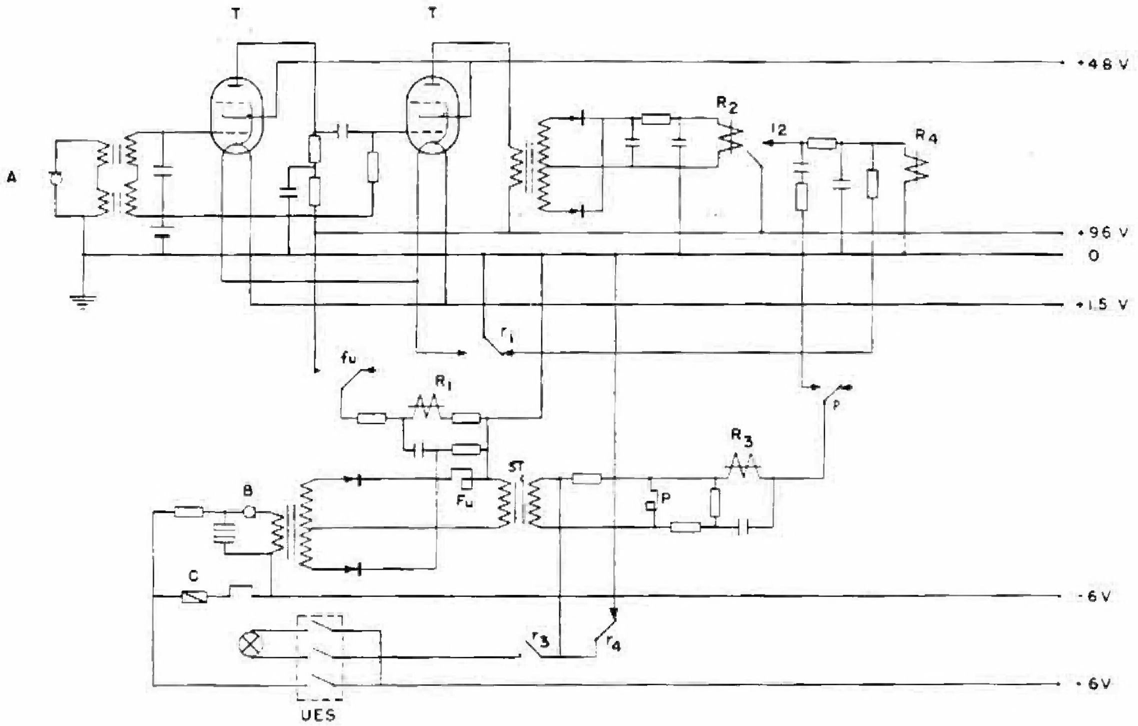
A - MAGNETOPHONE

B - MICROPHONE

C - FUSE DELAY FOR MAGNETOPHONE

T - RV 2.4 P 700 TYPE VACUUM TUBES

Figure 213 - AT 2 Unit Circuit



R_1 - RELAY

R_2 - RELAY

r_1 - GRID CONTACT

P - ANTI COUNTERMINING RELAY

Fu - OUTPUT RELAY

fu - OUTPUT RELAY CONTACT

UES-HYDROSTATIC CLOCK

r_2 - FIRING CONTACT

r_3 - CONTACT FOR R_3

R_3- DELAY RELAY

p - ANTI COUNTERMINING CONTACT

R_4- RELAY

r_4 - FIRING CONTACT

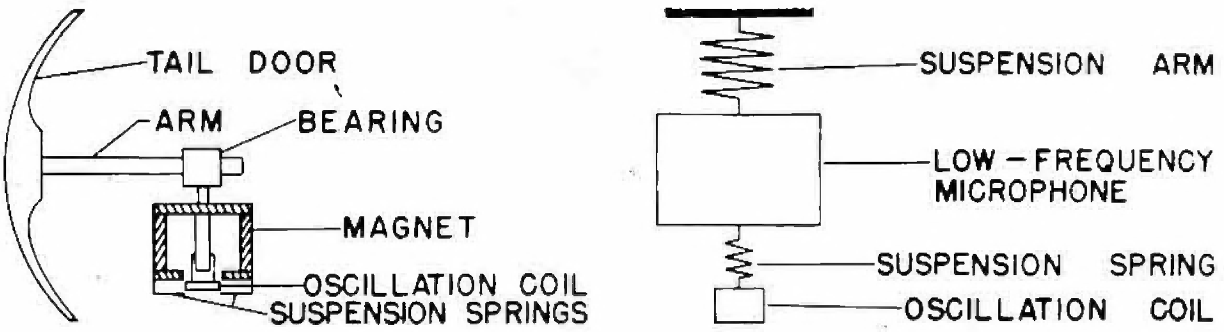
A - MAGNETOPHONE

B - MICROPHONE

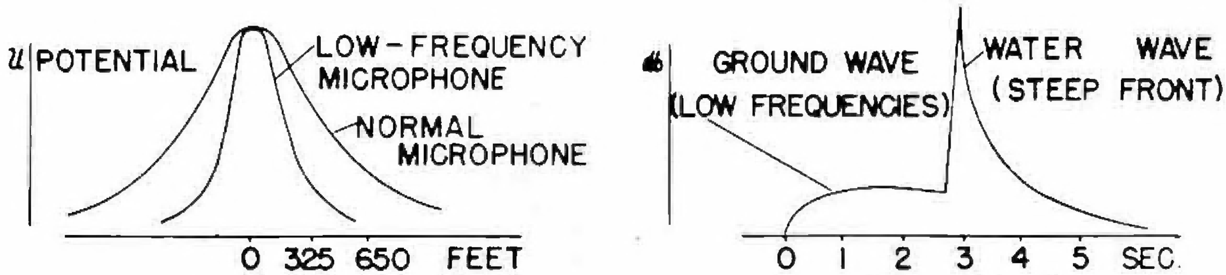
C - FUSE DELAY FOR MAGNETOPHONE

T - RV24P700 TYPE VACUUM TUBES

Figure 214 - AT 3 Unit Circuit



Construction and Principle of Magnetophone



Ship's Transit

Remote Detonation

Figure 215 - Principles of Subsonic Firing

axis of the coil. A zinc strengthening strip is bolted on the bottom. When the magnetophone is held in fixed position before the release fuse blows, a pin fits through a hole in this strip to hold the aluminum coil-mounting block against its limit stop and prevent damage due to impact. The system is designed to have a resonance of 22 cps. The mass of the magnetophone and the length of the suspension are the principal factors in determining this frequency.

AT 1. The AT 1 unit was the first attempt to produce a subsonic firing device. In the AT 1, a simple sonic-acoustic triggering system started a clock which kept the subsonic system armed for a period of about two minutes. It was found that this unit was too easily swept and was especially subject to firing due to explosions. This may be seen in figure [illegible] The diagram showing the sound level [illegible]s caused by remote detonations shows [illegible] transmission through the ground reaches [illegible] time approximately 2-1/2 seconds (in the case shown) before transmission through the water. It would be possible, in the AT 1, for the ground wave to trigger the unit by actuation of the sonic system and the water-transmitted wave to fire the mine. This fault was eliminated by the use of a different triggering system in AT 2. Therefore all existing AT 1 units, including those in the field, were converted to AT 2's, the modifications necessary for conversion lying primarily in the improvements in the acoustic triggering circuit.

Acoustic Triggering Circuit. The modified type of acoustic triggering circuit as used in AT 2 and AT 3 appears in their circuit diagrams, figures 213 and 214. The normal cantilever-type carbon-button microphone is used in a transformer and rectifier circuit. The output signal current actuates relay Fu. Closure of its contact (fu) connects relay R_1 to the 96-volt battery through a 100 K Ohm resistor. When contact (r_1) closes, it turns on the heater potential to the three tubes of the subsonic amplifier. The resistor-condenser system in parallel with the R_1 is designed to hold R_1 in the operated condition for three to four seconds if (fu) opens. This is designed to bridge any short interruptions in the triggering noise, but, at the same time, shut off again if the sound is other than a continuous one. This is an anti-sweep and anti-explosion feature. A continuous sound is necessary to keep the subsonic component of the unit alive, and it will remain alive until the sound stops. Detonation protection is also provided by transformer ST and its associated system. A detonation will produce a surge in the transformer which will operate relay P. Closure of contact (p) connects the time-delay system including the relay R_3.

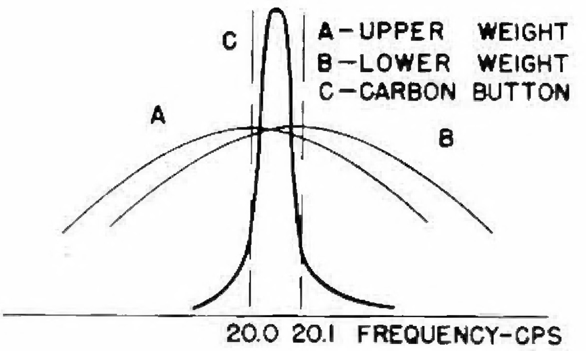


Figure 216 - Resonance Curves - "Hell" Doppelschwinger

When R_3 is energized, contact (r_3) opens, breaking the circuit from the firing (microphone) battery to the detonator. The time-delay keeps R_3 energized for a period of about three to four seconds to allow the surge to pass.

AT 2 Amplifier (Subsonic). The circuit of the AT 2 subsonic amplifier appears in figure 213. The amplifier consists of three vacuum-tubes. All are glass pentodes type RV 2.4 P 700. The magnetophone output is fed to a sharply-tuned transformer circuit. This circuit is tuned to 20-25 cps. The first amplifier tube may be tapped at three different points to determine the sensitivity of the unit. The output is condenser-coupled to the second stage. The output of the second stage is transformer-coupled to the third stage through a broadly-tuned transformer circuit. When the subsonic amplifier is switched on, contact (r_1) breaks the connection between the grid of the third pentode with the ground through the 10 Ohm resistor. Thus, the grid potential of the third stage pentode will depend upon the output of the second stage. The output of the second stage is rectified and fed to a time-delay circuit with a total delay of approximately two seconds. At the end of this delay the grid of the third stage pentode becomes more positive and draws plate and screen grid current through the operation coil of relay R_2. When contact (r_2) closes, the detonator is fired.

AT 3 Amplifier (Subsonic). The circuit of the AT 3 subsonic amplifier appears in figure 214. The amplifier consists of two vacuum-tubes. Both are metal pentodes, type DF 11. The circuit is essentially similar to AT 2, except that the substitution of the metal tubes with lower heater drain currents increases the continuous drain life on the amplifier batteries from 50 hours (in AT 2) to 14 days. The AT 3 has no provision for setting sensitivity similar to that used in AT 2. As well, the third stage is omitted, and the output of the second stage is transformer-coupled to a full-wave rectifier and time-delay circuit which operates a relay R_2. Closure of contact (r_2) puts the 96-volt battery across relay R_4. Closure of (r_2) fires the mine.

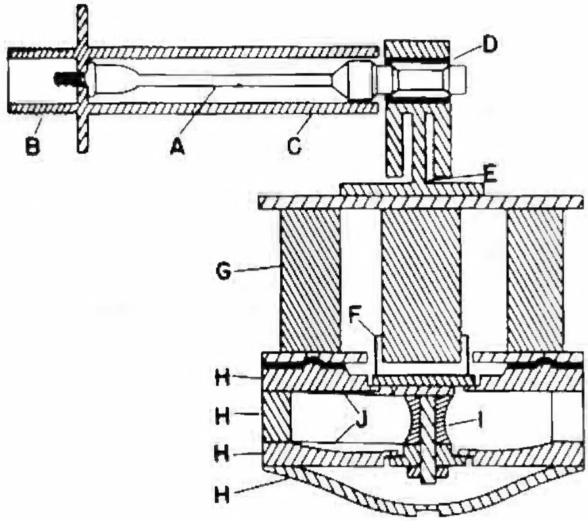
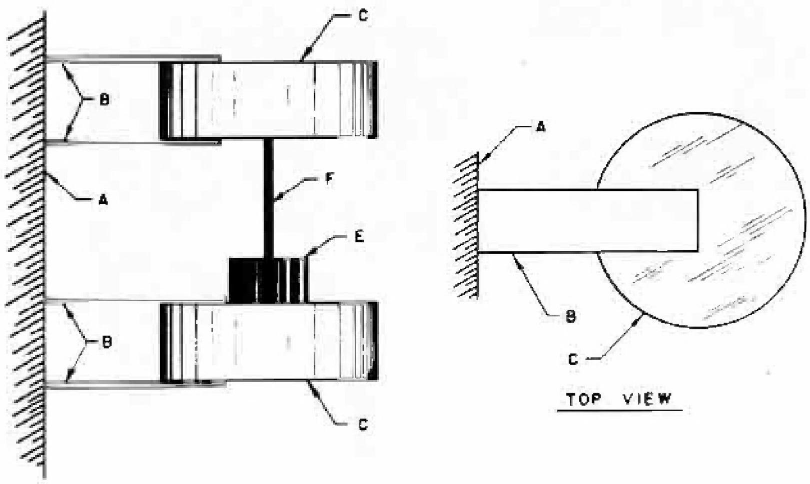


Figure 217 - "Hell" Doppelschwinger

Figure 215 shows a German representation of various phases of AT mine characteristics. A sketch and a schematic representation of the magnetophone are shown. The relative response of the sonic microphone and the subsonic magnetophone is shown in the first chart. The second chart shows the subsonic effect at a point due to explosions at distance.

"HELL" DOPPELSCHWINGER

When the AT units were in original development, part of the development was done by the firm Electroacoustic, Kiel, and part by Dr. Ing. Rudulf Hell, Berlin. The Electroacoustic (ElAc) development was finally accepted, and is the type described in the preceding paragraphs. Dr. Hell's subsonic detecting device is of some interest, however. The magnetophone used in the AT units is the work of Dr. Gerloff of SVK, Kiel, and required a vacuum-tube amplifier. Dr. Hell, however, concentrated his efforts on producing a detecting device which would have high enough output to operate relay systems directly, as



A — MINE CASE
B — SUSPENSION SPRINGS - 4
C — UPPER WEIGHT - 20.0 cps
D — LOWER WEIGHT - 20.1 cps
E — CARBON BUTTON
F — CONNECTING ROD

Figure 218 - "Einfacheschwinger"

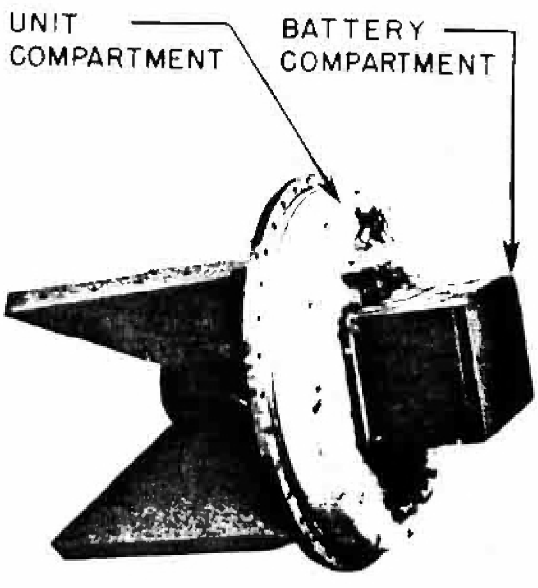


Figure 219 - A 2 Unit

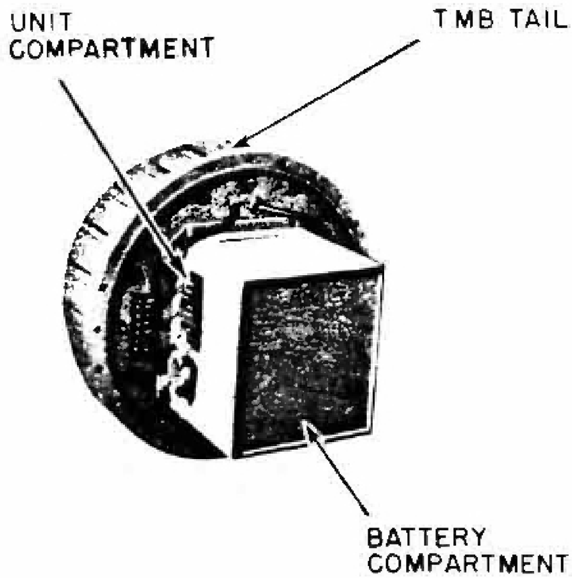


Figure 220 - AT 3 Unit

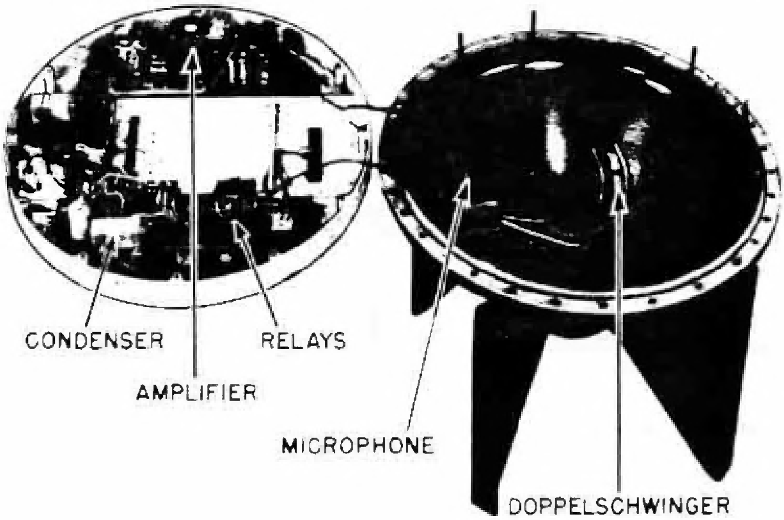


Figure 221 - AT 2 Unit

in the normal sonic acoustic systems. The experimental detector produced by the Hell firm was a carbon-button device which Dr. Hell claims had a very sharp resonance peak at approximately 20.05 cps. This device, known as the "Hell Doppelschwinger", the name having been changed because of unsatisfactory results with an earlier device known as the "Einfacheschwinger", was constructed as shown in figure 218, which is modified slightly for clarity. There are two weights, each mounted on two suspension leaf springs, one above and one below. The upper weight and spring system is adjusted to be resonant to 20.00 cps. The lower weight and spring system is adjusted to be resonant to 20.1 cps. These two weight systems have resonance curves approximating those shown in figure 216. When the frequency is lower than the resonant frequency of the weight system, the weights oscillate together with the mass of the mine case to which the detector is fixed. When the frequency is higher than the resonant frequency of the weight system, the weights oscillate approximately 180° out of phase with the mine case. When the frequency lies between 20.0 and 20.1 cps, the two weight systems are 180° apart, in phase. A carbon-button microphone element is connected to the two weight systems, and measures the relative motion between them. Thus, the output of the carbon-button reaches a peak when the frequency lies halfway between the resonant frequencies of the two systems (20.05 cps). The earlier type ("Einfacheschwinger") made use of only one resonant weight system, and the other part of the carbon-button was connected to a fixed part of the assembly. In this system the movement of the one system only is measured and there is no phasing effect. The "Einfacheschwinger" had a high subsonic output, but its response was too broad to be desirable for use in an AT mine.

Chapter 11 - Section 6

SUPERSONIC UNITS

AA 4 AND AA 106 UNITS

Part of the German mine-development program was directed to work on supersonic fired mines. At the end of the war in Europe four supersonic units were under development, and of these, the (AA 4) had been abandoned. The units were designated AE 1, AA 4, AE 101 and AA 106. Of these, the AE 1 and AE 101 are active ("pinging") supersonic units.

The German AA 4 and AA 106 are directional supersonic mine firing units. Because of the directional requirements, self-orienting properties are necessary to the directional elements. At first, SVK attempted to mount a group of directional magneto-strictive receivers (seven in number) in a belt around an LMB mine case. The topmost receiver was selected for operation by a weighted internal pendulum switch. This was unsuccessful. In the case of the AA 4, which was designed for use in the EMF and SMA mines, the directional elements were mounted in the cover-plate and, since the mine-case is self-orienting, no additional provision was necessary for vertical orientation. In the case of the AA 106 (sometimes referred to as A 106), the unit is

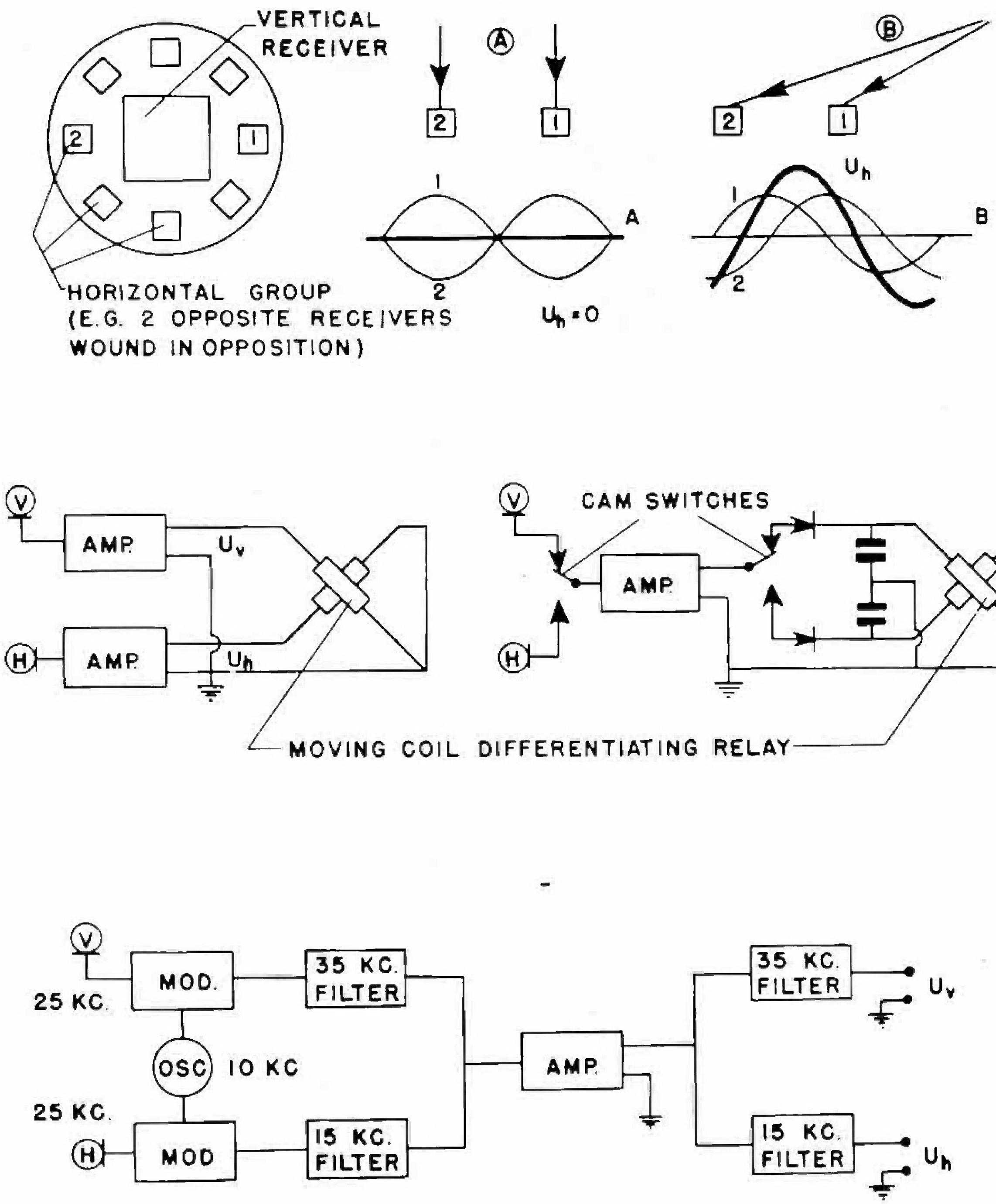


Figure 222 - Supersonic Firing for Moored Mines (AA 4)

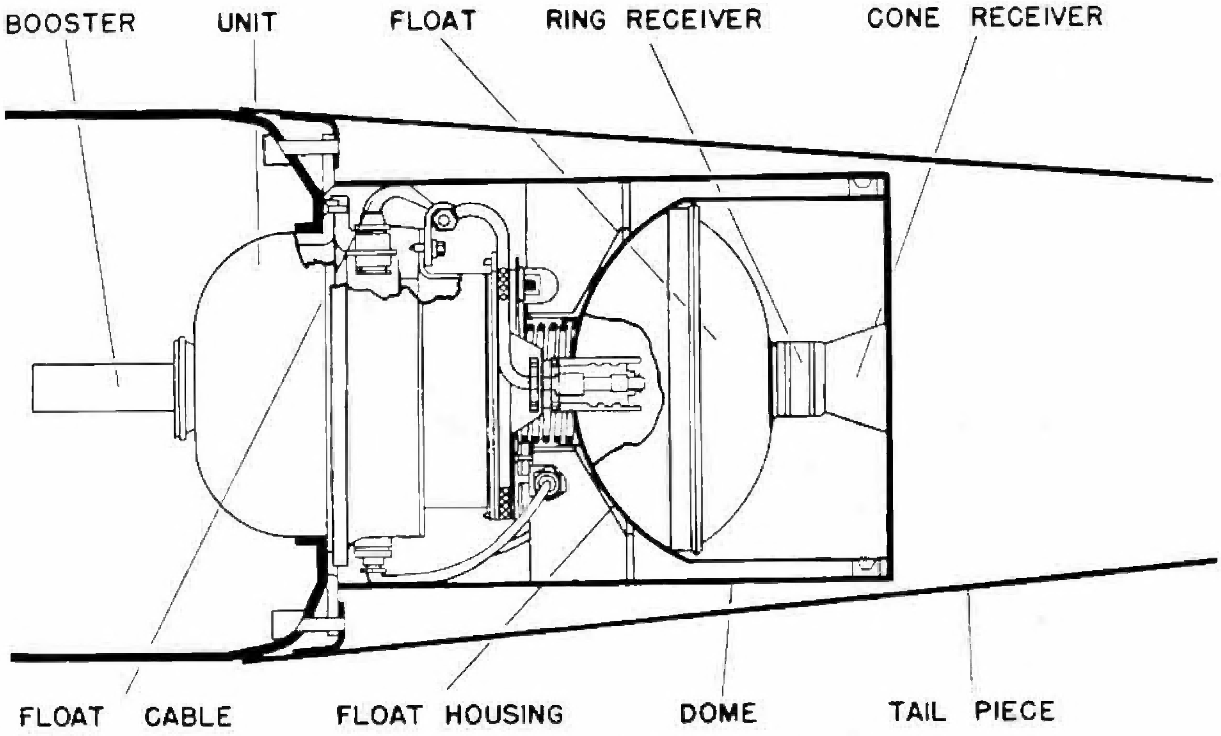


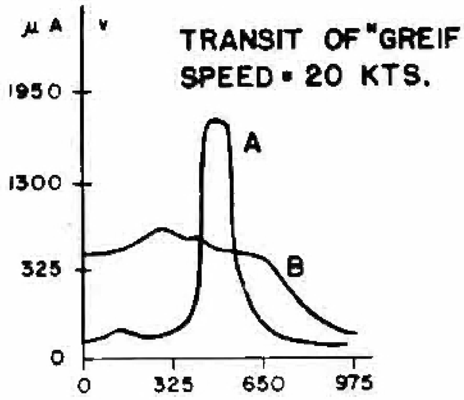
Figure 223 - AA 106 Float in BM 1000 H/L

designed for use in the BM 1000 H and BM 1000 L ground mines. When used in ground mines, the directional elements are mounted in a small float which is moored on a two-/three-foot length cable from the mine. The float is released shortly after the mine reaches the bottom. The supersonic system is switched on, to save battery power, by a simple sonic-acoustic system of low power consumption. The supersonic receivers were designed to fire when the target was nearly overhead and to discriminate against ships passing abeam.

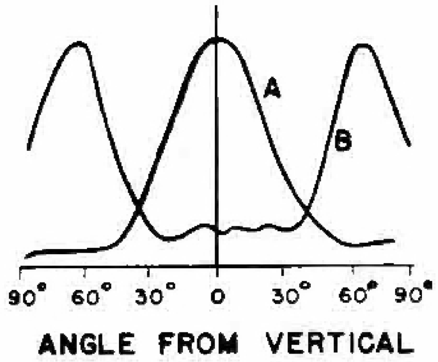
AA 4 UNIT

The AA 4 unit was started by SVK in 1943. It was abandoned in 1944 in favor of the Luftwaffe's AA 106 unit as a result of an agreement with the Luftwaffe concerning parallel developments. The AA 4 used nine magnetostrictive receivers tuned to 25 kc. mounted on the cover plate of an EMF or SMA mine. Of the nine receivers, one was a sharply-tuned vertically-directive receiver, and the other eight were broadly-tuned receivers with a directional characteristic. The receivers were arranged as shown in figure 222, with the eight broadly-tuned receivers arranged in a circle around the vertical receiver. The eight circumferential receivers were designed to operate in pairs, and the coils of each pair (which were placed diametrically opposite) were wound in opposite directions. Thus, a sound from overhead would find the receivers of all four pairs in phase with each other with respect to that sound, and the resultant potentials produced would nullify each other. However, when the sound did not originate from overhead, a differential potentials (U_h), which was used in the circuit for comparison with the potential produced by the sharply-tuned vertical receiver, would appear.

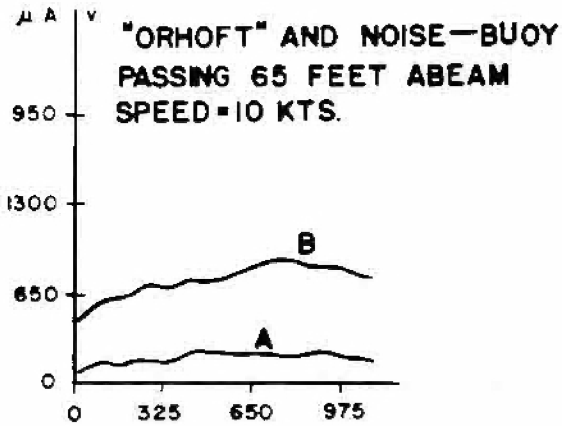
AA 4 Circuits. Several circuits were experimented with for the AA 4 unit. The first one used separate three-stage vacuum-tube amplifiers for the vertical and horizontal directional systems. The output potentials were fed to a differentiating relay, and when the sound originated from over the mine it fired. Some difficulties were encountered with the use of two parallel amplifiers, since construction of two amplifiers with identical characteristics proved to be difficult. The second circuit used a common amplifier for the two systems, with a periodic switching as shown in figure 222 to allow both systems alternate use of the amplifier. The third circuit used a common amplifier, but each system was connected to a modulator with a 10-kc. oscillator. Since the resonant frequency of the receivers was 25 kc., the resultant beat notes were 35 kc. and 15 kc. in each channel. The vertical channel was then filtered to pass 35 kc. only, and the horizontal channel filtered to pass 15 kc. only. Thus, the two signals were fed to a common amplifier, amplified, re-filtered into two channels, and finally sent to the differentiating relay. All three of these circuits are shown schematically in figure 222.



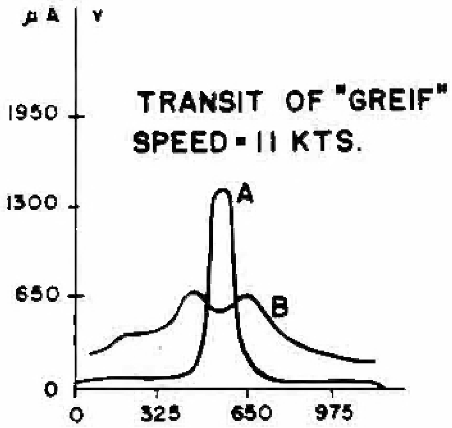
Reaction to Ship Transit



Directional Characteristic



Reaction to Ship Passing Abeam



Reaction to Ship

Figure 224 - AA 106 Receivers - Directional Characteristics

AA 106 UNIT

Acoustic Triggering Circuit. The acoustic triggering circuit is designed to switch on the supersonic circuit when ship noises are detected. It is very simple, and consists of a microphone, transformer, rectifier, and relay. The frequencies used are in the 200-500 cps. range. The acoustic triggering system is so arranged in the circuit that continuous acoustic signal is necessary to keep the supersonic amplifier energized.

Supersonic Receivers. The supersonic receivers consist of two nickel magnetostrictive receivers mounted on top of a small steel float which is released by the mine a short time after reaching the bottom, on laying. One of the receivers is mounted in a cone and has vertical directivity (trichter schwinger); the other receiver is mounted in a ring around the base of the cone receiver, and has horizontal directivity (ring schwinger). Figure 222 shows the directional characteristics of the two receivers: A, vertical receiver B, horizontal receiver.

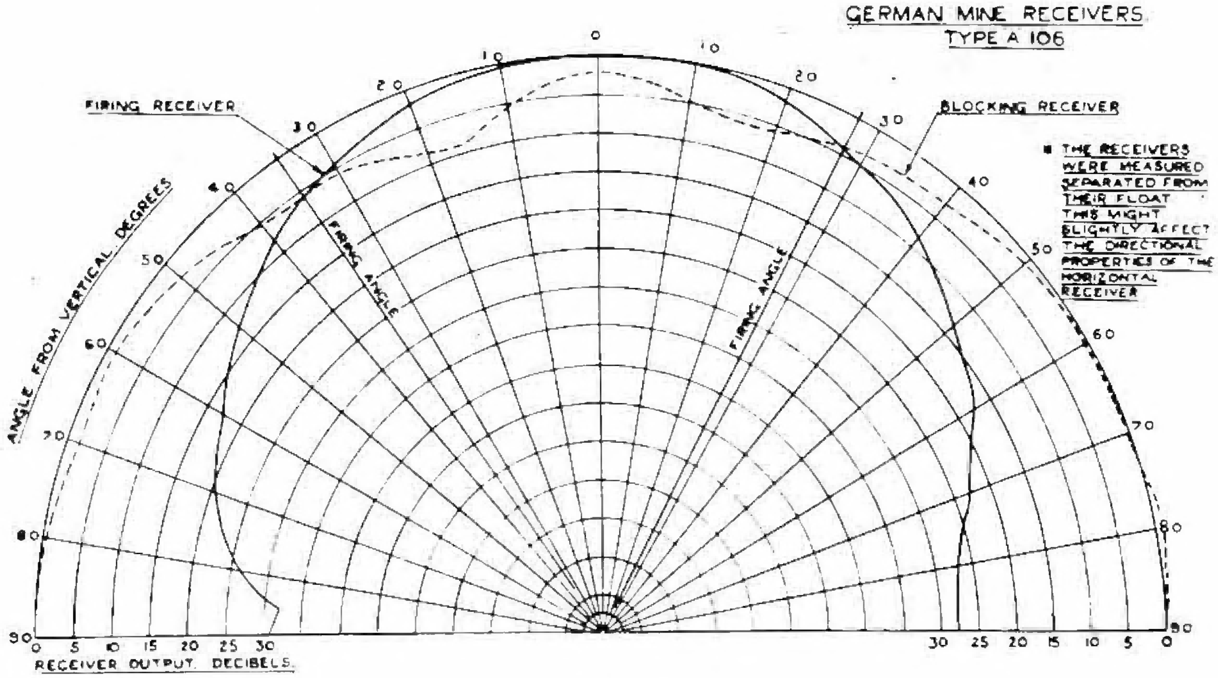


Figure 225

AA 106 Float and Float Release. Handling and releasing the float for the receivers was the chief difficulty encountered in the development of the AA 106. Several different types of shapes of floats were experimented with, but apparently no satisfactory one was developed. The main difficulty was to keep the float oriented properly when moored in a tideway on a short cable. Difficulty was also encountered in properly releasing the float from the mine. The float was carried inside the cylindrical open-ended protective cover (schutzhaube 10), and released,a short time after the mine reached the bottom,by the firing of an electro-mechanical device.

AA 106 - P.S.E. and Anti-Leak Device. There is evidence in the circuit of the same type of galvanic P.S.E. and anti-leak device formerly used in the MA 101. In the MA 101 this took the form of two loops of insulated wire of dissimilar metals wrapped around the switch board with the fuse-delay switches. If water entered the unit, a galvanic effect resulted between the two wires (CU and ZN) and relay was actuated. This device appears in the AA 106. Some of the test characteristics are known and are shown in figure 224.

AE 1 AND AE 101 UNITS

The Germans have developed two types of supersonic mine units; first a twin receiver unit known as the A 106; secondly an echo sounder unit known as the AE 1 when used in buoyant mines, and the AE 101 when used in ground mines.

By May of 1945 these units were in the advanced development stage. The Naval Officer in Charge for the development of naval influence mine units at SVK, Kiel, considered that the AE 1 was ideally suited for use against the U. S. because of the adaptability of the unit in deep water.

The Navy unit (AE 1) was designed for use in moored mines of the EMF and SMA type. The Luftwaffe unit (AE 101) was designed for use in ground mines, BM 1000 types and was also considered for use in the moored mine BM 1000 T. The electrical components of the units are almost identical, differing only in those respects peculiar to the mines for which intended. One of the main problems was the proper orientation of the echo sounder. In the case of AE 1 this problem was not too difficult, since the EMF and SMA mines, being of the moored type, are self orientating; the only change necessary in such mines was the redesigning of the top cover plate. To obtain proper orientation of the unit when used with the BM 1000 type mine, a special float was designed. The echo sounder was mounted in the float, the float being connected to the mine by a four-wire, rubber covered cable three feet long. The float was carried inside a protective housing and released therefrom by means of an electro-mechanical device, after the mine had settled on the bottom. This release device presented serious design problems and was one of the principal factors in delaying the development of the AE 101.

The A 106 consists of two magnetostrictive receivers tuned to 22.5 kilocycles per second. One receiver is focused vertically upwards, and the other in a ring having a maximum at about 55° from the vertical. A noise source which subtends an angle of more than 30° from

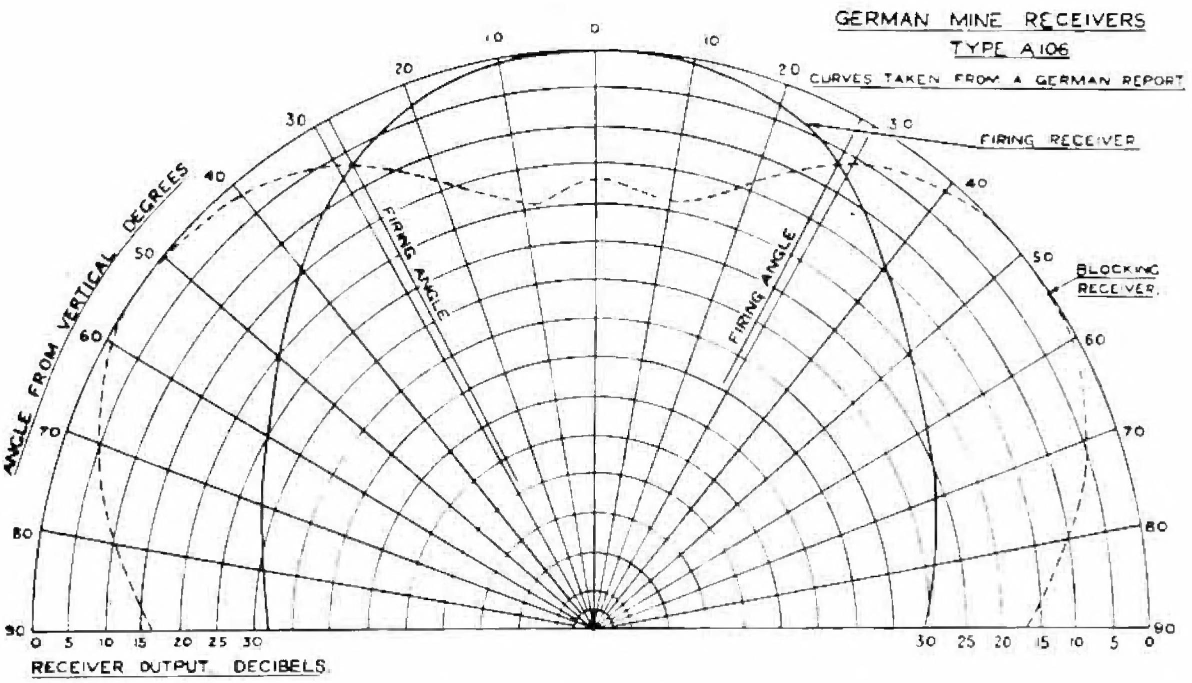


Figure 226

the vertical axis of the receiver produces a greater voltage output from the horizontally focussed receiver, and blocks the mine. A noise source which subtends an angle of less than 30° from the vertical axis produces a greater voltage output from the vertically focussed receiver and fires the mine. In this way the mine is made to have a definite range against ships, independent of their loudness, provided this is greater than a very small threshold value. The mine is also proof against acoustic sweeps or underwater explosions which are not directly over it. The receivers are maintained in the correct orientation by mounting them in a small float which is released when the mine is laid and is moored to it with about six feet of cable.

The AE 1 operates in a similar manner to a normal echo depth sounder inverted. It utilizes magnetostrictive transducers resonant at 30 kilocycles per second. A ship passing over the mine causes a sudden change in the apparent distance to the water surface, and the mine unit is so constituted that, when the rate of hange of this distance exceeds a certain value, the mine fires. Elaborate precautions have been taken to ensure that the mine will become passive if it receives a signal, such as the noise produced by an acoustic sweep or underwater explosion, at an instant when it is unlikely to receive an echo from the water surface or from a ship.

The twin-receiver mine was chosen by the Luftwaffe as an aircraft-laid ground mine in preference to the echo-sounder mine, first because of its greater simplicity, and secondly because it tends to fire under a ship's engine room. The major source of high-frequency noise from a ship is the propeller, and the mine will fire at a fixed distance of about 50 feet ahead of this. It will fire up to a similar distance abeam. The echo-sounder unit, on the other hand, is triggered when a vessel's bow comes into the transmitter beam, so the mine is fired slightly ahead of the ship unless a time delay is used in the firing circuit. The German Navy preferred the latter unit for the following application. They proposed to mount it in a buoyant mine carrying a charge of 780 pounds, which would normally be moored about 27 fathoms beneath the surface, too deep for normal wire sweeping. When the echo-sounder unit was actuated by a ship's bow, the mine would be released from its mooring cable, and, after a seven-second delay it would fire, having risen about 12 fathoms in the meantime. For this application the echo sounder units were mounted directly in the cover plate of the buoyant mine, and relied on its taking up an orientation which would be approximately vertical. A modified type of the AE 1 echo sounder unit, known as the AE 101 was mounted in a float for use in ground mines. It was proposed to lay these in depths up to 18 fathoms, with a 1,500 pound charge.

In order to prolong the life of the batteries and the tubes of these high-frequency mines, the Germans arranged that they should be switched on only when a ship was in the vicinity. This was accomplished by means of a sensitive carbon button microphone tuned to a 250 cps.

In the AE 1 and the AE 101 mine units the Germans used an ingenious anti-sweep arrangement in the trigger circuit. Each time the

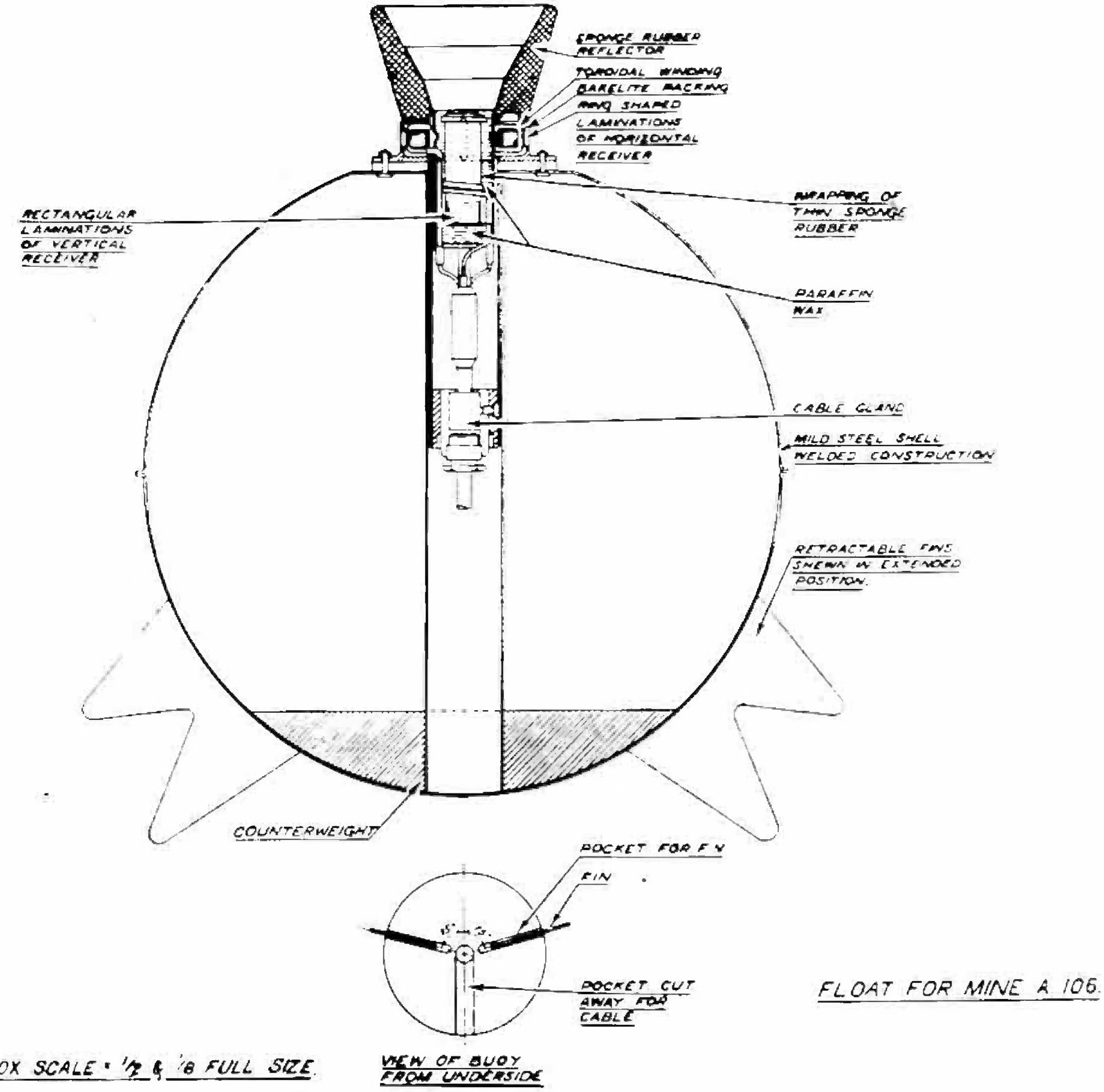


Figure 227

carbon microphone is actuated, it switches in the echo sounder for a period of 100 seconds. If the mine is actuated for more than about five such periods in rapid succession, it will go passive for a period of half an hour to an hour. This principle against mine-sweepers would seem to have a good application. However, it must be realized that the system has the limitation that the mine can be made passive by sweepers for a sufficiently long time to allow ships to pass over it in safety.

Prototype models of the two receiver units type A 106 had passed sea trials and shock trials, and stability tests of the float had been concluded. An order for two thousand units had been placed with Atlaswerke, and it was said that about 200 units had already been made at their works in Gnadenfrei in the Russian zone.

Experimental models of the echo-sounder unit had passed sea trials and shock trials satisfactorily. Twelve prototype units were almost ready for trials.

Possible Countermeasures to the Mine

The Twin-Receiver Mine. The greatest weakness of this mine appears to be that a ship can protect itself against it by towing

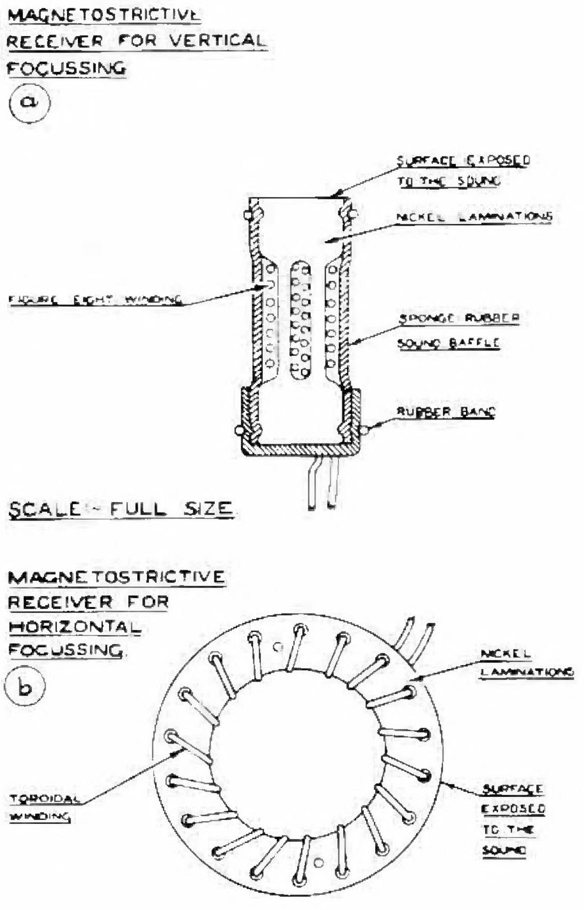


Figure 228

a high-frequency noise source such as a unifoxer. The noise source would maintain the output from the horizontal receiver at a higher level than that from the vertical receiver while the ship was over the mine, and thus prevent the mine from firing. When the noise source subsequently passed over the mine, it would be swept.

Attempts were made by the Germans to fire the mine from a distance by focusing on it a very powerful (500-watt) transmitter tuned to the resonance frequency of the mine unit. They were not successful. They could occasionally obtain fires up to a range of 500 yards, but thought that they could prevent them by slightly increasing the time constant of the firing circuit.

The echo-sounder mine should be sweepable by the technique of towing air-filled tubes adjusted to a suitable depth behind a shallow-draught vessel. The field swept would of course be very small, and the technique would call for very skilled seamanship.

A vessel could also protect itself against the mine by carrying a loud, continuous, high-frequency sound source, which would operate the blocking circuit. This would be dangerous, however, if twin-receiver mines operating on the same frequency were mixed with the echo-sounder minefield, and it would probably be difficult to protect the vessel by means of a towed noise source, on account of the very directional properties of the echo-sounder receiver.

TWIN-RECEIVER MINE A 106

The Magnetostriction Receivers (Figures 227, 228). The two receivers make use of the magnetostriction effect. They consist of packs of nickel laminations in which a permanent magnetic field is introduced by flashing them, and a winding consisting of a few turns of robust insulated wire. The dimensions of the laminations are chosen so that they have a mechanical resonance at 22.5 kilocycles per second. The vertically focussed receiver consists of roughly rectangular laminations, (figure 228), one wave length long, assembled together to form a pack having a square cross section. The top side of the pack is the receiving surface, while the other sides are screened by wrapping them up in a sheet of closed-cell sponge rubber, two millimeters thick, held in place by rubber bands. The small air bubbles in the rubber reflect and absorb the sound. The nickel pack, together with its windings and rubber screening, is held in place by casting them in paraffin wax. The exposed surface of the pack lies in the bottom of a funnel-shaped reflector, also made from closed-cell sponge rubber. The orifice diameter and internal angle of the reflector are carefully chosen to give the directional characteristics shown in figures 225 and 226.

The horizontally focussed receiver (see figure 228) is made from ring-shaped laminations pierced with 18 holes, allowing a toroidal winding. It is mounted round the base of the funnel-shaped reflector, and the lower side of the latter, together with the upper surface of the buoy, act as a ring-shaped reflector, and give the receiver the directional characteristics shown in figures 225 and 226.

The two receivers and their cable gland are assembled together in a single unit which could be mounted on the top of a float or buoyant mine as required. A drawing of this assembly is shown in Fig. 227.

The Float (Figure 227). The float was originally designed to be a simple sphere of 16 inches diameter. It was found, however, that it was unstable in tidal streams. Consequently two retractable fins were fitted; also the mooring point was moved from the base of the float to the center, with a piece cut out of the float to allow the mooring cable freedom of movement. In addition, a heavy counterweight was added in the base. With these modifications it was found to be completely stable in tidal streams having a speed of up to four knots; and 5° tilt was said to be the maximum.

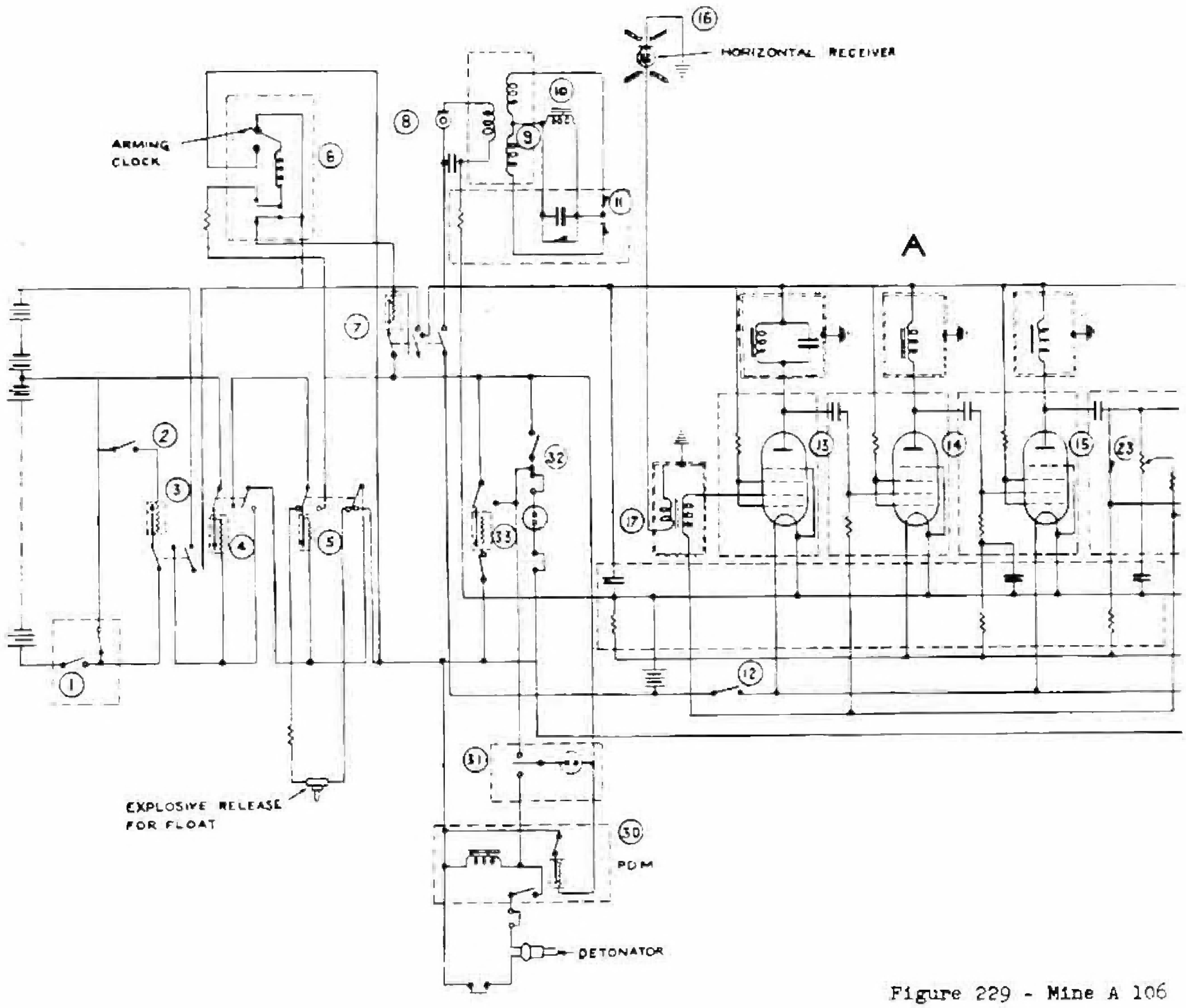


Figure 229 - Mine A 106

The float is constructed of mild steel 1/16 inch thick, welded together. Because of the awkward shapes of the fan and cable pockets, it was found that it was not strong enough for depths greater than 15 to 20 fathoms.

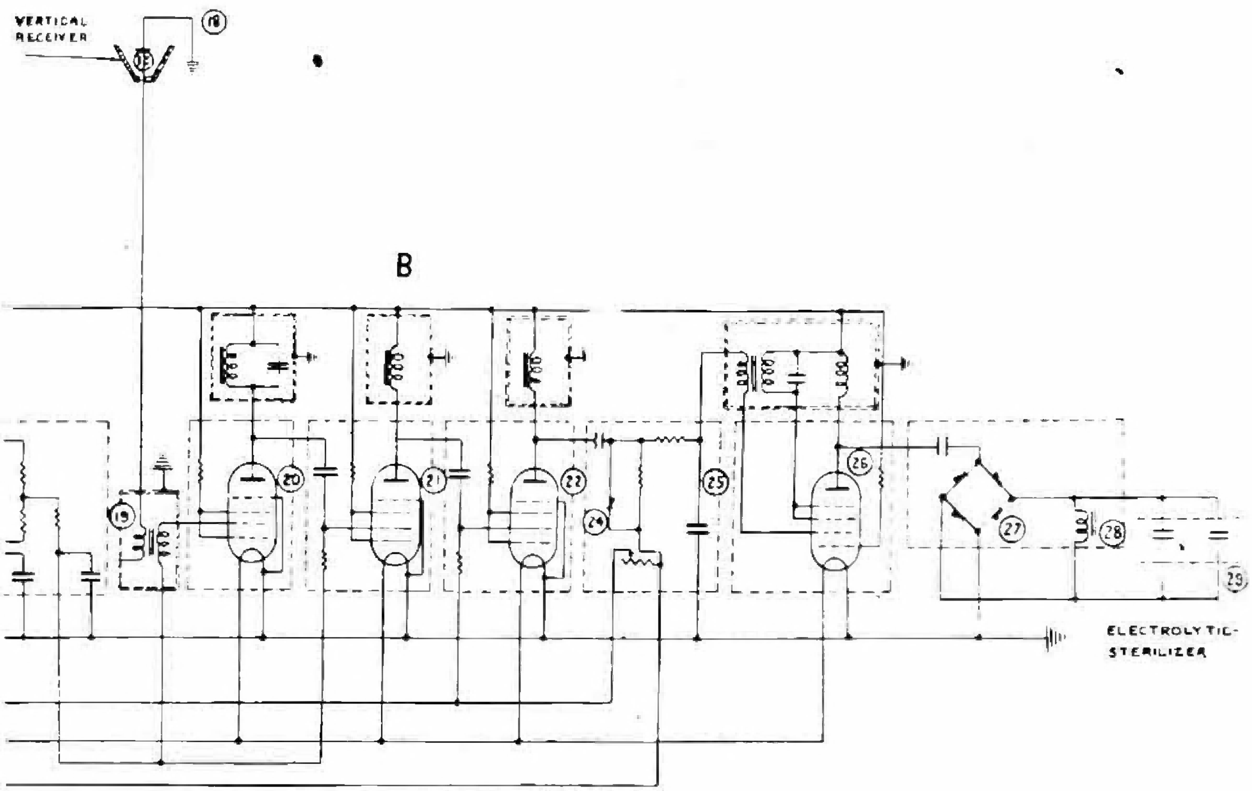
The float is normally carried in a hemispherical recess in the rear end of the mine case and is ejected from it when laid, by means of a spring. This spring is held back by a catch that is released by an impact switch, which fires an explosive release.

The Circuit (Figure 229)

Preliminary Switching On. An impact switch (1) is operated when the mine strikes the water surface. This switches in a battery protection switch (2), type KTSE, which operates only if the temperature lies between -5°Centigrade and +35°Centigrade. Switch (2) switches on a heater-coil time-delay switch (3), which switches on a second heater-coil time-delay switch (4), which operates an explosive release mechanism which fires the float carrying the receiver, and allows it to be expelled by a spring from the cup in the rear end of the mine, where it normally rests.

After a further short time-delay, heater coil (5) disconnects the leads to the float-release charge, thus preventing the battery from short circuiting to earth through the broken ends. Heater coil (5) also starts the arming clock (6), which after a further time delay switches on delay switch (7), which switches on the H.T. batteries to the high frequency amplifier and the batteries of the carbon microphone. The mine is now alive.

The Triggering Circuit. In order to conserve both tubes and batteries, the filaments



Circuit Diagram

of the tubes are not switched on until a ship approaches the mine, and operates an audio-frequency trigger circuit. This consists of a carbon microphone (8), connected in the primary circuit of a transformer (9), whose secondary output operates a sensitive relay (10), through rectifier (11). In parallel with relay (10) is a limiting rectifier to prevent overloading of the relay. A signal within the frequency band 200 - 600 cycles per second received by the microphone will thus operate relay (11) which closes contact (12) and switches on the amplifier filament circuit.

Amplifier A for the Horizontal Receiver. The horizontal receiver (16) is connected to its amplifier through a matching transformer (17). The amplifier has three stages. The first is tuned to 22.5 kilocycles per second, and the remaining two are resistance capacity coupled. The tubes used (13), (14), (15), employ space-charge grids, so as to allow the use of an H.T. supply of only 35 volts, while still maintaining a voltage gain of about 15.

Amplifier B for the Vertical Receiver. The vertical receiver (18), is connected to its amplifier through a matching transformer (19). The amplifier is similar to that for the horizontal receiver, and employs three space-charge grid tubes, (20), (21), (22). The output of amplifier A is rectified by a rectifier (23), and provides both automatic volume control for itself, and gain control for amplifier B. Hence the output from amplifier B is approximately proportional to $\frac{VB}{VA}$ where VB is the voltage output from the vertical receiver, and VA is the voltage output from the horizontal receiver.

Timing Circuit. The output from amplifier B is rectified by a rectifier (24) and smoothed

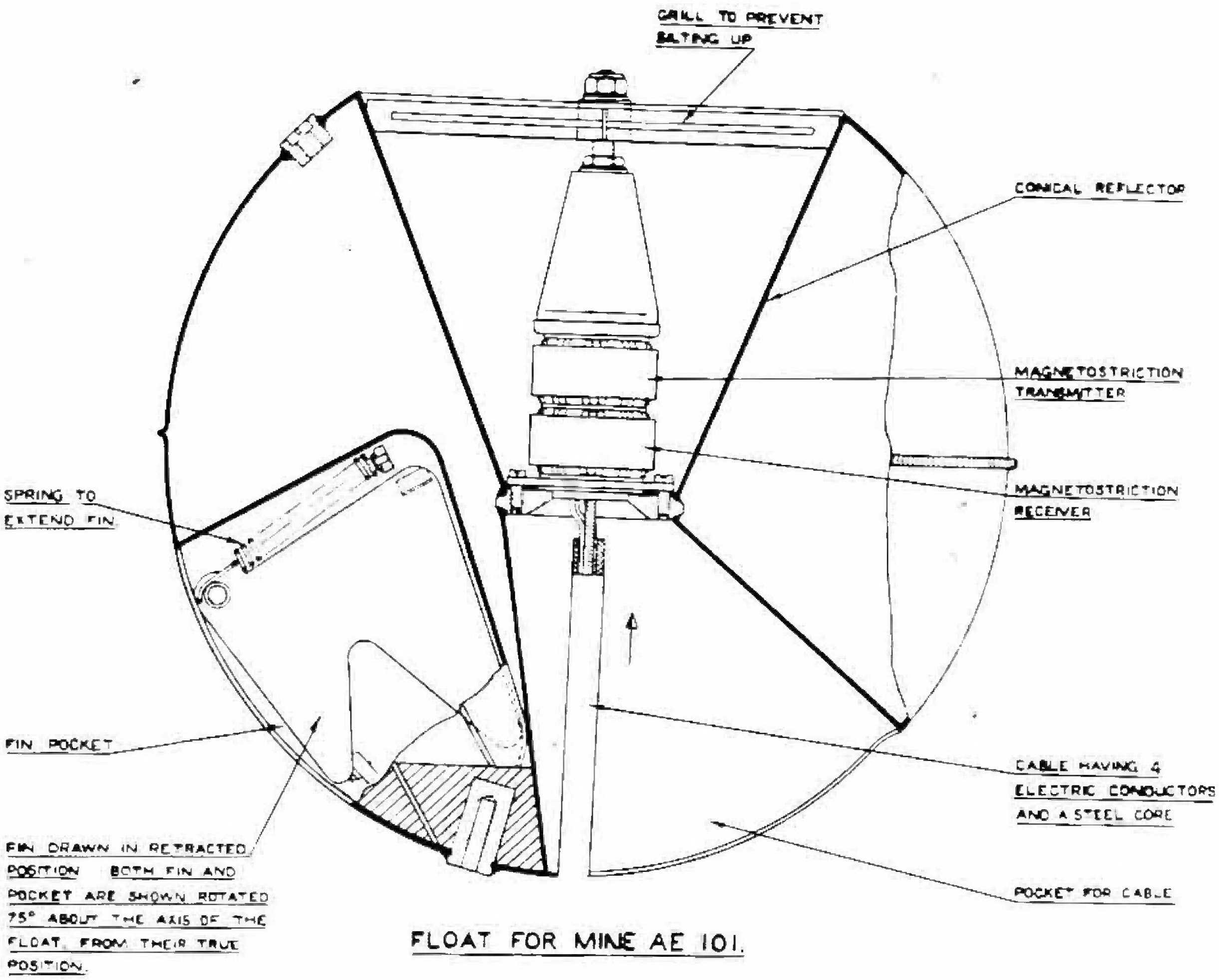


Figure 230

by a filter (25) operating the firing relay (28) through a trip circuit. The trip circuit consists of a tube (26) having positive feed-back between its anode circuit and grid circuits. Under normal conditions it will not oscillate, because it is biassed back beyond cut-off. When a firing signal is received from amplifier B however, this drives the grid of tube (26) more positive and the tube bursts into oscillation at roughly 1,000 cycles per second. The anode circuit of the tube is connected through a rectifier (27) to the sensitive relay (28). An electrolytic sterilizer (29) is connected in parallel with the relay. The relay (28) operates a P.D.M. (30) by means of its contact (31). The P.D.M. fires the detonator.

Anti-Freezing Switch. If the temperature of the mine falls below -5°Centigrade after it has been laid, an anti-freezing switch (32) blows up the mine. It is switched into circuit by heater coil (5), which switches in heater coil (33), which switches in the anti-freezing switch. Presumably the purpose of this switch is to prevent recovering of the mine by the freezing technique.

Sea Trials. Sea trials were carried out at Aarhus, Appenrade, and Frederizia in Denmark, in depths of 10 to 13 fathoms. No systematic attempt was made to measure the sound output from ships by means of hydrophones. The output voltage from the mine receivers was measured, however, for a number of targets, including the trials ship Greif freighters up to 5,000 tons, a tug, and small motor boats. The voltage output was from 1 to 1,000 microvolts from the ships, and the sea noise was less than one microvolt.

ECHO-SOUNDER MINES TYPES AE 1 AND AE 101

The Magnetostriction Transducers (Figure 230). The magnetostriction receivers are similar in design to the horizontal receiver of the two-receiver mine. They are somewhat smaller, however, and have a mechanical

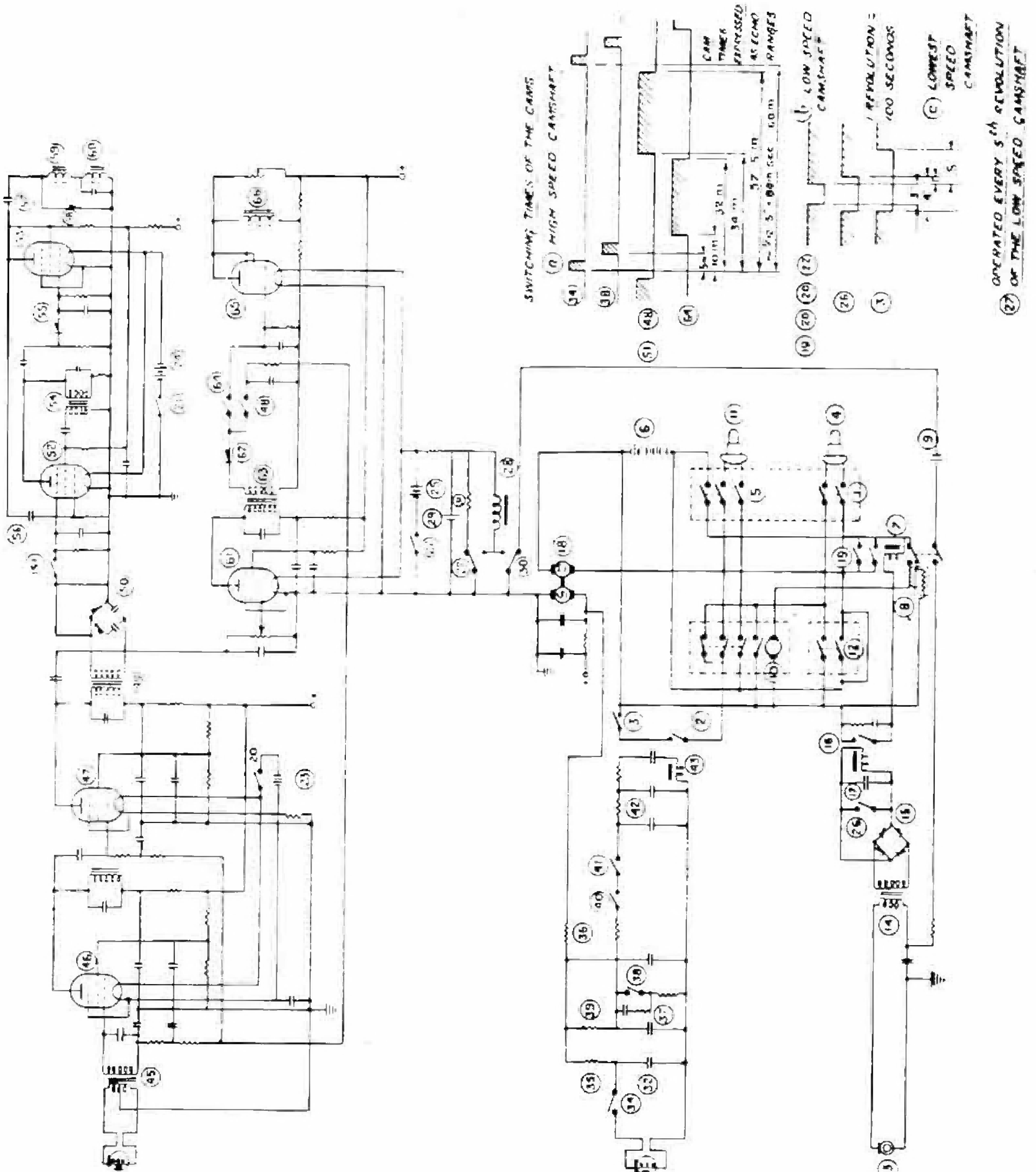


Figure 231 - AE 1 Unit Circuit

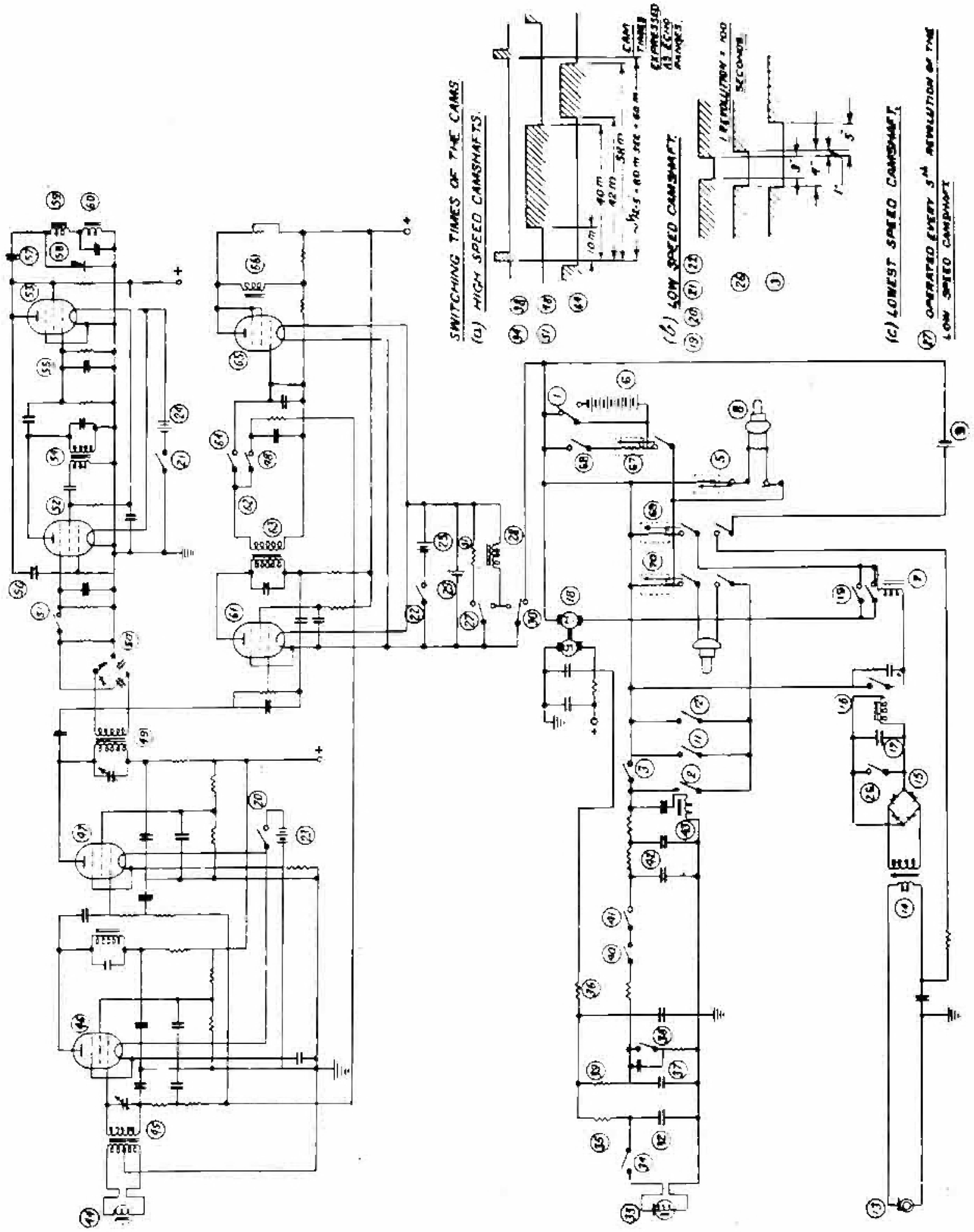


Figure 272 - AE 101 Unit Circuit

resonance frequency of 30 kilocycles per second.

The Float (Figure 230). A modified form of the float for the two-receiver unit was proposed for the AE 101, the difference being that the tube carrying the two-receiver unit was replaced by a large conical recess, the surface of which acted as the reflector. The recess had an orifice diameter of 4-1/2 times the wave length, thus producing a very directional beam. The two magnetostriction packs were mounted in the base of the recess. The orifice was protected from silting up by a grill having holes of 5-mm diameter spaced 5 mm apart.

The Mineshells. The AE 1 was to be mounted in a conical recess similar to that of the AE 101, but directly in the cover plate of a buoyant mine. The charge was 780 pounds.

The float carrying the AE 101 was normally carried in a cup in the rear end of the mine. The mine was to carry a charge of 1,500 pounds.

The Circuits (Figures 231 and 232). The circuits of the AE 1 and AE 101 are similar, except for the arrangements for arming and for the range of echo depths covered. The range is greater for the buoyant mine on account of its greater operational depth.

Arming of the AE 1. When the mine is first laid, a hydrostatic switch starts an arming clock with an adjustable delay time of 1/2 to six hours. After this delay period, the first set of contacts (1), figure 231, on the arming clock are operated. If the relay (2) or the safety switch (3) should be closed as a result of failure or a mistake, then these arming clock contacts switch a scuttling charge (4) into circuit, which destroys the mine.

Ten seconds later, the second pair of contacts (5) of the arming clock are closed, and connect the main battery (6) to the coil and contact of relay (7), also to the heater coil of heater-coil relay (8). The battery has a nominal rating of 31 ampere hours, 12 volts. Nearly all the batteries in the circuit utilize nickel cadmium cells.

Two minutes later the heater coil relay (8) switches on the microphone current from battery (9). It also switches on a small sterilizing motor (10), which operates four switches as described below.

Ten seconds later three contacts are operated by motor (10). One disconnects the scuttling charge, and the other two connect the main detonator (11) into circuit. The mine is now armed.

If the mine comes to the surface, it is scuttled by a hydrostatic switch (12), which connects the scuttling charge into circuit.

Six months after laying, the mine is scuttled by the fourth contact operated by motor (10).

Arming of the AE 101. When the mine is released from its aircraft, a thermite charge burns out and operates switch (1), figure 232. Switch (1) connects heater-coil relay (67) to the main battery (6), provided the temperature-protection switch (68) is closed. Switch (68) protects the battery by closing only when the ambient temperature lies between -5°Centigrade and +35°Centigrade. The battery has a nominal capacity of 12 volts, 10 ampere hours.

After two minutes, heater-coil relay (67) connects the main battery to heater-coil relays (5), (69), and (70), and to the detonator (8), which operates the explosive release mechanism for the float which carries the magnetostrictive receivers.

After 15 seconds heater-coil relay (5) disconnects the battery supply from the explosive release detonator (8) to prevent the broken leads from grounding the battery.

After two minutes, heater coil relay (69) partly connects the main battery to the coil and contacts of relay (7) at the same time it connects battery (9) to the carbon microphone which operates the acoustic triggering.

At the same time heater coil relay (70) connects the main detonator to the firing circuit. The mine is now armed.

If the mine is lifted into shallow water, the hydrostatic switch (12) fires the detonator.

If the temperature of the mine falls below -5°Centigrade, thermostatic switch (11) fires the detonator. Presumably this is to prevent recovery of the mine by some freezing technique.

Acoustic Trigger Circuit. The circuit utilizes a very sensitive carbon button (13) tuned to 250 cps., having a current consumption of 1.5 milliamperes (N.B. the battery life of the AE 1 is about six hours, and the AE 101 about 17 hours continuous running.) The voltage output is stepped up and the steady d-c component removed by transformer (14). The transformer output is rectified by (15) and operates a sensitive relay (16). A large condenser (17), in parallel with the coil of relay (16), prevents operation by noise of very short duration such as distant countermining. It also prevents repeat operation by self noise of the mine.

The Rotary Converter. The rotary converter (18) consumes two amperes at 12 volts from the main battery, and supplies 200 volts d.c. to the echo sounder transmitter, and to the H.T. line of the receiver amplifier.

The converter is switched on when the audio frequency sound from a ship actuates the carbon microphone (13) which operates relay (16) as described above. Relay (16) operates relay (7), which connects the converter armature and field windings across the main battery (6).

The converter also drives three camshafts as described below:

The High-Speed Camshaft. This gives 12.5 impulses per second to five sets of contacts in the echo sounder transmitter and receiver circuits as described below.

The Low-Speed Camshaft. This is geared down to rotate once in 100 seconds. It determines the time for which the echo sounder remains switched on after it has been started by the audio frequency acoustic trigger. It operates six sets of contacts.

It closes contact (19), in parallel with the contact of relay (7), and holds it closed until the end of the 100-second period. In this way it ensures that the converter remains switched on for the whole of this period, although relays (16) and (7) are switched off.

At the same time as the cam closes contact (19) it also closes contacts (20), (21), and (22) which connect the three filament batteries (23), (24), and (25) to their respective tubes in the echo-sounder receiver circuits.

It was found that the noise from the converter was sufficient to operate the sensitive carbon microphone, and hence the converter switched itself in again at the end of every 100-second period. To prevent this, the low-speed camshaft has been made to operate another contact (26), which short circuits the condenser (17) which is in parallel with the relay (16) of the acoustic-trigger circuit. The condenser is short circuited one second after the start of the 100-second period and unshorted again one second before the end of it. The sensitive relay (16) can not operate until after the converter has stopped at the end of the 100-second period, however, as a result of the delay introduced by the parallel condenser (17).

The low-speed camshaft also operates contact (3) in series with the detonator. The contact is closed five seconds after the start of the 100-second period, and opened one second before the end of the period. In this way the mine is protected from spurious fires due to voltage surges in the amplifiers either while the rotary converter is running up to speed when it is first switched on, or while it is slowing down after being switched off.

The Lowest-Speed Camshaft. This camshaft is geared down 5:1 to the low speed camshaft. It operates a circuit whose purpose is to prevent the mine batteries from being run down by an audio frequency acoustic sweep, and at the same time to make sweeping more difficult by making the mine passive under certain conditions. Every fifth live period the lowest-speed camshaft operates contact (27), which connects the coil of relay (28) to battery (29). Relay (28) then opens its contact (30) and so breaks the circuit of the carbon microphone, thus making the mine passive. Contact (30) also connects relay coil (28) across battery (29), so that the relay remains locked in until battery (29) runs down. This takes from about a half hour to an hour. When the battery voltage has fallen sufficiently, the relay drops out and the mine again becomes active.

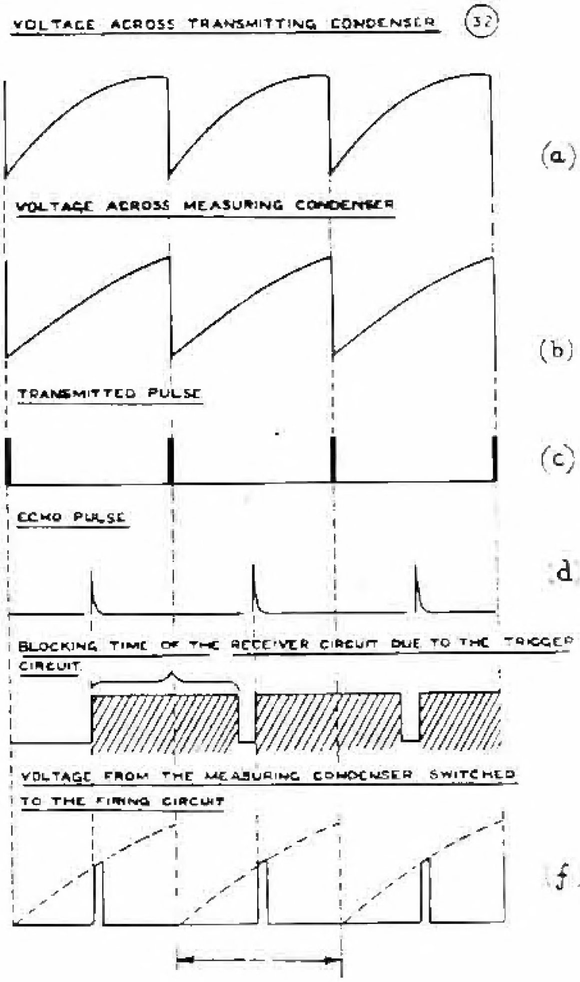


Figure 233 - AE 1 / AE 101 Voltage Curves

Battery (29) is normally in a run-down condition because it is shunted by resistance (31). It is charged up, however, during live cycles other than the fifth, because in each live cycle the resistance is disconnected by contact (27). Thus the mine will be rendered passive only on the fifth live cycle as described above, if the previous four cycles have occurred in fairly rapid succession.

Transmitter and Firing Circuits (Figures 231, 232, 233). A pulse of current is discharged through the magnetostriction transmitter (33), 12.5 times per second. This is effected by contact (34), which is driven by the rotary converter and momentarily connects the transmitter across condenser (32) for each revolution of the high-speed camshaft. Between pulses, (32) is charged up to 200 volts from the rotary converter, through resistances (35) and (36). (See figure 233.) The pulse frequency is chosen to give a maximum echo range of 33 fathoms. A measuring condenser (37) is charged through resistance (39) and

Figure 234 - AE 1 Unit

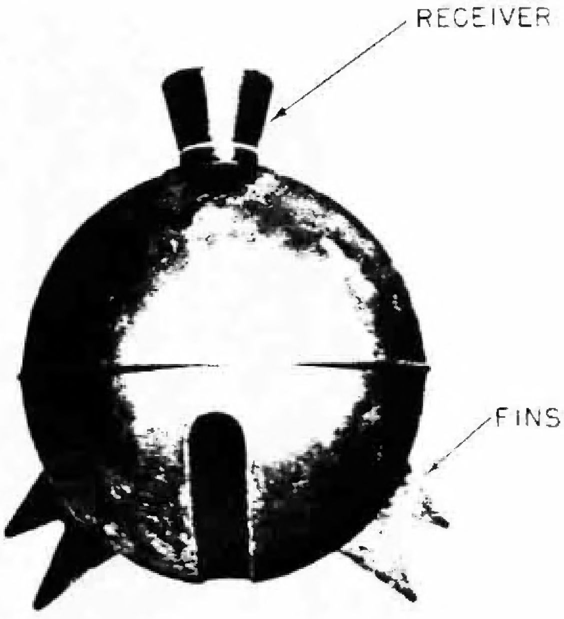


Figure 235 - AA 106 Unit Float

discharged through contact (38) in synchronism with condenser (32). Condenser (37), however, has a long time constant of charge, so that its voltage increases almost linearly with time between each pair of discharges. (See figure 233.) When an echo is received, contacts (40) and (41) connect condenser (37) to the firing circuit; thus the voltage applied to the latter is proportional to the echo time. (See figure 233.) The firing circuit consists of a low pass filter (42) and a capacity coupled relay (43). The low pass filter smoothes out the individual pulses of current from condenser (37), and hence the condenser-coupled relay (43) will not operate if the echo time remains constant. If the echo time changes, however, a current passes through relay (43) which makes contact (2) and completes the detonator circuit. In order to make relay (43) operate, there must be a sudden change in echo range of at least eight to ten feet, and this change must be maintained for at least five pulses. Relay (43) is polarized so that it will only operate on decreasing echo range.

The Receiver Circuit. The receiver circuit consists of three parts:

1. A two-stage amplifier connected to the receiver.
2. A trigger circuit connected to the amplifier output which applies a d.c. signal to the relays in the firing circuit, whose amplitude is independent of the strength of the input signal. The trigger circuit also gives some protection against acoustic sweepers or background noise, because it is only alive for about 10% of each echo cycle (See figure 233.)
3. The AVC amplifier and an anti-sweep circuit which makes the mine momentarily passive if a signal is received at such a time in the operating cycle that an echo cannot reasonably be expected. The Germans found that without this circuit the mine fired well ahead and to the beam of E-boats, because of their large output of high-frequency sound.

The Amplifier. The magnetostriction receiver (44) is connected through a tuned input transformer (45) to the two-stage amplifier. The amplifier uses two variable pentodes type F701 (46) and (47) with tuned anode circuits and AVC. The d-c voltage is applied to the AVC line by means of contact (48), which is closed only during the period when the echo is expected. In this way the gain of the amplifier is controlled by the loudness of the echo, and not by the directly transmitted pulse, or interfering signals.

The amplifier requires an input voltage of 35 microvolts to operate the mine.

The Trigger Circuit. The amplifier output is transformed by transformer (49), and the echoes are rectified into negative pulses by

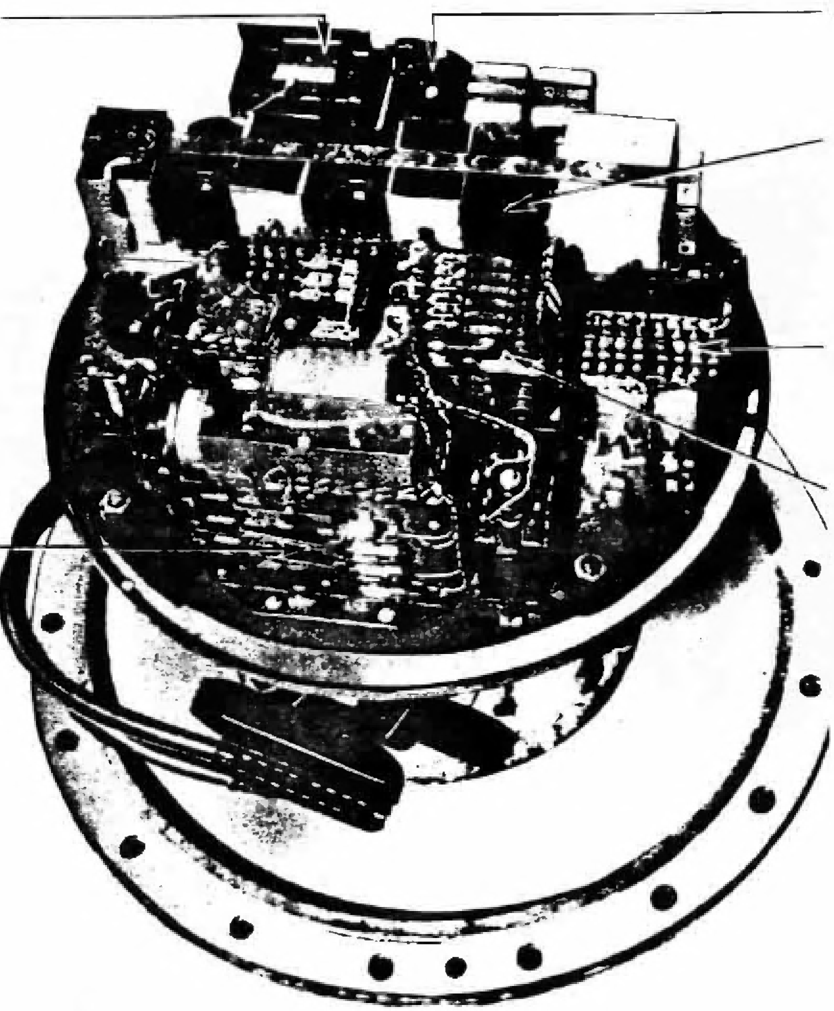


Figure 236 - AE 1 Unit

rectifier (50). The pulses are connected to the triggering circuit through switch (51), which is closed by the high-speed camshaft of the rotary converter only during the period when an echo is expected. This period corresponds to an echo range of 19 to 33 fathoms in the case of the AE 1, and 5 to 22 fathoms in the case of the AE 101.

The triggering circuit contains two pentodes type P700, tubes (52) and (53). The screen of tube (52) is coupled by means of transformer (54) to the anode circuit. Thus, tube (52) is made to oscillate at a frequency of about 25 kilocycles per second. This output is rectified by (55) and applied to the grid of tube (53) as a negative voltage, biasing it back beyond cut-off.

When an echo is received, a negative pulse from rectifier (50) is applied to the suppressor grid of tube (52), which stops oscillating. Tube (52) in turn unblocks tube (53), and drives its anode more negative. This effect is made more certain by d-c feedback from the anode of (53), to the grid of (52) through condenser (56), which drives the control grid of tube (52) more negative. Tube (52) cannot now oscillate again until the charge on condenser (56) has decayed through the grid leak of tube (52). This decay time is adjusted so that the oscillator is blocked for 90% of the time between one echo pulse and the next. (See figure 233.)

The blocking and unblocking action described above causes the plate voltage of tube (53) to follow a rectangular curve. This output is differentiated by means of a small coupling condenser (57), which thus gives a positive and negative voltage peak each echo cycle, the negative peak corresponding with the echo. The positive peak is short circuited by rectifier (53), while the negative peak operates relay (59), which operates contact (41) in the firing circuit.

It was found difficult to avoid relay (59) rebounding, for the whole tolerance range of supply voltage; therefore a second relay (60) was connected with its coil in series with relay (59)'s coil, and its contact (40) in series with contact (41). Contact (40), however, is normally closed and its relay coil (60) is shunted with a condenser so that it opens shortly after (41) closes, and remains open during the rebound time of (41).

AVC Amplifier and Anti-Sweep Circuit. The control grid of another pentode type P700, (61), is connected to the output of the two-stage amplifier by a capacitive potentiometer. The output of tube (61) is coupled to switches (48) and (64) by means of a tuned transformer (63), and a rectifier (62). Switch (48) is closed by the high-speed camshaft of the rotary converter during the period when an echo is expected, and supplies the AVC voltage to the two-stage amplifier, as described above.

Switch (64) closes after the initial noise of the transmitted pulse has died away, and remains closed only during the period when an echo is not expected. It connects the rectified output of pentode (61) to the control grid of pentode (65). If a signal is received during the period when an echo is not expected, the control grid of pentode (65) is driven negative, thus blocking the anode circuit of (65). This unbalances a bridge circuit, across which is connected relay coil (66), which is wound on the same core as relay (60). Relay coil (66) opens contact (40), and prevents closing of the firing circuit by contact (41), thus blocking the mine, and preventing premature firing of the mine by loud continuous noise sources, such as fast ships or acoustic sweeps.

Chapter 11 - Section 7

PRESSURE AND PRESSURE-COMBINATION UNITS

PRESSURE MINE UNITS AND DETECTING COMPONENTS

There are eight German influence-mine firing components whose designation is prefixed by the letter "D". Of these, four are pressure-detecting components which are used to detect pressure differentials for all types of pressure-operated units. These are the D 1, D 101, D 2 and D 102 units. The other four are plain pressure units. To avoid prematures in rough waters, pressure units are normally used in combination with influence units of other types. However, for use in rivers or other relatively smooth waters, the Germans undertook the development of pressure units which could be used alone. These units were designated D 103, D 123, and D 133, and were intended for use in the BM 250 mine case.

The information contained herein on the D 2, D 102 and D 103 is based on captured documents and examination of the specimens captured. Information on the other units was obtained from German prisoners of war and scientists.

Of the four pressure-detecting components herein described, the D 1, D 101, and D 102 were used operationally. The D 2 was on the verge of operational use at the end of the war.

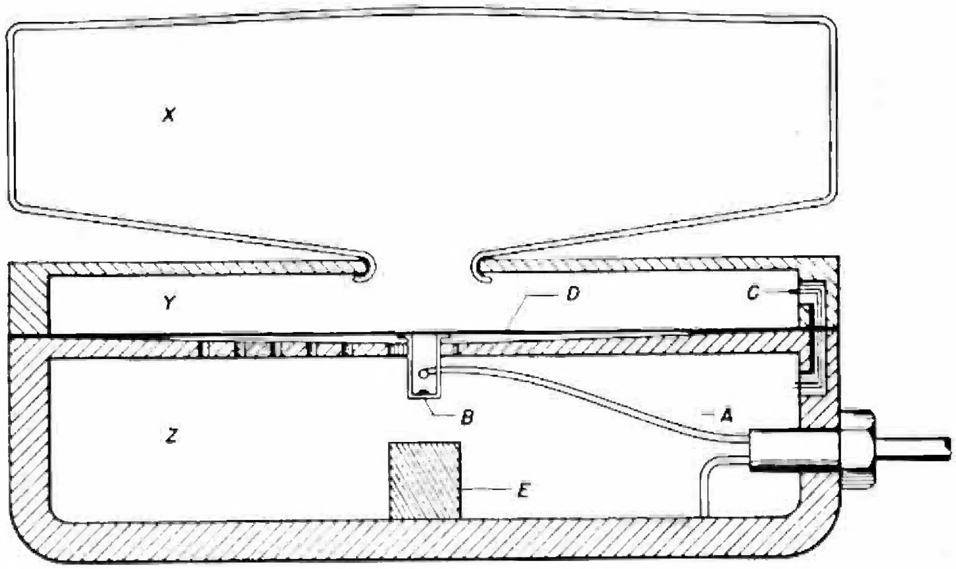
Of the four pressure units, the D 103 was completely developed and used operationally in the latter stages of the war. The other three units of the series were to be of the same basic type as the D 103, but were never completed.

PRESSURE-DETECTING DEVICE

General. The pressure component which the Germans have successfully combined with their acoustic and magnetic firing units consists essentially of a pressure-detecting device which detects and operates on negative pressure differentials; an associated electrical circuit is controlled by the device. When a negative pressure differential is detected by the device, a switch contact is made for the duration of the detected differential, provided that the actuation falls within the design limits of the device.

The operational characteristics of the two types of pressure components are controlled, with the exception of sensitivity, by the arrangement and constants of the electrical circuits associated with each. These constants determine the period of circuit closure required to record an actuation, and also determine whether the pressure component will be of the integrating or non-integrating type. Indirectly, they also determine the degree to which such disturbing effects as wave motion will affect the pressure component.

Description. The pressure-detecting device (figure 237) consists of three volume tanks, X, Y, and Z, of which only X is variable. Y and Z, although separated by diaphragm D, are connected through construction C. The over-all unit consists of a machined aluminum casting surmounted by a collapsible rubber bag. Volume Y serves only as a connecting link between X and the diaphragm. Z is entirely closed except for the constriction C,



A - Fixed Contact (Adjustable)
B - Moving Contact
C - Constriction
D - Diaphragm
E - Dessicator
X - Variable Volume
Y - Front Volume
Z - Back Volume

Figure 237 - Pressure-Detecting Device

which is filled with adjustable, fibrous material (not shown on drawing). This serves as a variable resistance and regulates, within limits, the passage of air through the constriction.

D is backed up, except for a small circular area in the center, by aluminum reinforcing which forms part of the main casting. The surface of the casting is well machined and is bored with five small holes which prevent the diaphragm from sticking due to a possible vacuum seal.

The switch consists of two contacts, one fixed and one movable. The movable contact consists of a stirrup, mounted on the center of the diaphragm inside Z. The fixed contact is mounted as indicated in the drawing, and is adjustable. Leads from the two are taken out of the device through a packing gland by a double-conductor cable, passed through another packing gland into the main body of the mine case (as in LMB) or the firing unit (as in BM 1000).

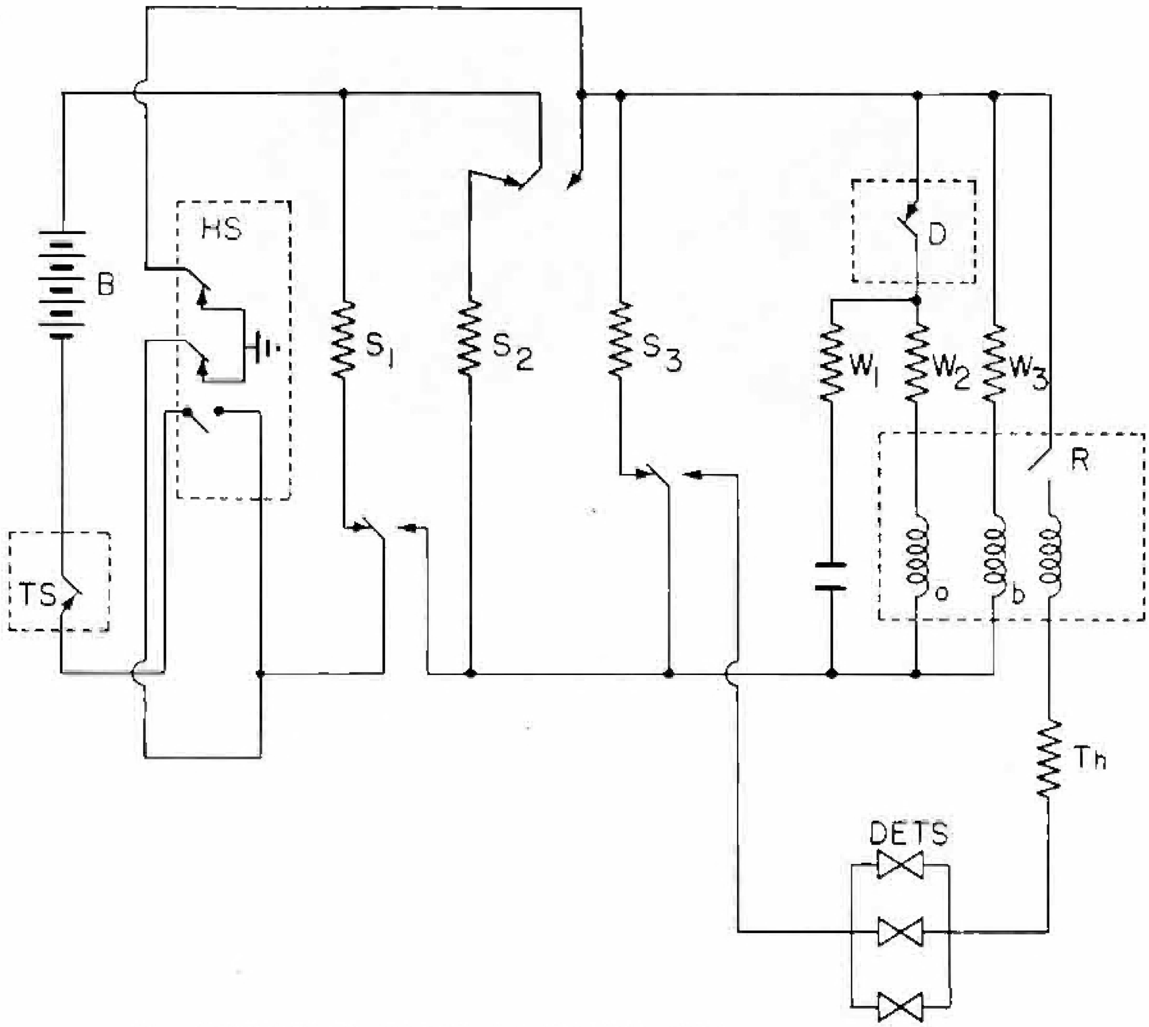
It should be noted that figure 237, the drawing of the pressure detecting device, is schematic in nature and omits some of the refinements present in the actual device.

Operation. When the mine is dropped, it sinks rapidly to the bottom, with a resulting rapid increase in hydrostatic pressure head, proportional to the depth of water. This pressure is transferred to X, which is compressed thereby. Compression of X creates a pressure differential between Y and Z, causing the diaphragm to move inward toward Z and opening the switch wider than usual. The pressure differential leaks off through C, and, when it has been reduced to zero, D and the fixed contact resume normal condition and contact gap. (0.007 in.).

Any negative pressure differential on X, equal to about 2½ inches of water, will cause X to expand and allow the contact to close, provided that the change in pressure occurs quickly enough. Pressure differential caused by natural causes such as tides and seiches occurs over periods too long to be effective, since C allows the pressure to equalize without expanding the diaphragm sufficiently to make contact. However, large pressure differential caused by action of a ship, or even by a large wave or swell, will affect the diaphragm sufficiently to close the contact, since C cannot equalize the pressure rapidly enough. From this point on, the associated electrical circuits of the pressure component govern further operation, with the pressure-detecting device serving only to close its switch for the duration of the pressure differential.

PRESSURE COMPONENTS D 2 AND D 102

The first type of pressure detector used by the Germans was the single suction-contact



B- BATTERY 7.2 V. (0.4 AMP. HR.)
C- CONDENSER 10μF
D- PRESSURE DETECTOR - D 102 UR/KS
R- RELAY (TYPE HK II)
HS- MASTER SWITCH (HAUPSCHALTER)
TS- TEMPERATURE SWITCH (KTSE)
Th- THERMISTOR (600 OHMS - APPROXIMATELY - COLD)
W_1 - RESISTOR 200 OHMS
W_2 - RESISTOR 300 K OHMS
W_3 - RESISTOR 300 K OHMS
S_1 - S_2 - S_3 - FUZE DELAY SWITCHES (24.5 OHMS)

Figure 238 - D 103 Unit Circuit

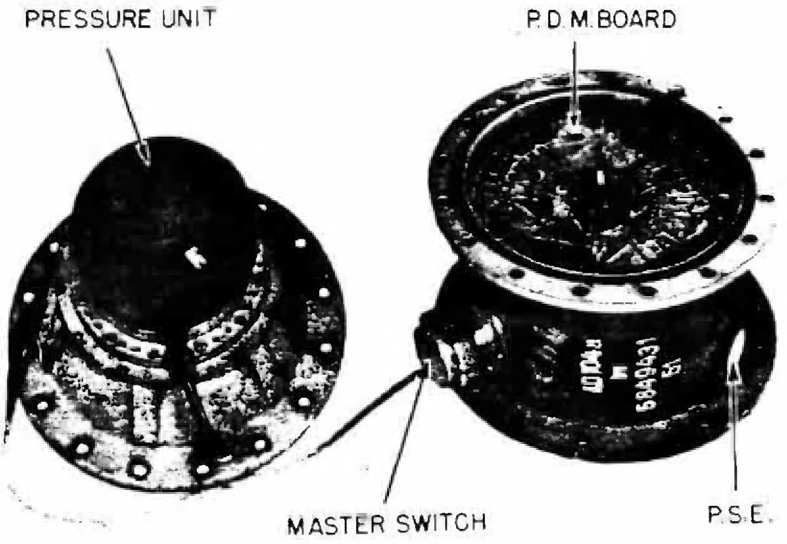


Figure 239 - AD 104a Unit Switch

type. This type closed contact if negative pressure differential of sufficient magnitude occured. The normal sensitivity is 1.5 to 2.5 cm of water. When used by the Luftwaffe in the AD 104 unit, the detector is designated D 1. It was felt that this device was too subject to actuation by nearby explosions and, to eliminate this and other defects, the D 102 and D 2 were developed.

The second type of pressure detector developed by the Germans was filled with two separately adjustable fixed contacts. One contact is mounted to close on suction, similar to the D 1 (D 101) action. The other contact is mounted on the pressure side and is normally closed in its primary application as a passive contact. The pressure-measuring diaphragm is of smaller diameter, and the entry hole from the rubber bag is fitted with a detonation-protecting valve which blocks only when large, sudden surges of air attempt to operate the unit. This type of unit is generally designated D 2 when used by the Navy and D 102 when used by the Luftwaffe. Although D 2 has never been used, D 102 has been used operationally as the detecting device for DA 102 and D 103, and its application to all later Luftwaffe developments involving pressure operation as projected. The following designations and their apparent meanings of D 2 and D 102 units were known to exist:

1. D 102 U	6. D 102 U/UR/KS
2. D 102 UR	7. D 2 U/KS
3. D 102 U/UR	8. D 2 U/UR/KS
4. D 102 U/KS	9. D 102 K
5. D 102 UR/KS	10. D 102 L

U = Unterdruck = Suction = contact fitted

UR = Uberdruck Ruhig = Pressure contact (Passive) fitted

KS = Knallschutz = Detonation protecting = valve fitted

K = Kurz = Short (Period)

L = Lang = Long (Period)

D 102 UR/KS and D 102 U/UR/KS are operational forms; D 2 U/KS and D 2 U/UR/KS were on the verge of being operational when hostilities ceased; the other types are experimental and testing devices. D 102 K and D 102 L have short and long (equalization) periods, respectively, for pressure-discriminating circuits.

OPERATION OF D 103 UNIT (FIGURE 238)

Upon impact, the bomb fuze operates the master switch, and if the temperature is within the proper range, the bi-metal temperature switch is closed. The battery energizes fuse delay switches S_1, S_2, and S_3 in sequence, which gives an arming delay of about three minutes. Since the pressure switch D is normally closed, the two coils of the galvanometer-type relay R are energized equally, and the relay remains in its equilibrium position. During this period, the condenser C is charged through resistor W_1 to the full battery potential.

When a negative pressure differential is applied to the pressure device, contact D opens, putting the full load of maintaining coil (a) of relay R on to the condenser C. If the pressure differential is maintained for three seconds, the condenser discharges sufficiently for relay R to make contact due to the current flowing constantly in coil (b). Closing of the contact energizes the hold-on coil of the relay, and, after a short delay due to the thermistor (Th), the detonator is fired.

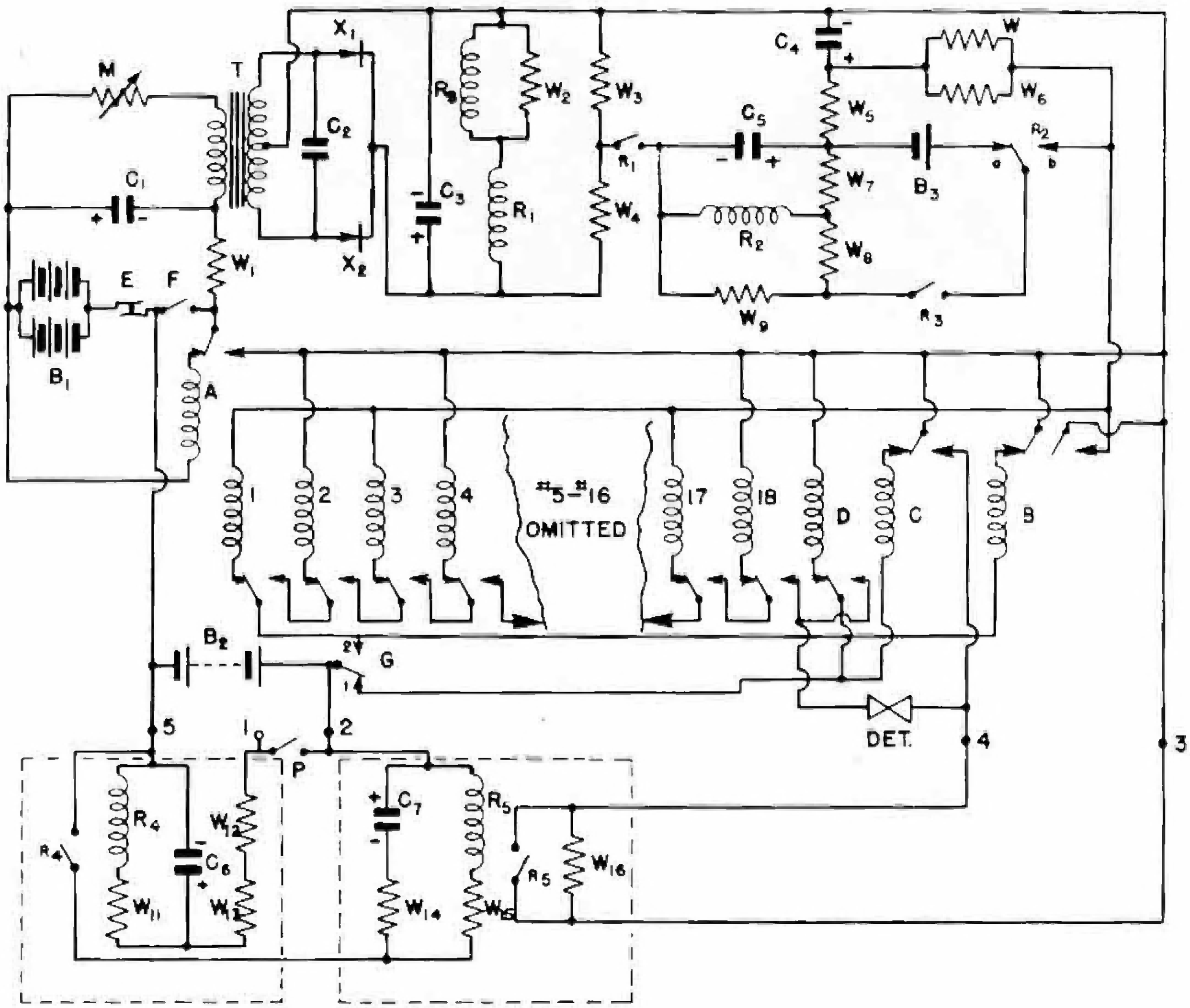


Figure 240 - AD 104 Unit Circuit

If the pressure differential is not continually maintained for three seconds, the pressure switch D closes before the relay has made contact; condenser C is quickly recharged through the relatively low resistor W_1, and firing is prevented.

Anti-countermining protection is provided in three ways:

1. The pressure detection device is fitted with an anti-detonation valve.

2. A continuous pressure of three seconds duration is required.

3. The thermistor requires that the relay contact be closed more than momentarily to allow sufficient current to flow and operate the hold-on coil.

If a mine fitted with the D 103 unit is raised from under water, the decrease in pressure may be sufficient to cause normal firing of the mine.

CHARACTERISTICS OF THE D 113

Sensitivity: 1-2 cm of water

Period: 6-7 seconds negative, 2-3 seconds positive

Contains anti-explosion device and anti-swell feature.

CHARACTERISTICS OF THE D 123

Sensitivity: 1-2 cm of water

Period: 4-5 seconds negative

Contains anti-explosion device and anti-swell feature.

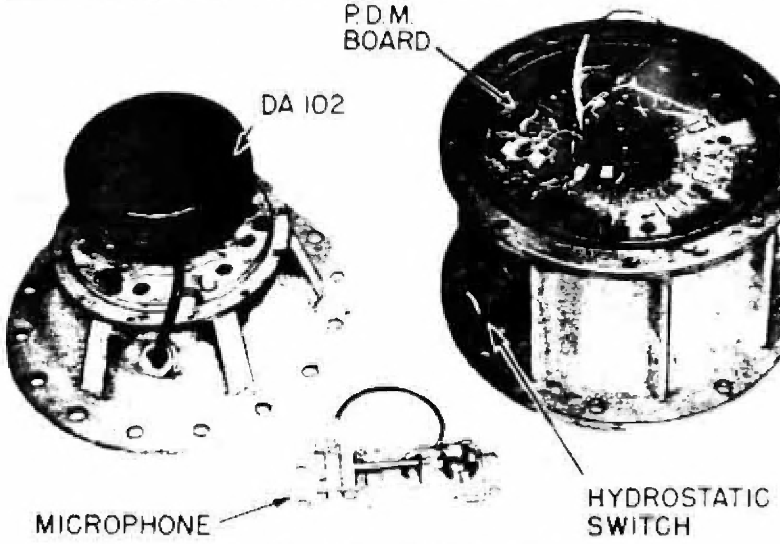


Figure 241 - AD 105a Unit with D 102

CHARACTERISTICS OF THE D 133

Sensitivity: 8-10 cm. of water (stumpf)

Period: 2-3 seconds negative

Intended for use in shallow waters against fast motor boats.

AD 104 UNIT

The AD 104 unit was developed for the Luftwaffe by Dr. Hell. It was started in the autumn of 1942 and completed and used operationally a year later. The unit was a combination of the A 104 and the D 101 and was designed for use in the BM 1000 I/II mine case. The time delay in the D 101 circuit could be selected for either 4 to 6, or 6 to 8 seconds at a 20 - 30 mm suction.

The A 104 is modified to include the D 101 and its associated relays R4 and R5.

It is further modified by the addition of W 10 which changes its normal anti-countermining action. Addition of W10 reduces the resistance of the charging circuit from B2 to C4. There will therefore be no discharging of C4 and C5 if the sound does not rise rapidly from initiating level to firing level.

Operation. After the unit is armed, both the acoustic and the pressure components are continuously alive. "Blind" P.D.M. actuations (9 maximum) are run off by the acoustic component only, and, upon completion of the P.D.M. actuations, the unit is receptive to acoustic-pressure firing.

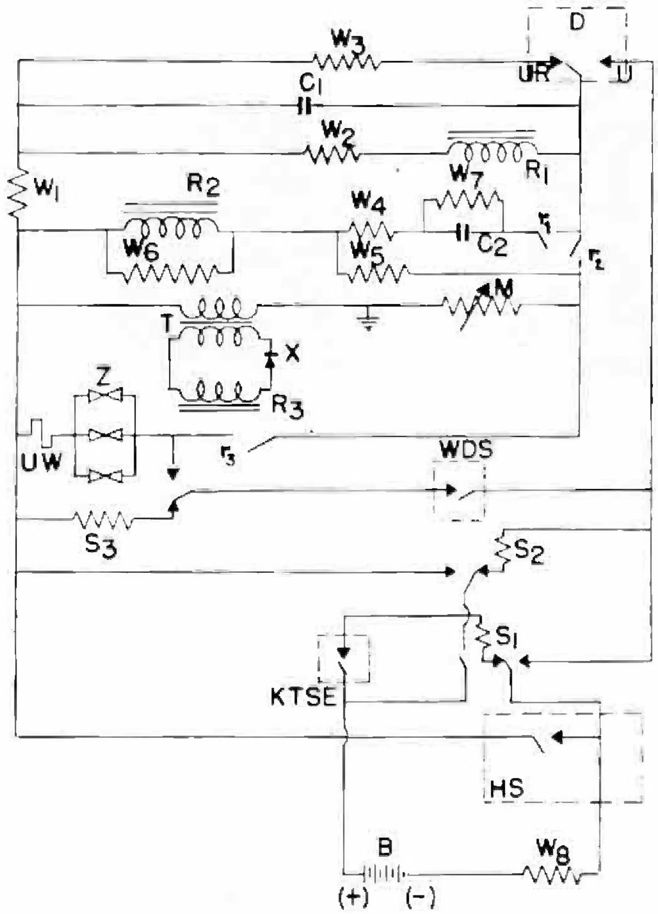
Acoustic Actuation. An acoustic firing actuation operates R_1, R_2, and R_3, in order, closing them to contacts R_1, R_{2b}, and R_3 respectively. This completes the circuit from B_2 through the three contacts above, through W_3, W_9, W_{16}, and the detonator. The addition of W_{16} raises the unit resistance to a point where the current flow is not sufficient to fire the detonator, nor to hold the relays closed. If the sound falls off, the circuit and relays return to normal.

Pressure Actuation. A decrease in hydrostatic pressure closes pressure switch P. This causes B_2 to start charging C_6 through W_{12} and W_{13} in an attempt to operate R_4 through W_{11}. If P remains closed for a sufficient period, R_4 makes and B_2 charges C_7 through W_{14} in an attempt to operate R_5 through W_{15}. If R_5 makes, it shorts W_{16} and reduces the resistance of the detonator circuit, leaving the unit receptive to acoustic firing.

Combination Actuation. If acoustic actuation occurs first, the sound must be maintained at firing level until pressure actuation is complete. In this case, the closing of R_5 by actuation of the pressure components, allows the acoustic unit to fire the detonator.

If pressure actuation occurs first, acoustic actuation may reach completion at any time thereafter up to 45 seconds, because after P opens, the charge on C_6 and C_7 keeps R_5 made until the charge drains off.

Integrating Firing Feature. The pressure component is designed to register an actuation if P is closed continuously for a period of seven seconds. This interval, however, may be somewhat decreased if C_6 and C_7 are partially charged at the time of actuation, since the arrangement and circuit do not permit rapid condenser discharge. If the condensers are partially charged by a P switch closure of less than seven seconds duration, and if, before the charge leaks off, another P switch closure occurs, it is possible for additional closures, none of



D- D102 U/UR/KS

M- D102 MI

B- BATTERY 15 VOLT

C_1 30 MF

C_2 30 MF

W_1 250 K OHMS

W_2 300 K OHMS

W_3 200 OHMS

W_4 10 K OHMS

W_5 20 K OHMS

W_6 200 OHMS

W_7 - 10 M OHMS

W_8 5 OHMS

X COPPER RECTIFIER

UW THERMISTOR (URDOXWIDERSTAND)

Z DETONATORS (=) 13 OHMS

HS MASTER SWITCH ELAZ 56 A II

WDS HYDROSTATIC SWITCH 0.5 ATM.

KTSE TEMPERATURE SWITCH

$R_1 R_2 R_3$ RELAYS- TYPE F

$S_1 S_2 S_3$ FUZE DELAY SWITCHES (145 OHMS) SWITCH OVER WHEN SOLDER IS MELTED BY HEATER COIL

Figure 242 - DA 102 Unit Circuit

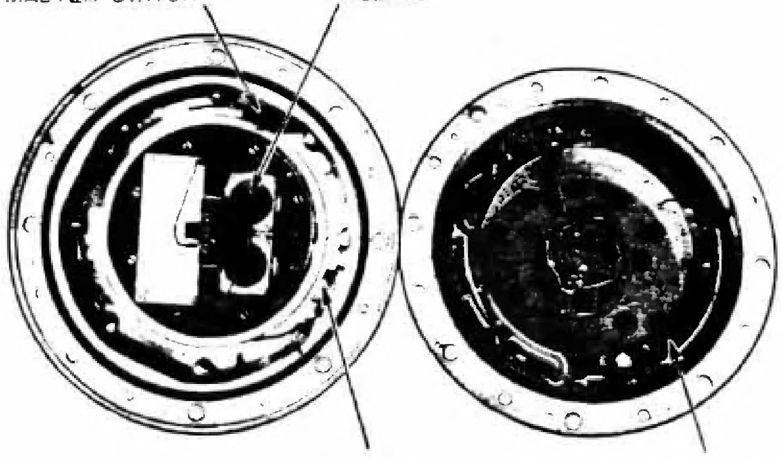


Figure 243 - DA 102 Unit

which may be seven seconds long, to register a complete actuation. Such an actuation is, of course, dependent upon the short-interval closures occurring close together. This effect may be produced by wave action under certain conditions and thereby cause the pressure component to be continuously actuated. If this occurs, the unit is, in effect, a straight acoustic unit.

DA 102 MINE UNIT SERIES

The DA 102 mine unit series consisted of eight combination pressure-acoustic firing mechanisms developed under the direction of the Luftwaffe.

The DA 102 is a combination pressure-acoustic unit which was used operationally toward the end of the war. Other units in this series are designated DA 112, DA 122, DA 132, DA 142, DA 152, DA 162 and DA 244. None of these latter units was developed to an operational stage. Some attempt at making a pressure-discriminating unit is evident in the early documents on DA 102. The latest attempt appears in the form of the experimental DA 244 unit.

The distinguishing characteristic of the DA 102 is that the unit consists primarily of a pressure mechanism with a "permissive" acoustic circuit. The unit is fitted with anti-swell protection. This protection is so positive that the mine will not fire against a target ship during periods of rough weather. The pressure unit is designated D 102 U/UR/KS, and the microphone is known as D 102 Ml (Hasag Mikrophon).

The Microphone. A special microphone, the D 102 Ml., was developed by the firm of Hasag, Leipzig, for use with the DA 102. It is a carbon button type microphone mounted on a diaphragm at the bottom of a D 102 mechanism. In order to accomodate this microphone, the D 102 is modified in the following manner:

1. The internal diaphragm is removed.

2. The bottom plate is replaced by a special disc. This disc has a hole in its center which houses a thin, rubber-covered, metal diaphragm. The microphone button is mounted on the inner side of the diaphragm.

3. The anti-detonation valve is removed.

The microphone button is fitted with a small leak-hole leading from the inside of the microphone pot to the carbon granule chamber. By this arrangement, the microphone diaphragm is exposed to the water, but, since the hydrostatic pressure is equalized by compression of the air within the rubber bag, there is no loading of the carbon granules and the sensitivity of the microphone remains unaffected.

This microphone is highly sensitive and has an essentially flat response for both sonic and subsonic frequencies. The sonic frequencies are transmitted to the carbon button by the diaphragm, and the subsonic frequencies by the rubber bag.

Operation (Figure 242). When the mine is laid, both detecting devices (D 102 U/UR/KS and D 102 Ml.) are exposed to water, and the pressure is equalized for the depth at which the mine plants. Upon impact, the bomb fuze causes the master switch HS to close contact and break its safety shunt. If the water temperature is between -5° Centigrade and $+35^{\circ}$ Centigrade, temperature switch KTSE is closed and battery B energizes fuse delay switch S_1. When S_1 has operated (with a delay) it cuts in switch S_2, which renders the circuit alive. At this point, if the mine is in less than 15 feet of water, hydrostatic switch WDS will energize S_3 and fire the detonator. (There is a slight delay in firing, due to the making of switch S_3 and the passing of current through thermistor UW.) Under normal operating condition, WDS is open and the mine is alive.

Pressure-detecting device D is normally on its passive contact (UR). A negative pressure differential will cause D to break the passive contact UR and make contact U (provided that the pressure differential has a magnitude of from 1.5 to 2cm of water). When D closes to contact U, battery B will operate relay R_1 with a delay of six to nine seconds, due to C_1. Condenser C_1 is assured of being totally discharged, since it is connected across W_3 in the normal passive state. When r_1 contact closes, the resultant surge to charge condenser C_2 allows relay R_2 to operate, closing r_2 which give R_2 a self-holding circuit. Closure of r_2 also energizes the microphone M in series with the primary winding of the microphone transformer T. If sound is now present, the resultant alternating currents in T are rectified, operating relay R_3 to close r_3, and the battery fires the detonator through the U contact of D, r_2, and r_3 with a delay due to thermistor UW.

If pressure reaction takes place, but no sound is present, re-opening of the U contact of D will de-energize R_1 and R_2, and r_1 and r_2 will reopen. C_1 will discharge quickly through W_3. C_2 however, may discharge only through W_7, which has a resistance of 10 megohms. Until C_2 is fully discharged, closure of D to the U contact will not cause sufficient surge of current through R_2 to operate it to close r_2. Thus, the unit is passive to pressure actuation for five minutes. Therefore, during periods of rough weather, it may be expected that the pressure differentials incident on D will keep C_2 charged continuously, long enough to prevent the mine from firing when a ship passes overhead.

DA 102 UNIT

Figure 244

DA 112. The DA 112 unit is fitted with a long delay time constant of 9 to 12 seconds. Because of the long delay, the swell-protection feature is considered unnecessary and is not installed. This unit is suitable only for use against large ships.

DA 132. The DA 132 unit is similar to DA 122, but has a delay period of three to four seconds. The pressure sensitivity is on the order of approximately 10 cm of water, as opposed to the 1 to 2 cm sensitivity of DA 112 and DA 122.

DA 162. The DA 162 unit is a combination of the principal features of the DA 122 and DA 152 units.

DA 244. DA 244 is fitted with two D 102 pressure detectors and a D 102 Mi. microphone. This is considered to indicate a pressure-discriminating circuit.

DA 122, DA 142, and DA 152. The information on DA 122, DA 142, and DA 152 units is conflicting. The two sources of information are OB. Stab. Ing. Rommel and Fl. Stab. Ing. Speiler of the Luftwaffe E-Stelle. Spieler was a specialist in pressure units, and his information may be more authentic than Rommel's, since the latter was in charge of all Luftwaffe mine material development. The contrasting opinions are as follows:

DA 122 (Spieler) - Same as DA 102 with a coarse acoustic component as an anti-mine-sweeper circuit.

DA 122 (Rommel) - Similar to DA 102 with a six- to seven second time constant for pressure actuation. Anti-swell protection renders the unit passive for 1/2 hour after pressure actuations subside, if two or three pressure actuations are recorded without acoustic actuation.

DA 142 (Spieler) - Same as DA 102, but requires an 18-second pressure pulse for use against large ships and to increase sweeping difficulty.

DA 142 (Rommel) - Same as DA 122, but with low-frequency (20 cps.) acoustic component.

DA 152 (Spieler) - Same as DA 102, but with rate-of-change acoustic similar to A 105.

DA 152 (Rommel) - Has four-contact pressure component requiring rate of change pressure signature.

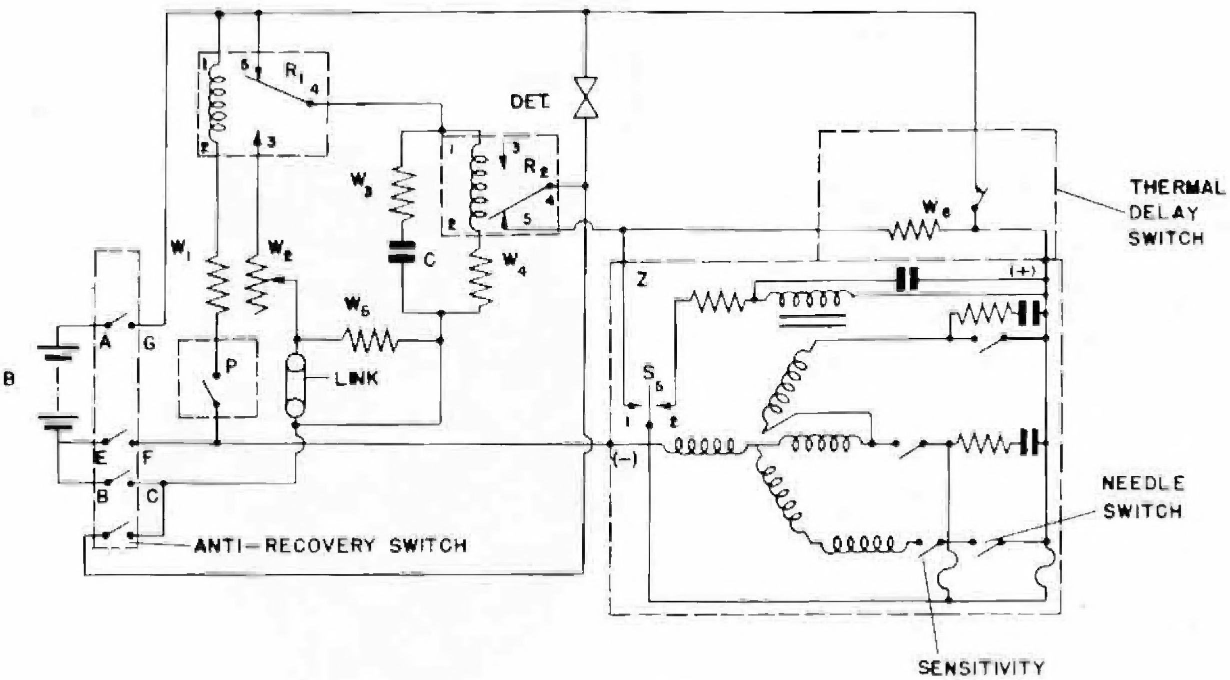


Figure 245 - DM 1 Unit Circuit

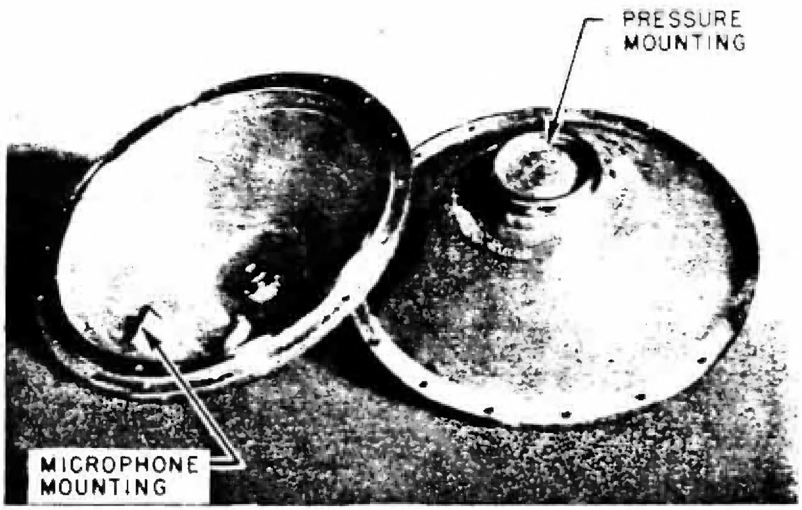


Figure 246 - LMB/S Tail

DM 1 UNIT

The DM 1 unit is a combination pressure magnetic unit designed by Hasag, Leipzig, for SVK, for use with the LM and TM mines. Work on it began early in 1942, and it was completed and ready for operational use in the summer of the same year. The first unit of this type was recovered in Normandy in July 1944, Figure 248.

This unit utilizes the M1 with a sensitivity setting of 5 mg and the D 1 with a delay of 8 seconds at 15 to 25 mm suction.

A thermal delay switch (15 to 40 seconds) determines the interval after actuation of M 1, during which actuation of D 1 may fire the mine.

Arming. When the hydrostatic clock runs off its delay setting, A-G and B-C close. B then charges C through W_3 and the closed contact (4-5) of R_1. When C is charged, R_2

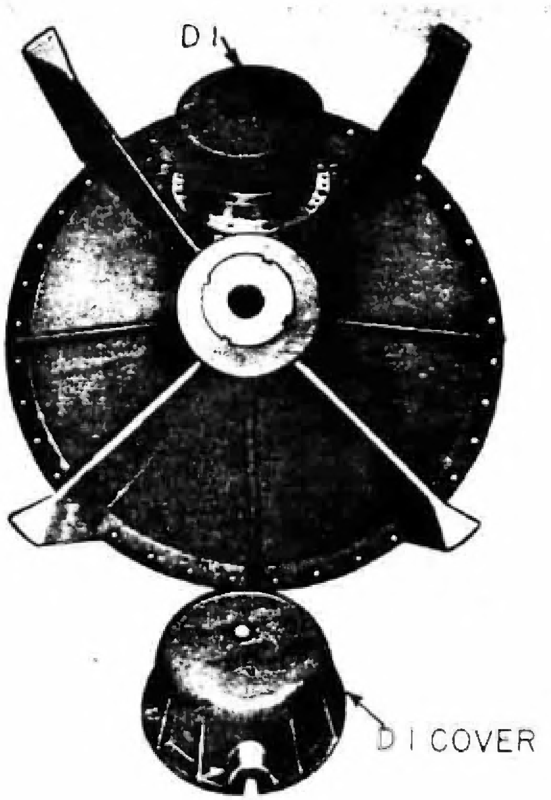


Figure 247 - LMB Tail with D 1 Unit

operates, breaking 4-5 and making 4-3, thereby removing the detonator from the circuit. Eighteen minutes later, E-F closes, the magnetic component goes through A.L.A. and is armed.

Magnetic-Actuation. Actuation of the magnetic component closes the needle switch and operates the air core relay, thereby closing S_5 to contact No. 1. Hold-on current and thermal delay-switch heater current pass through the normally-closed contact of the thermal delay switch. This condition persists until the thermal delay switch opens, breaking the magnetic hold-on and heater current. The magnetic component then returns to normal.

Pressure Actuation. A decrease in hydrostatic pressure closes pressure switch P. This causes B to energize R_1, breaking 4-5 and making 4-3. Battery current to C is thereby cut off, causing C to discharge through W_3 and R_2. When C has discharged sufficiently, it no longer holds 4-5 open. The foregoing constitutes a single pressure actuation for which nine seconds continuous closure of P is required.

Combination Actuation. If magnetic actuation occurs first, pressure actuation may be completed at any time within 25 seconds thereafter. At the end of the 25-second period, the thermal delay switch breaks the magnetic circuit. Pressure actuation within the 25-second interval causes contact 4-5 of R_2 to make, firing the detonator through contact No. 1 of S_5.

If pressure actuation occurs first, P must be held closed until the magnetic actuation is complete, if the detonator is to fire. Otherwise, opening P de-energizes R_1, recharging C and thereby opening 4-5, which takes the detonator out of the firing circuit.

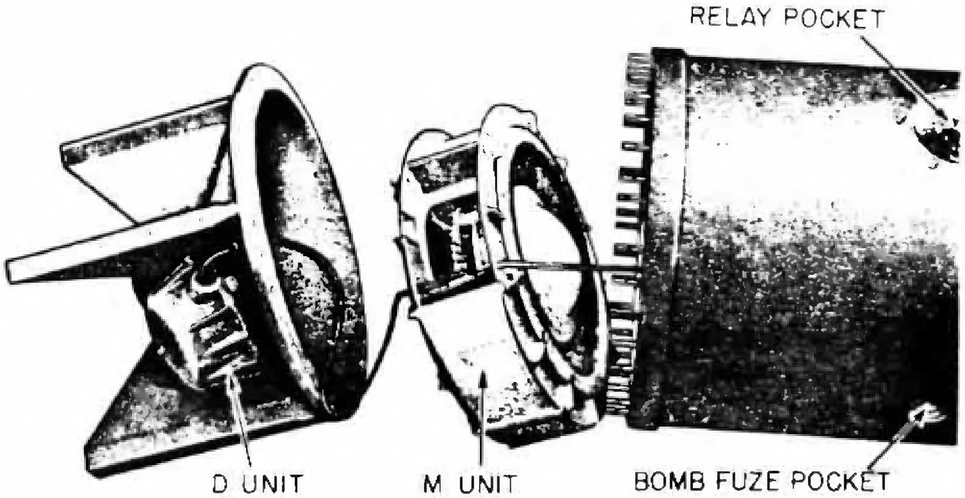


Figure 248 - DM 1 Unit

Non-Integrating Firing Feature. The pressure component is designed to register an actuation if P is closed continuously for a period of nine seconds. This interval is not subject to decrease, due to partially charged condensers as in the case in AD 104. In the DW 1 unit, the arrangement and constants of the circuit allow C to recharge fully through W_3, if P opens for 1/4 second or more. This feature is due primarily to the low resistance of W_3, and the lack of delay on R_1. The pressure component, then, is unlikely to be seriously affected by natural causes such as waves and swells.

Chapter 11 - Section 8

EXPERIMENTAL UNITS

SEISMIK MINE UNIT

The "Seismik" was an experimental attempt to produce a mine-firing unit which operates on very low frequencies. It was in the developmental stage, and was intended to be used in combination with firing units operating on other principles.

The "Seismik" (Seismograph Microphone) is used in a system which the Germans call the "S-Systeme". The system consists of a special microphone and a simple electrical circuit designed to be used as a low-frequency component for a combination mine unit. It was intended to combine the Seismik with M 4, A 4, and D 2. The last was to have been designated DS 1, but never went beyond the idea stage. The Seismik microphone is designed for frequencies of the 1 to 10 cps. range, but had been applied in development only to a circuit whose optimum frequency was 5 to 8 cps.

The Microphone. The Seismik microphone is a normal D 1 pressure unit component, modified by the removal of the suction contact, which is, in this case, replaced by a carbon-button microphone driven by the thin internal aluminum diaphragm normally found in D 1 units. Thus, because of the equalizing channel in the unit, the carbon-button is not loaded by hydrostatic pressure, and retains its original operating point and sensitivity.

The Circuit. The circuit of the Seismik is shown in the upper half of figure 249. The microphone is fed by a battery in a transformer circuit. Introduction of the transformer is connected, unrectified, to the operating coil of relay F, which must oscillate with the alternating-current output, thus eliminating the high frequencies, depending upon the degree of damping of the relay. Oscillation of relay contact (f) alternately charges condenser C_1 from battery B_2 and discharges it through the operating coil of relay R on the other half-cycle. Closure of contact (r) causes charging of C_2 through W_1 and the charge on condenser C_2 occurs in a manner similar to that shown in the lower half of figure 249, with W_2 causing the small discharges. When C_2 is charged sufficiently to operate relay Fu, contact (fu) closes and B_2 fires the detonator, or permits another influence firing component to do so.

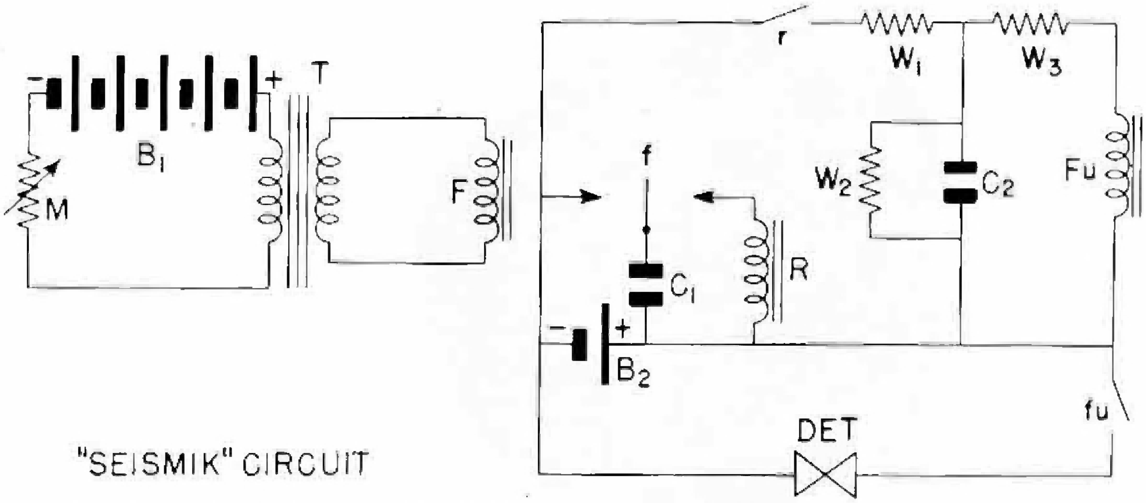
Frequency Response. The optimum frequency response of the system described is reported to be 5 to 8 cps. The microphone itself, however, is reported to have an essentially flat response down to one cycle per second. The lower frequencies are eliminated partially by the microphone transformer, and partially by the values of W_2 and C_2. The higher frequencies are eliminated by the unrectified signal current on the relay coil. This microphone might be used for other purposes where a pressure-equalized diaphragm type is necessary, but SVK considered that, because of its mounting, the response would start to fall off at about 15-20 cps., with possibly a peak at 70 cps. due to the fact that the rubber bag resonates at that frequency.

AJ 102 AND AJD 102 UNITS

The Germans never made a serious effort to lay an induction or induction-combination mine, although approximately 200 experimental BMA mines were laid. This principle was, however, the object of considerable experimentation. The Luftwaffe was allotted some nickel for induction mine production, and the Firma Dr. Hell produced the experimental AJ 102 and AJD 102 combination units.

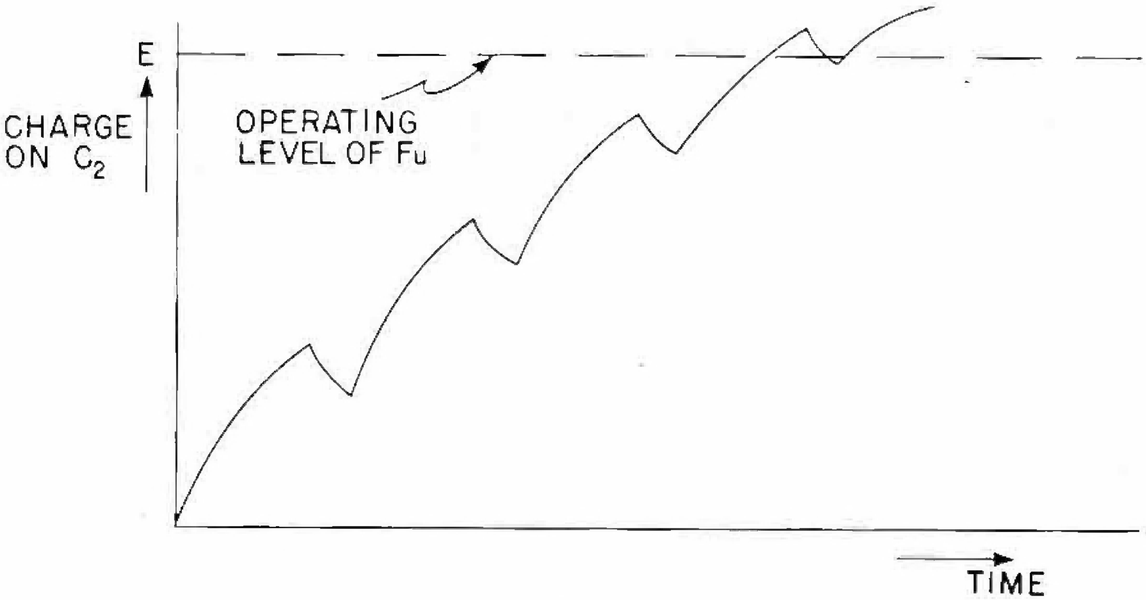
The German AJ 102 and AJD 102 mine units are combined acoustic-induction mine units designed for use in the BM 1000 J mine. The AJD 102 mine has, in addition, a "permissive" pressure unit component designed to make sweeping more difficult. The induction-acoustic combination used a short induction coil (approximately 25 cm) in parallel with the normally-closed contacts of a cantilever-type vibrating chatter-switch. The output of this combination is fed to a two-stage vacuum-tube amplifier with two pentodes

The rapid opening and closing of the vibrator contacts produces high-frequency transients which are then amplified. The vibrator uses carbon contacts and may, possibly, have a microphonic effect. Records of some trial runs with ships indicate that the vibrator does not go into operation and produce any high-frequency transients until approximately amidships and, as the amplitude increases with the approach of propeller noises, the vibrator output level increases tremendously in the after half of the ship.



"SEISMIK" CIRCUIT

B_1 - MICROPHONE BATTERY-12v
B_2 - FIRING BATTERY-15v
C_1 - CONDENSER - 2 μfd.
C_2 - CONDENSER - 240 μfd.
F - RELAY; f-CONTACT OF F
Fu - RELAY; fu-CONTACT OF Fu
M - MICROPHONE
T - MICROPHONE TRANSFORMER
W_1 - RESISTOR - 5 K-OHMS
W_2 - RESISTOR - 8 K-OHMS
W_3 - RESISTOR - 5 K-OHMS
R-RELAY (TELEPHONE TYPE); r-CONTACT OF R
F-15 μfa; Fu-65 μa R-1 ma.



CHARGING CURVE FOR C_2

Figure 249 - Seismik Unit Circuit

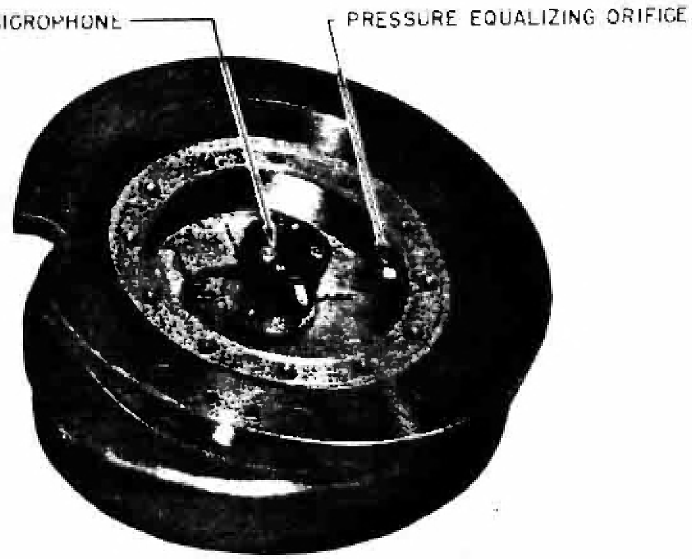


Figure 250 - D 1/A Seismik Unit

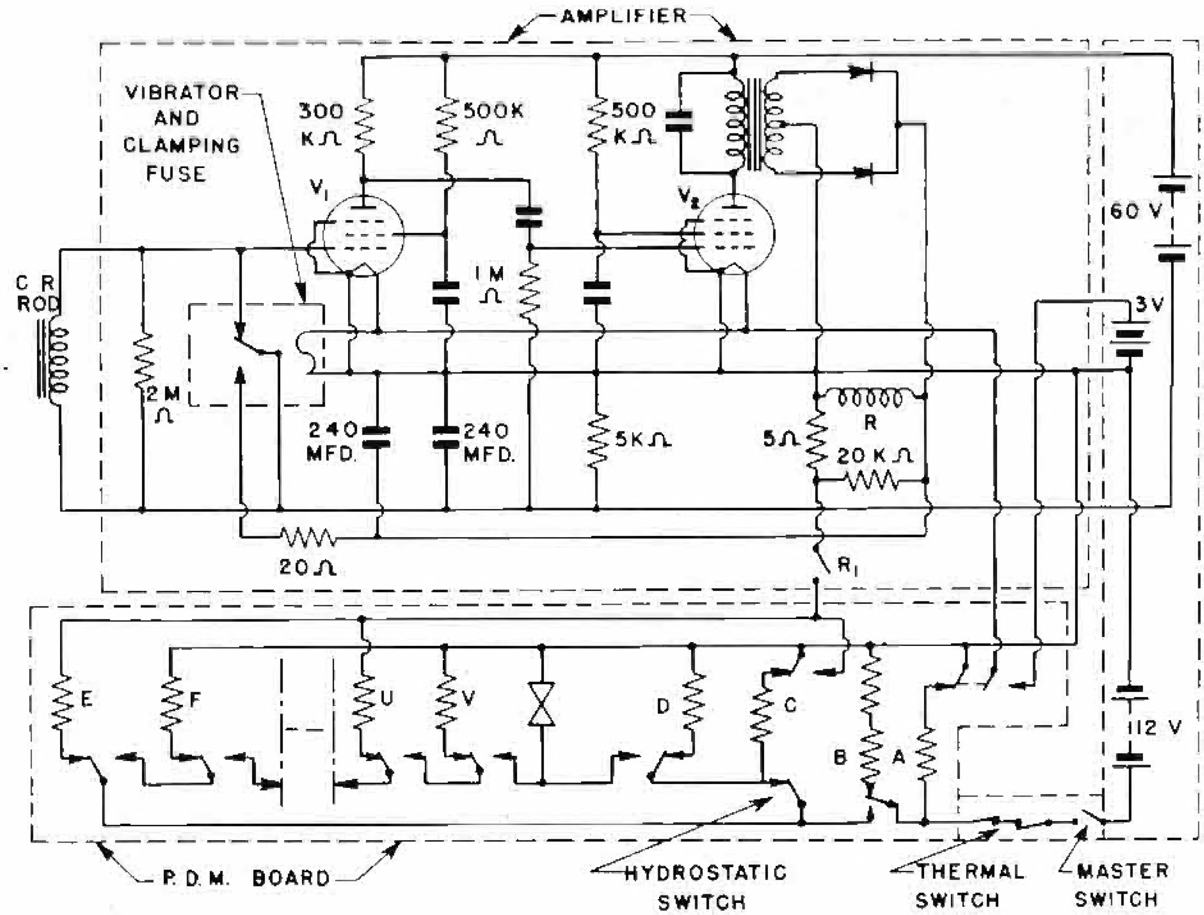


Figure 251 - AJ 102 Unit Circuit

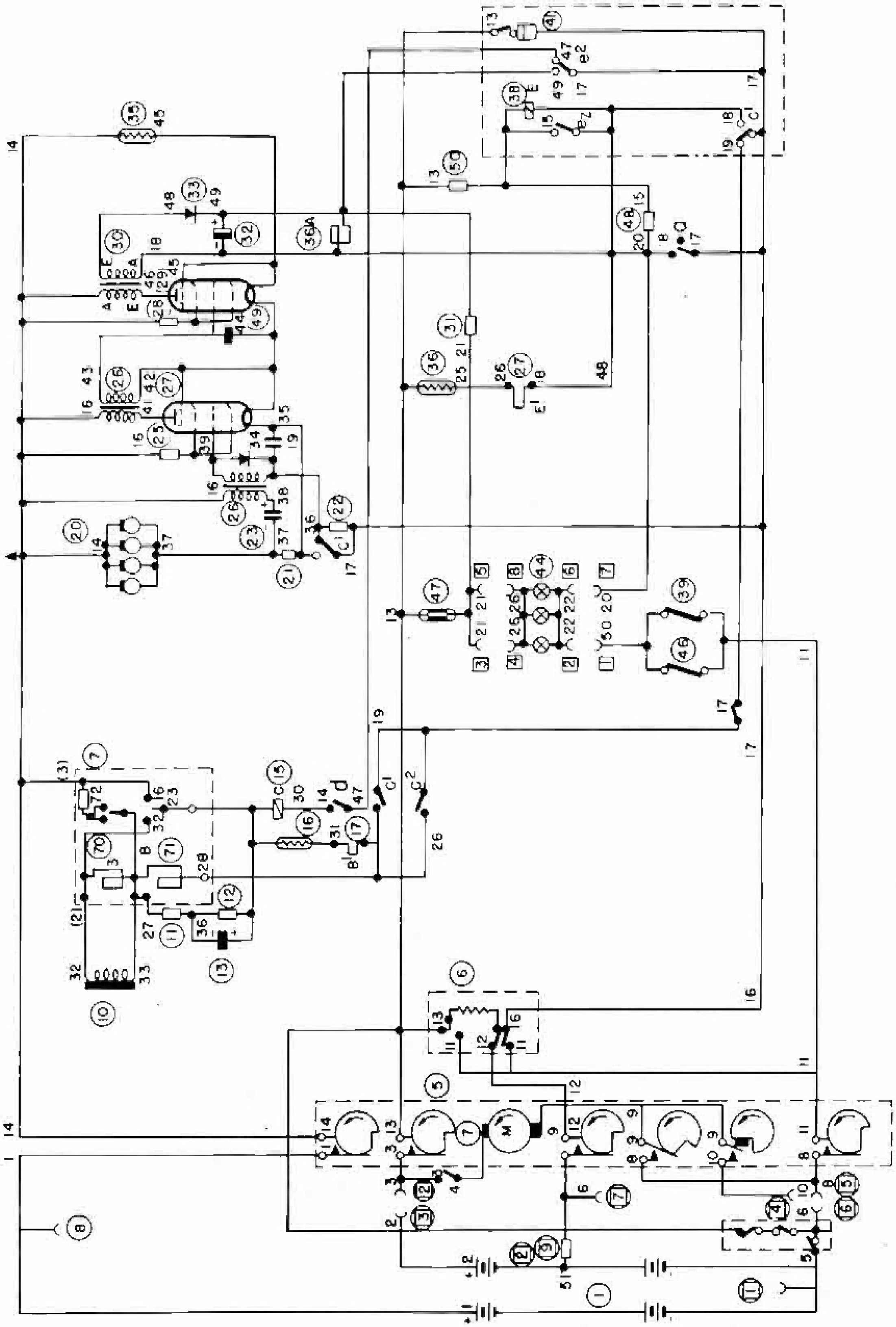


Figure 252 - JDA 105 Unit Circuit

The induction component of the circuit has a sensitivity of 0.2 mg/sec., with a fixed sensitivity setting.

Construction. The unit is of the same basic type construction as the MA 101. Instead of the magnetic hemisphere which appears on the MA 101, there is a dish-pan shaped cover of the type used on A 105. In addition, on the unit frame where the four microphones are normally mounted on MA 101, only four fittings appear at right angles to each other:

1. The master switch (0°)
2. The hydrostatic switch (90°)
3. Packing gland for the induction coil-rod (180°)
4. Plug for the arming pins (Scharfsteker) (270°)

JDA 105 UNIT

The German JDA 105 mine unit is an attempt to substitute an induction influence component into a combination mine-firing mechanism. Essentially, the JDA 105 is the same as the MA 105 unit, except that in JDA 105 an induction circuit is used instead of the dip-needle magnetic, and a "permissive" pressure circuit is added. No samples of the subject unit have been captured.

The JDA 105 unit is a combined induction-pressure-acoustic mine-firing mechanism of the same basic design as the MA 105. It is identical in appearance to the MA 101 except that it is fitted with an aluminum plate mounting the pressure-detecting device instead of the magnetic component hemisphere found on MA 101. As well, JDA 105 is fitted with a packing gland for leads to the coil-rod, which is mounted separately from the unit in a tube in the case of the BM 1000 J mine. Except for the introduction of the pressure component and substitution of the induction system, the unit appears to be identical to the MA 105.

AMT UNITS

Because of some operational shortcomings, the AT 2(AA 2) and AT 3(AA 3) units were considered unsatisfactory. Combination of these units with the M 4 unit was in development at the end of the war in Europe. The resultant combinations are known as AMT 1 and AMT 2 (Acoustic-Magnetic-Subsonic). No samples of the AMT units were captured.

The operational AT units had two faults:

1. Both AT 2 and AT 3 tend to detonate spontaneously in strong currents.

2. Because of constant switching in the vicinity of a sound source, the life of the AT units is short, especially AT 2. (50 hours for AT 2 - 14 days for AT 3.)

Combination of AT 2 and AT 3 with M 4 into AMT 1 and AMT 2, respectively, is designed to

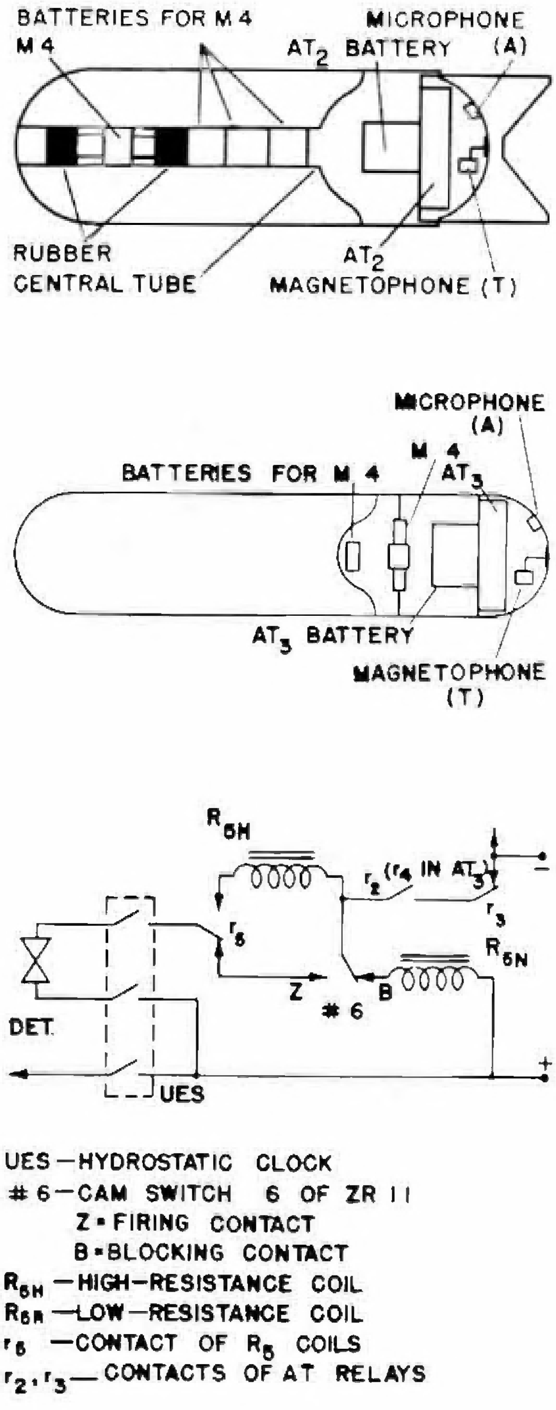
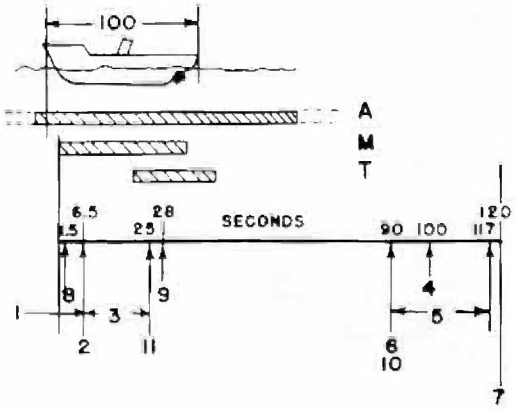


Figure 253 - AMT Unit Mounted in LMB and TMB



1 = UNIT BLOCKS IF "T" OPERATES
2 = CAM SWITCH #6 SWITCHES FROM "B" TO "Z"
3 = UNIT IS SUBJECT TO FIRING
4 = CAM SWITCH #6 SWITCHES FROM "Z" TO "B"
5 = M 4 COMPONENT READJUSTS
6 = M 4 AUTOMATIC SETTING IN
7 = M 4 AUTOMATIC SETTING CUT
8 = HEATER CURRENT ON
9 = HEATER CURRENT OFF
10 = ANODE POTENTIAL ON
11 = ANODE POTENTIAL OFF

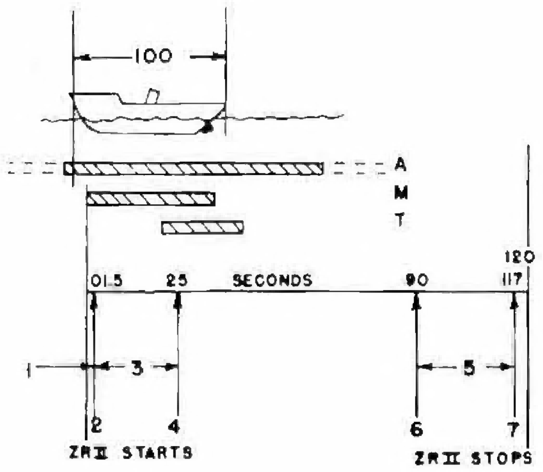


Figure 254 - AMT 1 and AMT 2 Characteristics

overcome these two faults and, in addition, make the mine more difficult to sweep. Combination is made with the use of a ZR II motor-driven cam system to set the time interval relations between the three influence components of the unit.

Mounting. The AMT 1 is mounted in LMB IV, and the AMT 2 is mounted in TMB or TMC, as indicated in figure 253. The AT 2 component is mounted normally. The M 4 component is rubber-mounted, with its associated batteries in fixed orientation within an aluminum tube running axially through the mine. Fixed orientation of the M 4 is possible, since it is capable of compensating fields from 700 mg RED to 400 mg BLUE. The AT 3 component is mounted normally. The M 4 component is mounted on a fixed aluminum frame on the diameter of the mine.

ZR II Mechanism. The ZR II mechanism determines the time relations between the influence components of the AMT units. Because of the shorter life of the AT 2 component, additional switching is necessary to conserve the battery in AMT 1, so a different type of ZR II mechanism is used. Two such mechanisms are known, ZR IIb and ZR IIc, and the basic switching in is similar. The ZR II mechanisms are motor-driven cam systems.

Blocking. A blocking circuit, figure 253, is used to block firing if the subsonic influence causes the "T" component to react prematurely. (Contact r_2 closes when the "T" component fires). If the "T" component reacts prematurely, ZR II cam 6, will be on its blocking contact when r_2 closes. The low-resistance coil of R_5 (R_{5a}) is energized and r_5 switches over, energizing the high-resistance coil (R_{5b}), which acts to produce self-holding of R_5 as long as r_2 remains closed, and the resistance of R_{5b} prevents detonator firing.

Operational Characteristics of AMT 1 (Figure 254). The acoustic component is normally alive, and is actuated first. If now the "M" component is actuated, the ZR II mechanism is energized and runs for 120 seconds. After 1.5 seconds, the vacuum-tube heaters of the "T" component are switched on and are given five seconds to heat. After 6.5 seconds, cam switch 6 of ZR II operates, switching out the blocking circuit and switching in the firing circuit of the "T" component. If "T" (subsonic) actuation occurs before 25 seconds after "M" actuation, the mine fires.

If the mine does not fire after 25 seconds, the ZR II switches out the plate supply to the "T: amplifier. At 28 seconds, the "T" amplifier heater current is turned off. This three-second interval is allowed to prevent premature firing due to the cooling of the vacuum-tube heaters.

At 90 seconds the plate supply is again switched on, and the "M" component is run through latitude adjustment to assure proper correction in case of faulty adjustment or

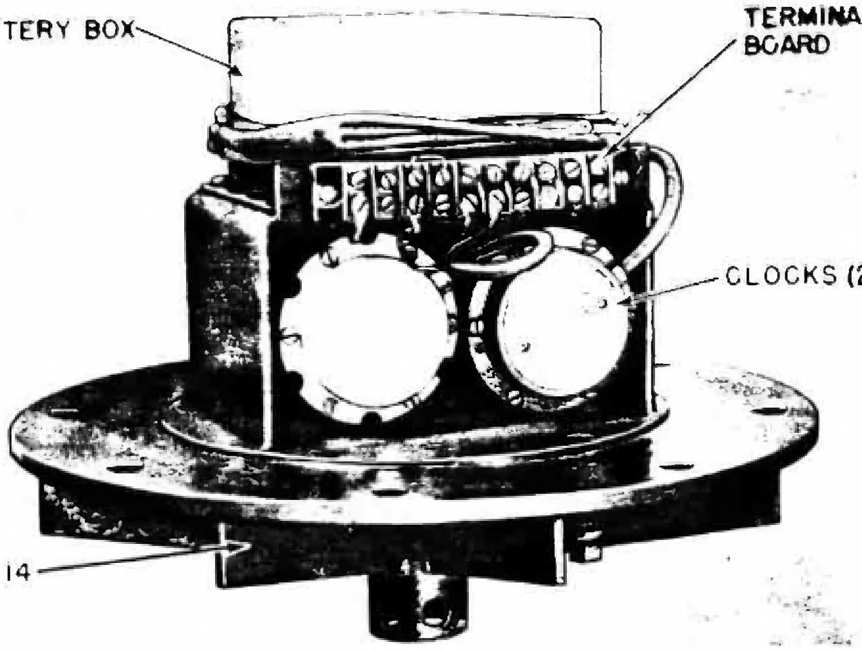


Figure 255 - S 101 Unit

small changes in the prevailing magnetic field. This procedure continues until complete, and is switched out at 117 seconds. If this 27-second period is insufficient (as in the case of initial latitude adjustment) the ZR II will go through successive cycles until adjustment is complete.

At 100 seconds, cam switch 6 does back to its blocking contact.

If the action is triggered by "M" actuation, the "T" component amplifier will not be switched on until acoustic actuation is complete. In the normal case (A-M-T sequence) the unit will be fired by a subsonic actuation between 6.5 and 25 seconds after magnetic actuation.

Operational Characteristics of AMT 2 (Figure 254). The ZR II mechanism does not control the switching of plate and heater supply to the "T" component amplifier tubes, since the battery has much longer life than in the AT 2 component of AMT 1.

The acoustic component is normally actuated first and switches on the "T" component when actuated. However, the "T" component is blocked by cam switch 6 until 1.5 seconds after "M" actuation. The mine is then active for "T" firing from 1.5 seconds to 25 seconds after "M" actuation As in AMT 1, the interval from 90-117 seconds is allowed for resetting of the M 4 unit.

S 101 UNIT

The S 101 is a clockwork unit designed for use in the BM 1000 F (Sommerballoon), anti-power-plant mine. Development of this unit was begun by AEG for the Luftwaffe in the fall of 1944 and it was completed and ready for operational use in two months.

Component Operational Parts

Two clocks; circle 17 fuze modified, with master switch starter and contacts in place of striker; preset delay from 1.5 to 54 minutes.

Two transient voltage control tubes; gas-filled photo tubes in the filament heater circuit of thermal delay switches.

Two bi-metallic thermal delay switches, the contacts consisting of two strips of metal, the outer strip having a greater coefficient of expansion than the inner.

One circle 25C Rheinmetal fuze; contains three vertical trembler switches and one axial switch.

One type 157/3 Rheinmetal fuze; standard mine-arming fuze.

One flapper switch fitted in a transverse water channel in the forward section of the mine.

All the component operational parts of the mine are fitted to a 10-contact terminal board on the S 101 unit. The S 101 unit is constructed of cast steel mounted on the circular tail plate. It contains the circle 25C fuze, the battery box, the clocks, and a 10-contact terminal board. Fitted in the

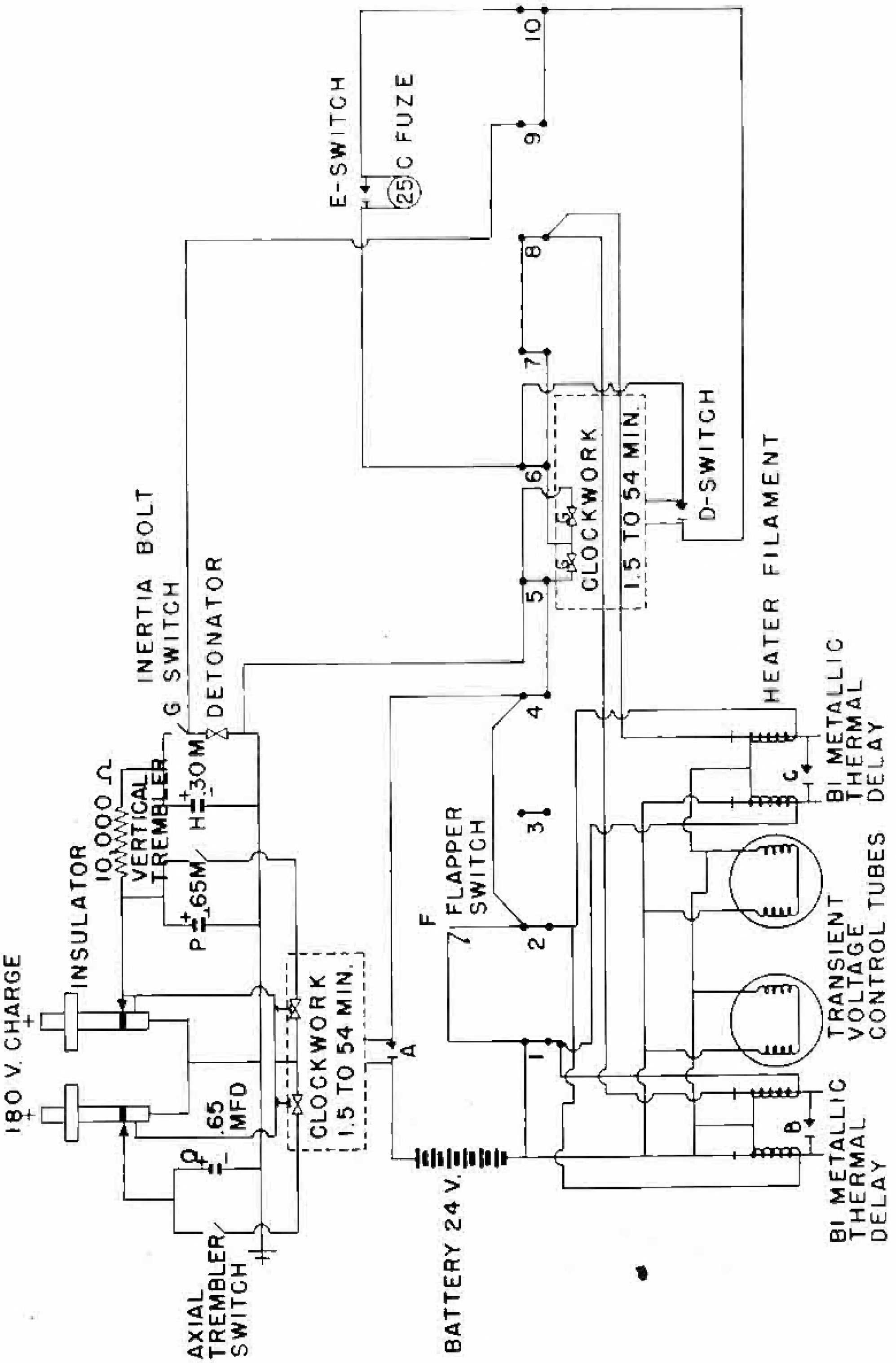


Figure 256 - S 101 Unit Circuit

battery box are the two bi-metallic thermal delay switches and the voltage-control tubes.

Tactical Operation. The mines are laid in groups of three and will drift with the current nose-down. The transverse channel containing the water flap is exposed at all times. If the mine should snag, the current through the channel will throw the flapper switch. With the flapper switch closed, the mine may fire upon receipt of a countermining shock, or at the end of a clock delay period initiated by closure of the flapper. The flapper must be closed or the mine cannot fire. In substance, if two mines are in the power plant together they will detonate simultaneously. If the third mine is immediately outside the plant at the time, it will not detonate until it drifts in and the flapper switch is closed.

Operational Sequence. The mine fuze is charged prior to its release from the parent aircraft by application of a 180-volt potential to the plungers on the top surface of the fuze. If the mine strikes a hard surface producing a deceleration of over 200g, an inertia switch mounted within the fuze will close, discharging the fuze condenser into the mine detonator and firing the mine. If the mine strikes water with a deceleration of less than 200g, the axial and the trembler switches will close, discharging the fuze condensers through the master switch. The master switch consists of two thermit igniter squibs. The firing of this assembly will start the first clock. This clock, after a delay of from about 1.5 to 54 minutes, will arm the S 101 mine-firing circuit by placing a voltage across the contacts of the flapper switch. The flapper switch is wired in series with the heater elements of the thermal switches. Contained in the heater circuit are the gas-filled photo tubes; these tubes are, in effect, transient voltage control units. In operation they serve much as resistors whose magnitude is inversely proportioned to the light intensity of the tube; in other words, when the flapper switch is closed, there is a surge of current across the heater circuit, but as the tubes heat up the current will fall off, thus preventing the filament of the thermal switches from being overheated and consequently burning out. It will take the heater circuit, thus regulated, approximately 30 seconds to heat the bi-metallic strips sufficiently for closure of the thermal switches. When the thermal switches have closed, the second clock starts in a manner similar to that of the first. At the end of the preset delay (1.5 to 54 minutes), the mine will detonate. If at any time between the closure of the thermal switches and the lapse of the delay period the mine receives a countermining shock, the circle 250 fuze will operate, detonating the mine.

Operational Circuit Sketch (Figure 256). If the mine strikes land, inertia bolt switch (G) will close, discharging condenser (H) through the detonator. If the mine strikes water, either the axial trembler switch or the vertical trembler switch or both will close, discharging either condenser (P) or condenser (Q) through clockwork igniters (I). After the clock delay, switch (A) will close, placing a voltage on terminal (5) and on one contact of thermal delay switches (B) and (C) and also on terminals (1) and (2) across flapper switch (F). Closure of flapper switch (F) will energize the thermal switch heater circuit. Closure of the thermal switch (B) and (C) will energize terminal (6), firing the clockwork igniters (G). After the clock delay, switch (D) will close, charging terminal (9) and completing the circuit from terminal (9) through the detonator to terminal (5). If at any time prior to the closure of (D) switch (E) operates, it will complete the circuit from terminal (6) to terminal (9) through the detonator to terminal (5).

MDA 106

The MDA 106 unit was a combination magnetic-pressure-acoustic unit started by the AEG firm in the fall of 1944 and incomplete at the war's end. It was intended for use with the BM 1000 H/M mines and was to be a combination of the MA 105 and D 101 units. No experimental data are available.

COSMIC RAY UNIT

The German cosmic ray mine unit (figure 257) was an experimental attempt to produce a mine-firing unit which operates on changes in the cosmic ray background due to the transit of a ship over the mine. It was in the developmental stage, and was not developed sufficiently for production.

The unit consists, essentially, of a group of Geiger-Muller counter tubes in a ground mine and a suitable amplifier to use the cosmic ray pulses. When such a system is submerged, the layer of water above it will cause a constant amount of absorption to cosmic rays. If a ship passes overhead, a certain mass of water is displaced by thin layers of iron; i.e., the ship's bottom and decks. The absorption is thereby decreased and the cosmic ray level increases. If the gradient is sufficiently large, a rate-of-change circuit operates, and the mine fires.

The Counter Tubes. The counter tubes are Geiger-Muller counters of standard manufacture. The ones experimented with were of glass, with a silver lining as one electrode and an iron wire on the axis as the other. The tubes are air-filled (possibly Ne or A) at 0.1 mm pressure. These were found too fragile for dropping from aircraft, and an experimental type of steel tube was in the development. The tubes, 24 in number, were mounted in an LMB mine-case, and cast into the explosive. They were mounted in a circle, with their axis parallel to the axis of the mine.

The Circuit. If one counter tube were used in this type of mechanism, the effect on the rate-of-change circuit would be unsatisfactory, since the interval between cosmic ray pulses passing through one tube would be too long. As well, sharp peaks are produced in the output circuit of one counter tube. If several tubes are used, the resultant mixing of pulses produces a smoother back-

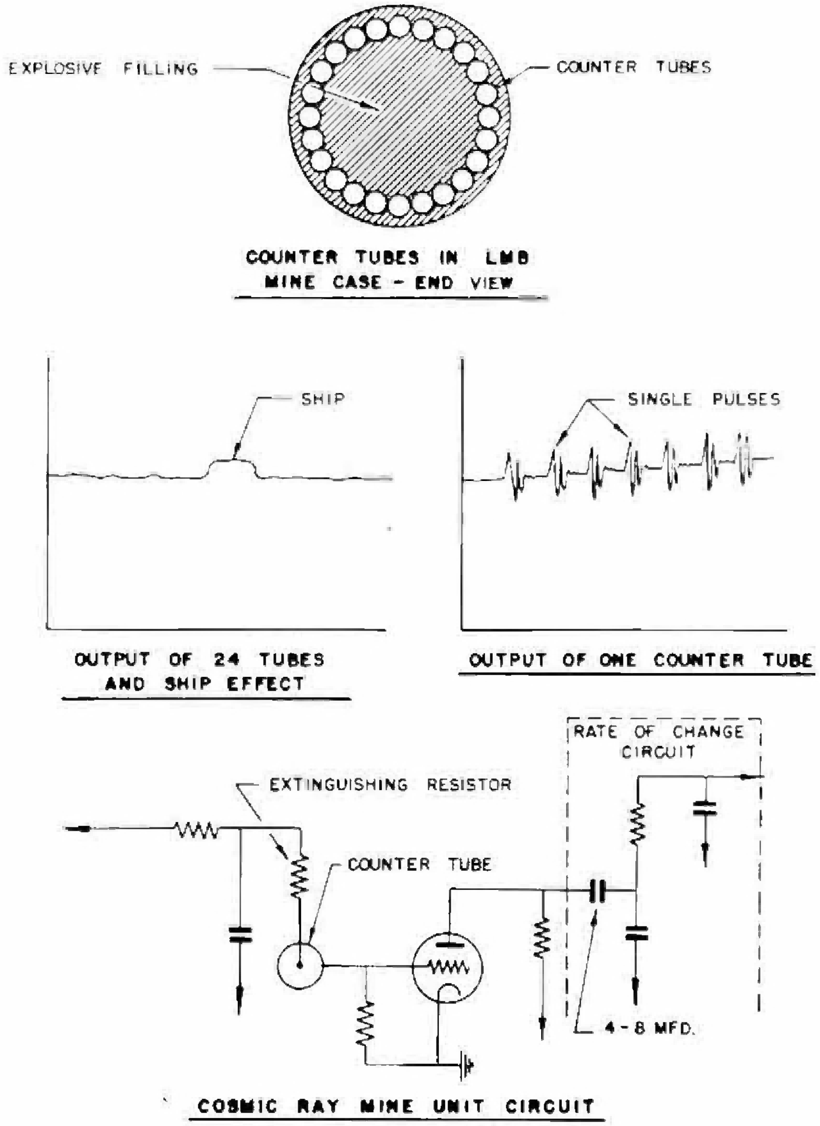

EXPLOSIVE FILLING
COUNTER TUBES
COUNTER TUBES IN LMB
MINE CASE - END VIEW
SHIP
SINGLE PULSES
OUTPUT OF 24 TUBES
AND SHIP EFFECT
OUTPUT OF ONE COUNTER TUBE
RATE OF CHANGE
CIRCUIT
EXTINGUISHING RESISTOR
COUNTER TUBE
4 - 8 MFD.
COSMIC RAY MINE UNIT CIRCUIT

Figure 257

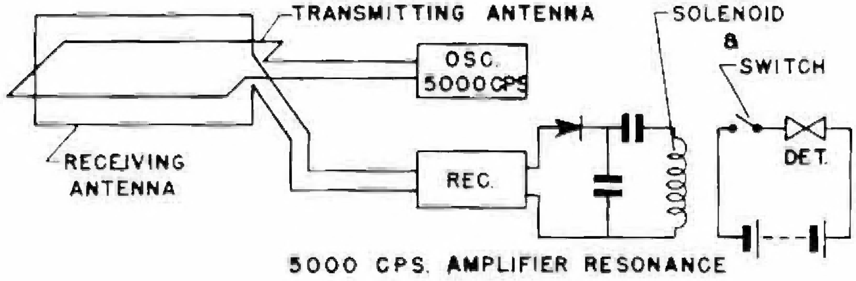


Figure 258a - Wellensonde Unit

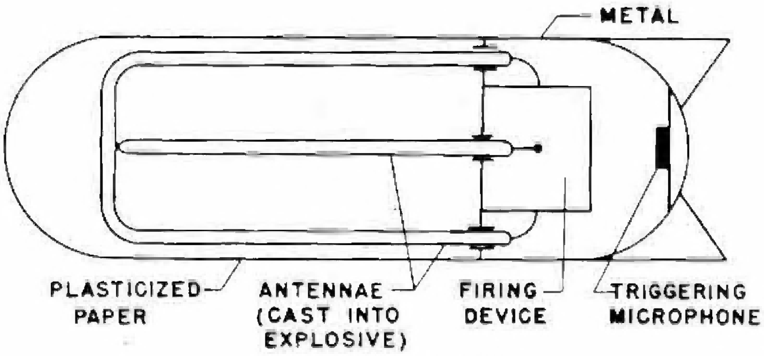


Figure 258b - Unit in LMB

Figure 258, Parts a and b - Diagram of Wellensonde Unit

ground level. In the German experiments, 24 such tubes were used to make a fairly smooth background, and the effect of a ship on such a background is shown in figure 257. It was intended to use a circuit of the type shown, using a one-tube extinguisher for each counter tube, and feeding a common rate-of-change circuit. This type of circuit was used to discriminate against tidal changes, constant small changes in cosmic ray background level, and changes caused by waves and swells.

Power Supply. The principal difficulty encountered was proper voltage regulation. A potential of 1,000 to 1,500 volts was used, and potential regulation of 0.1% was considered necessary for proper extinguishing characteristics of the counter tubes. At one time the work on this unit was nearly abandoned as a result of the "nearly insuperable difficulties" with potential regulation. There is also, of course, some difficulty in handling such a high potential in a mine case. The main effort to produce a satisfactory high-potential supply was directed to the so-called "Volta-Pillar", consisting of a great number of very thin copper and zinc plates piled up with sheets of wet paper between.

Directional Effect. While this unit was under development, one of the proposed variations was to make the unit directional. This was to be accomplished by making tubes operate in pairs, and requiring that a cosmic ray pulse operate the two tubes in a pair before it registered in the circuit. This proposal was entirely in the idea stage, and the Germans considered that it would require too many counter tubes and would unnecessarily complicate the circuit.

WELLENSONDE (WAVE SOUNDER) UNIT

One of the special developments carried on in mine-firing devices by the Germans was in the distortion caused by target vessels to high-frequency alternating-current fields. The only experimental product of this development is the so called "Wellensonde", (figure 258), a development of Dr. Hell. The "Wellensonde" is an experimental device and never reached advanced development or trials.

No specimens of, or documents relating to, the "Wellensonde" were captured; and all information contained herein has been obtained through interrogation of prisoners of war.

The "Wellensonde" (wave-sounder) creates an alternating electro-magnetic field around the mine case. When this field is distorted by the transit of a ship or other body, the mine fires. The firing unit devised consists of a transmitter, a receiver, antennae for both transmitter and receiver, and a firing circuit. The transmitter has an output of five watts at 5000 cps. Each antenna is rectangular, made of metal tubing, and 50 by 80 cm in size. The two antennae are mounted in the LMB IV mine-case and cast into the explosive. Since the antennae are mounted at right angles to each other, there is little or no mutual induction. The mine-case is made of plasticized pressed paper (pressstoff) for minimum interference with the field pattern. If the symmetry of the field produced by the transmitter is disturbed by the metal mass of a ship passing overhead, a small amount of alternating current appears in the receiver's antenna, and the firing circuit of the receiver output fires the mine.

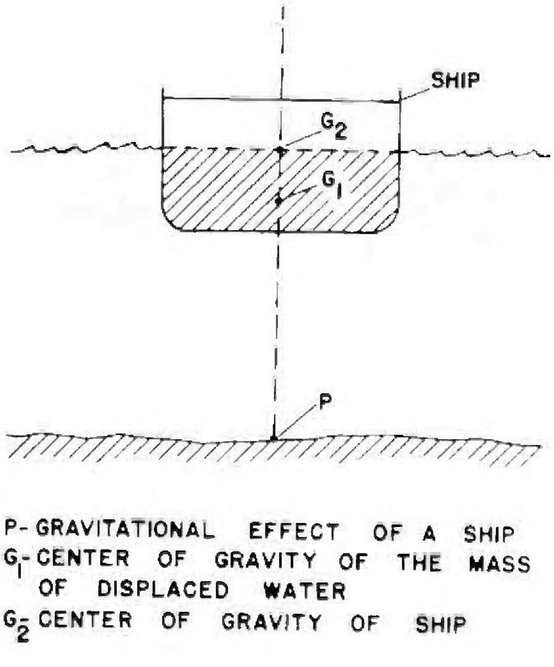
Characteristics. The distortion effect at the receiving antenna through field disturbance varies inversely with the 5th to 6th power of the distance to the disturbing force. Thus, the sensitivity is greatly dependent upon the depth of water. A change in depth of water from 65 to 72 feet will result in reduction of sensitivity by 50 per cent.

The high battery consumption of such a system makes it necessary to use a triggering system which will allow the "Wellensonde" to stabilize before the firing impulse arises. It was intended to use a simple acoustic triggering system. A few seconds are necessary for the "Wellensonde" to come to equilibrium. A high geometric and electrical symmetry of the antennae and amplifiers is necessary to make the system operate properly. However, after a long period these characteristics tend to vary somewhat, and spontaneous firing may occur after the "Wellensonde" has been repeatedly switched on. In order to avoid this, a rate-of-change circuit is used in the firing circuit to allow firing only when sudden surges occur. This principle, however, was not adopted, because of the great variation in sensitivity with depth, and was considered of no operational value in a mine.

GRAVITATION MINE UNIT

The gravitation unit (figure 259) is an experimental and not-too-successful attempt to produce a mine-firing unit which operates on changes in the gravitational effect on a mine due to the transit of a ship over the mine. It was in the idea stage, and was not developed sufficiently for production. No samples of equipment have been captured.

The gravitation unit is an idea only, worked out as a result of some calculations made by the Askania Werke in Berlin in cooperation with the Geophysical Institute at Potsdam. The gravitational effect of a ship, measured at P, is of second order. The mass of displaced water whose center of gravity is G_1 is displaced by the equal mass of the ship whose center of gravity is G_2. Because the distance $P - G_2$ is greater than $P - G_1$, there is a difference in gravitational effect at P such that a mass at P with a ship overhead has a smaller weight than the same mass without the ship overhead. This difference in gravity is very small, even when caused by a large ship; but it can be measured by high-precision apparatus of the type used in geophysical research.



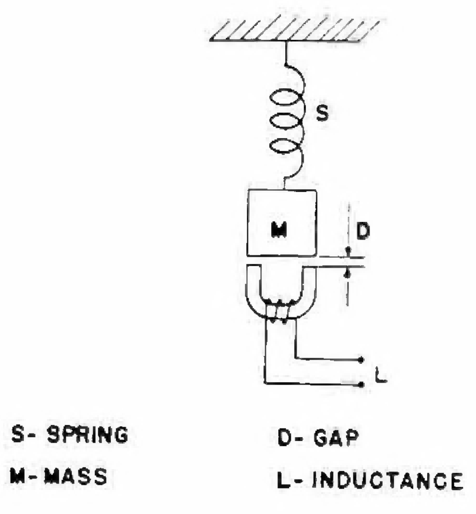


Figure 259 - Schematic Drawing of Gravitation Unit

The Mechanism. The type of mechanism visualized for this measurement is similar to the Askania gravity balance. Mass M is suspended by spring S. The small gap D between M and the core of inductance L changes

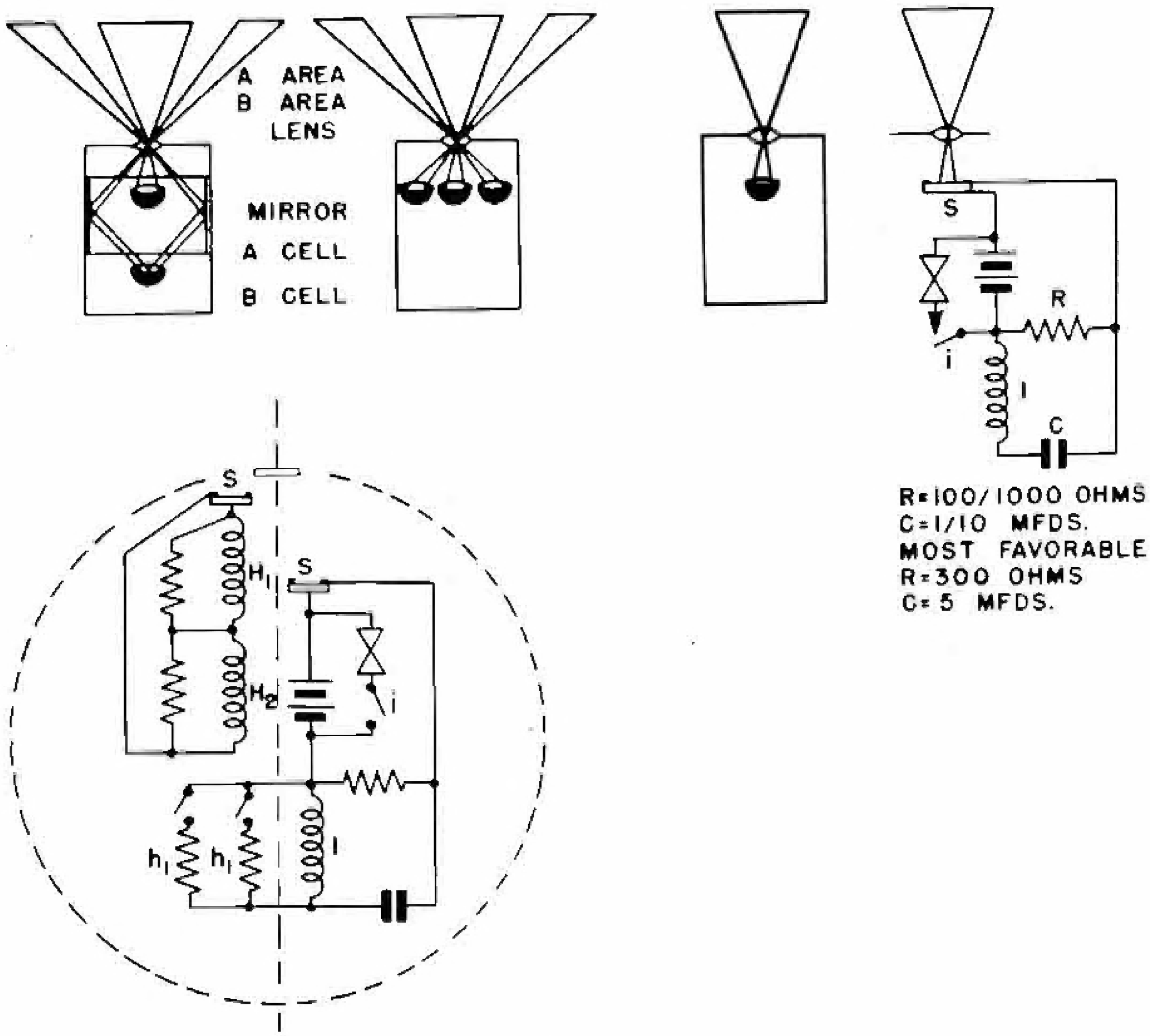


Figure 260 - Optical Mine-Firing Mechanisms

slightly when the gravitational effect around M is altered. This change in inductance can be measured by standard equipment with high accuracy. If such a mechanism were to be used operationally, some means must be provided to compensate for the temperature effect on the mass, etc. Even if a mine unit with such high precision could be produced, the whole system would be extremely sensitive to the natural vibrations of the ground, and would have to be protected against such vibrations by means yet to be devised.

ELECKTRODEN EFFEKT

During the course of World War II the Germans discovered an underwater phenomenon which they termed "Elektroden Effekt". This phenomenon refers to a modulated component of the galvanic currents which are created in water by the passage of a ship. They thereupon undertook research into the causes for such currents. At this point the German Navy became alarmed at the possibility of the Allies developing a firing device operating on this principle as a countermeasure against U-boats. To frustrate any such development, they equipped all U-boats with a short circuit between the propeller shaft and hull. Furthermore, they sought to develop a mine unit that would fire on the same principle. However, this research was never completed.

Data.

1. By placing two copper electrodes approximately 100 feet apart under water it was discovered that a ship or submarine passing over these electrodes caused an alternating current to flow. It was also found that this current could be amplified into an audible signal, even if the electrodes were placed

as far as 950 feet apart. The necessary amplification gain to create an audible signal was 10^6 to 10^7; high-gain amplifications being necessary as a result of the inefficient method of pickup.

2. The galvanic currents from various parts of U-boats were on the order of 30-40 ma. and the modulation 40 per cent. The modulation occurs only if the propeller shaft rotates; when it is at rest there is a short circuit and no alternating current component is present. The modulating effect was attributed to the varying thicknesses of oil film on the propeller shaft during rotation.

3. Experiments were carried out to determine the signatures of all classes of ships, U-boats being emphasized. Great difficulty was experienced in finding the transit point of a ship on signature curves produced. Experimental data including ship signatures are unavailable.

DEVELOPMENT OF OPTICAL MINE-FIRING MECHANISMS

The possibility of applying optical principles to mine-firing units was suggested to the Kriegsmarine by the firm of Leybold, Koln. Considering the suggestion worthy of investigation, SVK, in conjunction with Leybold, commenced its research into underwater optical conditions and developed the six test units discussed herein. All these units were designed for use in sea mines, but none were developed to an operational stage.

Luftwaffe Units. At approximately the same time the Luftwaffe E-Stelle, in conjunction with the firms of Dr. Hell, Berlin, and Hagenuck, Kiel, commenced a similar research and development designed to produce an optical unit for use in rivers against bridges. Toward the close of the war they had completed the Forelle unit, which is discussed later and which was used with some success by the Naval sabotage group (KdK).

SVK Test Model 1

Unit Construction. This model consisted of a lens made of plexi-glass mounted in the center of the upper cover of a sheet-brass cylinder closed on all sides. Directly under the lens two identically constructed photocells were installed. The inner ring surface of the cylinder was coated with silver and polished to form a mirror. The individual parts were measured and fitted so that the beams of light were directed in the following manner:

> The light from area A was projected on cell A by the lens.
>
> The light from area B was projected on cell B by the lens and mirror surfaces.

The output current from the photo-cells A and B at any intensity of 1000 lux (measured from the lens) is equalized by the use of auxiliary voltages and resistors, so that normally the differential current is zero. When the light area over one of the cells is darkened by the passage of a ship, a differential current is caused, which, after being amplified, operates a neon-tube firing relay.

Unit Batteries. The following dry-cell batteries were necessary for operating the unit:

> Two batteries of 80 volts each for the A and B cells
>
> One battery of 120 volts for the neon tube relay
>
> One battery of 120 volts for the amplifier switch
>
> One battery of four volts for heating the amplifier tubes

Difficulties with Unit. The first model presented the following difficulties:

1. Battery drain was high; and because of the large number of batteries involved, considerable space was necessary to house them. It was difficult to maintain a constant voltage at the neon tube. This was found to be necessary, since with a small reduction of voltage the differential-current was insufficient to increase the primary potential of the neon relay to a firing level. It was found that a dry-cell battery changes approximately $\frac{1}{200}$ volts per cell for each degree of Celsius temperature. To obviate the variations of voltage involved in transferring the unit from air to water, the primary voltage was, in the initial tests, controlled from shore.

2. Since the sensitivity of the photo-cells varied, the differential-current could be adjusted to zero only at certain intensities. Consequently, at all other intensities a differential current of sufficient strength to fire the mine was created by conditions other than the passage of a ship.

3. The sensitivity of the photo-electric cells proved to be too low under water. The cells used were a standard type made by the Infram Firm, Leipzig, which were more sensitive to the red-yellow band of the spectrum than to the blue-green band, which has a greater intensity in water. Since part of the light received by the B cell was transmitted by reflection, an unavoidable loss of energy resulted. Area B was too small in comparison to area A, and insufficient importance was placed on the fact that the surface brightness of the water, the length of the path through the water, the light absorption of the water, and the surface intensity on the lens surface and on the photo-electric cell surfaces are all functions of the cosine of the angle of entry. Additional difficulties were experienced

with reflection losses in the air-water areas which increase with greater angles of entry, and with the fact that, when the sun shone directly onto the photo-cells, their outputs became unequal, so that the unit would operate properly only under an overcast sky.

SVK Test Model 2

Unit Construction. This model differed from the first as follows:

1. The mirror and B cell were removed and replaced by a photo-cell in ring form installed around the A cell.

2. The cells were made more responsive to the blue-green end of the spectrum. (The manner in which this was achieved is a trade secret of the Infram Firm.)

3. The cells were selected from the total number available with a view to pairing those with the most similar sensitivities.

4. The neon-tube relay was replaced with an I relay, form C or form Fu.

5. Exposure of the ring photo-cell to the direct rays of the sun was prevented by means of a sun shade suspended on a rotatable ring made of hardened steel wire and magnetized to maintain constant orientation.

Test Results. Tests were conducted in the Ottersee with satisfactory results. (The Ottersee is approximately three miles wide and 12-1/2 miles long, and ranges up to 590 feet in depth.) The target vessel was 65 feet in length, with a 13-foot beam extended to 40 feet by means of wooden floats secured alongside. Firing was obtained at a daylight intensity of 3,000 lux (beginning evening twilight) in depths of 210 to 325 feet. Tests with the same unit at Hela on the Baltic resulted in self-firing during high seas on a sunny day.

SVK Test Model 3

Unit Construction. This model was similar to the second, except that it employed only the A cell. The current from the A cell was amplified and fed to the I relay over a condenser (in series) so that when slow changes in light intensity occurred the current flowing to the relay was too weak to operate it. On the other hand, when rapid changes occurred the relay was operated. Thus the unit depended not only on the change in light intensity, but also on the ratio of light intensity change per time unit. This change was occasioned by the fact that, since the light intensity variations caused by sea motion could not be prevented, it appeared futile to attempt to suppress the effects of all other variations in light by means of complicated differential circuits.

Test Results. Trials of the third model revealed that it would also fire under conditions of heavy seas and sunshine due to the cylindrical lens effect of wave crests. However, it was contemplated that this difficulty could be overcome by using an acoustic unit to trigger the optical one. In the course of further trials with this unit, it was found that the depth effect of the optical unit had much less significance than the translucence of the water and the water depth, since the translucence of a layer of water is a logarithmic function of its thickness.

SVK Test Model 4. This model was substantially the same as the third, except that the photo-electric cell was replaced by selenium cells and the current fed over a condenser, without amplification, to the I relay. The selenium cells had a primary potential of three volts. Tests of this model in the Baltic and North Sea were completed with satisfactory results. Firing was obtained from target ships of 1000 gross registered tons at speeds above three knots in depths up to 65 feet.

SVK Test Model 5. This model was the same as the fourth, except that the lens was eliminated. The limitation of the field of vision of the cell was determined by the size of the window opening and the distance of the cell from the window. It was found that units consisting of four or five selenium cells with a diameter of about three inches were most suitable. (Although seven cells connected in series proved more efficient, it was felt that the greater expenditure in construction was not warranted.) Tests of this model gave results similar to those conducted with the fourth model.

SVK Test Model 6. The design of this model was based on the following considerations:

1. The difference in light intensity caused by the passage of large ships (at least 1,000 tons) is greater than that caused by the motion of the sea in sunlight.

2. The sensitivity of the unit can be reduced by the addition of resistors in parallel with the I relay, so that the unit will discriminate between differences due to wave motion and the passage of ships.

3. If desired, these resistors can be switched in and out of the circuit by means of another I relay connected to a supplementary selenium cell.

A single test of this model in the Kieler Bucht gave satisfactory results in a smooth sea and sunshine. However, since further tests were not made, no further evaluation of the unit was possible.

Conclusions. As a result of the tests made with the six test models, the following conclusions were drawn:

Effective Depths. Effective depths of the unit in the North and Baltic Seas ranged from 65 to 100 feet; along the Atlantic coast (European) 100 to 165 feet; and up to 230

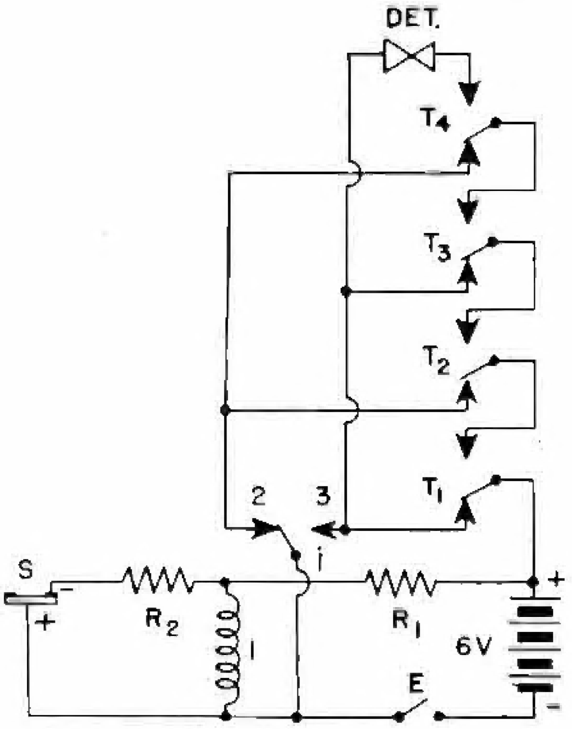


Figure 261 - Forelle Unit Circuit

feet in the Mediterranean. Muddy bays and river estuaries are not suitable for these units.

Contemplated Mine Cases. For depths up to 100 feet, the most suitable type of mine shells would be a hemispherical type similar to RMA or a type even flatter. For depths from 100 to 230 feet, a moored mine would be necessary. Since in depths over 100 feet target damage is small, it was contemplated that the moored mine would rise to the surface on actuation and then explode. The mechanism to accomplish the release of the mine was to be an explosive device coupled to the mine mooring.

Window Construction and Protection. Safety glass of 3/4 inch thickness capable of withstanding a pressure of 130 pounds per square centimeter was satisfactory for the unit window. The problem of keeping the window clear of marine growth was most difficult. A poisonous lacquer paint was tried. To prevent the paint from coming loose, the smooth surface of the window was roughened by sand. The binding material in the lacquer was slightly water-soluble to permit the paint to give off its poisons continuously, the poisons selected being arsenic and copper salts. It was found that a paint of this type would last about three months and did not impair the transparency of the window if the lacquer and the glass had the same index of refraction. A desiccator was used to prevent fogging of the window.

Luftwaffe Forelle Unit

Unit Construction. The circuit of the unit is shown in figure 261. Its optical construction was similar to that of SVK test model 4, except that a cylindrical shaft with several transverse walls was fitted to shade the unit from the direct rays of the sun. For operational use the unit was placed in a log with an explosive charge placed about 25 feet below, and floated downstream. The circuit is so designed that the unit will fire only after three looks; however, by removing the thermal switches, the required number of looks may be reduced down to one.

Unit Operation. The operation of the Forelle unit is as follows. While switch E is open, contact arm (i) of relay I moves between its mid-position and position 2 until the selenium cell S is illuminated, in which case (i) moves to position 2. After a preset time, switch E is closed by a delay clock, permitting current to flow from the battery through I and opposing the current flowing from S. Resistors R_1 and R_2 are calibrated so that a light intensity of over 300 lux incident on cell S creates sufficient current to overcome the battery-bucking current. When S is darkened by passage under a bridge (the same result would occur due to darkening by evening twilight or other shadows) the battery current overrides the S-current closing contact (i) to position 3, permitting current to flow through thermal switch T_1, which closes after a ten-second delay. After the 10 seconds, the unit should be clear of the bridge shadow, permitting the S current to override the battery current and throw contact (i) back to position 2. Current will then flow through T_2, closing contact T_2 and opening the circuit for another look. When a second look occurs, the same sequence follows through T_3 and T_4, closing contact T_4. The third look puts the battery across the detonator and the mine fires.

Designated units in this category were the S 102, S 103, S 104, and S 105. The S 102 was a passive optical unit designed for use in the Wasserballoon against bridges. It was started in the Fall of 1944 and completed that winter, and was used operationally. The S 103 was similar to the S 102, a passive optical unit with six photo-electric cells. This was started the same time as the S 102, but never completed. The S 104 and S 105 were active acoustic units with transmitter and receiver and a light-flashing component of 13 flashes per second.

INDUCTION MINE UNITS

At the time the Germans first started experiments with magnetic mines in 1923, they realized that they would never have a sufficient supply of nickel to make induction mines. Therefore, all energy was devoted to the development of dip-needle type mine units. They reasoned that, although there was nickel available, mining would take secondary priority with respect to other weapons and the aircraft industry. This is undoubtedly the reason why only needle-type mines were laid operationally in any large number. How-

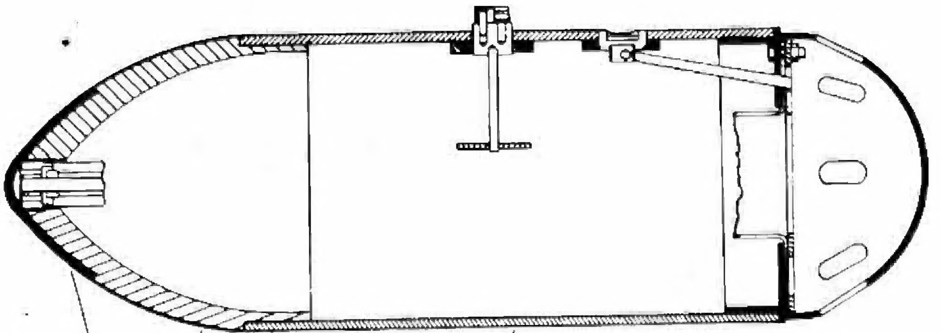


Figure 262 - BMA Cross Section

ever, when the Germans recovered the first British induction mines, they were stimulated to experimentation with similar circuits and coils. Although it appears that some 200 experimental BMA mines were laid, the nickel shortage prevented a serious induction mining effort. At some further advanced points in the war they actually intended to use British coil-rods and other British components recovered from mines dropped on land to lay against the British. This, however, never took place. There is no documentary information on induction mines; however, samples of the BMA I, II, and III and J-1 were found.

Because of the shortages of nickel, cobalt, and copper, several schemes of substitution were used. The shortage of nickel seriously impeded the production of coil-rods, and Krupp was given the job of producing coil-rods of high-permeability transformer steel, which were to be wound with aluminum windings. To overcome the loss of permeability due to nickel shortage, there was to be more than one coil-rod, to make up the loss in sensitivity. These coils were to be arranged in a circle, parallel to the axis of the mine and cast into the explosive. The cylindrical portion of the BMA case into which they were placed was to be of non-magnetic steel. Most BMA mine-cases found were fitted with tubes for two coil-rods. However, others have been found with six and some with eight. Approximately 200 such cases were manufactured, most of which were used for experiments. As a result of these unsuccessful experiments, some work was done on "amplified-induction" units, which were to be fitted to the aluminum-cased LMB mine. These experiments were not pursued exhaustively, and no satisfactory unit resulted. The circuits described below are entirely SVK developments. The Luftwaffe was more favored by the German High Command and was allocated a small amount of nickel for induction-mine production. Two induction combination units were completely developed and ready for production at the end of the war in Europe. These were the AJ (D) 102, developed by Dr. Ing. Rudolf Hell, and the JDA 105, developed by Dr. Werner of A.E.G.

BMA II. The BMA II mine was designed for laying without parachute from an altitude of 8,000 ft., or from S-boats. The induction coils were wound with aluminum wire, and the resistance of one coil was approximately 15 Ohms. The self-inductance of the coil-system is 25 Henry. Each coil-rod was covered with rubber (Oppanol), and the main charge poured into the mine-case around it. The BMA II mine case is very similar in design to the BM 1000 I.

BMA III. The BMA III mine was similar in design to the BMA II, except that it was an experimental one-coil mine (mounted on the axis) with nickel specially allocated for the work. The mine was designed to be laid safely from an altitude of 10,000 feet. The coil was wound with copper wire on a Mu-metal core 60 inches long and one inch in diameter. The sensitivity of this system was 5 to 10 mg. as opposed to approx. 25 mg. for the BMA II. However, because of a shortage of materials, the development was stopped.

J I. The J I unit is an attempt to copy one of the simple British systems. It is a one-look, random-direction device, with a 12-place F.D.M. and detonation-protection. It may be fitted to the BMA II or BMA III mines and consists simply of the necessary induction coil, a sensitive relay, 12-place F.D.M., UES (hydrostatic clock), a vibration-actuated anti-countermining switch, and resistors and a condenser. When the hydrostatic clock runs off, three switches are closed and the circuit is fully armed. If the induction coil detects a magnetic signal, it energizes the coil of the relay through two resistors. When the relay closes contact, the battery produces a self-holding current for the relay. The ZK II mechanism is actuated and runs off, during which process the holding current is broken before the cycle is complete. When the ZK II switches over, it switches in the detonator and the protection circuit. A final firing actuation will produce a large surge through the detonator to charge the main condenser. The mine then fires. If a detonation occurs when the ZK II has switched over to put the detonator into the circuit, the result is that a vibration-switch makes contact before the relay can close. Closing of the vibration switch immediately charges the main condenser fully, so that, when the relay makes contact, the resultant surge through the detonator to charge the main condenser is too weak to fire the detonator and self-holding of the relay does not take place. It is reported that this blocking condition lasts for approximately one minute.

JV. The JV is an attempt to develop an amplified induction mine unit. JV = Jnduktion Verstarker (Induction Amplifier). This was attempted purely as a result of the shortage of critical materials, nickel and copper. Two types were experimented with. One was a plain induction unit for use in the LMB mine, and the other for use in combination with a unit component operating on another influence in the LMB mine. The coil was wound on a soft-iron core one inch in diameter and 24 inches long, and consisted of two coils in series totalling 60,000 turns of 0.03-mm copper wire. In the JV unit the medium and high frequencies are by-passed by an additional unit. The circuit is designed to respond only to very low frequencies, (approximately 1/30 to 1/50 cps.). Some experimentation was also carried on with a similar three-stage amplifier, arranged in such a way that, after the induction system had been amplified and operated, it would be switched out and the amplifier used as a low-frequency amplifier ("Klotz-verstarker") for a low-frequency detector. Development work on this system was stopped, as it was considered too difficult a problem to work out a satisfactory protection system against nearby detonations.

CHARACTERISTICS OF INFLUENCE MINE UNITS - NAVY

	M 1	M 3	A 1	A 1st
Sea-bottom conditions			Sensitivity reduced by soft, sticky mud.	
Ocean swells in shallow water	If ground hard - pendulum oscillation may run down battery.	Detonation possible		
Burying of mine in soft ground due to current		Detonation possible	Becomes less sensitive	
Shifting of bottom due to currents	Pendulum oscillation may run down battery.	Detonation possible	In strong currents detonations may result.	
Movement of mine on hard bottom due to currents	Pendulum oscillation may run down battery.	Detonation possible	Detonation possible	
Magnetic disturbances	From 0° to 60° latitudes chances of firing less than once per year. In higher latitudes, chances greater.			
Index numbers showing greatest depth efficiency (0- to greatest efficiency)	4	5	2	6 or 0
Target accuracy	good	good	inaccurate	uncertain
Estimated life	2 years	2 years	6 months	6 months
Ship speeds			moderately dependent	

Figure 263 - Characteristics of

CHARACTERISTICS OF INFLUENCE MINE UNITS - NAVY

MA 1, 2, and 3	AA 1	AA 2	DM 1
	In the ooze and mud of harbors or in soft ground may lose sensitivity and be sweepable within a radius of 500 ft.		
If ground hard, pendulum oscilla-tion may run down battery.			Possibility of use limited. Pendulum action same as in M 1.
	Subsequent tumbling of mines stuck in bottom may cause detonation		
Pendulum oscilla-tion may run down battery.	Same as A 1		Same as MA 1
Pendulum oscilla-tion may run down battery.	Same as A 1		Same as MA 1
From 0°-30° latitudes firing chances less than once per year. 30°-60° up to twice. Over 60° up to 12.			Same as MA 1
3	1	0	3
good	good		good
6-12 months	6 months		6-12 months
slightly independent	slightly independent		strongly dependent

SWEEPING CHARACTERISTICS OF INFLUENCE MINE UNITS - NAVY

Unit	Response to Ships		Response to Sweeps		Aircraft Sweeps	
	With GB	Without GB	LL Astern GB at Bow	Detonator Sweeps	Magnetic	Acoustic
M 1			Sweepable		Sweepable	
M 3			Sweepable		Sweepable	
A 2st	Danger	No danger	Explodes close to ship	Sweepable		Sweepable
A 4st	Danger	No danger	Explodes under ship	Generally no result		
A 4		Danger	Generally no result	Generally no result		
AT 2	Danger	Danger	Sweepable only with low frequency GB	Sweepable		
MA 1	Little danger	Danger	Sweepable		Sweepable	Sweepable
MA 1st	Danger	No danger			Sweepable	Sweepable
MA 2	No danger	Danger	Usually unsweepable		Sweeping possible	
MA 3	No danger	Danger	Usually unsweepable		Sweeping possible	
MA lar	Danger	Danger	Usually unsweepable		Sweepable	Sweepable
DM 1	Danger	Danger	Swell sweeping or sweeping when long waves present; both possible			

Figure 264 - Sweeping Characteristics of Influence Mines

CLOCKS AND ASSOCIATED DEVICES

INTRODUCTION

The clocks and associated devices described herein operate on one of the following principles; electrical, mechanical, electrolytic, or electro-mechanical combination. These devices are used separately or in combination in ground influence, moored influence, moored contact, or drifting contact mines. The following mechanisms are described: Arming clocks, disarming clocks, sterilizers, on-off arming-disarming clocks, scuttling clocks, and period delay mechanisms.

ARMING CLOCKS

UES I. The UES I (original model - with soluble washer; revised model - without soluble washer) was the first hydrostatic arming clock used in German sea mines. To operate properly, this clock requires constant hydrostatic pressure in depths of 17 feet or more; after a continuous run of 20 to 30 minutes the mine is armed. This clock was replaced by the UES II.

UES II. The UES II is a hydrostatically operated clock requiring an initial pressure equal to 17 feet for starting; however, it will continue to run even if pressure is removed. This clock can be set to arm the mine at any time from a half hour to six hours, in 15-minute intervals, or from a half day to six days at six-hour intervals. The purpose of this clock is to delay the switching-in of the detonator into the mine circuit to prevent premature firing until the mine unit has properly oriented itself.

UES IIa. The UES IIa is the same in all respects as the UES II, except that it requires constant pressure for continuous running.

CLOCK STARTER PLATE. The clock starter plate for the UES II and UES IIa can accommodate the LiS (anti-recovery switch) and/or the Vorkontakt (intermediate contact).

UES II AND UES IIa WITH LiS. The LiS is an anti-recovery switch used with the UES II and UES IIa. The preset time of the UES must run off for the LiS to operate. After normal operation of the clock, if the mine is removed to a depth of less than 17 feet, the mine will explode.

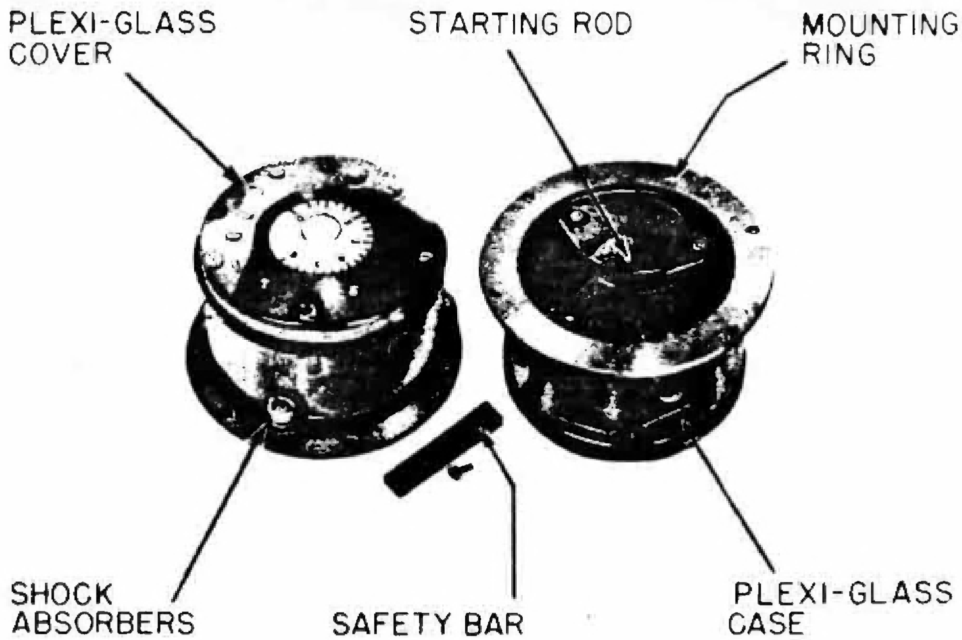
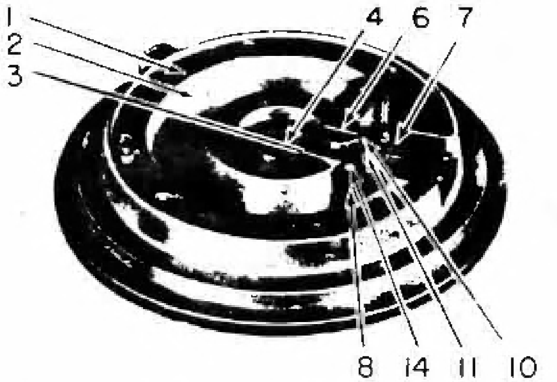
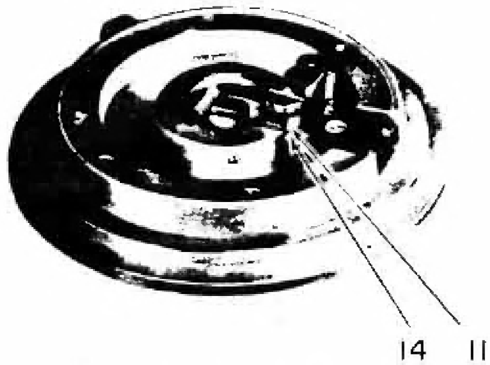


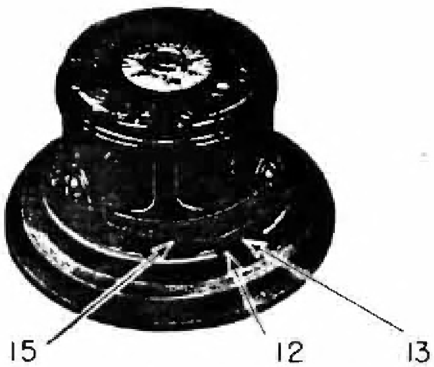
Figure 265 - UES II and UES IIa



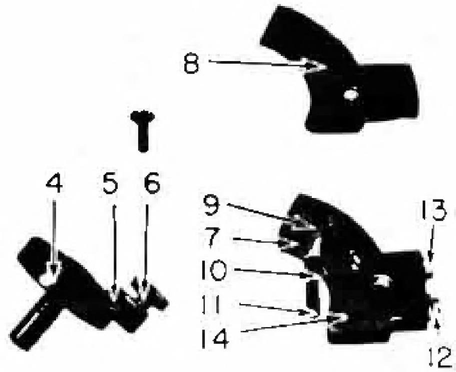
CLOCK STARTER PLATES SHOWING THE LIS IN THE UNARMED POSITION



CLOCK STARTER PLATE SHOWING THE LIS IN THE ARMED POSITION



U.E.S. II OR IIA SHOWING THE TERMINAL BOARD FOR THE LIS



LIS COMPONENTS

1) CLOCK STARTER PLATE
2) ANNULAR GROOVE
3) RADIAL GROOVE
4) HYDROSTATIC PISTON
5) CARRIER BLOCK FOR SWITCHING SCREW 6
6) SWITCHING SCREW
7) CONTACT PLATE
8) INSULATION PLATE
9) LEVER
10) CONTACT SPRING
11) SPRING CONTACT
12) CLAMPING SCREW
13) CLAMPING SCREW
14) CONTACT
15) LEAD WIRE

Figure 266 - The Lis

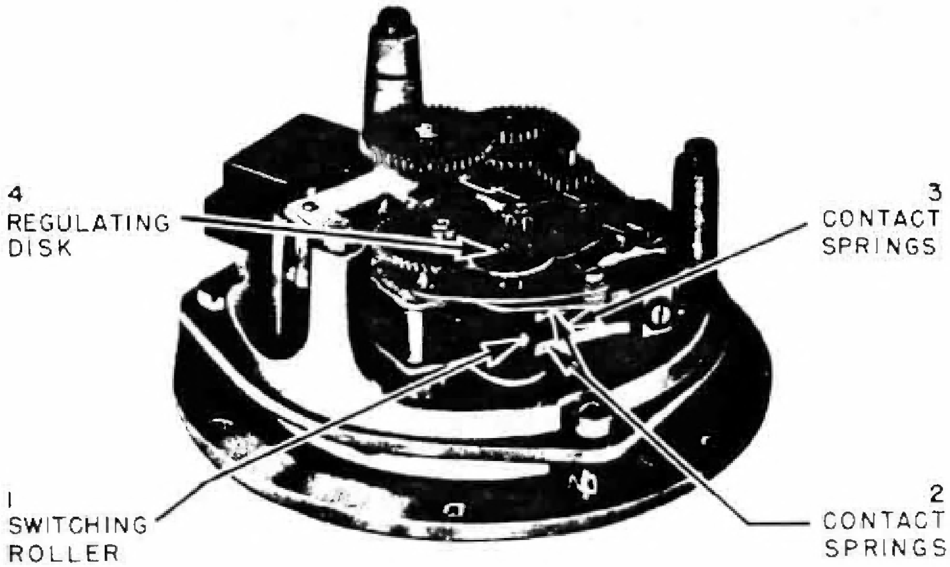


Figure 267 - UES II/IIa

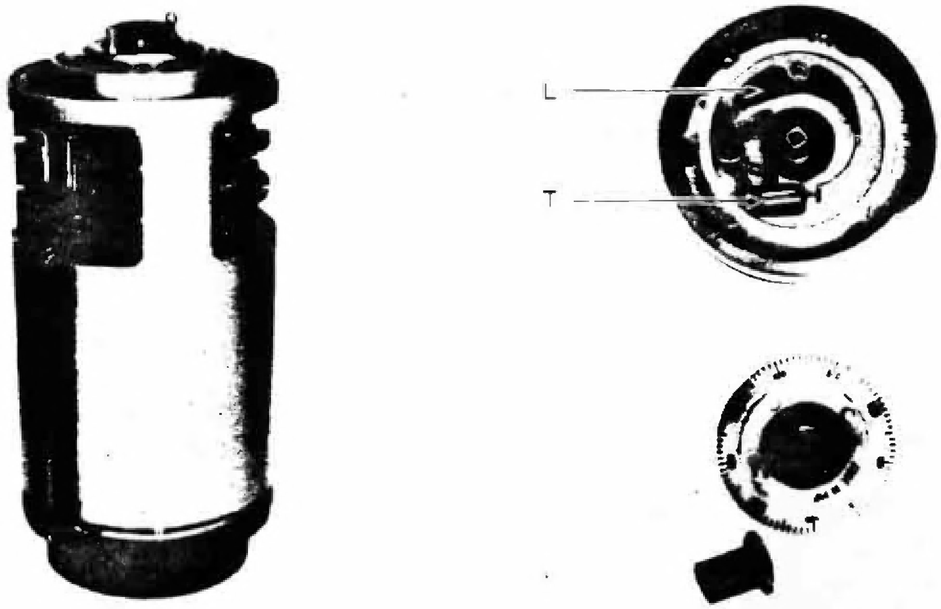
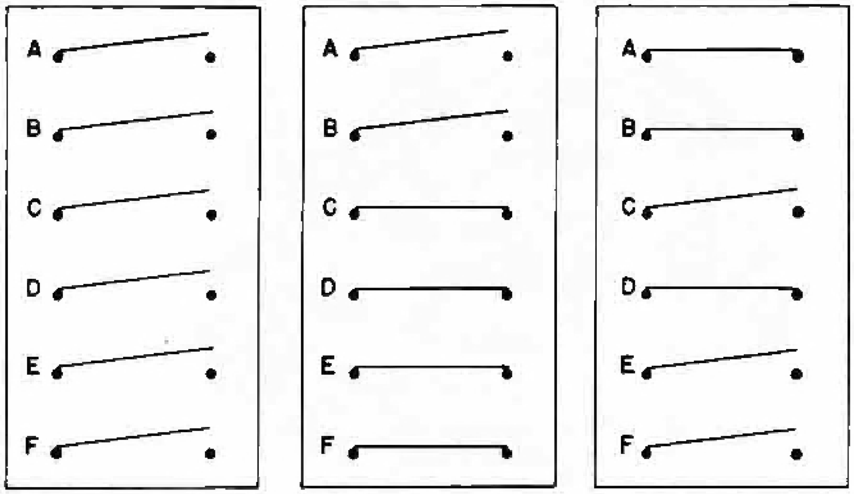


Figure 268 - ZE I

Operation (Figure 266). Before pressure has been applied to the clock contact arm 10, housing contact 11 is held off contact 14 by retaining screw 6. When the mine reaches a depth of 17 feet, hydrostatic pressure forces 6, which is attached to hydrostatic piston 4, upward, allowing spring-loaded lever 9 to move over and against the switching screw. Under normal operating conditions contacts 11 and 14 remain open. A reduction of water pressure of between eight inches and six feet causes screw 6 to force spring lever 9 downward, closing contacts 11 and 14 and firing the mine.

UES II and UES IIa with Vorkontakt. The Vorkontakt is an intermediate switch which is closed 15 to 20 minutes after the UES has started. Its purpose is to switch in the anti-recovery switch (LiS) and any other scuttling charges incorporated in the mine.

POSITION OF SWITCHES DURING VARIOUS STAGES OF OPERATION OF THE Z.E.I



POSITION OF SWITCHES BEFORE THE Z.E.I HAS STARTED	POSITION OF SWITCHES 40 TO 50 MIN. AFTER THE Z.E.I HAS STARTED	POSITION OF SWITCHES AFTER THE Z.E.I HAS RUN OFF

Figure 269 - Operation of ZE I

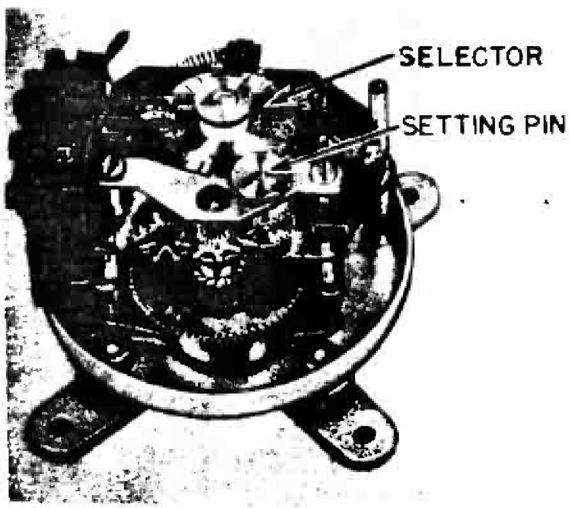


Figure 270 - ZE II

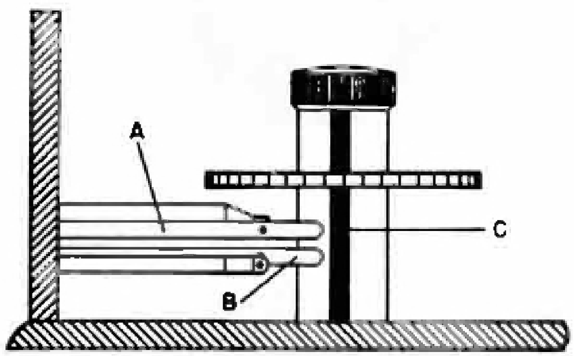


Figure 271 - Switch Roller for ZE II

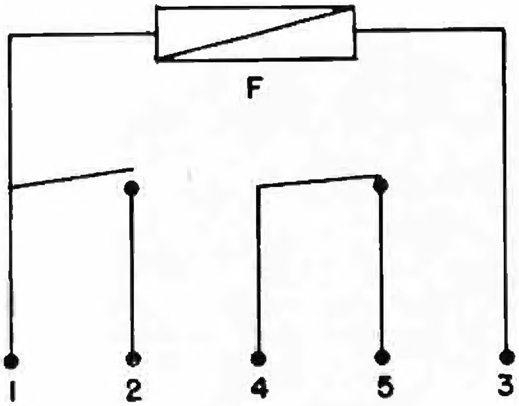


Figure 272 - ZE II Wiring Diagram

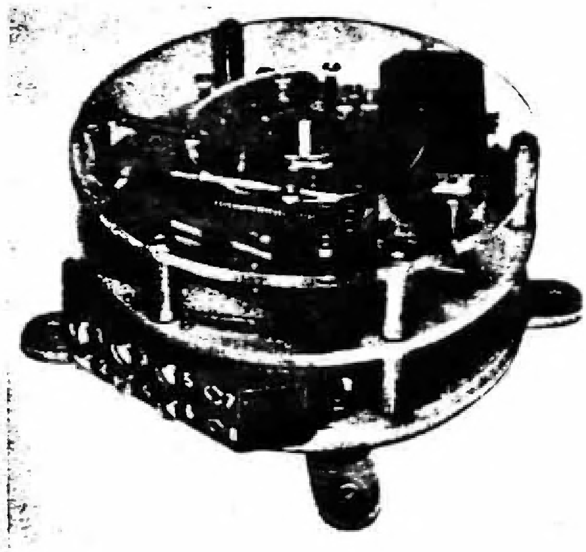


Figure 274 - ZE III

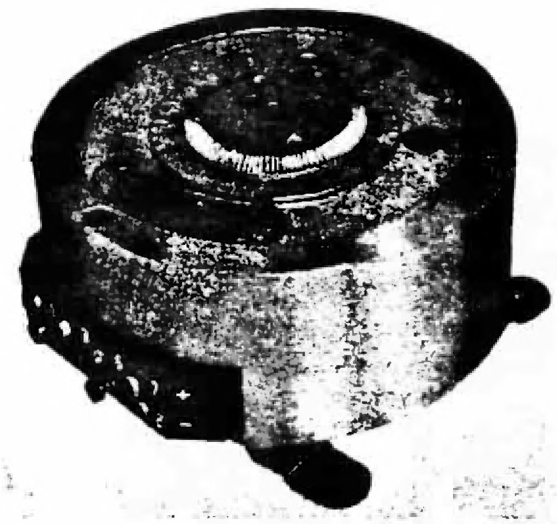


Figure 273 - ZE III

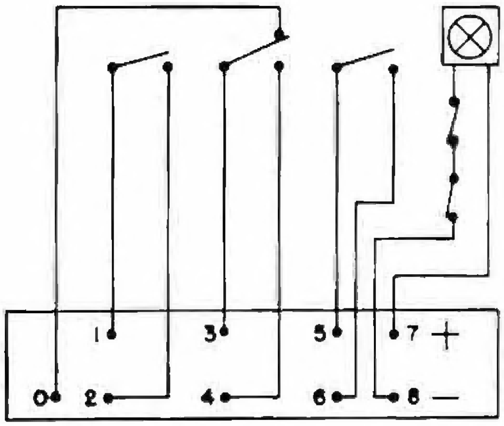


Figure 275 - ZE III Switches before the UES has run off

Operation. The Vorkontakt, in either the UES II or UES IIa, is a double-pole switch consisting of two sets of leaf springs held apart by a grooved roller, 1, figure 267. One set of leaf springs, 3, fits into the groove on the roller which is geared to the clockwork mechanism. Rotation of the roller in a clockwise direction causes leaf springs 2 and 3 to make contact and switch in the LIS.

STERILIZERS (ZEIT EINRICHTUNGEN)

All Zeit Einrichtungen, with the exception of the ZE IVb, are used exclusively as sterilizers. Although the ZE IVb is a sterilizer, it was used as an anchor-release clock for the SMC mine anchor, and in this case was designated NU II.

ZE. The ZE and ZE I were developed simultaneously, but the ZE was abandoned in favor of the ZE I.

ZE I. The ZE I is a spring-driven 80-day mechanical sterilizing clock used in the EMC, EMD, EMF, SMA, TMA, and TMB mines.

Operation. Closure of UES contacts allows current to flow through solder plug T of the ZE I, figure 268. When T melts, it releases clock-starting lever L. 40 to 50 minutes after the ZE I starts, switches C, D, E, and F are closed. C and D put the clock safety feature into the circuit; E and F switch the detonator into the circuit and make the mine ready for normal firing. At the end of the preset period, contacts C, E and F open and A and B close. A and B put the battery across the flooder detonator, and the resulting explosion scuttles the mines.(Figure 269).

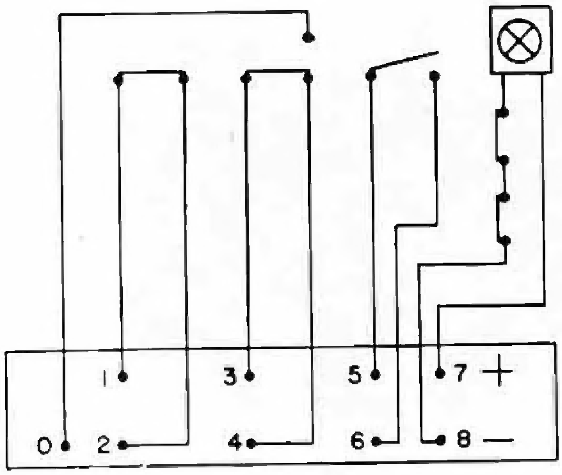


Figure 276 - ZE III Switches 10 to 15 seconds after ZF Starts

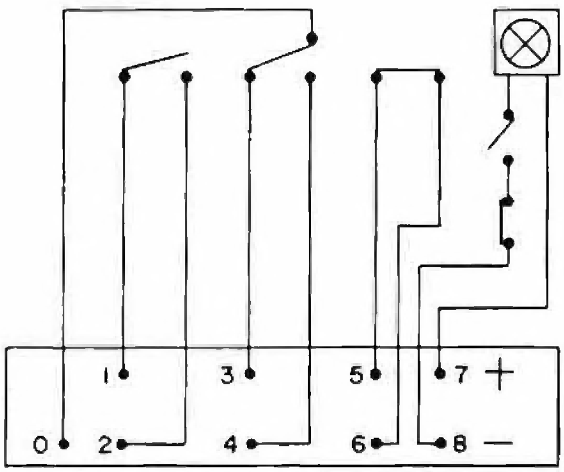


Figure 277 - ZE III Switches after Run-off of Pre-Set Time

ZE II. The ZE II is a spring-driven mechanical sterilizing clock that can be set from one to six days at six-hour intervals. On the ZE II, the UES is connected across terminals 1 and 3; the battery is connected across 1 and 2; and the mine unit is connected across 4 and 5. When the UES has concluded its run, a potential is applied across 1 and 3, blowing fuse F, and freeing the escapement to start the ZE II. At the completion of the ZE II run, leaf springs A and B slide into groove C, figure 271; contacts 1 and 2 close, shorting out the battery; and contacts 4 and 5 open, opening the firing circuit. (figure 272)

ZE III. The ZE III has the same function as the ZE I, but is designed primarily for the LMB mine, which cannot accomodate the ZE I. It is a 200-day clock driven by two small springs wound by a small 9-volt motor.

Figure 278 - ZE III for 360 Days

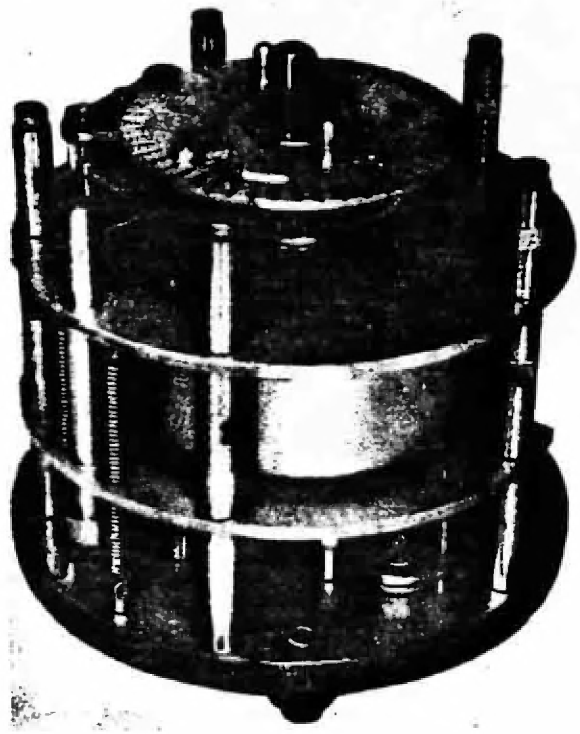


Figure 279 - ZE IV

The clock consists of three main parts; the winding system, the clockwork and switches, and the safety mechanism. This clock can be set from 45 to 200 days by turning the setting dial clockwise past zero to the desired position. Termination of the UES run connects a 9-12-volt battery across terminals 7 and 8, starting the clock motor. After a run of 10 to 15 seconds, contacts 1-2 and 3-4 close, and the motor continues to run for 40 to 50 seconds until both springs are wound. The safety spring winder, which is driven by a notched disc, automatically cuts off the motor current for 30 minutes when initial winding is completed. After a delay of 30 minutes, the motor starts, again rewinding the springs. This process continues until the ZE III reaches its preset period, at which time contacts 1-2, 3-4, and 7-8 are opened and contacts 1-3, and 5-6 close.

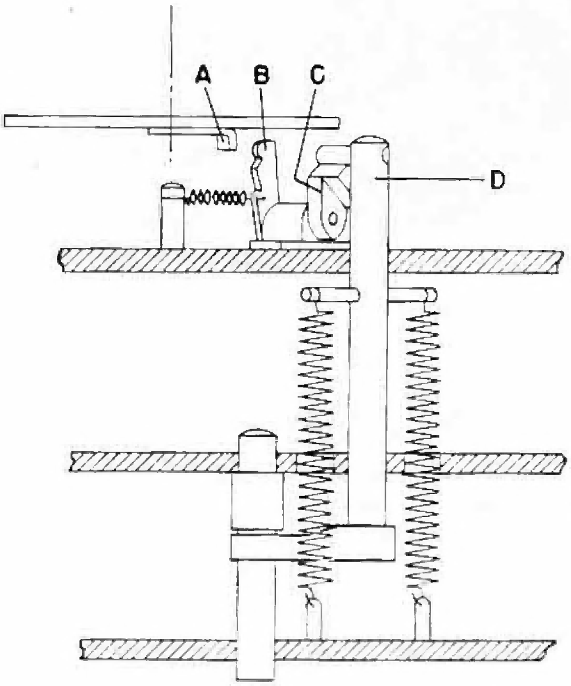


Figure 280 - Diagram of ZE IV

If a mechanical failure occurs after the clock starts, the independent safety system operates. From [illegible] to [illegible] minutes after the failure, all contacts are made in the same manner [illegible] the clock had completed its [illegible]

ZE III for 360 Days. This clock, figure 278, is similar to the ZE III, except it was designed for 360 days. It was under development at the close of the war, and the only specimen available is a laboratory model.

ZE IV. The ZE IV is a 45-day mechanical, spring-driven, sterilizing clock designed for use in the OMA mine. The clock is set by rotating the dial counterclockwise to the desired period opposite the red arrow. At the end of the clock's run, lug A, figure 280, trips spring-retained rocker arm B, which rotates lever cam C, releasing spring-loaded striker D. This clock was not used operationally because the time period was considered too short.

Figure 281 - ZE IVa for OMA Mine

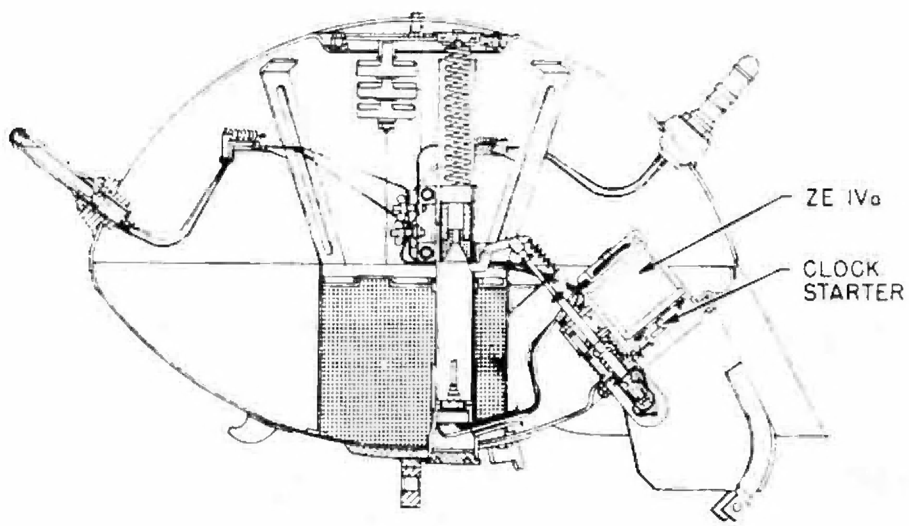


Figure 282 - OMA/K Mine with ZE IVa

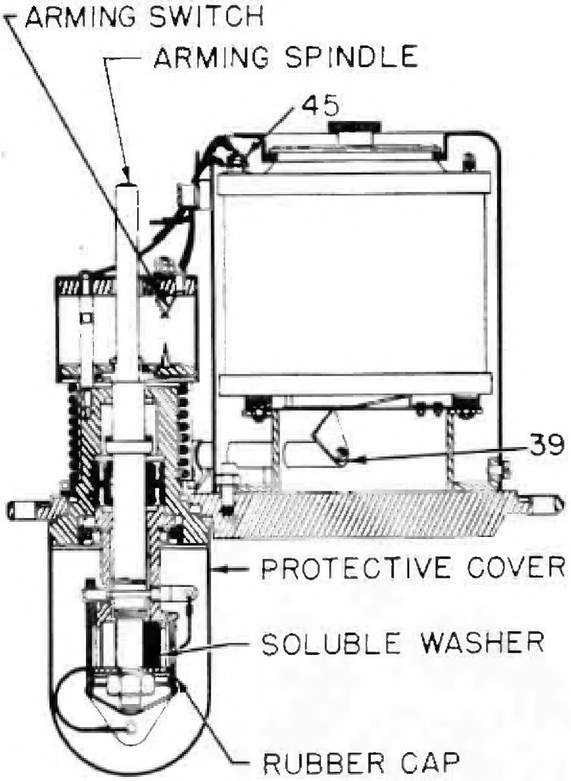


Figure 283 - Diagram of ZE IVa

Figure 285 - ZE VI

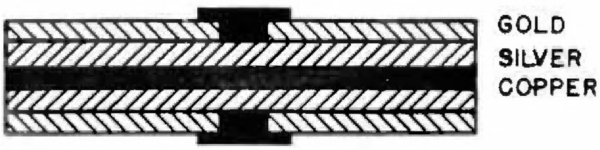


Figure 286 - ZE VI Electrode

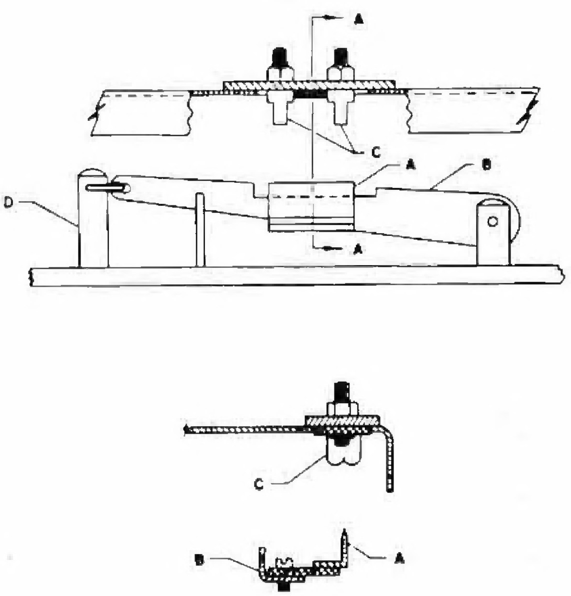


Figure 284 - ZE IVa, Section A - A

ZE IVa. The ZE IVa is a 60-day sterilizer developed to replace the ZE IV, and it operates on the same principle. When the ZE IVa is used in the OMA mine, the detonator is connected across terminals 45, figure 283 The clock is started by cam 39. At the end of its run, striker D, figure 284, is released in the same manner as in the ZE IV, disengaging the knife switch A and opening the detonator circuit, thereby disarming the mine.

ZE V. The ZE V was an electrolytic sterilizer abandoned and superseded by the ZE VI.

ZE VI. The ZE VI is an electrolytic 200-day cadmium cell sterilizer. The cell consists of a silver-plated fine copper wire. The silver plating is covered with a thin layer of gold, except for one minute spot. Enough copper to initiate galvanic action, but to delay action on the silver plate, is deposited on this spot. When the ZE is switched on, electrolytic action takes place. The small particle of copper on the gold plate is attacked first; next the silver plating is expended, and finally, when the copper wire is consumed on the 200th day, a spring-loaded switch is released, shorting out the battery and sterilizing the mine.

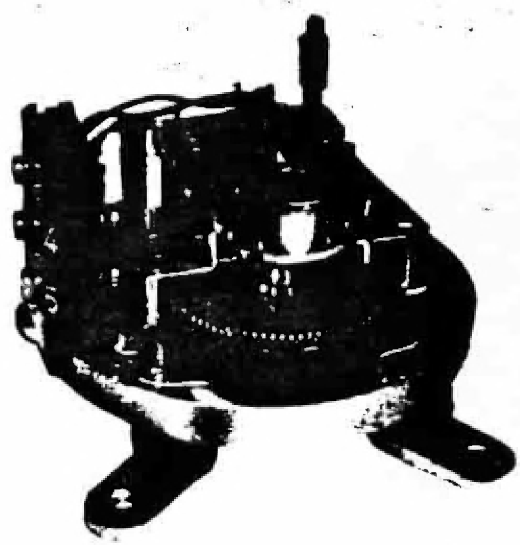


Figure 287 - ZK II

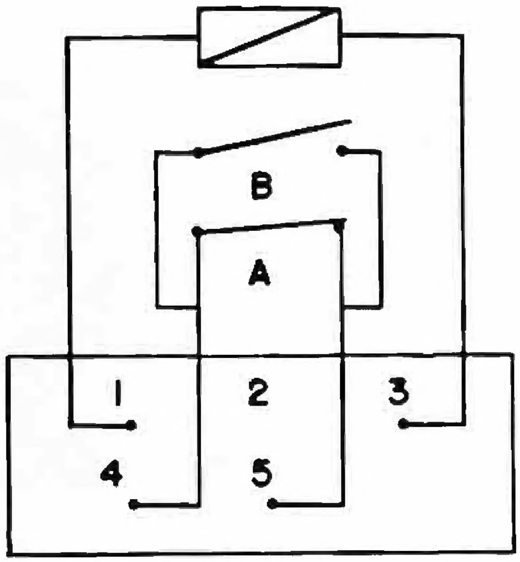


Figure 288 - ZK IIe, Switches

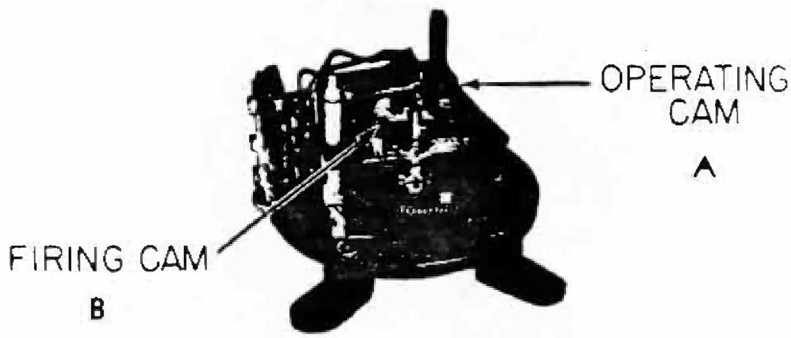


Figure 289 - ZK IIe

PERIOD DELAY MECHANISMS (ZAHL KONTAKT)

All German period delay mechanisms are spring-driven clockwork systems whose escapements are released by electromagnets. However, the mine-firing unit must be activated before the escapement electromagnet of the period delay mechanism can be energized.

ZK I. The ZK I is a mechanical six-place period delay mechanism whose electromagnet operates at 8 to 12 volts and 0.2 ampere. The time for the completion of one step-up cycle after actuation is approximately 40 seconds. The ZK I was developed for the M 1 mine unit and was replaced by the improved ZK II.

ZK II. The ZK II is a mechanical 12-place period delay mechanism whose electromagnet operates at 8 to 12 volts and 0.2 ampere. The time interval for the completion of one step-up cycle after actuation is two minutes. The ZK II was used with the M 1, A 1, A 4 and MA 2/3 mine units. In the MA 2/3 it was designed to operate after the magnetic actuation.

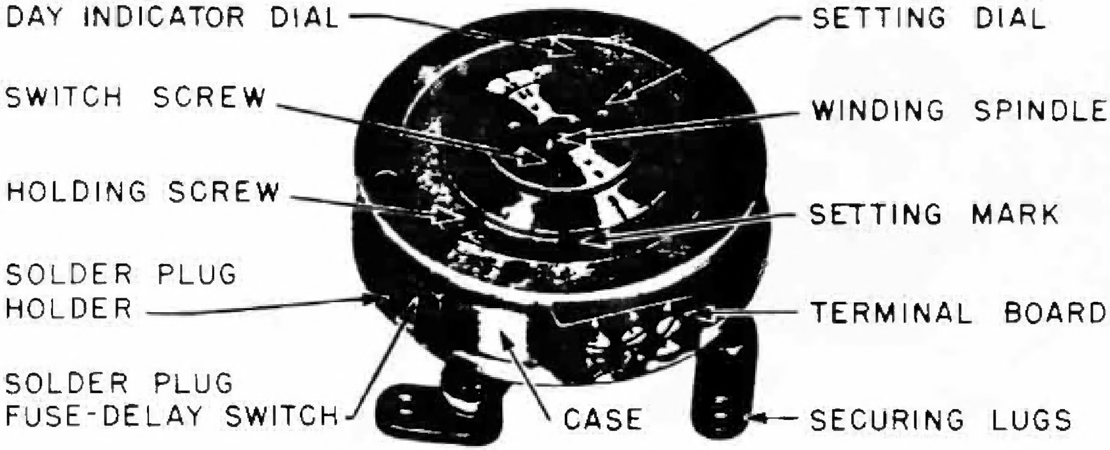
ZK IIa. The ZK IIa is the same as the ZK II, except that the time interval is increased from two minutes to four minutes.

ZK IIb. The ZK IIb is the same as the ZK II, except that the electromagnet operates off the microphone battery at three to four volts and 0.5 ampere. This clockwork was used with the AT 1 and AT 2 mine units.

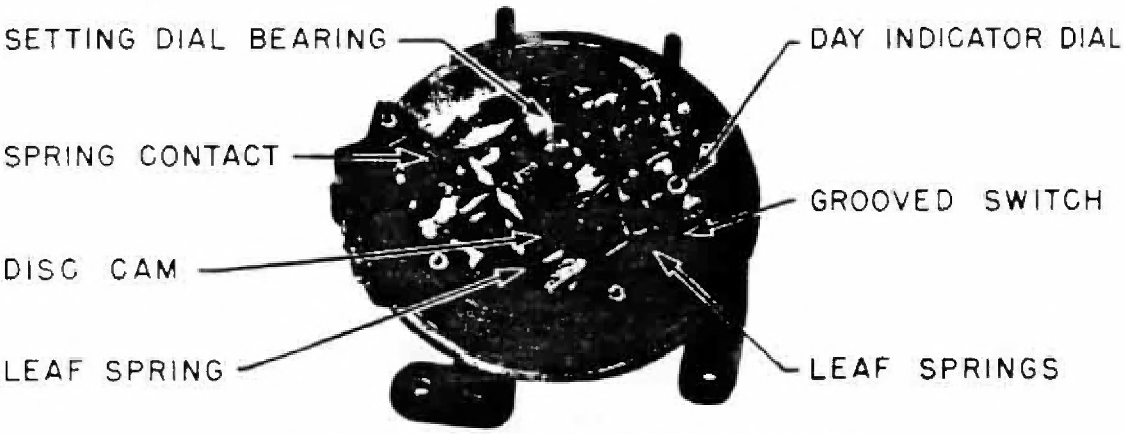
ZK IIc. The ZK IIc is the same as the ZK II, but is designed to operate on a very short electrical impulse. This modification enables the ZK IIc to be used with the MA 2/3 mine units and to operate after the magnetic and acoustic systems have been activated.

ZK IId. This device was under development at the close of the war, and no information is available.

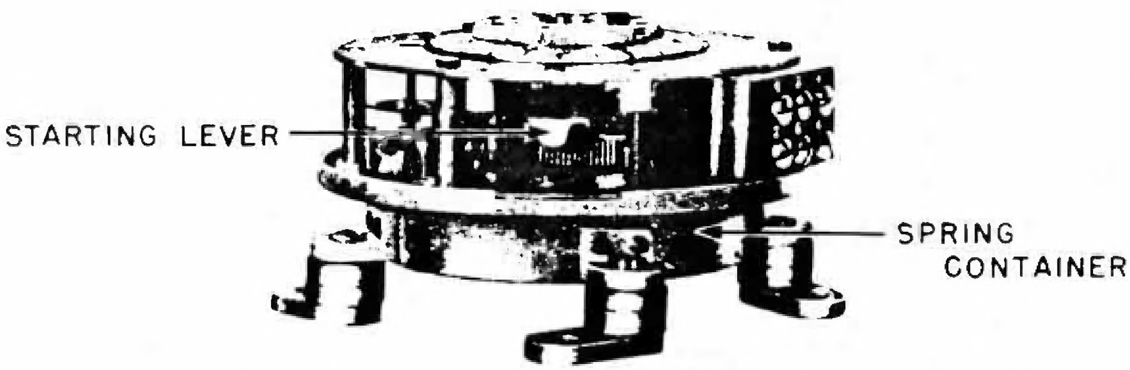
ZK IIe. The ZK IIe (figures 288, 289) is a specially modified period delay mechanism used with the MA 1st Mine unit. It is



PAUSENUHR



PAUSENUHR CLOCK WORK



PAUSENUHR, SHOWING STARTING LEVER

Figure 290 - Pausenuhr, Three Views

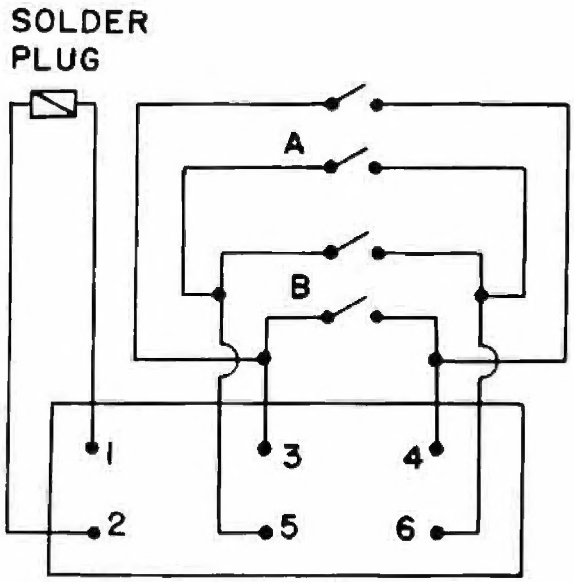


Figure 291 - Pausenuhr Wiring Diagram

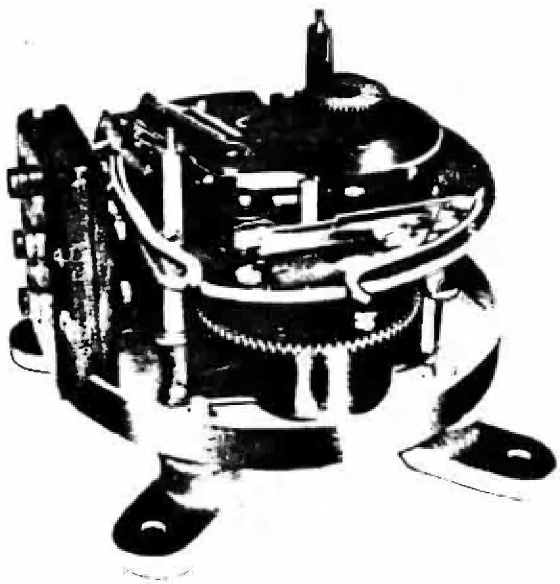


Figure 292 - VK II

operated by the Magnetic system of the MA 1st. A magnetic actuation starts the ZK, and after 15 seconds, cam A opens the normally closed switch A for approximately 2 minutes. If a proper acoustic actuation does not occur in the 15-second interval, the mine will not fire because switch A re-opens, de-energizing the acoustic component. After 84 such actuations cam B closes switch B permanently, putting the acoustic system in the circuit.

ZK IIf. The ZK IIf is the same as the ZK II, except that the time interval is decreased from two minutes to five seconds.

MISCELLANEOUS CLOCKWORK MECHANISMS

Pausenuhr (Arming and Disarming Clock). The Pausenuhr is an 15 day electrically driven on-off clock developed to arm and disarm a mine once every 24 hours. Settings are made in multiples of three hours for a 24-hour cycle; example: 3 hours on, 21 hours off, 6 hours on, 18 hours off, etc.

The Pausenuhr was designed for use with the UES in the EM, LM, RM, SM, TM, and MT mine series.

Operation. When the UES has concluded its run, a potential is applied across the terminals shown in figure 290, upper portion , allowing current to flow through the solder plug, Figure 290, upper portion, which melts, releasing the starting lever. After the clock has run for two hours, the star switch is moved by a pin on the bottom of the setting dial bearing. The step-up of the star switch arms the mine for the preset period. The switch screw turns the star switch, opening switch A, figure 291, and disarming the mine for the remainder of the 24 hours. This process is repeated for 18 days, at the end of which time the grooved switch roller, driven by clockwork accepts a leaf spring to close switch B, figure 291, thereby permanently arming the mine.

Setting. The switching screw is removed and the setting dial is turned 369 degrees counterclockwise to the zero position. One of seven possible delays is selected, and the screw is replaced.

Entscharfer Werke (EW) (Disarming Clock). The EW is a 12-hour test clock used in the EMF, LMF, and SMA mines. This clock consists of the standard spring-driven German clockwork mechanism driving a rotary contactor shaft. The unit is designed to close electrical contacts.

The setting is entered manually by positioning an indicator disk fitted to the top surface of the clockwork assembly. The disk is graduated in azimuth from one to eleven in increments of 0.5 and moves against a fixed index.

The contacts of the six contact terminal board are wired in series with the contacts located on the rotary contactor shaft.

Verzogerungs Kontakt (VK) (Delay Contact) The VK, figures 292, 293, is a spring-driven clockwork that runs for 38 seconds. It is used with the M 1 mine unit and is designed to prevent the mine from firing unless the magnetic influence persists at the end of its preset time.

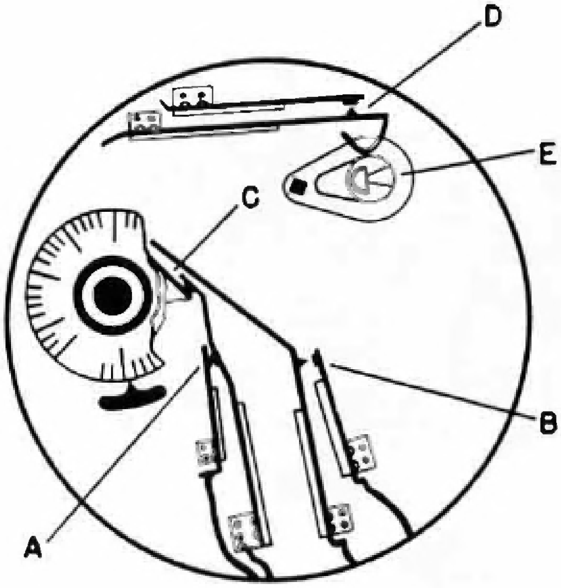


Figure 293 - VK II, Diagram

Operation. The setting dial is set to the desired number of seconds. When the M 1 mine unit is actuated, it causes the clock solenoid to operate, thus starting the clock. One second before the end of the preset time, Cam C (figure 293) opens switch A, which opens the hold-on circuit for about one second. When the hold-on circuit is opened, the needle will come off the firing contacts. However, if magnetic influence is present at the end of the preset time, C will close the firing circuit and fire the mine. If the mine does not fire after approximately 80 actuations of the VK, switch D closes cam E, thus arming the mine permanently, allowing it to fire normally.

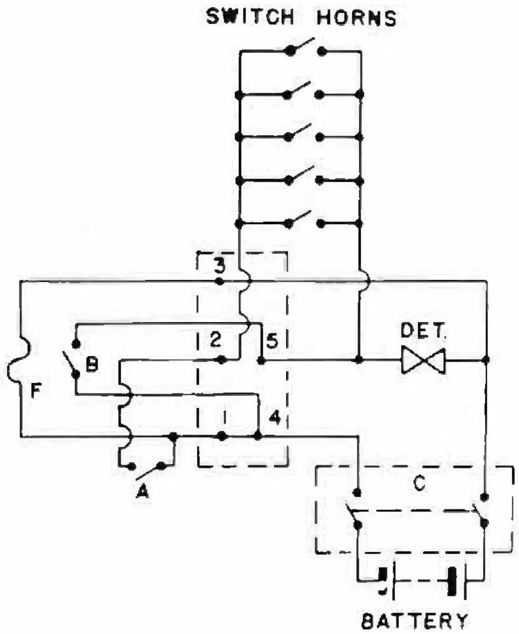


Figure 295 - VW in EMS Mine Circuit

Verzogerung Werke (VW) (Delay Clock). The VW is a spring-wound six-day scuttling clock used in the EMS mine. It can be set from six hours to six days by intervals of six hours. Figure 294.

Operation. A soluble washer in switch C, figure 295, dissolves, allowing a potential to be applied across terminals 1 and 3, which blows fuse F and starts the clock. After the clock runs for approximately 10 minutes, arming switch A closes and the mine is armed. At the end of the preset time, scuttling switch B closes, placing the detonator across the battery to destroy the mine.

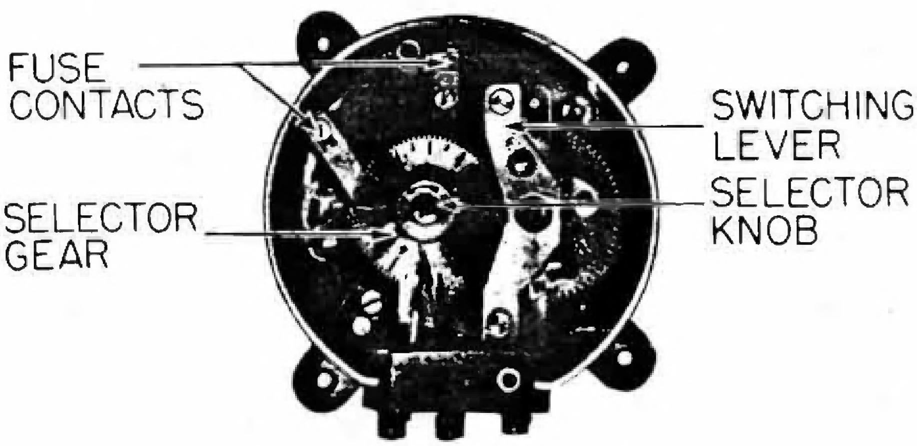
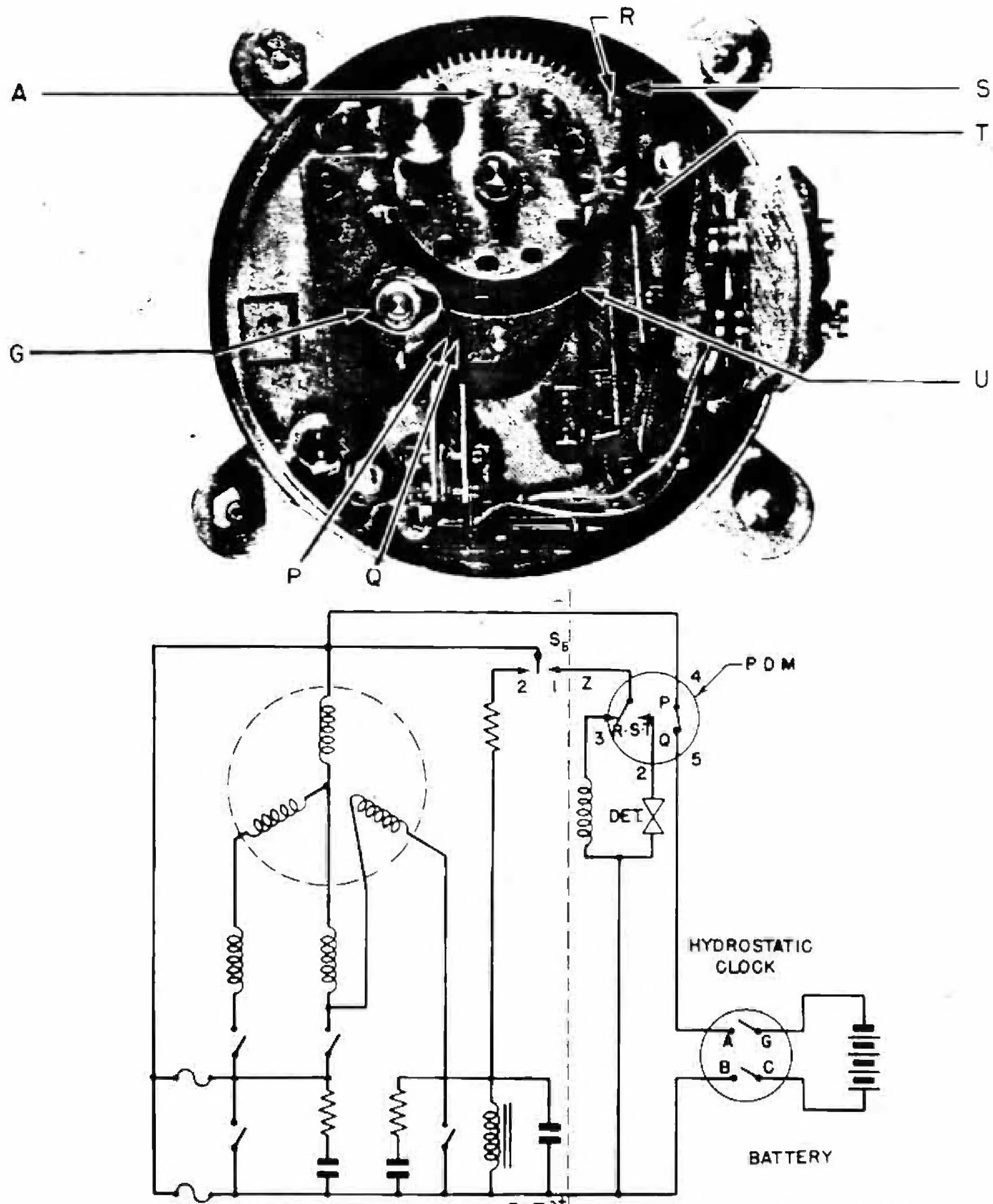


Figure 294 - VW



A-PDM WHEEL
B-BATTERY
C-CLOCK-HYDROSTATIC
G-PDM CAM

a-g } HYDROSTATIC CLOCK SWITCHES
b-c
R-S-T- PDM CHANGEOVER SWITCH
P-Q- PDM DE-ENERGIZING SWITCH
U- CAM SPRING

Figure 296 - Mechanical P.D.M. and Circuit

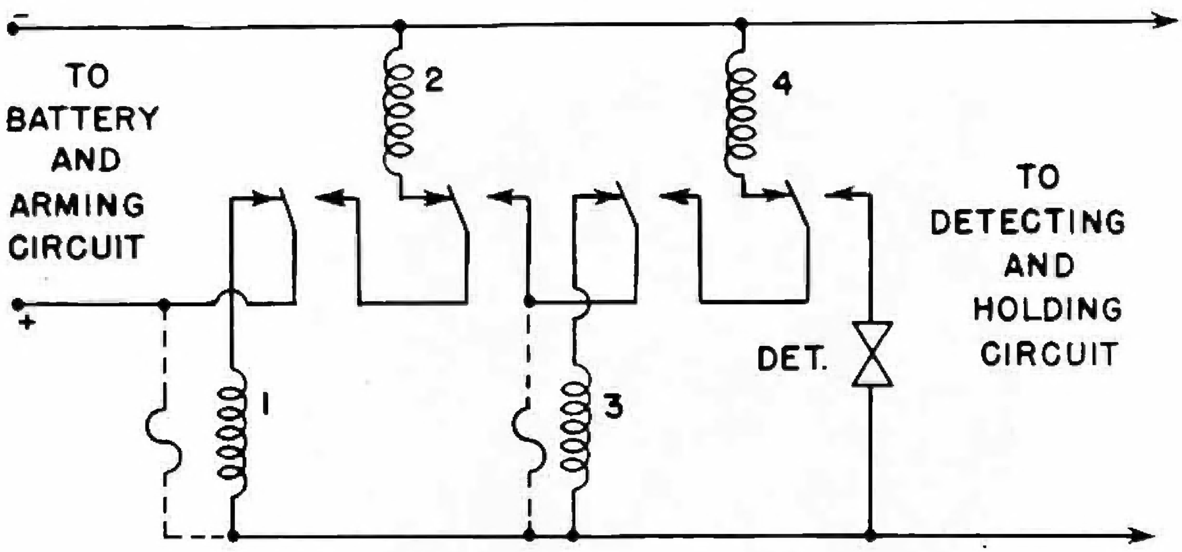


Figure 297 - Electrical P.D.M. (Fuse Delay Switch) Circuit

PERIOD DELAY MECHANISMS (P.D.M.)

Mechanical P.D.M. The unit and P.D.M. are rendered active when the hydrostatic clock switches close, figure 296. A magnetic actuation closes the needle switch, and the air core relay closes S_5 to contact No. 1 and energizes the P.D.M. solenoid through contacts R-S. The solenoid releases wheel G and the P.D.M. clockwork.

1. In the twelve-place P.D.M., G rotates one revolution, while A rotates 1/12th of a revolution clockwise.

2. In the six-place P.D.M., G rotates one revolution, while A rotates 1/6th of a revolution clockwise.

After 11 seconds of rotation, G allows P-Q to break, de-energizing the unit hold-on coil and the P.D.M. solenoid. After 120 (45) seconds, P-Q remakes and the wheel stops.

A movable pin with a flanged collar may be put in any setting hole, and is indicated as being in hole No. 6 in the accompanying photograph. In the case illustrated, five actuations of the P.D.M. would cause the flanged collar to bear against the U-bend in the spring contact S, causing it to break contact with R and make with T. This substitutes the detonator for the P.D.M. solenoid in the circuit.

The six-place P.D.M. is used with M 1 units and has a 45-second operating period per "blind" actuation. The twelve-place P.D.M. is used with A 1 and MA 1 units and has a 120-second operating period per "blind" actuation.

Electrical P.D.M. - Fuse-Delay Switch (Figure 297). The accompanying diagram shows a typical fuse-delay switch type P.D.M. set to "3". If an actuation is registered on the unit detector, current from the battery flows through fuse-delay switch No. 1, although in some cases a by-pass fuse is used to reduce the resistance of the circuit to a value low enough to allow rapid holding in the detecting circuit. After a short delay period, switch No. 1 switches over, cutting out its own heater coil, opening the holding circuit, and passing all current through switch No. 2 for a period long enough to allow the detecting circuit to recover.

When switch No. 2 operates, it puts switch No. 3 in the circuit and the unit is alive again. As this process is repeated, switches No. 3 and No. 4 operate in a like manner, with a third actuation firing the detonator. P.D.M.'s of this type may have as many settings as can be fitted to the unit's P.D.M. terminal board, with the P.D.M. setting of any unit being determined as follows:

X equals 2N -2, where X equals the number of fuse-delay switches and N equals the P.D.M. setting.

This device is used with BM 1000 units.

AUTOMATIC LATITUDE-ADJUSTMENT DEVICES (A.L.A.)

Mechanical A.L.A.

Operation (Figure 298). When the hydrostatic clock completes its delay period, fuse L blows, seating the needle on its knife edges. Rotation of F allows E to rotate on its pivot, and the A.L.A. clockwork starts to run. Oscillation of escapement lever D drives C in a clockwise direction, with M and G being restrained by fuse K. Clockwise rotation of C drives B clockwise, and, since A is geared to B, A rotates counter-

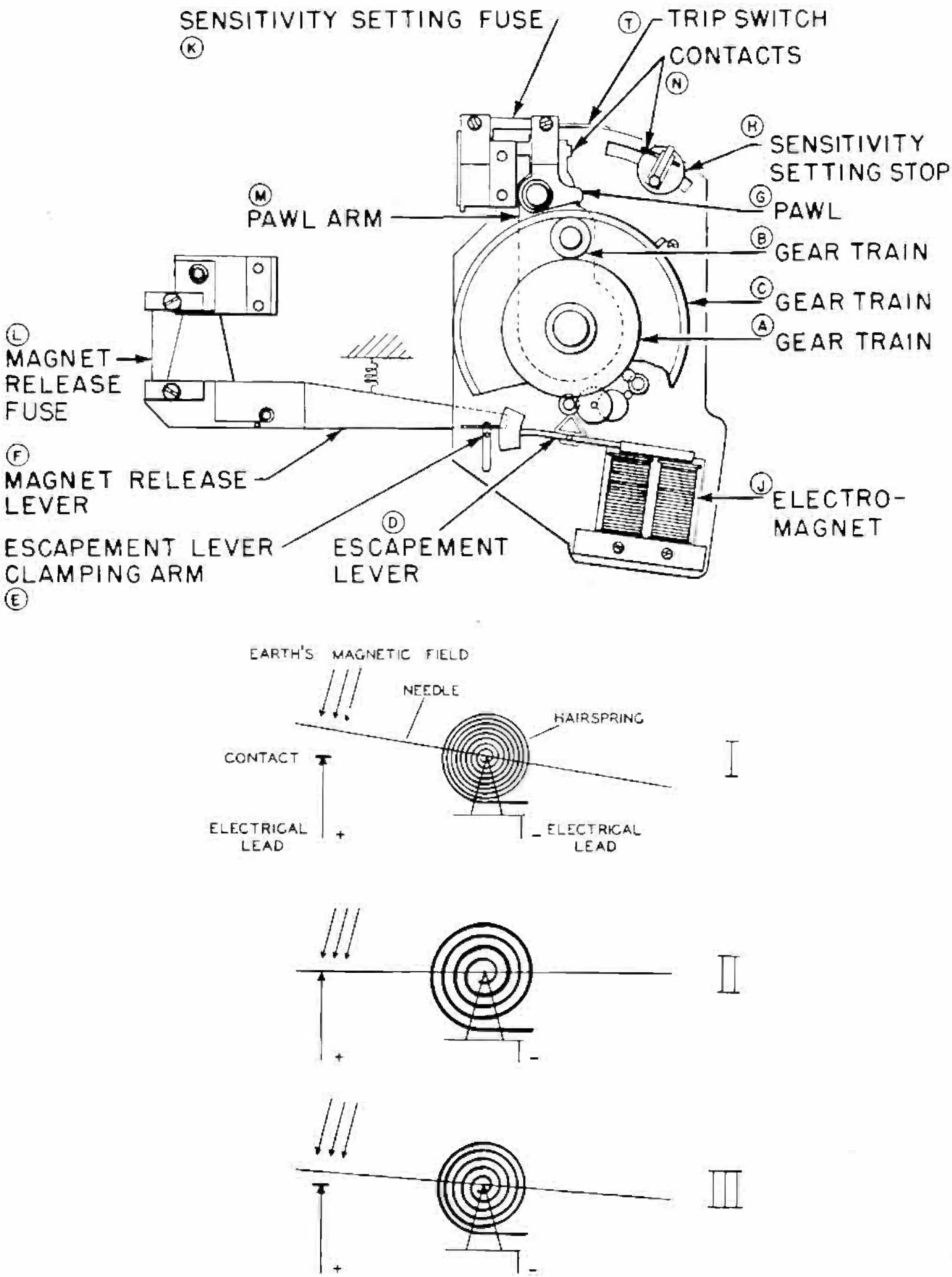


Figure 298 - Mechanical A.L.A.

clockwise. Counterclockwise rotation of A decreases tension on the needle hairspring to which A is attached.

When hairspring tension on the needle axis decreases so that the forces acting on the needle are equal and opposite to the force of the earth's magnetic field, the needle makes its contacts, blowing fuse K. When K blows, a small hairspring rotates G until it engages A. Blowing of K also releases M, allowing the pawl to lock the gear system. Since C is still rotating clockwise, the entire assembly consisting of A,B,C,G, and M rotates clockwise. This puts tension back on the needle spring and opens the needle contacts. To assure that the needle contacts open at this point, rotation of M closes switch T momentarily, thereby energizing the hold-off circuit.

The assembly rotates as noted above until M comes up against H, the distance traveled by M before contacting H determining the amount of hairspring tension on the needle and thereby the sensitivity setting of the unit. If, at any time during the above process, a countermining shock is received, closure of the pendulum switch energizes J, which holds D inoperative until the pendulum switch reopens.

Magnetic A.L.A. This mechanism consists primarily of two permalloy rods, offset and made into pole pieces with a magnetized spider or disc on a vertically oriented pivot between them. (See figure 300.) Figure 300 shows the adjusting magnets D and D_1, which are fitted to concentric shafts. Rotation of these magnets is controlled by the clockwork escapement (figure 299).

Prior to operation, fuse No. 1 holds the lower arm against spring tension and the arm in turn holds the spring-loaded V-clip arm in at the top. Fuse No. 2 also holds a spring-loaded arm in the upright position. The needle extension arm lies between two sets of fixed contacts, so oriented that it tends to rotate toward the contact and hold-on magnet (L) on the left side. This is due to the vertical earth's field which is fed to the needle arm through the vertical pole pieces.

When F_1 blows, the A.L.A. escapement starts and the V-clip moves to mid-position; i.e. it restrains the needle extension arm on the RED (left) side only. The escapement rotates magnet D and, in so doing, introduces a constantly increasing component of its field into the pole pieces around the needle body. This component is BLUE and tends to counteract the earth's field.

When a point of equilibrium between the two magnetic fields is reached, the needle extension no longer bears against the V-clip, and, since the escapement continues to run, an excess BLUE field is brought to bear on the needle, carrying it over to the BLUE (right) contact. When contact is made, F_2 blows, and the following operations are performed almost simultaneously:

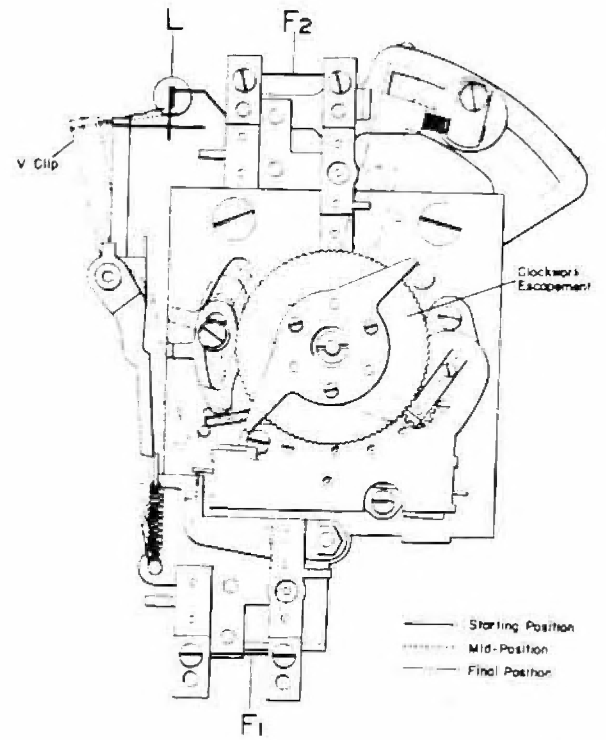


Figure 299 - Magnetic A.L.A., Showing Clockwork Escapement and Needle Arrangement

1. The spring-loaded arm is released and flies to its limit stop, figure 299.

2. The A.L.A. escapement stops and magnet D stops rotating. D_1 is rotated by the spring-loaded arm a sufficient amount to remove the excess BLUE magnetic field on the needle.

3. The resetting clamp points BB_1 are freed and fly apart as a result of the action of the spring which pulls AA_1 together and snaps the needle extension arm to the center.

The needle is now in mechanical and magnetic equilibrium. Rotation of the resetting cam is controlled by a separate escapement in the M 3 unit and by the PDM assembly in the M 3. This rotation will separate clamp points CC_1 and thus free the needle arm by spreading of AA_1.

Electromagnetic A.L.A. (figure 301). The needle consists of an aluminum drum, mounted horizontally and fitted with a magnetic belt which is magnetized diametrically. It is placed between two sets of vertical pole pieces which conduct the vertical component of the earth's field through the needle. The needle G thus tends to rotate counterclockwise as a result of the RED field effect.

A separate local magnet J, wound with a coil, is also fitted to the unit. Its polarity is such that it puts out a BLUE magnetic field which tends to rotate the needle

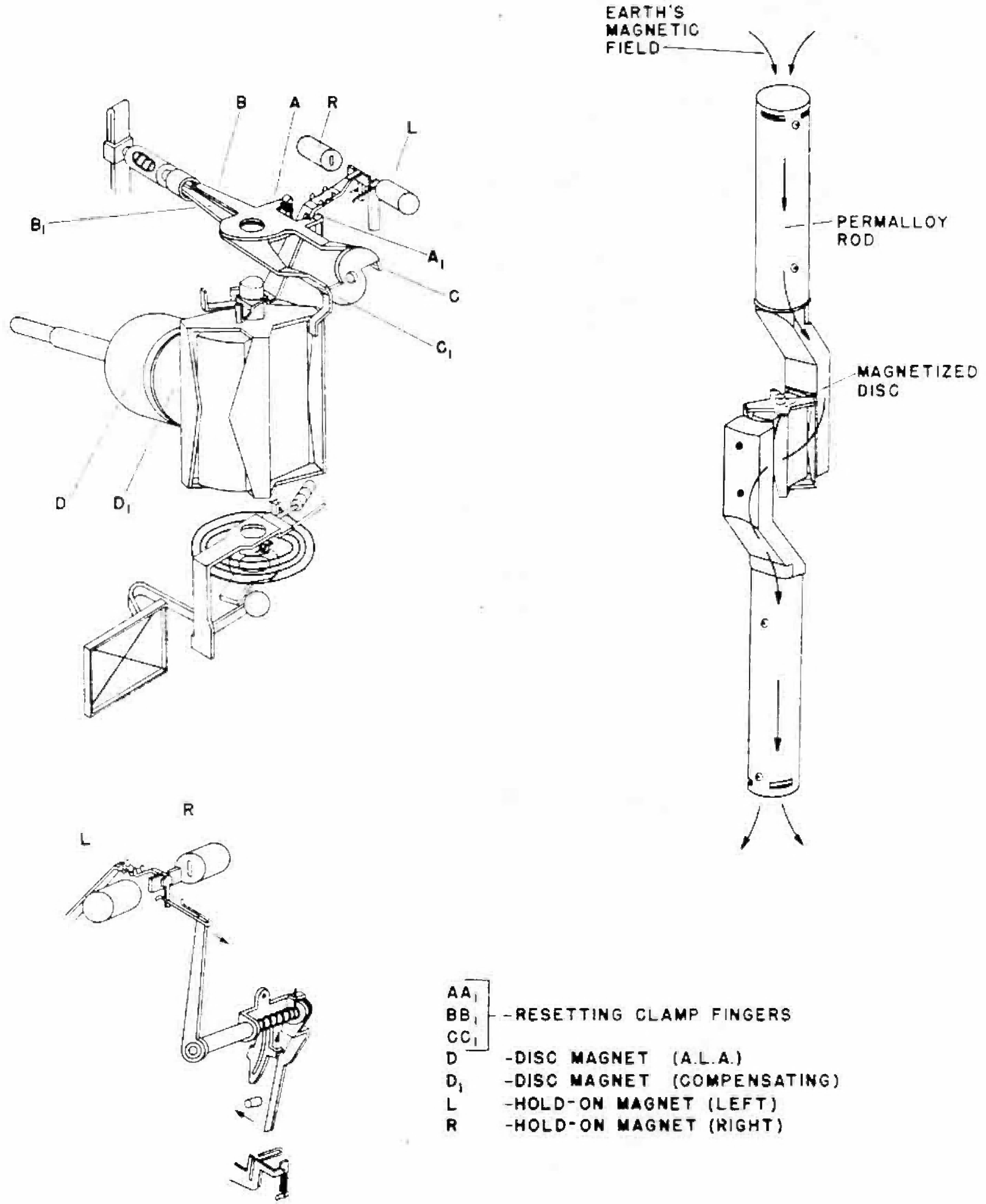
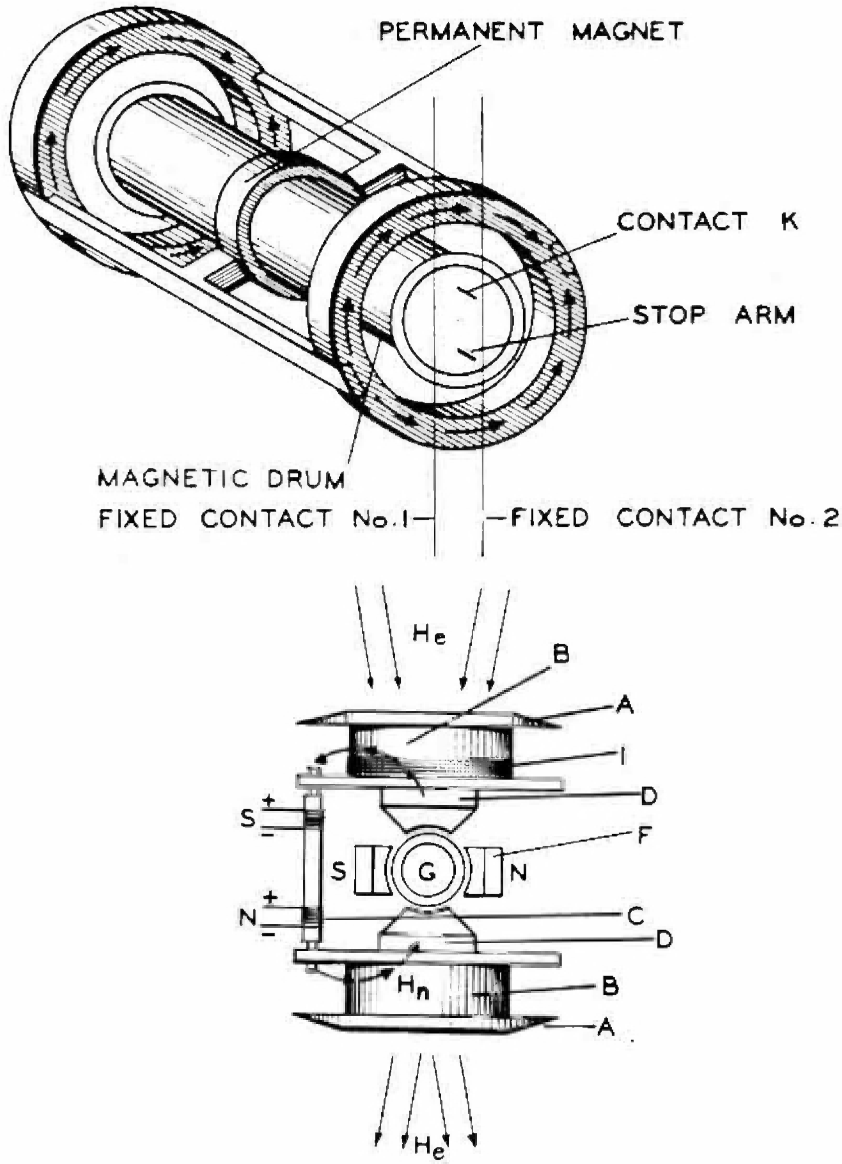
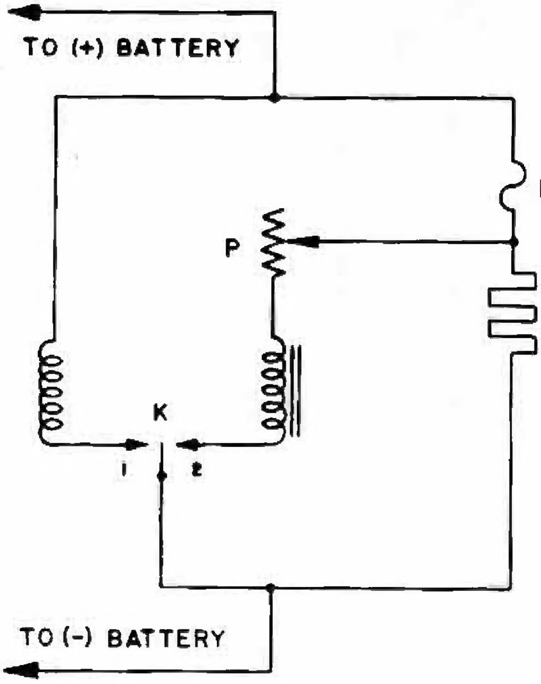


Figure 300 - Magnetic A.L.A. Component Parts



A CAPS (SOFT IRON)
B INTENSIFIERS (SOFT IRON)
C LOCAL MAGNET
D POLE PIECES
E PERMANENT MAGNET CORE
F SEPARATE POLE PIECES (RING)
G MAGNETIC DRUM
He EARTH'S MAGNETIC FIELD
Hn FIELD OF MAGNET
I HOLD-ON COIL
J SEPARATE LOCAL MAGNET

Figure 301 - Electromagnetic A.L.A. Component Parts



K — CONTACT
M — THERMISTOR
P — POTENTIOMETER
R — FUSE

Figure 302 - Electric A.L.A. Circuit

clockwise. This BLUE field is stronger than the earth's field; and, as a result, the needle rotates clockwise to its limit stop.

A contact K is mounted on the drum, and two vertical wires are placed in such a position that clockwise or counterclockwise rotation of the drum causes K to make contact No. 2 or No. 1 respectively. Thus, contact No. 1 becomes the RED contact and contact No. 2, the BLUE contact; and, since the field of the local magnet is stronger than that of the earth, the needle will make contact K2 when the mine is laid.

When the unit is energized by the battery, current through fuse R (figure 302) energizes the latitude-adjuster coil S and thermistor M. S is wound on the local magnet and is energized so that the field produced will be opposite to that of its core (i.e. the local magnet). The field produced by energizing S is strong enough to overcome the BLUE field of the local magnet, causing the needle to break contact K2, thereby breaking the electromagnetic field of S. Since the residual magnetism of the local magnet is strong enough to swing the needle back again, contact K2 is again made and S re-energized.

This pulsing, or deperming, continues until the residual magnetism of the local magnet is no longer capable of making switch K2. This process is assisted by the heating of thermistor M, whose decreasing resistance allows it to pass more current, thereby decreasing the pulsing current through S.

PREVENT-STRIPPING EQUIPMENT (P.S.E.) (GEHEIMHALTEREINRICHTUNG)

Various devices of this type, commonly called "booby traps", have been used by the Germans to preserve the security of their mine assemblies. They are ordinarily fitted as case accessories, designed to prevent access to the interior of the case at the most obvious points of entry such as cover plates and tail doors. However, as shown below, they may be incorporated as unit accessories or as integral parts of the unit.

LMB P.S.E. (used with Mines Type LMB and Type LMA) (Figure 303). This device consists of a plunger switch which is held open when the tail door or mechanism plate to which it is attached is in its normal position, i.e., mine completely assembled. If an attempt is made to remove the mechanism plate or tail door, the spring-loaded plunger is released during removal and completes a circuit from the main mine battery through a special P.S.E. detonator, firing a small two-pound charge to destroy the mine unit.

The device is armed prior to launching by inserting a safety pin which closes a break in the P.S.E. circuit. This pin is inserted in the mine case through a plug hole, 135° from the top center line, six inches before the tail door flange. If the P.S.E. is fitted to the case, this hole will be present, although filled and painted over so as not to be obvious.

TMA P.S.E. (Used with Mine Type TMA). This device is essentially the same as the LMB type, although it is rigged so as to operate if the mechanism plate is removed or if the case is separated at the flange. It is armed in the same manner as the LMB type, the safety pin being inserted underneath a screw on the mechanism plate, 180° from the bowden wire channel.

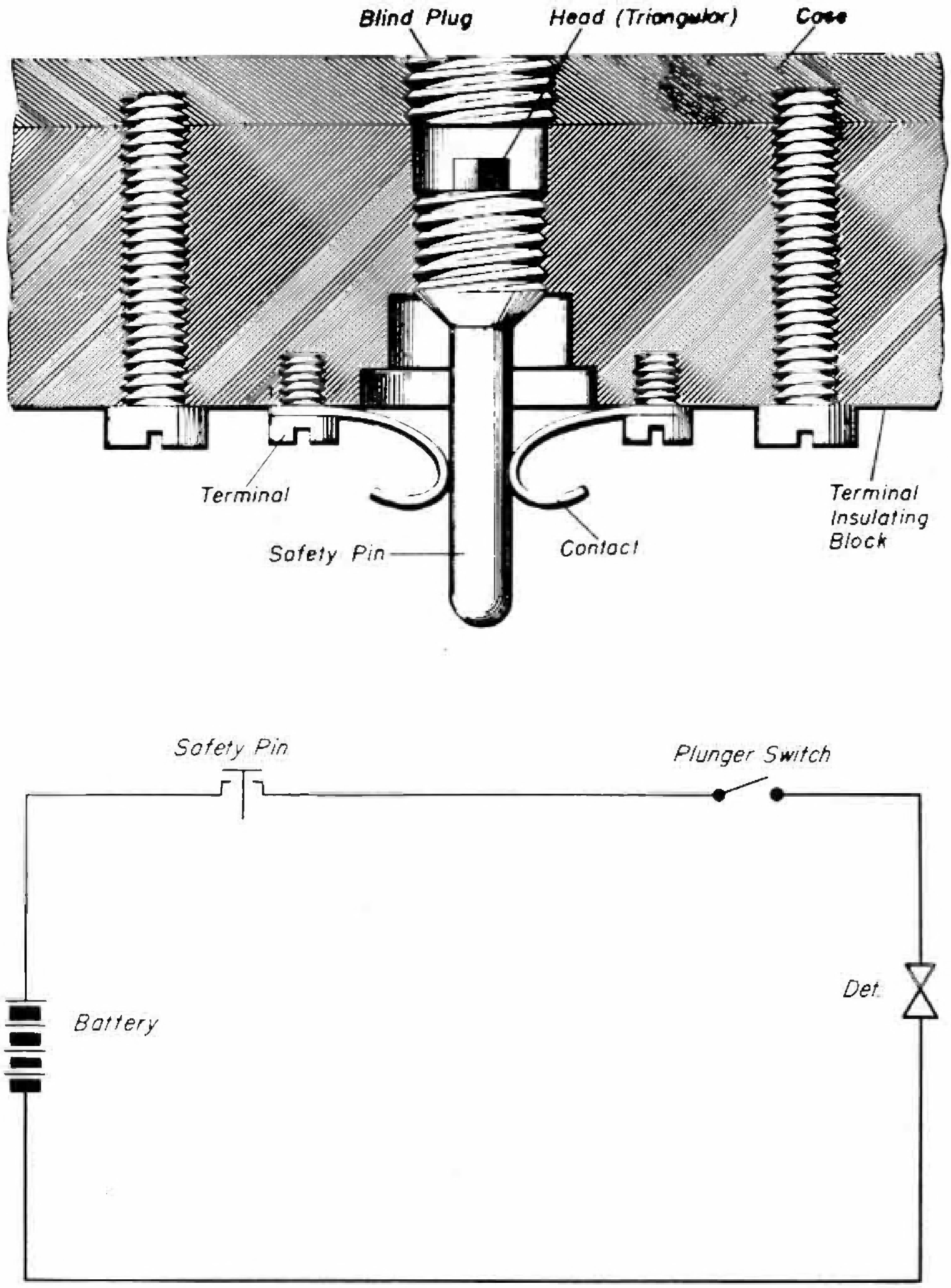


Figure 303 - LMB P.S.E. Safety Pin Arrangement

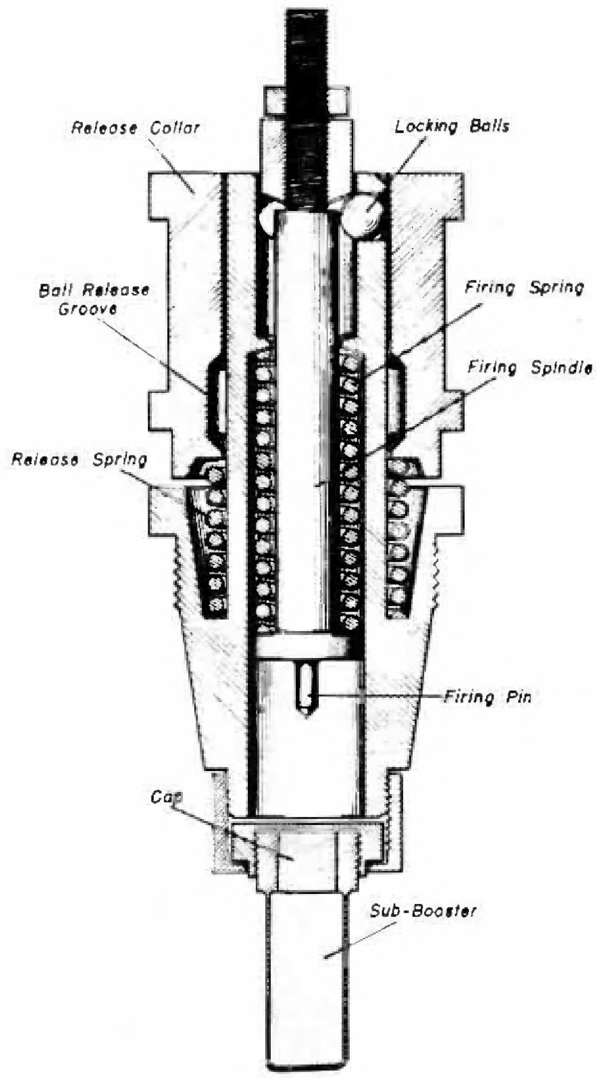


Figure 304 - Mechanical P.S.E.

BM 1000 P.S.E. (Used with Mines Type BM 1000). This device consists of two photo-electric cells, mounted on either side of the firing unit, which, when exposed to light, operate a relay and close the unit firing circuit, firing the main charge. The device becomes armed when the firing unit arms. It may be fitted to any BM 1000 Mine which is fitted with a firing unit that incorporates M 101 or subsequent modifications thereof. The presence or absence of this device cannot be determined from an examination of the exterior of the mine case.

Mechanical P.S.E. (Used with Mines Type LMB and Type LMA) (Figure 304). This device consists of a spring-loaded firing pin which is held by two lock balls, when the tail door or mechanism plate to which it is attached is in its normal position, i.e., mine completely assembled. If an attempt is made to remove the tail door or mechanism plate, movement of a spring-loaded spindle allows the lock balls to move into a recess, releasing the spring-loaded firing pin to impinge on a special P.S.E. detonator, firing a two-pound charge to destroy the mine unit.

The device is armed prior to launching by removal of a safety pin which leaves the firing pin restrained only by the lock balls. The safety pin is removed from the mine case through a plug which is located 90° from the top center line on the flange.

Sea-Cell P.S.E. (Used with MA 101 Unit in Mine Type BM 1000). This device consists of two wires, made of dissimilar metals, which are coated with a salt and laid side by side in a small trough. If humidity or moisture enter the trough, the salt dissolves, creating a small battery cell. The cell operates a sensitive relay, completing a circuit from the main battery to a special P.S.E. detonator, firing the main charge.

The device becomes armed when the firing unit arms and has only been found fitted to MA 101 in Mine Type BM 1000. The presence or absence of this device cannot be determined from an examination of the exterior of the mine case.

ZUS-40 Anti-Withdrawal Device. This device consists of a spring-loaded firing pin which is designed to be released when the accessory under which it is fitted is removed. When the mine is dropped, impact with the surface causes a lock ball to fall away, leaving the firing pin restrained only by its extension arm, as shown in figure 305. If the accessory is withdrawn 0.6 inch, the extension arm moves clear of the body of the accessory, releasing the firing pin to impinge on a special detonator, firing the main charge.

This device was originally designed to be fitted under bomb fuzes, and its use in mines is thereby restricted by its basic design to mines Types LMB, LMA, and BM 1000, the only mines that have contained bomb fuzes. It should be noted, however, that this device may be used under any fitting, the physical construction of which would permit effective operation.

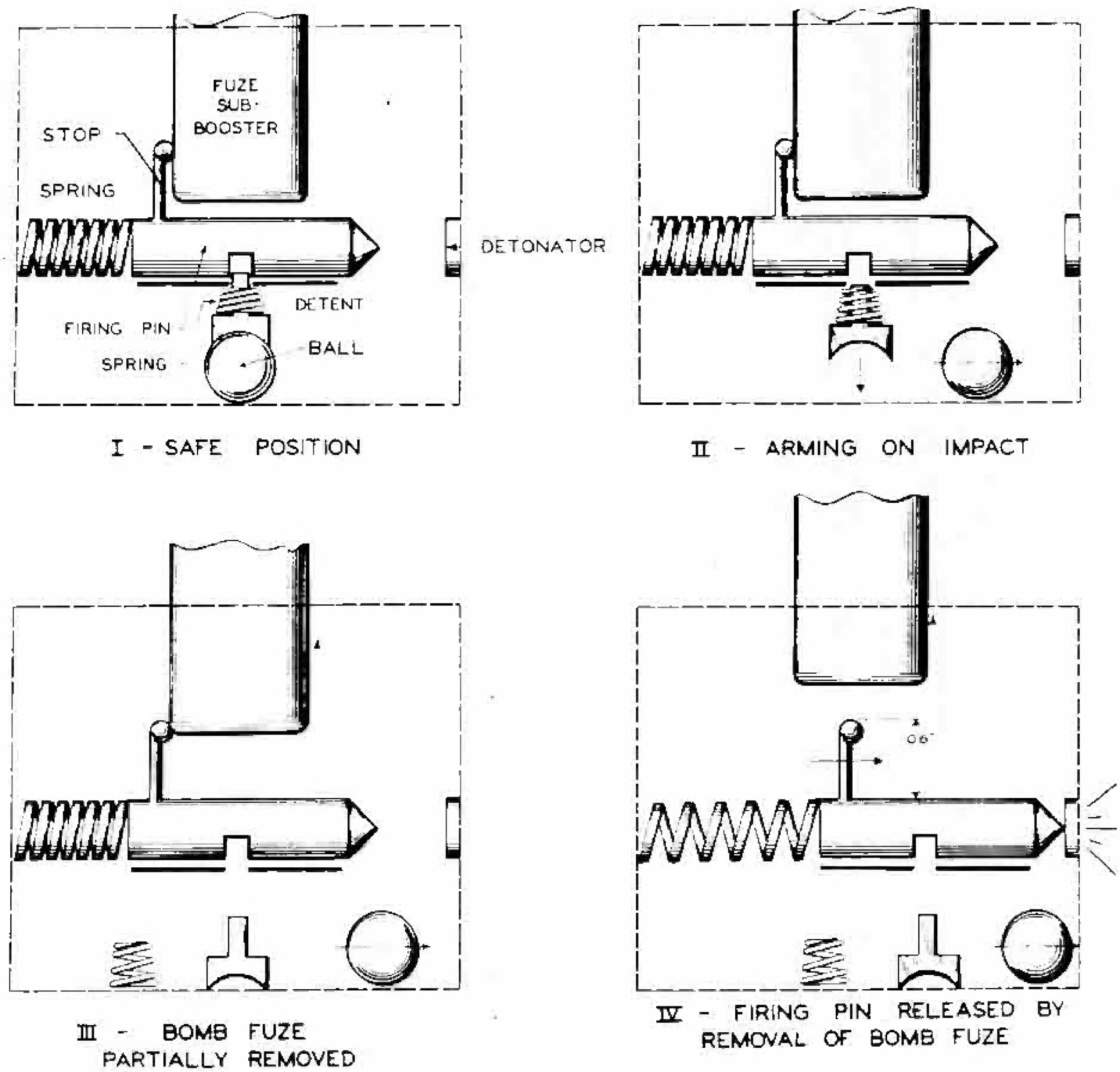


Figure 305 - ZUS-40 Anti-Withdrawal Device

Chapter 13

MISCELLANEOUS MINES

KK MINE

The KK (Kleine Kugel) mine was one of a series of captured enemy, locally improvised, mines. They fall under the general heading of Improvisieren Minen (improvised). The KK originally was a British mine captured at Dunkirk. In this way huge stores of captured enemy mines were improved, modified, and utilized for local defenses.

General. This is a moored or ground, contact, chemical-horn mine, laid by surface craft.

It is a defensive mine for use in shallow water. It may also be used as an antivehicular land mine on beaches or as a demolition charge. When used as a land mine, it is buried in the sand.

Description of Case

Shape	Elliptical
Material	Steel
Diameter	15 in.
Charge	25 lb. approx.

Total weight in air 65 lb. approx.

Description of External Fittings

Horn	One, on top center of case, secured by keep ring
Base plate	In center of lower hemisphere
Pockets	Four, staggered around upper hemisphere; three blank, fourth contains "A-E" switch.
Lifting eyes	Two, 180° apart on upper hemisphere

RK MINE

General. The RK (Russich Kugel) mine is another in the Improvisieren series. It was captured during the invasion of Russia, improvised locally and used mostly in the Baltic. It is a moored, contact, chemical-horn mine, laid by surface craft for use in maximum depth of water of 300 feet.

Figure 306 - KK Mine

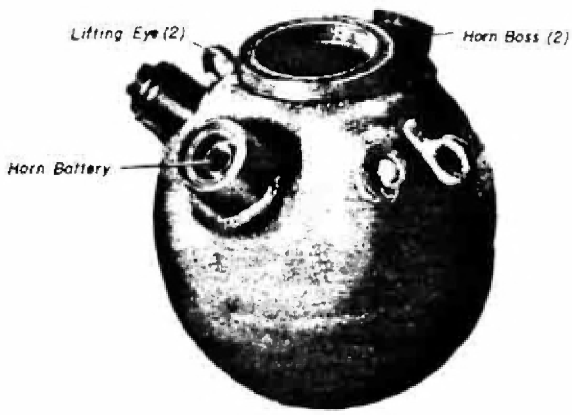


Figure 307 - KK Mine

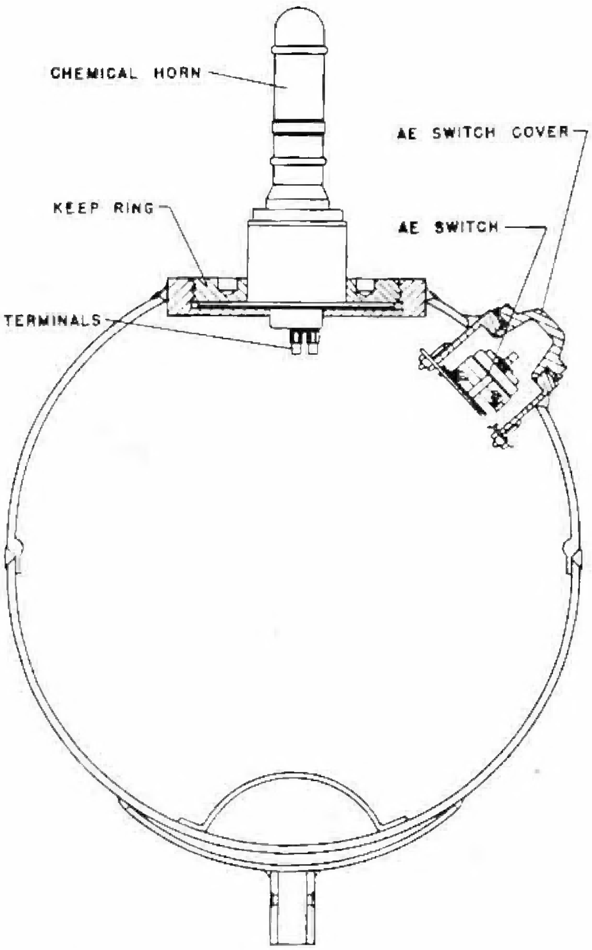


Figure 308 - KK Mine - Cross Section

Figure 309 - KK Mine Afloat

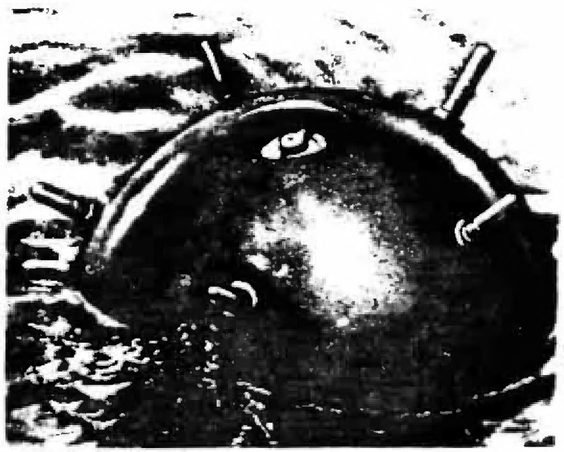


Figure 310 - RK Mine Afloat

Description of Case

Shape	Spherical
Material	Steel
Diameter	34 in.
Charge	250-lb. cast TNT or hexanite

Total weight in air 375-lb. approx.

Description of External Fittings

Horns	Five, equally spaced, around upper hemisphere, 15 in. from center
Hydrostatic switch	7.5 in. diam., in pocket in center of upper hemisphere secured by locking ring with four set screws
Lifting eyes	Two, 180° apart, 19 in. from center of upper hemisphere; fitted with lifting rings
Mooring eye	In center of lower hemisphere

Operation. The mine takes depth by plummet. Dissolution of a soluble plug allows water pressure to depress the spindle of the hydrostatic switch, closing the firing circuit; and the mine is thus armed.

Standard chemical-horn firing is employed.

The only self-disarming device is the hydrostatic switch, which is designed to disarm the mine by opening the firing circuit upon release of hydrostatic pressure.

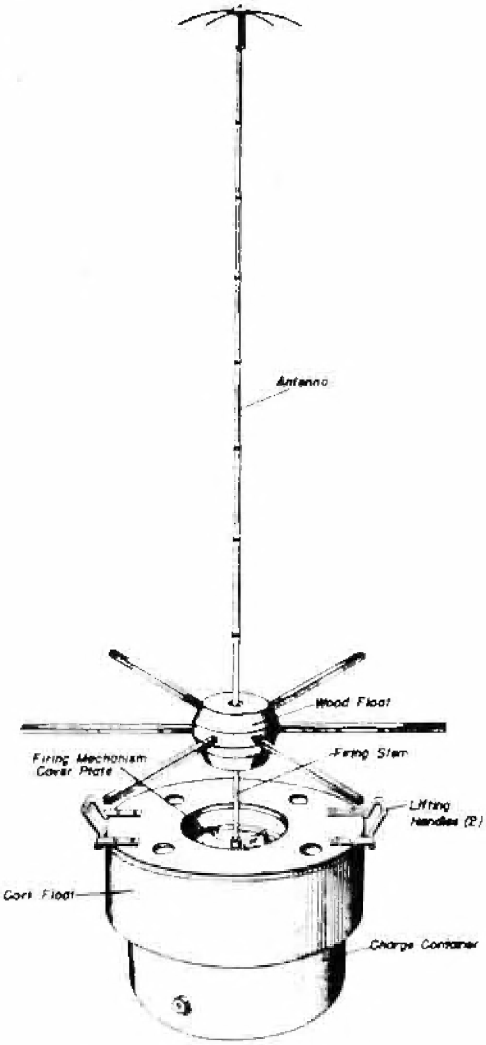


Figure 311 - K TR Mi 38 Mine

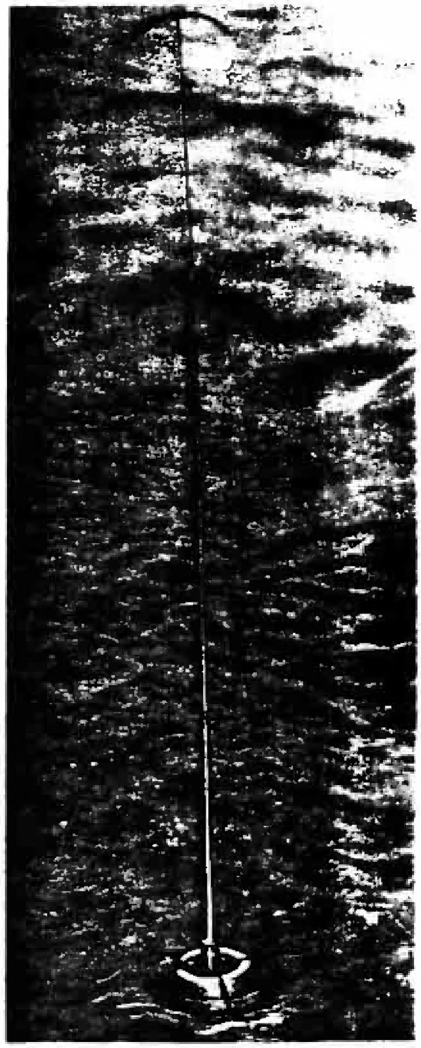


Figure 312 - K TR Mi 41 Mine Afloat

K TR Mi Mines of the Wehrmacht

General. The K TR Mi Mines were developed, procured and used solely by the Army offensively, in rivers and harbors, against bridges, dams, docks, etc. Normal depth of case when drifting is one foot.

K TR Mi 38

Description of Case

Shape	Cylindrical, with antenna protruding from top center of case
Material	Wood
Diameter	17-3/4 in.
Length	6-1/4 in.
Charge	44-lb. TNT with Tetryl booster

Total weight in air 66 lb.

Description of External fittings

Antenna	4-1/2 ft. long, bamboo or hazlewood fitted to top of metal firing stem on top center of case
Firing-mechanism cover plate	Threaded into well on top center of charge container
Wood float	Secured to firing stem, fitted with six wooden contact arms, each 13 in. long.
Lifting handles	Two, 180° apart, on top edge of case

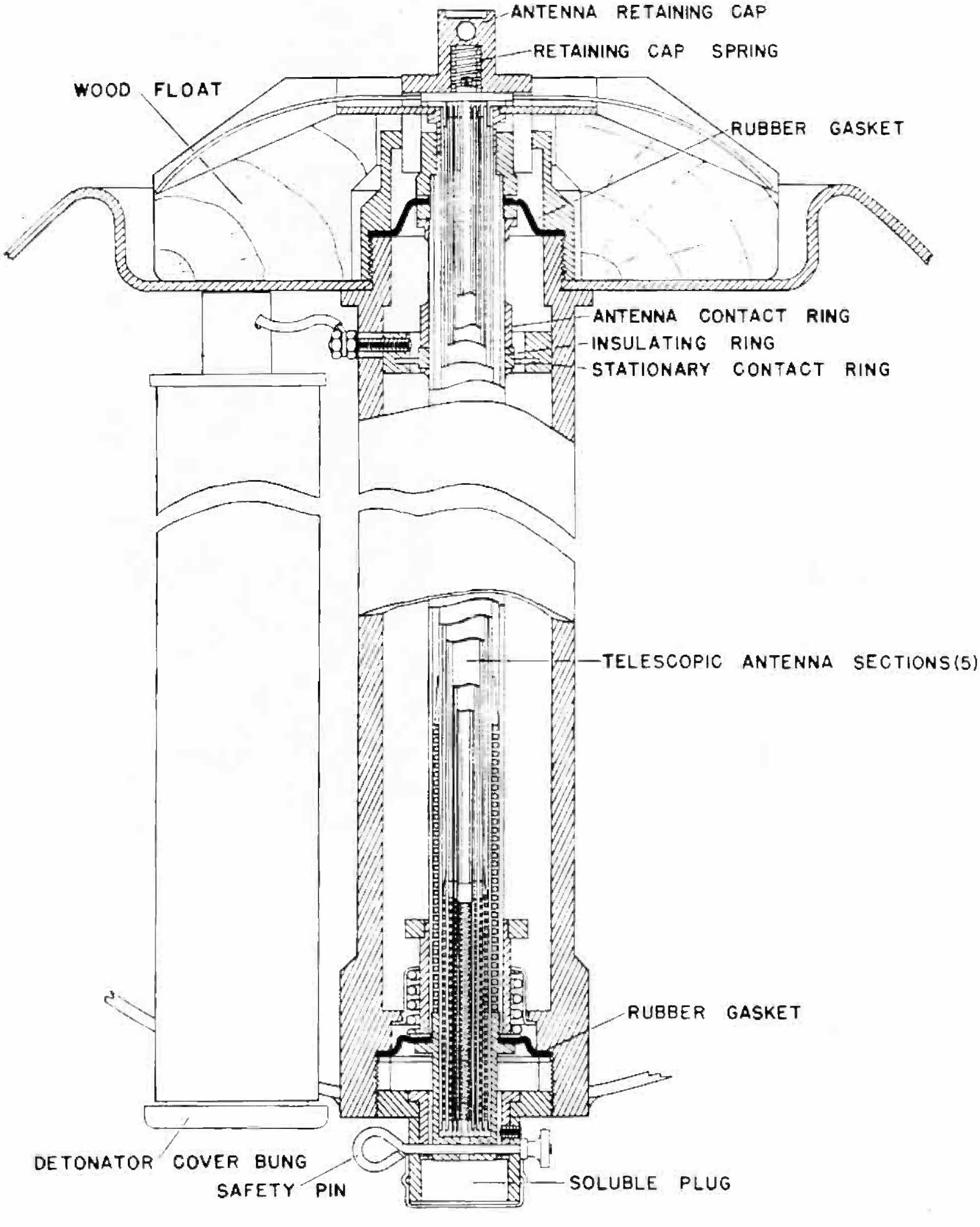


Figure 313 - K TR Mi 41 Detonator-Booster Cross Section

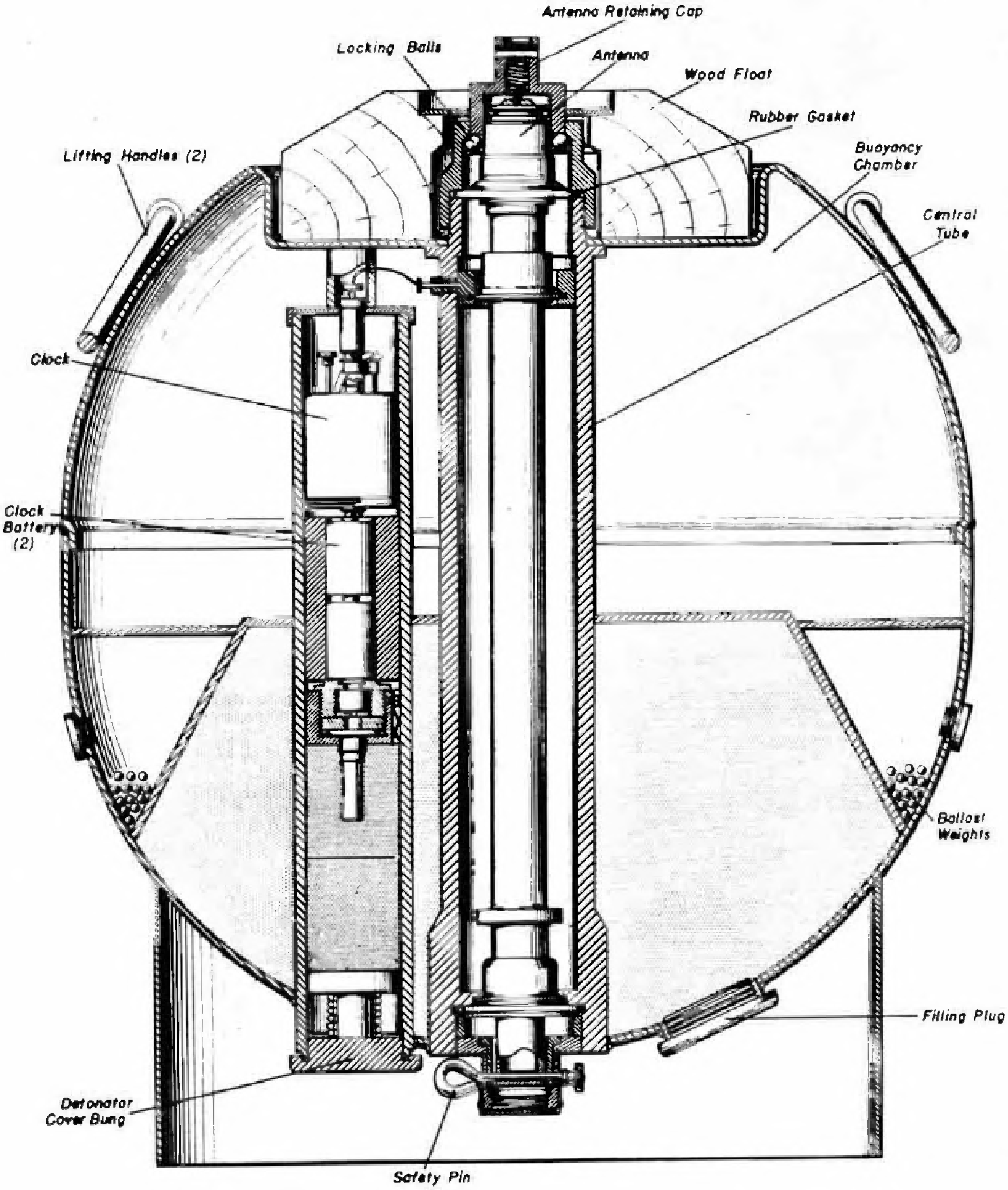


Figure 314 - K TR Mi 41 Mine - Cross Section

Figure 315 - K TR Mi 41 Mine

Operation. This mine is armed by a ten-minute arming clock in the firing mechanism.

The mines are fired by percussion upon impact. The arming clock is fitted with a self-destroying feature which will explode the charge after a maximum delay period of six hours.

K TR Mi 41

Description of Case

Shape	Oval, with 4.5-in. skirt around base. Antenna protrudes from top center of case
Material	Steel
Diameter	15 in.
Length	
Over-all (includes antenna)	6 ft. 9 in.
Case	18 in.
Charge	25 lb. cast TNT
Total weight in air	76 lb.

Description of External Fittings

Antenna	5 ft. 3 in. long, brass, fitted to top of case, consists of five telescopic, spring-loaded sections. Fitted with four snag wires at top.
Detonator-cover bung	2-1/8 in. diam., 2-3/4 in. from center of bottom of mine
Filling plug	Screwed into base, 2-1/8 in. diam., 3-1/2 in. from center.
Wood float	7.4 in. diam., recessed into top center of case prior to laying; free to rise and fall on lower sections of antenna after mine is armed
Soluble plug fitting	In base of antenna housing

Operation. A safety pin is withdrawn from the base of the antenna prior to launching. When the mine is launched, dissolution of the soluble plug allows the lower section of the antenna to be forced downward, releasing the locking balls and the antenna retaining cap, and allowing the antenna to extend to its full length. The wooden float takes position depending on the buoyancy of the mine, which is then fully armed.

The mine fires when the antenna is bent in any direction against its internal contact ring. A self-destroying clock with a maximum period of six hours is fitted.

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Glossary of Torpedo and Mining Terms Used	1966-S 45	24 Apr. '45	ComNavEu
Summary of Enemy Mining in American Waters During November 1942	0324330	9 Dec. '42	CNO
Information Regarding Enemy Mines in the Mediterranean	135-43	12 Nov. '43	S.O. (I)
Preliminary Report on German Mining Clocks	910-2600	13 Jun. '45	ComNavEu

MISCELLANEOUS REPORTS (Continued)

Mine Type GR, Fitted with Snag Line	910-2600	28 Dec. '43	ComNavEu
Ground Mines Recovered in England	360	11 Feb. '42	Naval Attaché London
German Influence Mines	143	10 Jan. '42	CNO
German Minelaying Program	0639	1 Aug. '45	NavTechMisEu
Mk III Hydrostatic Clock	1353	26 Jun. '41	Naval Attache London
GT off Weymouth, England	1701	21 Jul. '41	Naval Attaché London
GO Mine	2480	15 Jun. '43	Naval Attaché London
Rendering German Ground Mines Safe	L-516	1944	Vernon Pamphlet
Mines Recovered at Halifax N.S.	0807930	13 Nov. '43	CNO
Latitude-Setting Device of GG Magnetic	1523	10 Jul. '41	Naval Attaché London
Microfilm Prints of Captured Correspondence	00158	21 Jun. '45	NavTecEu
1600-ton Minelaying Supply U-boat	01867916	20 Jul. '45	OP-16-Z
U-boat Minelayers and Mines	A16-2(3) EF30	15 Jul. '43	OP-16-Z
Interrogation of Rommel	2589-S-45	26 Jun. '45	ComNavEu
Summary of Markings on Recently Recovered Mines	739-S-45	16 Feb. '45	Com12thFlt
GF Mine	1732	28 Apr. '43	Naval Attaché London
Recovery of GP and Anchor at Falmouth, England	2315	9 Jun. '43	Naval Attaché London
German Ground Mines	2822	2 Oct. '42	Naval Attaché London
Recovery of "G" Mine near Bristol	1720	20 Jul. '41	Naval Attaché London
Report on GT Recovery	1698	26 Jul. '41	
Details of 1600 Ton U-boat Minelayer	01695316	13 Jul. '43	OP-16-Z
Markings found on German Mine Cases, Mine Units, and Auxiliary Mine Devices	2994-S-45	7 Aug. '45	ComNavEu
New-Type Tail Doors for GC (Acoustic)	2301-S-44	6 Dec. '44	Com12thFlt
German Sinker Type "C" for Mine Type G.P. Used with Parachute for Laying by Aircraft	2276-S-45	22 May '45	ComNavEu
German Mine Disposal	2047	20 May '45	Naval Attaché London

MISCELLANEOUS REPORTS (Continued)

German Acoustic Pressure Unit from Mine Type GG AM with Double-Contact P Unit	2384-S-45	2 Jun. '45	ComNavEu
Summary of Markings on Recently Recovered Mines	739-S-45	16 Feb. '45	Com12thFlt
Description of German Mineshells and Units	2689-S-45	3 Jul. '45	ComNavEu
Description of German G Mine	1511	10 Jul. '41	Naval Attaché London
Mine Detectors on Marine Influence Mines	2075-S-45	7 May '45	ComNavEu
Information on GG False Nose and Tail Fittings	5017	17 Dec. '43	ComNavEu
Crushing Test of GG Mineshell	527	12 Feb. '44	ComNavEu
Information on the Effect of Mud on Hydrostats	5142	28 Dec. '43	ComNavEu
Recovery of GG and GD Mines	619	12 Mar. '42	Naval Attaché London
Information on Recovery of First AM II (AM Mk III)	00618	7 Feb. '45	Com12thFlt
Flame and Fragment Velocities from GG Mine	021944	27 Oct. '43	BuOrd
Analysis of Numbers and Marks on GG Mines	1968-S-45	30 Apr. '45	ComNavEu
German Aircraft Mine Attack and British Defense	1849	Part II 30 Jun. '42	Naval Attaché London
Report of "S" mines fitted for sabotage at Bizerte	2470	16 Jun. '43	Naval Attaché London
P.S.E. in GT Mine	1672	18 Jun. '42	Naval Attaché London
German Mine Clocks	2550-S-45	14 Jul. '45	ComNavEu
German Mine Clocks	2775-S-45	Jul. '45	ComNavEu
ZE III Used as a Delay Arming Mechanism in German Mine Unit M-1	2720-S-45	10 Jul. '45	ComNavEu
German Mine Type G.P. with Flooder and Eleven-Hour Clock	2278-S-45	22 May '45	ComNavEu
Acoustic Mine Unit AM Mk III	892-S-45	26 Feb. '45	ComNavEu
Effects of Running Down of the Battery in the GGPM Mk I Unit	878-TS 45	4 Sept. '44	ComNavEu
Sweeping Trials of "A" Mk V Unit	2304	15 Jun. '44	ComNavEu
German Mine Unit Type AA 2	2280-S-45	22 May '45	ComNavEu
GB M/S of PM German Unit by Explosive Pulses	793-TS-44	29 Aug. '45	ComNavEu
Mk IV Mine-Firing Mechanism from Type GG	004885	30 Jun. '44	BuOrd
New Acoustic-Type Unit from Mine Type GG	1970	24 May '44	ComNavEu

MISCELLANEOUS REPORTS (Continued)

Modification of German Unit Type A Mk V	2557	20 Jun. '44	ComNavEu
German Acoustic Pressure Mine Unit for Type GC Mine	2311-S-45	24 May '45	ComNavEu
German Unit Mk VIII	1118	5 May '42	Naval Attache London
Sensitivity of German M Mk II Units from Mines Type GC-PM	1514-S-44	25 Oct. '44	Com12thFlt
Sensitivity of German M Mk II Units Recently Recovered	1766-S-44	13 Nov. '45	Com12thFlt
German Magnetic Mine-Firing Unit	NIU/OO 336	6 Jul. '45	NavIntellAustria
Acoustic Units and their Sweeping	281601	28 May '45	ComNavEu
Markings, Characteristics, and Sensitivities of Relay Packs and Pressure Units from German Pressure Magnetic Mines	1922-S-45	27 Apr. '45	ComNavEu
Summary of Sensitivity Settings of German Mines	978-S-44	8 Sept. '44	ComNavEu
Running down of Battery in German Unit FM Mk I by Plain Magnetic Actuation	2298-S-44	13 Dec. '44	Com12thFlt
Unit FM Mk II from Modified GS Mine	1308-S-45	20 Mar. '45	ComNavEu
Influence Mining	2589-S-45	26 Jun. '45	ComNavEu
German Influence Mine Mechanisms	00254	23 Aug. '45	NavTechMisEu
Markings found on German Mine Cases, Mine Units, and Auxiliary Mine Devices	1968-S-45	30 Apr. '45	ComNavEu
Interrogation of Conv. Kapt. Niemling of the German Navy	1004-6850	22 Jun. '45	ComNavEu
Period Delay Mechanisms and Modification Fitted to Recently Recovered German Mine Units	2570-S	8 Jun. '45	ComNavEu
German GC Mine with Parachute	00618	22 Feb. '45	Com12thFlt
German Mine Type GS II with FM Mk II	1805-S-45	19 Apr. '45	ComNavEu
Enemy Mining Material Recently Recovered	17-S-45	2 Jan. '45	Com12thFlt
Mine Type GSII with FM Mk II Unit from Midget Submarine	1805-S-45		ComNavEu
Oyster Mines and Relevant Countermeasures	1089-S-45	9 Nov. '45	Com12thFlt
Electrical Characteristics of Recent AF Mk I	1969-S-45	27 Apr. '45	ComNavEu
German Mines and Mine Units and Sweeping Countermeasures	2630-S-45	27 Jun. '45	ComNavEu
Influence Mining	3042-S-45	Aug. '45	ComNavEu
Modifications of German Aircraft-Laid Mines	93-S-44	10 Jul. '44	ComNavEu

ADDENDA

PERSONALITIES

	SVK
Mar. Ob. Baurat Dr. Hagemann	Head of department charged with investigating the physical technological aspects of influence mine units and the countermeasures therefor.
Dipl. Ing. Scheffler	Acoustic units and testing gear, acoustic countermeasures
Mar. Baurat Dr. Reiff	Magnetic and pressure units and testing gear
Mar. Oberbaurat Schuller	Moored mines, submarine-laid mines, moored-mine firing devices
Mar. Baurat Dr. Raschig	Submarine-laid mines
Mar. Baurat Dr. Clodius	Moored mines, mine planning
Dipl. Ing. Schneider	EMF mine
Mar. Baurat Kluver	EMC, UMB mines
Mar. Ob. Baurat Behrens	Mine components
Mar. Baurat Sanders	Magnetic and acoustic mine sweeping gear
Mar. Ob. Ing. Geller	Moored mine sweeping gear
Mar. Baurat Lautze	Pressure sweeping
Mar. Ob. Baurat Wildenhayn	Assistant to Dr. Hagemann
Mar. Baurat Klie	Magnetic countermeasures
Ob. Ing. Kretschmer	In charge of production under Dr. Hagemann
Mar. H. Baurat Dr. v. Harlem	Testing (Sperrbrecher Sweeps)
Mar. Ob. Baurat Kersten	Ground mines and aircraft mines
Dipl. Ing. Eickhof	Metals and metal substitutes
Dr. Ing. Polley	Measurement technique
Dr. Ing. Lenze	Magnetic units
Dipl. Ing. Steffani	Induction units
Dipl. Ing. Decker	Magnetic units - high-frequency technique
Mar. Baurat Brauer	LM mine cases
Mar. Baurat Bottcher	LMF mine
Mar. Baurat Schleichert	RMA, RMD, and BMC mines

E - Stelle

Oberst. Rommel	Development of Luftwaffe mine material
Maj. Fulda	Rommel's technical assistant and executive officer
Hauptmann Eitel	Influence mines and testing equipment
Flug Stabsing. Spieler	Pressure experiments and development of D 103, BM 250, 34 A and 34 B fuzes for LMB
Flug Haupting. Borsdorf	Acoustic-pressure units
Gefreiter Goepel	Acoustic measurements and units, optical units
Stabsing. Bessel	Acoustic measurements and pinging units
Stabsing. Dr. Mahler	Pressure measurements and units
Haupting. Kehrer	Development of AA 106, JDA 105
Stabsing. Wulf	Mine batteries
Haupting. Kern	Development of Winterballoon, Wasserballoon, and Sommerballoon
Haupting. Fahnrich	Aircraft carrying gear for bombs and mines
Haupting. Killinger	River mines (Wasserballoon, BM 500, aircraft moored mines)

Others

Dr. Thienhaus (FRA Kiel)	Mine-design work
Dr. Von Klitzing (Skagen)	Pressure measurements
Obering. Schau	Acoustic and pressure measurements

FIRMS WORKING ON MINE DEVELOPMENT

Firma Dr. Hell, Berlin-Dahlem, Kronprinzenstrasse 149
- "A 104", "A 105", "A 107" - Dr. Hell and Dipl. Ing. Koll

Haseg (Hugo Schneider A.G.), Leipzig
- development of all pressure mines and preliminary experiments with subsonic units. Dr. Christoph, Ing. Meyer, Ing. Zimmer

AEG, Berlin, Friederich-Karl Ufer 4
- "AA 106", "MDA 106", "JDA 105", "D 102" ("M 101", "M 103", "MA 101")
Dr. Buch, Dr. Ing. Werner, Dr. Ing. Zimmermann, Dipl. Ing. Bakes

Atlas Werke, Bremen
- "AA 106" (Schwingersysteme) Dr. Grandiot

ELAC-Kiel
- "AE 101". Dr. Fahrentholz, Dr. Koehler (microphone specialist), Dipl. Ing. Genehrlich

AEG-Werk, Nurnberg
- Mine cases. Dir. Fleckenstein

Vereinigte Oberschlesische Huttenwerke, Gleiwitz
- Mine cases. Ing. Foreita

Firma Reichling, Krefeld
- Protective casings ("Schutzhauben") and related parts
Ing. Reichling

Rheinmetall-Borsig, Breslau/Sommerda
- Fuze "50", for aiming units and for opening main switches

Otto Gossel, Glashutte Sachsen
- Delay switches for "AE 104" and "A 105"
Ing. KIESLING

Firma Benger, Stuttgart
- Parachutes (LS 3) for mines

Hartung Und Braun - Frankfurt
- Magnetic units and relays

Hagenuk - Neufeld und Kuhnke - Kiel
- Design and manufacture firing mechanisms

Pohl - Kiel
- Firing mechanisms

Gebruder-Anderson - Kiel
- Mine bodies and magnetic-unit housings

Schmidding Werke - Cologne
- Light metal mine housings

RESEARCH INSTITUTES WORKING ON MINES

AEG-Forschungsinstitut, Neustadt Coburg
- Active light units (infra red) for "Wasserballoon"
Ing. KREWETT, Ing. RUDAT

CPVA-Kiel
- Preliminary experiments in use of "Argus" tube (as in "V-1") for sweeping sub-sonic acoustic mines

Forschungsanstalt Graf Zeppelin, Stuttgart-Ruit
- Hydrodynamics (Water ballistics), and effects of underwater explosions
Dipl. Ing. Snay

- Mine parachute development
Dipl. Ing. Heinrich

Forschungsanstalt Hermann Goering, Braunschweig
- Mine parachute development
Dr. Schussler

PTR
- Measurements of sea-waves and water pressure
Dr. von Klitzing. Obering. Schau
(Their own extensive experiments at Skagen, Denmark)

Marine Observatorium, Greifswald
- Oceanographic problems
Oberbaurat Hansen

Physikalische Reichs Anstalt, Kiel
- Mine-design work
Dr. Thienhaus

ABBREVIATIONS

German	Translation
A 1 - Akustisches Fernzundgerat - Nr. 1	Acoustic firing device
AA 1 - Akustisches Fernzundgerat mit Akustischer Einschaltung	Acoustically triggered acoustic firing device
At - Ankertau	Anchor
ANZ - Atennenzundung	Antenna
BMA - Bombenmine A	Bomb mine A
BR - Bombenreissboje	Bomb-type anti-sweep device
BS - Bugspiegle	Flat-nosed cylindrical speed-retarding nose
BV - Bugverkleidung	Streamlined false nose
DM - Druckmagnetisches Fernzundgerat	Pressure magnetic firing device
E.E. - Entscharfereinrichtung	Mechanical disarming device
EMA - Elecktrische Mine A	Electrically fired mine Type A
EMC - Einheits Mine C	Universal mine Type C
EMF - Einheits Mine F (Ankertaumine mit Fernzundergerat)	Moored influence mine Type F
EMR - Sperrschutzboje (EMC - Gefass mit Kette)	Anti-sweep device (EMC mine case with chain mooring)
EMR/K -	Same as EMR with double-chain mooring
EMS - Sehrohrtreibmine	Drifting periscope mine
E.W. - Entscharferwerk	Disarming clock
FMA - Flussmine A	River mine A
HMA - Haft Mine A	Adhering mine A
HV - Hochstandsvernichter	Hydrostatic setting device for UMB
K - Korper	Case
KA - Kontakt Apparat	Tombac tubing
KE - Kontakt Einrichtung	8th horn
KMA - Kustenmine A	Coastal mine A
LFS - Luftfallschirme	Parachute
LIS - Lichtsicherung	Anti-recovery switch
LMA - Flugzeuggrundmine A	Aircraft-laid ground mine A
LMF - Flugzeugankertau Mine	Aircraft-laid moored influence mine
LS - Luftschirme	Parachute
LW - Leitwerke	Plastic tail
M 1 - Magnetisches Fernzundgerat	Magnetic firing device

German	Translation
M 101 - Magnetisches Fernzundgerat fur Bombenmine	Magnetic firing device for bomb-type mine
MA 1 - Magnetisch - Akustisches Fernzundgerat	Magnetic-acoustic firing device
MTA - Minentorpedo A	Mine torpedo A
OB ENT - Oberflachenstands Entscharfer	Mine-disarming device (keeps mooring spindle locked)
OB VERN - Oberflachen Versenkingsein-Richtung	Delay arming device (scuttles mine if not set properly)
OMA - Oberflachen Mine	Moored contact surface mine
PU - Pausenuhr	Off-On delay arming clock
R - Raumschutz	Anti-magnetic sweep device
RA -	Positive buoyancy
RB - Reissboje	Mechanical anti-sweep device
RMA - Regulare Mine A	Control mine A
SE - Scharfereinrichtung	Arming device
SH - Schutzhaube	Protective covers
S.K. - Scharferkontakt	Arming contact
SMA - Schachtmine A	Shaft mine A
S.S.E. - Sprengbuchsensicherheintsein-richtung	Booster detent
Spr. B.D. - Sprengboje D	Explosive anti-sweep device
TE - Tiefensteller	Depth setting
TMA - Torpedo Mine A	Submarine torpedo-tube-laid mine A
UES - Uhrwerkeinschalter	Clockwork arming device
UMA - U-Bootsabwehrmine A	Anti-U-boat moored mine A
UMA/K - Oberflachenmine fur Kustenvorfeld	Moored contact defensive surface mine
V.E. - Versenkeinrichtung	Scuttling device
V.K. - Verzogerungskontakt	Delay contact
VS - Versenkingseinrichtung	Delay Arming Mechanism
VS II - Verzogerungsschalter fur Fernzundgerat DM 1	Delay switch for pressure-magnetic device
VW - Verzogerung Werke	Delay clock
WT - Wassertiefe	Water depth
ZE - Zeiteinrichtung	Sterilizer
ZK - Zahlkontakt	Period delay mechanism

MINE UNIT DESIGNATIONS

Allied	German
M Mk II	M 1
M Mk II (rev.)	M 1
M Mk III	M 1
M Mk VII	M 2
M Mk IV	M 3
M Mk IVa	M 3
M Mk V	M 101
M Mk VI	M 101
M Mk VIII	M 101
M Mk IX	M 103
A Mk I	A 1
A Mk II	A 1
A Mk III	A 1
A Mk VI	A 1st
A Mk VI	A 2st
A Mk IV	A 104
A Mk V	A 105
AM Mk I	MA 1
AM Mk II	MA 101
AP Mk I	AD 104
MP Mk I	DM 1

A Mk II = similar to A Mk VI except for "stumpf" microphone

A Mk III = one battery replaced by filter

A Mk II has two tubes.

A Mk III has three tubes.

MINE DESIGNATIONS

Allied	German
GC^1	LMB
GC^2	LMB/S
GD	LMA
$GG^{1-2-3-4}$	BM 1000 I/II
GH	RMA
GI	RMH
GJ^1	KK
GJ^2	KK
GK	KMA
GL	K TR Mi 41
GL-F	K TR Mi 38
GM	BMC
GN	TMB(S)
GO^1	SMA
GO^2	EMF
GP	LMF
GQ	FMC
GR	UMB
GS	TMB
GT	TMA
GU	EMA/EMB
GV	EMD II
GV*	EMC II
GW	RK
GX	EMD I
GX*	EMC
GY	EMC I
GY*	EMC II
GZ	UMA