RESTRICTED OP 1673A

GERMAN UNDERWATER ORDNANCE
MINES

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NAVY DEPARTMENT

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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.

G. F. HUSSEY, JR.
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 1927, 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. Hell 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 1r 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 alloated, 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 Kalungborg, 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 800 tons, the "Grief".
2. One ship of under 800 tons, the "Vorau[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
- 1 - Mines (von Linden)
- 2 - Influence Sweeps (Lambrecht)
- 3 - Anti-Submarine and depth charges (Davids)
- 4 - Mechanical Sweeps (Gemein)

Flotilla (Rodiger)

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

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

Foreign Mines

Shops

Personnel & Administration

Mine School

Arsenals

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 Erprobungsttellen
Military Control located at Hamburg)

Travemunde

Other Test Stations
(Erprobungsttellen)

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.

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 or 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 1944 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 1940 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.

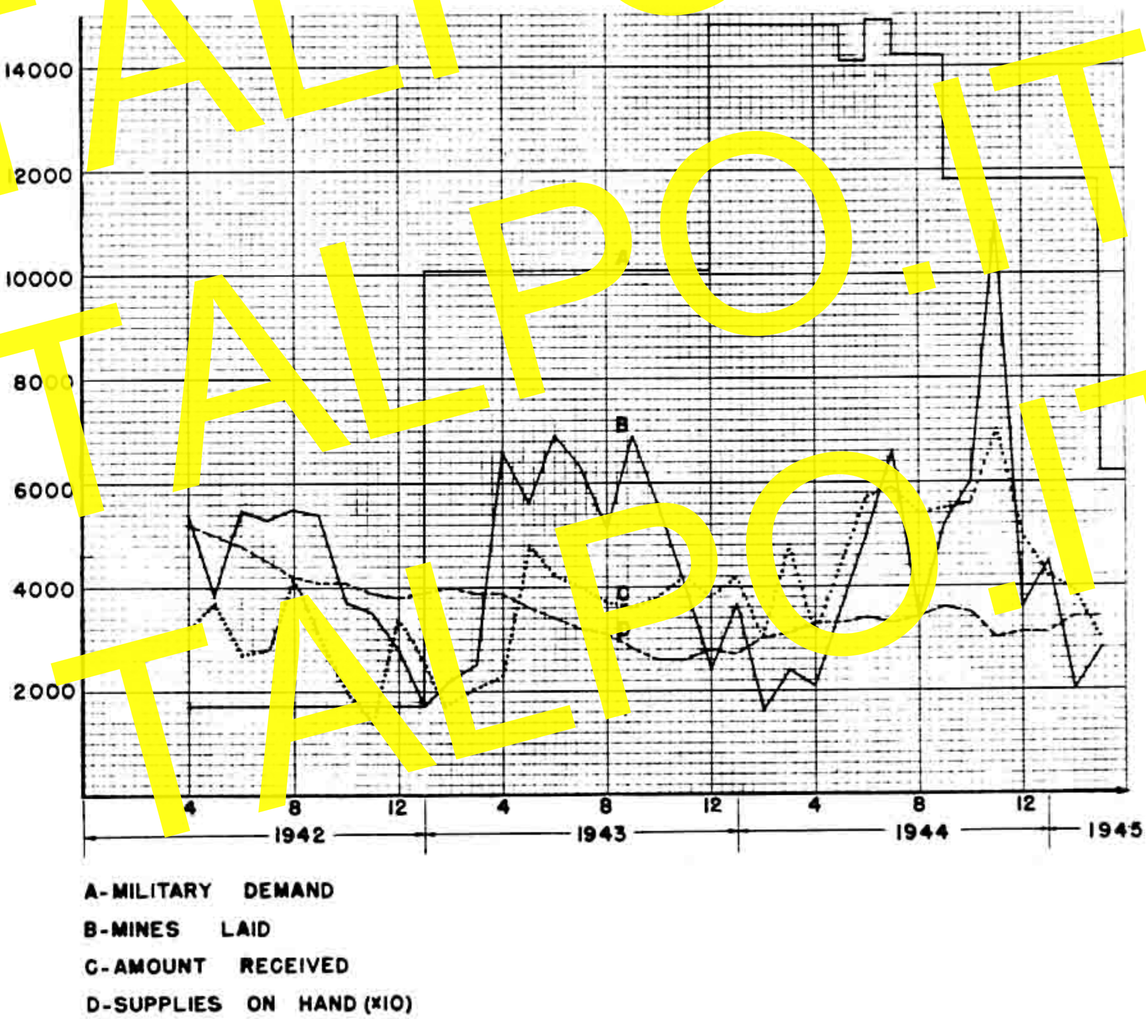

Figure 3 - Graph of Mines Laid.

MINES LAID

Year	Month	BMC	FMB	FMC	UMA	UMB	OMA/I	BMC/S	BMS	BMA	BMH	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	1728		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	6600
	4	5600
	5	6800
	6	6300
	7	5200
	8	5800
	9	5400

Figure 4 - Mines Laid.

Chapter 4

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 midsection.
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

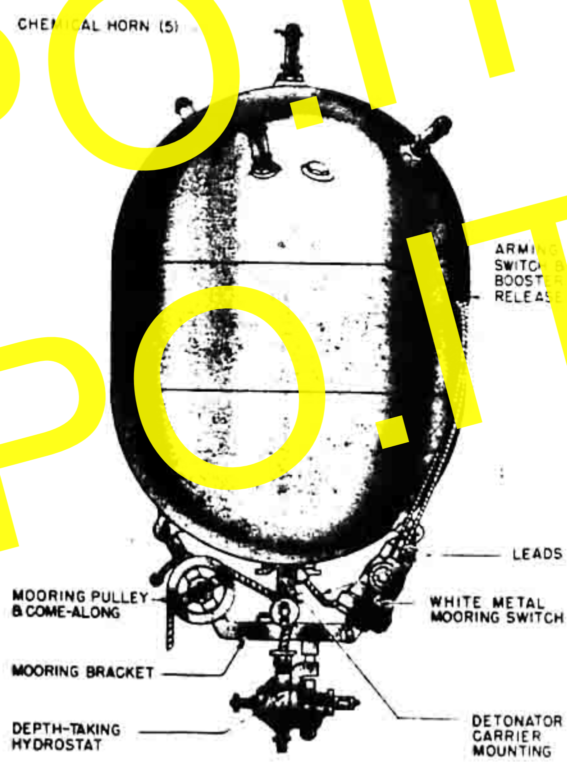

Figure 6 - EMA/EMB Mine

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

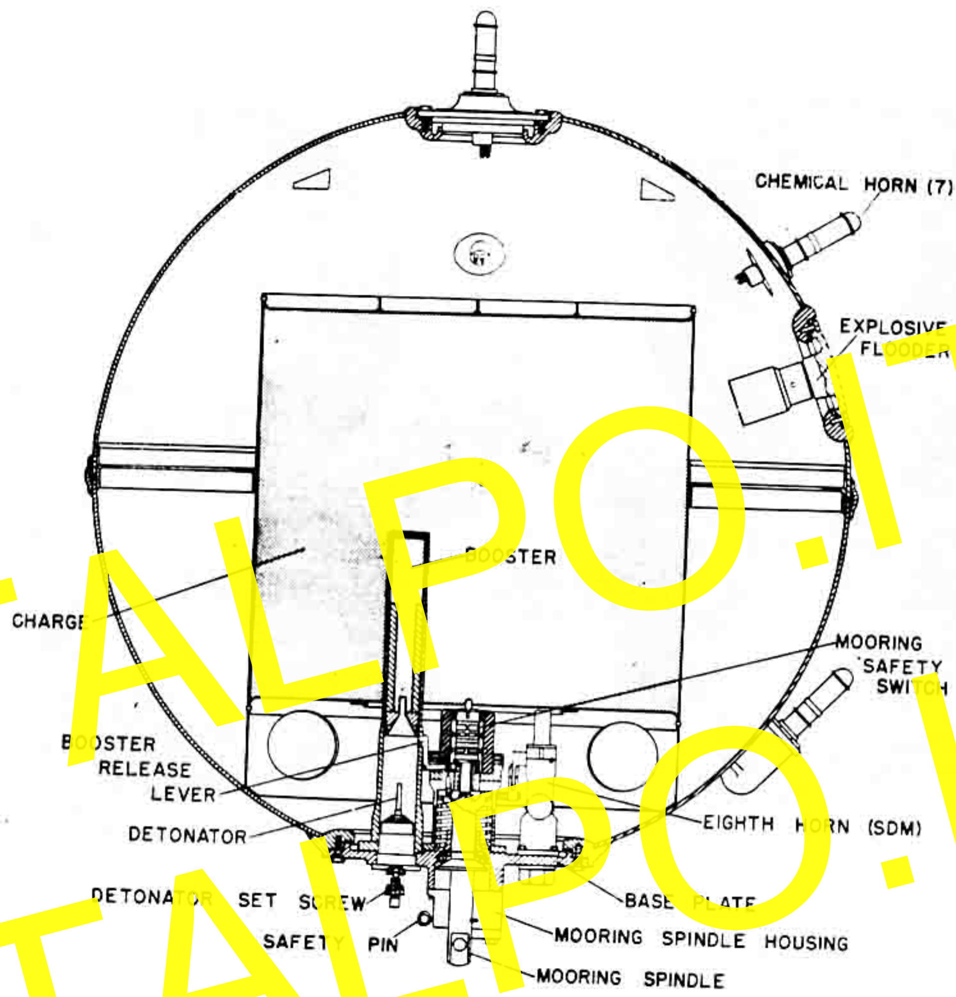

Figure 11 - EMC II Mine - Cross Section

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.)

<u>The EMD Mine</u>. 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

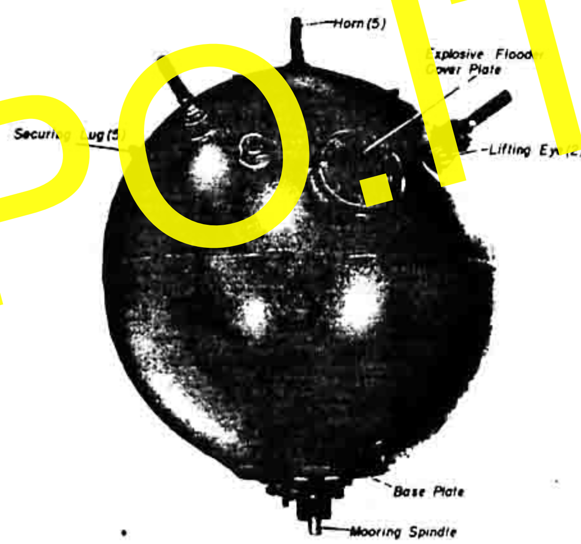

Figure 14 - EMD I Mine

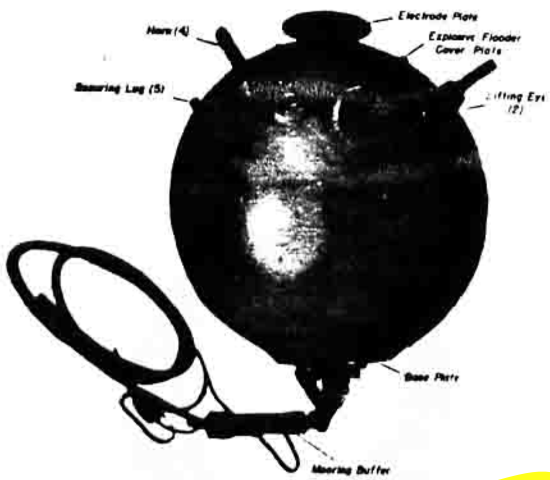

Figure 15 - EMD II Mine - Upper-Lower Antenna

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 1100 feet.

Description of Case

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

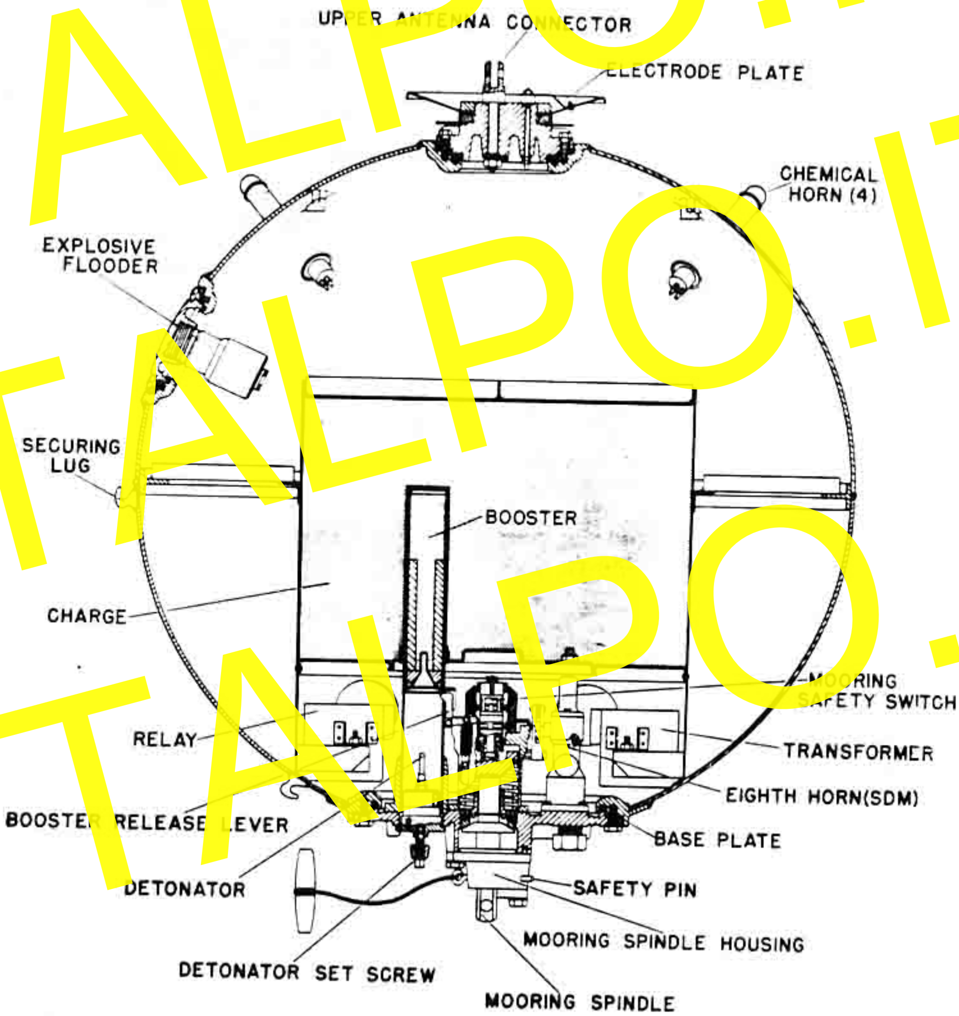

Figure 16 - EMD II Mine - Cross Section

Figure 17 - EMC 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 EME 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

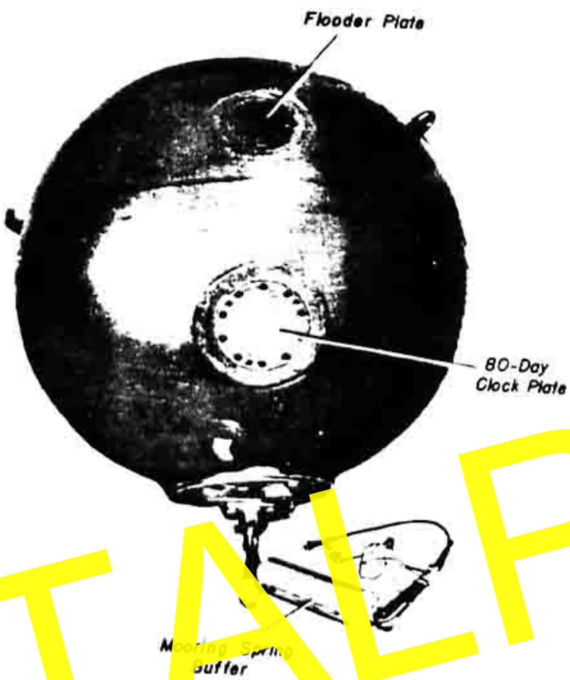

Figure 19 - EMF Mine

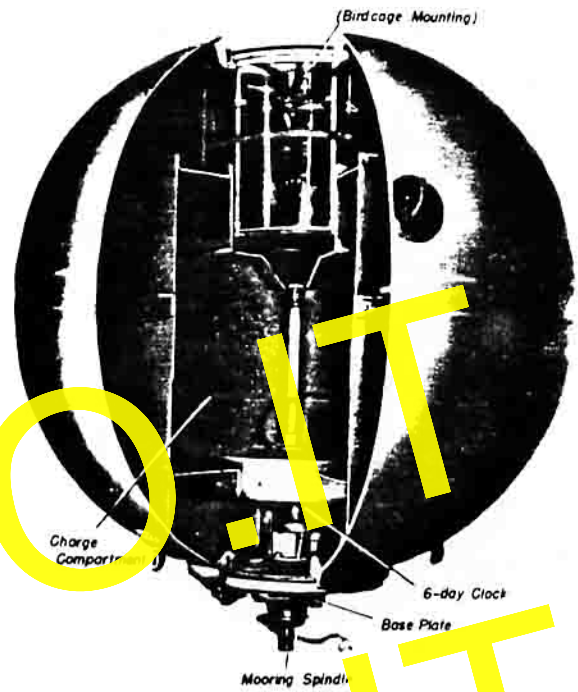

Figure 20 - EMF Mine with M 3 Unit

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	50 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, 11½ 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.

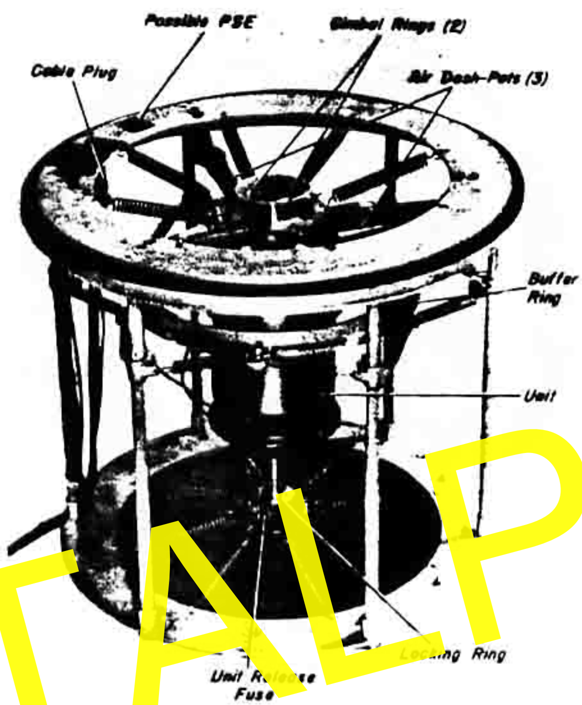

Figure 21 - EMF Mine - Birdcage Suspension for M 3 Unit

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.

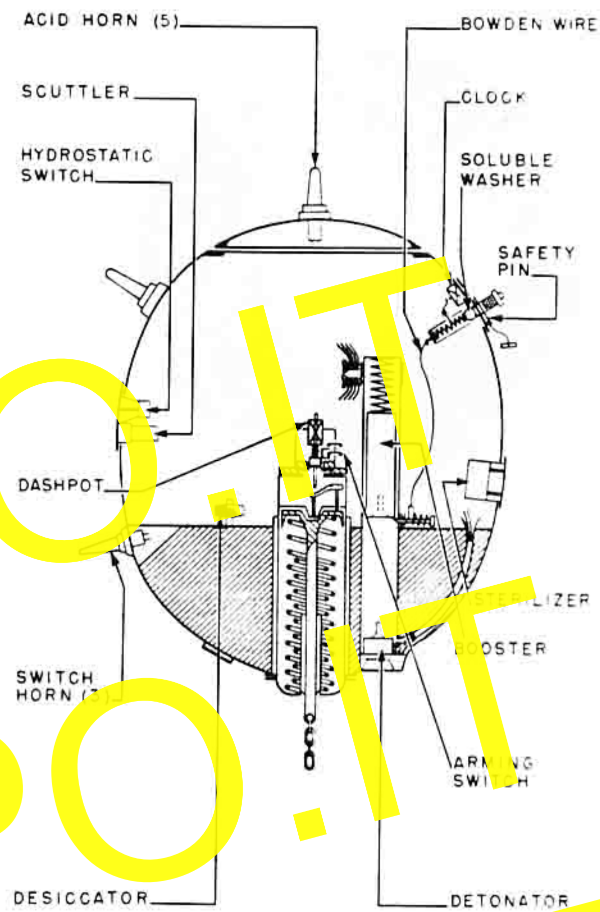

Figure 22 - EMG Mine

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.

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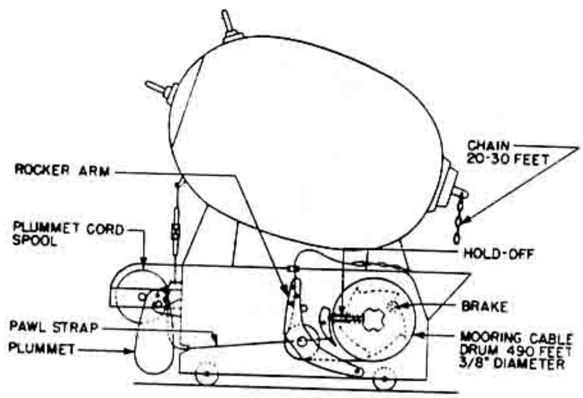

Figure 23 - EMU Mine and Anchor

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.