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## LAND MINES


### Development History of an Antitank and Antipersonnel Weapon Constant Technical Adaptation to a Growing Demand for Increased Performance

by

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Long before World War I, the term 'Mine Warfare' was well known. The term was used to denote tunnels, advanced towards enemy positions and usually filled with large amounts of explosives which, when initiated, were to bury enemy positions or destroy them, in order to make possible the breakthrough of friendly forces. Also covered by this term was combat against ships with naval mines. While this article is entitled 'land mines', its discussion is limited to antitank mines and mines used against other ground vehicles, as well as mines used against live targets on the ground. Both types of mines had their origin as a result of the conditions prevailing during World War I.



#### MINES OF WORLD WAR I AND WORLD WAR II

##### Antitank Mines

When in 1917, for the first time, tanks appeared in great numbers near Cambrai, there was little that could be pitted against these colossi. With great luck, the tanks were stopped either through direct hits from infantry



guns or through efforts to tear apart their tracks with concentrated explosive charges. Under favorable conditions, daredevils managed to enter a tank from the rear and knock out the crew with charges thrown into the vehicle. Such measures, however, were inadequate against the multitude of tanks, which in 1918 had a decisive impact on the course of the war at the Somme, the Aisne and the Marne rivers.

Until the end of World War I, Germany remained unsuccessful in its efforts to stop the approaching steel behemoths with an effective counter-weapon, except for tanks of their own design and the cited defense systems, and except for improvised mines, whose effect usually remained doubtful. Germany, however, was unable to solve the problem of an antitank mine fuze which would satisfy all requirements.

Probably the most sensitive area of an armored vehicle at that time was the track. Therefore, all countries endeavored to design prepared charges which were set off by the pressure of a track. In most cases, these charges consisted of simple containers filled with explosives with enough force to rupture a track. In order to protect such a fuze against inadvertent initiation, perhaps by a soldier running across it, three different methods were mainly employed which are briefly described below:

The *shear pin safety mechanism* which usually incorporated a metal pin going through the striker which was sheared off under heavy pressure, thus releasing the spring-loaded striker;

The *lever lock safety mechanism* in which the lever carrying the striker is held in place by a second lever which is in contact with the pressure cover of the mine. With a load applied to the cover, the second lever turns about its pivot point releasing the striker lever at a given point;

The *ball lock safety mechanism* in which the spring-loaded striker pin is held in place by two or three balls resting between the striker pin and a sliding element which, under pressure from a tank track, is depressed so that the balls can fall into recesses provided for this purpose and thus release the striker.

Of these three systems, the last cited is still considered the most commonly applied system.

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It is understandable that the early land mine designs were intended primarily to knock out attacking tanks, and there was little concern for environmental effects upon the mines or their rapid emplacement and detectability in terrain. Thus, these mines had a rather high profile and no suitable protection against moisture or dirt. Following are a few examples:

*French antitank mine* (Fig.1). An iron case filled with explosive and a cover over it. Length 25 cm, width 15 cm, height of the cover 9 cm. The mine was set off by means of a simple shear pin fuze.

*Belgian antitank mine*. Also consisting of a strong, square-shaped iron case with a pressure cover. Two carrying straps are mounted on the side of the case. The height is nearly 22 cm and the length of the edge is 25 cm.

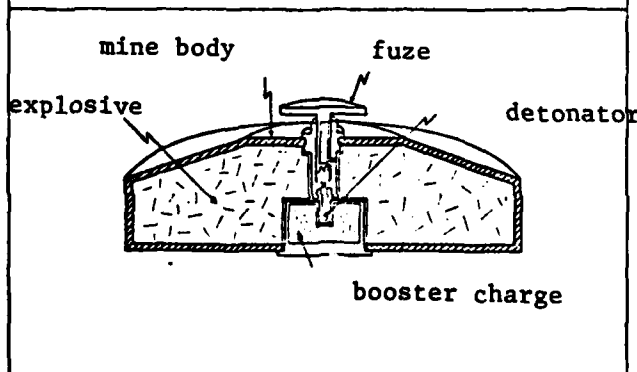
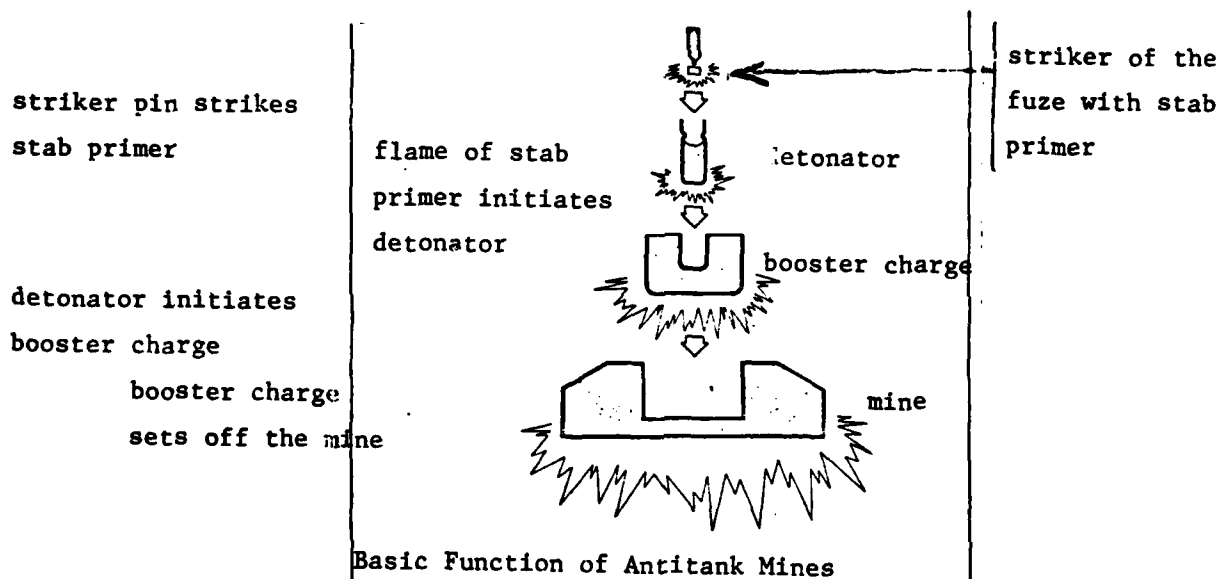
*British antitank mine Mk III* (Fig.2). It has a shape similar to a tin can, contains cast TNT (2.9 kg), has a total weight of approximately 4 kg and is covered with a pressure lid shaped like a hood. Including the pressure lid, which had a small recess in the center for the striker pin head of the shear pin fuze, the height of the mine was 13 cm, the diameter approximately 16 cm. This mine was probably developed on short notice, since the two previous models, Mk I and Mk II had proved to be too insensitive to pressure, due to the additional support of the pressure lid by leaf springs and also as a result of its low effectiveness, due to the small amount of explosive. The shear pin fuze was activated only with applied pressure of 150 kg or more. Furthermore, these mines had no safety devices, and the fuze had to be installed immediately prior to emplacement of the mine. The same was true for the detonator which had to be inserted into a well on the side of the mine. The only difference between the Mk I and the Mk II was the design of the fuze; the external dimensions, as the diameter of 18 cm and the height of 8.25 cm, remained the same. The weight was approximately 3.8 kg, 1.8 kg of which was Baratol 10/90.

Soon thereafter, efforts were made to protect the mines and their fuzes against environmental effects, to adapt the amounts of explosive to the respective requirements and to provide the mines with a shape which would assure detonation of the mine even if it was not completely contacted by the tank track. Usually, a round configuration with a gently rounded pressure cover was preferred. As examples, a Dutch antitank mine which was still in the inventory until the beginning of the war in 1939 is shown in Figure 3 and a Polish mine, whose explosive content consisted of four packs, 200 g each, of TNT, is shown in

Figure 4.

### Function and Design of Antitank Mines

No matter how much, in the course of development, technology may have changed the appearance and the effect of mines, for instance through improved explosives and the shaped charge principle, the basic principle of the function and design of antitank mines will hardly change with respect to their characteristic criteria. As an aid for better understanding of the development history of these defensive weapons described in this paper, both the function and the design of mines are presented in the following drawings.



What about the German developments? The prewar Reichswehr had an anti-tank mine as defensive weapon, the so-called Panzermine 29 which was later replaced with the well-known T-Mi 35 (antitank mine).

The T-Mi 35 (Fig.11) with a total weight of 9 kg, approximately 5 kg of which was explosive, had a screw-type fuze and a height of 10.5 cm, with a diameter of 32 cm. It was triggered by a load of 190 kg in the center, or 100 kg on the edge of the pressure cover. Its blast effect tore apart tank tracks up to 70 cm in width, if the mine was covered by 2/3 of the track. The fuze of this mine (Fig.5), which could be used only in the T-Mi 35, had a double safety and was issued to the troops with the detonator already installed.

In addition to this heavy antitank mine, a light antitank mine had been developed (Fig.6), which was designed especially for use against wheeled vehicles, but perhaps also for use in the preparation of hasty barriers and for application by airborne troops. It was considerably lighter than the T-Mi 35 (4 kg, almost half of it for the explosive) and had a smaller diameter. During transport, the mine was protected against inadvertent initiation of the detonator due to accidental release of the fuze, by a safety spindle which had to be raised during arming of the mine. When a vehicle drove over the mine, the container sections were compressed and one or several of the five pressure fuzes located between the sections were initiated. For the purpose of a hasty barrier, two mines, connected by a pressure bar, could be used.

The growing lack of raw materials soon after the beginning of World War II, made it impossible to meet the demand for the brass fuze used in the T-Mi 35 mine. For this reason, a simpler shear pin fuze, the so-called T-Minenzuender 42 (T-mine Fuze), shown in Figure 7, was developed, and the previous T-Mi 35 mine, shown in Figure 11, was slightly modified. It was equipped with a radially finned steel cover with a pressure cap and, where necessary, a different fuze seat.

When, in 1941, the war against the Soviet Union began, troops encountered the box-shaped TM 38 and the round TM 41 mines, fielded by the Soviet Army. Both mines, like all previous mines of other countries, had metal casings (Fig.8).

There were several means to detect and eliminate such metal-case mines. The most primitive means was a bicycle spoke or a bayonet, which, at that time, was still carried by all soldiers. These were used by the soldiers to probe the ground in search of mines. Engineers already had special mine probes of different lengths. Since these methods were rather time-consuming and not without danger for the soldier, electric mine detectors were developed as early as the beginning of World War II. These detectors built up an electromagnetic field through a current flow which was disturbed by the metal mine body. The presence of an "interfering" obstacle was indicated to the soldier operating the device, either visually (Fig.9), or, in most cases, through a whistling sound in his earphones. At the end of a long rod, the "search head" was shaped like a ring or flat. The latter was moved back and forth by the soldier at a height of approximately 5-10 cm above the ground.

The fact that metallic mines could be detected with such mine detectors, and also the fact that, especially in Germany at the time, raw materials became increasingly scarcer, prompted the use of non-metallic material for mine casings. The Russians were masters in this respect. In addition to the wooden box mine *TMD-B* (Fig.10), they employed all types of mine casings, such as oil-soaked paper, mixtures of turf and bitumen or even resins. Other countries resorted to different means. They protected their mines in minefields against detection with electronic mine detectors (and against possible later removal) by emplacing the mines together with antipersonnel mines which were either non-metallic or had a very low metallic content. These antipersonnel mines will be discussed in more detail later.

In 1942 and 1943, the German T-mine was again modified (Fig.11), the expensive production of the T-35 mine with its brass fuze was terminated altogether, and only the production of the T-42 mine was continued. The weight of slightly more than 9 kg and the previous dimensions of the T-42 and T-43, the latter also referred to as *T-Mi 43 Pilz* (mushroom), on account of its pressure component, were retained. Both mines had a sheet steel case.

In addition to these "standard mines", produced in large, yet insufficient numbers, there were, beginning in about 1941/42, a great number of other mines

which were either non-metallic or had a low metal content, so that they could not at all be detected with mine detectors or only with great difficulty. These mines were not always of German origin.

The *Topfmine A 4531* (pot-shaped mine), shown in Figure 12, did not have any metal parts, had the shape of a pot or bowl and weighed about 9 kg. Its diameter of 33.4 cm was somewhat greater than that of standard T-mines, and it had a greater height (14 cm). The mine was set off by a non-metallic, chemical fuze, which was triggered when the pressure cover of the pot mine was subjected to a load in excess of 140 kg (Fig.13).

The *Glasmine 43* (glass mine), shown in Figure 14, like the aforementioned mine, was made primarily in France. It consisted of a glass container, the bottom section of which was filled with explosives. A Sprengkoerper 28 (explosive body 28) served as booster and location for the fuze. The glass mine could be equipped with a non-metallic, chemical fuze, the so-called "Buck Fuze", or with the newly developed "Schuco Lever Fuze" (Fig.15). When the thick glass pressure plate of the Schuco Fuze was pushed down onto the lever under the weight of a crossing vehicle, the lever gave in by turning about its pivot point, whereby a pin, holding the striker in place, was pulled out through the upward movement of the tines located at the end of the lever. The spring-loaded striker was released and could strike the primer whose flash set off the detonator cap and thus the mine. The glass mine was used in great numbers on the Channel coast and the Atlantic coast of France.

Two versions of the *Pignone Bakelite Mine* were manufactured by the Italian firm Pignone of Florence, Italy. Its bakelite construction was designed to prevent detection by electric mine detectors. However, there were so many metal parts in the fuze of the mine that it could be detected with sensitive instruments. The only difference between the two mines is the size of the pressure covers and the difference in pressure required to set off the mines. With Type I, only about 60 kg of pressure (pressure plate approx. 32 cm) is required. With Type II (Fig.16), the required pressure is approximately 140 kg (pressure plate approx. 14 cm). Noteworthy was the fact, that once the fuze was armed with a key that had to be pulled off the fuze at that time, it could be disarmed only with the key belonging to that particular fuze. The weight of the explosive was approximately 3 kg, the overall weight slightly above 4 kg.



The *Panzerschneellminen A and B* (instantaneous antitank mines), shown in Figures 17 and 18, were used only in Normandy, which leads to the conclusion that it was also made in France. These mines could also be detected with sensitive mine detectors, because steel nails were used for the wooden case which contained approximately 6 kg of explosive charge (picric acid), wrapped in water-repellent paper, and because of iron handles on the mine.

The instantaneous mine A, similar to the antipersonnel mine 42, to be described later, was equipped with the ZZ 42 pull fuze (Fig.19), while mine B was set off through two built-in Buck fuzes, i.e. chemical fuzes.

The *Riegelmine 43* (crossbar mine) had a totally different configuration (Fig.20). It was a typical pressure mine which - as the name implies - had an elongated shape. It was issued to the troops with two installed pull fuzes ZZ 42 and installed detonators, i.e. the mine was armed and operational. The mine had two main sections: the mine body with 4 kg of explosive and the housing made of black sheet metal- the upper and lower section. Mine housing and mine body were connected by means of two shear wires. The lower case with the mine body was covered on both end sides with a bridge, making contact with the safety pin of the pull fuze 42. Two locking bolts held the upper and lower case in position during transport, so that there was no possibility of cutting off the shear wires, due to improper handling, and setting off the fuze prematurely. The safety pins had to be removed prior to emplacing the mines. In addition to the two built-in fuzes, the mine had three additional fuze wells for use with other activation means. The 80 cm long, approximately 10 cm wide and 8 cm tall mine was very effective against tank tracks and also against the vehicles proper. The overall weight of this weapon was 9.3 kg.

So much for the development status of antitank mines at the end of World War II. Following is a discussion of "antipersonnel mines".

#### Antipersonnel Mines

Antipersonnel mines are mines intended for use against live targets and have small explosive charges up to approximately 150 g. However, these mines

are perfectly capable of incapacitating a soldier, certainly for an extended period. Today, these mines are usually non-metallic, while they still had metal casings during the last world war. A special category are the "antipersonnel bouncing mines". They are effective not only against the individual infantryman, who triggers the mine through the weight of his body or by contacting a trip wire, but also against nearby personnel, since the mine springs out of the ground to a height of about 1.5 m, before it detonates, whereby a great number of fragments are dispersed over a large area. In most cases, the fragments are lethal up to a distance of 10 m and beyond, and cause serious injuries even at a distance of 50 m. For practical reasons, all these mines are metallic. Some of these antipersonnel mines used in World War II are listed and discussed below.

Figure 21 shows the German *Schuetzen-Dosenmine* (cylindrical antipersonnel mine) which was also referred to as "Schuhwichsschachtel" (shoe shine can), because of its shape.

A similar, simple antipersonnel mine was used by the Russians - the *PMK 40* (Fig.22). Its casing was made of impregnated kraft paper. Also shown, in the same figure is the *PMD-6* wooden box mine often used by the Russians. Under load, the pressure cover of this mine would push the safety pin out of the extended striker, thus releasing it. These mines were filled with 200 g of explosives. This type of mine was the model for the previously described instantaneous antitank mine A, and also for a German version with the *ZZ 42* pull fuze.

The first *French canister mine* (fragmentation mine) was a bouncing mine, as were the later cited models. It contained a 60 mm mortar projectile which was detonated at about a man's height after ignition of the propellant charge. This mine was adopted in a modified version by the Dutch Army as the high-explosive antipersonnel mine *M2A3* (Fig.23).

A *British bouncing mine* (Fig.24) worked in accordance with a similar principle. After actuation of the pull fuze, the striker struck a black powder cartridge. The mine body, mounted with two bolts on the bottom of the can, was ejected by the gas pressure of the burning black powder and was detonated

at a height of about 1.7 m by a lever fuze released upon ejection.

In 1935, Germany introduced a totally new design of a high-explosive bouncing mine, the *S-Mine 35*, a cross-section of which is shown in Figure 25. When the associated S-mine fuze 35 (Fig.26), whose three pressure pins barely protruded the ground above the mine, was subjected to pressure from a soldier who stepped on the mine, the ignition flame activated the 4.5 sec delay train, which in turn set off the propellant charge located on the bottom of the mine. This process not only activated the short-time delay elements located ahead of the detonators, but also vertically ejected the mine charge (explosive charge with a steel ball sleeve) from the can remaining in the ground, and exploded at a height of 1 - 1.5 m above the ground.

In 1944, the S-mine 35 was simplified; in lieu of the previous three activation wells which had to be screwed onto the mine for arming purposes and had to be equipped individually with a primer, only one activation well was present on the new version, with the fuze seat, which had been located in the center of the cover, relocated closer to the edge of the cover. The fuze was also slightly modified and designated S-MiZ 42. With the exception of the above changes, configuration, weight and handling remained the same as for the S-mine 35.

This high-explosive fragmentation mine, which was kept virtually secret until the start of the war in 1939, was copied by almost all of the countries then fighting Germany during and even after the war. Some of these mines are shown in Figures 27 - 30.

In addition to the simple tread mines, whose explosive charge could, upon detonation, smash a soldier's foot or more, and the aforementioned bouncing mines, there were also simple fragmentation mines. The best known of these was probably the Russian stick-mounted fragmentation mine *POMZ-2* (Fig.31) which was copied and used by the Germans during the war, but made of concrete with embedded steel fragments. Both types of mines were usually used with trip wires in difficult terrain.

Not too well known is probably the US fragmentation mine *M 3* (1941), which

had a 1 cm thick steel body and two fuze wells. It was filled with flake TNT (Fig.32).

## DEVELOPMENTS SINCE WORLD WAR II

### Antitank Mines

As mentioned before, the antitank mines of World War II were usually explosive charges with a metal body that could be detected and located with electronic mine detectors which usually operated on the basis of the induction bridge principle. A certain amount of protection was offered for this type of antitank mine by fuzes that could be initiated by induction. However, these fuzes were obviously very expensive. Protection was also provided through the emplacement of "mixed minefields", i.e. the metallic mines were protected through non-metallic antipersonnel mines, or antipersonnel mines with a low metallic content which were laid at the same time.

After the war, the trend toward non-metallic mines was continued by all countries. Plastic materials which made their appearance during and after the war were ideal for this purpose.

However, it was not always possible to construct antitank mines completely without metal, since the requirements imposed on these mines in terms of lethality were growing rapidly after the war, and the weight was to be kept as low as possible, which in turn meant a smaller explosive charge.

With the formation of the Bundeswehr (West German Federal Armed Forces), the question of antitank defense by means of mines again became acute for the Germans. Since it was not possible to have German production, all obtainable non-German mine designs were studied in large-scale tests and compared to determine their advantages and disadvantages. Within the course of the general development, special emphasis was placed on non-metallic mines. Some of these models, tested at the time, are shown in Figures 33 - 36. Figure 36 shows the French *Alsetex mine* which best met the German requirements and was selected

as the standard mine for introduction into the Bundeswehr.

The 7 kg mine consisted completely of cast TNT and had a fragmentation groove between the cover plate and the main body. A rod, provided with a friction element, served as a fuze. Similar to a match, the rod was ignited on friction surfaces and set off the detonation with the ensuing flame. In order to preclude unintentional activation, the rod was provided with supports which broke only under the pressure of a given load. In order to give more support to the actual mine body, a small amount of glass wool was embedded during casting of the TNT, especially on the upper side of the mine. The body was protected against moisture by a colorless lacquer. Since there was no metal used in this mine, neither for the actual mine body, nor the fuze, it could not be detected with the electronic mine detector used at that time. The antitank mine fielded by the Bundeswehr under the designation *DM 11*, was soon given a different fuze design, which also did not include any metal parts. Even the primer housing was free of metal. In this new design, the usual metal spring was replaced with a plastic Belleville spring (Fig.37).

All of the nations of the East and West worked of course on improved developments of mines. In the US, the M 6 antitank mine (Fig.38), which was still available in large numbers after World War II, was replaced with the new version *M 15* during the Korean War. The M 15 had a greater explosive effect, but was still a metal mine (Fig.39). Several years later, the square non-metallic *M 19* (Fig.40) became the standard mine. This mine, similar to the German *DM 11* mine, was activated by a Belleville spring when weight was applied to the pressure cover. The mine is delivered with the fuze installed, but is not armed until the safety lever is turned after removal of the safety clip, serving as a safety protection during transport.

Great Britain introduced a new model, the *Mk 7 antitank mine* (Fig.41). The latter is a round metallic mine with a diameter of approximately 30 cm. For shipping and storage, the mine was provided with a protective cover, held in place by three clamps. There were other mines in development, one of which was non-metallic. Another version utilized the system of the former German *Riegelmine* (crossbar mine). This mine will be discussed in more detail later

in conjunction with mine-laying equipment (Fig.42).

Belgium considerably improved its *PBR III* mine, reducing the size, while increasing the penetration by a new explosive mixture, and removed almost all metal from the fuze, so that this mine can be detected only with highly sensitive metal detectors (Fig.43).

As could be expected, little is known about the developments in the Warsaw Pact countries. The Soviet *TM-46* mine (Fig.44) is a metal-case mine which may be considered as standard. Also known is the Czech non-metallic *PTMIBa 54* mine (Fig.45), which is similar to the German DM 11 in its dimensions, and perhaps also in its design. A non-metallic mine equipped with three fuzes was reported from Yugoslavia. It is said to be made of asbestos cement and plastic. This mine is detonated under a weight of 180 kg or more. This allegedly non-metallic mine cannot be detected with electronic mine detectors.

Several attempts have been made in the Federal Republic of Germany to construct non-metallic mines. Among others, a mine was made with the "HOLTEX" explosive, which was manufactured as early as World War II and used for special purposes. However, this mine had to be rejected not only because of its high production cost, but also because of malfunctions encountered during testing and during extended storage. Another non-metallic mine which seemed to be promising was encased with a highly resistant plastic material. This mine fully met the then established requirements for an approximately 5 minute delay from the moment the mine was armed, until full activation of the fuze (Fig.46). This requirement had been imposed since these mines were designed to be automatically armed and emplaced by mine-laying vehicles which will be discussed later. However, this development was terminated in favor of a simultaneous development for the so-called "Panzermine II" (antitank mine), a metallic mine, which was designed as a replacement for the DM 11 antitank mine.

With its revolutionary fuze design (Fig.48), the metal-case *Panzermine II* (antitank mine), shown in Figure 47, was an almost ideal mine, since it met in almost all respects the requirements then imposed on a high-kill mine. It could be laid by helicopters from altitudes of up to 10 m without risk of

detonation upon impact in its armed condition, and was even protected by its tilt cover design from activation by an exactly central load, such as is generated by a shock wave, and/or nuclear explosions. Only one step was necessary to arm the mine for either manual or mechanical emplacement. After five minutes, the mine was fully operational. Its explosive content weighed 5.6 kg, with an overall weight of slightly in excess of 10 kg.

Logistic considerations, in particular, caused the Federal Republic of Germany and other countries to establish criteria for the size, overall weight, explosive weight and desired lethality of mines. They also established some new requirements for mines, such as droppability from the air from greater altitudes, and the destruction of an attacked vehicle in lieu of mere neutralization through a destruction of its tracks. This led to a re-design of the antitank mine II which was already being tested.

#### Shaped Charge Mines

The aforementioned requirements also prompted various friendly countries to offer and test a number of additional mine designs. In particular the requirement for "destruction of vehicles and crews" by the mines gave new impetus to the incorporation of shaped charges. As early as the end of World War II, tests were conducted with mines, whose explosive charge had been designed in accordance with the so-called "Misznay-Schardin Principle".

After the war, three designs were developed and tested in France.

The *Mle.48-55* antitank mine with flat charge (Fig.49). The initiation of this antitank was caused by a tilt-rod fuze. The fuze first removed the ground cover above the mine by detonating a ring of primacord. The slightly bulged "mine plate" resting on the explosive charge is hurled like a projectile against the tank's hull after the detonation of the explosive charge, and cut a large hole into the hull. The shock waves from the explosive charge could enter the hull through the unobstructed opening to destroy the interior of the vehicle.

The *Mle. STRIM* antitank mines (Fig.50) were also activated by tilt-rod fuzes, which were connected in pairs by a detonating cord in such a way that upon activation of one mine by a track of a tank, the other mine was activated under the hull of the vehicle.

By the end of the 60's, the *HPD* mine, which also contained a flat charge, as did the *Mle. 48-55*, was tested. This was a plastic-case mine which could be laid either mechanically from a special vehicle or by hand. It weighed 5 kg, 2 kg of which were Composition B explosive. The mine was activated by a magnetic dual-component fuze emplaced separately from the mine, the power source of which was operational approximately 15 min after emplacement. This mine cannot be laid from the air.

The Swedes, with their *FFV 028* mine (Fig.51), went a step further and incorporated the induction fuze in the mine. If the induction field of the mine is disturbed by an armored vehicle, the detonating train is initiated, and, first, the activation mechanism and any camouflaging of the mine are blown away, so that the shaped charge jet forming during the detonation of the main charge can develop without interference. This mine is not activated by artillery shells, unarmored vehicles or by a nuclear shock wave. On the other hand, it does not matter whether the tank disturbs the induction field with its hull or track. This makes it possible to save at least 1/3 of the explosive of the mine, as compared to pure pressure mines. The *FFV* shaped charge mine is delivered and laid with a built-in fuze. The mine is armed after removing the transport safety simply by depressing and turning an arming lever. After 15 minutes, the mine is operational for several months. The shaped charge consisting of 3.5 kg RDX/TNT can damage a tank to knock it out of action.

The *M 21* mine originated in the US. This is also a flat-charge mine whose 3.9 kg explosive charge can knock a tank and its crew out of action. The total weight of the mine is approximately 6.5 kg.

This problem was also tackled by the Warsaw Pact countries. Figure 51 shows a Hungarian shaped charge mine.



In the Federal Republic of Germany, efforts were also made to improve the effectiveness of mines through the shaped charge effect. Several companies introduced models, yet none of the proposals survived the test stage. Shaped charges are fully effective only if the jet can develop without interference. Therefore, a given free space is required above the shaped charge cone. It is also important that any camouflaging does not obstruct the shaped charge jet. Tests were also conducted with the objective of replacing the cone-shaped liner of the shaped charge, which usually consisted of copper or steel, with ceramic material in order to prevent detection of these mines.

In this context of shaped charges, the "horizontal mine", also referred to as "*remote antitank mine*", should not be ignored. This concept, developed by a German company, was particularly suitable for combat against tanks in terrain which cannot be blocked with conventional mines (swampy or flooded ground) or also for blocking of roads and narrow passes. The mine, arranged on a fixture, was filled with high-performance explosive, usually Hexatol, and had a metal casing shaped like that of a flat charge. During detonation, the casing impacted the tank's armor similar to a KE projectile flying at high speed, and penetrated even reinforced sections. The mine was activated through electric wires which were crossed by the tank, or by direct observers (Fig.53).

The French Army reproduced and improved this mine as an antitank mine. It was fielded as *MAH Mle. F1*. The overall weight of the French mine is 12 kg, about half of which is explosive. The diameter is 18.5 cm, the maximum height of the mine, which can be tilted from the horizontal plane to a certain degree, is approximately 40 cm.

Let us now return to the German *Panzermine II* (antitank mine), which was considerably reduced in weight and size, in accordance with the new logistic requirements, and was improved with respect to its handling safety. Because of the changed height of the mine, the fuze had to be redesigned (Fig.54-55). The mine can now also be dropped from greater altitudes. An undoubtedly unintended side benefit resulted from the redesign, that is the fact that the charge now roughly has the effect of a shaped charge. This fact was determined during testing.

One of the mines that can be dropped from high altitudes is the Italian *MATS mine* which has a fuze mechanism that functions in accordance with a pneumatic principle (Fig.56). This plastic-case mine was developed for a special laying device which makes it possible to quickly scatter the mines from helicopters flying at rather high speed in order to block a tank spearhead, or to interdict advancing tank columns through a rapidly installed minefield. Whether this equipment and other mostly older mechanical mine-laying equipment, shown in Figures 57 - 61, will be successfully deployed, cannot be determined, especially since the trend is towards mine-laying by means of wide-area fire weapons.

There cannot be any doubt that, in addition to scatter mines laid by rockets, conventional mines will still have a future. Only the configuration of such mines is still open to question. Due to advances in the state of the art, increasing emphasis is being given to the mine fuze, as compared to the actual explosive charge. Even today, "piezo-ceramic impulse fuzes" are used in many cases, in lieu of mechanical or mechanico-electric fuzes. In the field of mine technology as well, tests are being conducted which have led to very positive results, and through utilization of such fuzes, it might become possible to again place more emphasis on the antitank mine within the antitank concept, especially since in that event certain tactical and technical requirements which otherwise could not be met, or be met only with great difficulty, might become achievable.

To conclude this section on "antitank mines", I would like to briefly mention a type of mine which belongs in this category and which can be used against armored fording and amphibious vehicles - the "*river bed mine*" (Fig.62). Such a mine was developed in Germany in cooperation with the Netherlands. The old Alsetex mine DM 11 is used for the explosive body of this mine. As is known, the effect of an explosive detonation is much more effective under water than on land; it is lethal for a tank. The mine functions with an electronic proximity fuze which floats approximately 30 - 50 cm under the surface of the water, and which remains active for about 90 days. The mine is initiated when a tank makes contact with the fuze mechanism or pulls it close by means of the coaxial cable connected to the mine (Fig.63-64).

## Antipersonnel Mines

After World War II, considerable improvements were made in the area of antipersonnel mines; first, with respect to direct employment of these mines against attacking units, and second, as previously mentioned, in order to protect antitank minefields of metallic mines, which are not under constant surveillance, against detection and removal. The configuration of the antipersonnel mine designs varied a great deal, but they all had one thing in common: They were non-metallic or had a very low metal content. Two Belgian mines of this type should be mentioned:

The *PRB-AP-BAC-H28* (Fig.65) is practically non-metallic, has a diameter of 9 cm and a height of 2.8 cm. With an overall weight of 165 g, the explosive mixture of TNT/RDX weighs approximately 65 g. Despite the very short functioning distance of its fuze of only 2 - 3 mm, this mine could be scattered without risk.

The *PRB-AP-M 35* (Fig.66) had a slightly greater height and a smaller diameter, and consisted of a mine body and a fuze. The overall weight of the mine was 158 g, the explosive weighed 100 g.

Another non-metallic mine was the British *AP 6 Mkt* antipersonnel mine (Fig.67), which was also referred to as "carrot" because of its shape. The fuze was embedded in the ground and activated through pressure on a three-prong pressure element.

The French designed a non-metallic antipersonnel mine which, similar to the Alsetex antitank mine, was provided with a friction fuze. The French *Model 51* is shown in Figure 68. This antipersonnel mine was also used by the Dutch Army (*Mijn AP 22*). The Italian *SACI 56* antipersonnel mine was of rather simple design.

Much more complex, and provided with a re-arming capability, was the US *AP-M 14* plastic mine, in which only the striker for the primer was still made of metal (Fig.69). It had a diameter of 5.6 cm and a height of 4.3 cm.

The West German Army fielded the Swedish antipersonnel pressure mine of

the LIAB company under the designation *Schuetzenmine DM 11* (Fig.70). The latter is a non-metallic mine, which is initiated by a Belleville spring under a given pressure (Fig.71).

The Canadians took a completely different approach with their antipersonnel mine, the *M 25 Elsie* (Fig.72), which has a cone-shaped plastic housing, pointed at the bottom, and can thus be easily pressed into the ground. It has a shaped charge which, in spite of its low weight of only 10 g, is very effective. Tests have shown that at least the foot of the soldier stepping on the mine, is shattered. The mine was further improved by British development agencies and was given the designation *AP No 8 Red Elsie*. However, it is not much different from the Canadian mine. A British development of a scatterable antipersonnel mine with the designation *Dingbat* is of interest. The mine is partially armed by inserting the detonator slide. However, the mine is not fully armed until the safety pin is removed and reinserted until it makes contact with the stop (Fig.73).

A scatterable antipersonnel mine, similar to the antitank mine MATS, which can be dropped from high altitudes without risk, was developed by an Italian company. This mine also has a pneumatic fuze system, but its dimensions are smaller than those of the antitank mine.

Along the East German border to the Federal Republic of Germany, the German Democratic Republic laid dark-brown, plastic-case antipersonnel pressure mines as an antipersonnel barrier. Several of these mines were recently washed onto West German territory during flooding of the area. This Soviet *PMN 6* mine (Fig.74), which has a low metal content, has a rather large explosive charge of 240 g of TNT. It also incorporates a delay safety mechanism which leaves the mine inactive for about 20 minutes after disarming and emplacement, as an additional protection for the soldier who is laying the mine. This delaying action is achieved through a built-in lead platelet which has to be cut by a steel wire connected to the spring-loaded striker. The same type of delay action prior to activation is found in the somewhat older Soviet antipersonnel pressure mine *PMND-2* (Fig.75).

This selection of antipersonnel mines may suffice to provide an idea of sizes and configurations. In contrast to antitank mines, few (if any) revolutionary changes in technology are expected in this area. Antipersonnel mines are too small, and too many of them are required, to provide them with complex fuze mechanisms. By emplacing a large number of these mines, the attacker is to be weakened through personnel losses and confused. The situation is slightly different with respect to antipersonnel fragmentation mines. In this category of mines, a new approach was taken with the US *M 18 Claymore* mine (Fig.76). However, this mine cannot, as is possible for the German *DM 31* fragmentation mine, be employed in three modes as tread (step on) mine, trip wire mine or command-fired mine, but can be initiated only by an observer. The US *M 18 Claymore* antipersonnel mine consists of a slightly bent plate which is inserted into the ground. This plate is coated, on the side facing the enemy, with an explosive layer and pre-fabricated fragments. The mine is initiated electrically either by closing a battery-fed circuit or via a firing unit assembly.

In addition to being used in open combat, the antipersonnel fragmentation mine will, in the future, be employed more and more for local defense. However, the most suitable design configuration would still have to be found.

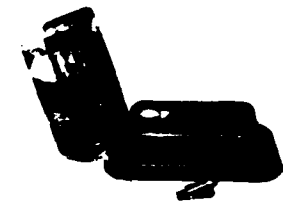
#### Bibliography:

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Army Regulations: HDv 220/4b; ZDv 3/79 (West German Army), and one Dutch regulation - "Mijnen".

Industry Publications: Dynamit Nobel AG, Troisdorf; Industrierwerke Karlsruhe-Augsburg; Pouderies Reunis de Belgique; Metallwerk Eisenhuette GmbH vorm. Schwartzkopff.

## ILLUSTRATIONS



1

Figure 1: French antitank mine with 2 fuzes;  
pressure cover open



2

Figure 2: British antitank mine MK III with  
pressure cover removed; fuze still  
has a safety splint.



3

Figure 3: Dutch antitank mine with transport  
cap removed.



4

Figure 4: Polish antitank mine with pressure  
cover removed; in the front, the fuze.



5

Figure 5: T-Mine Fuze 35 (brass)



Figure 6: Light antitank mine with protective cover for transport purposes.

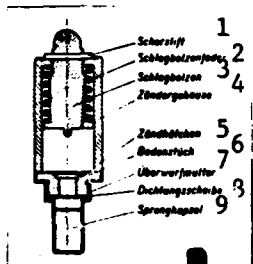


Figure 7: Cross-section of the T-Mine fuze 42.  
1. shear pin; 2. striker spring; 3. striker;  
4. fuze housing; 5. stab primer; 6. base  
element; 7. counter nut; 8. seal; 9. detonator.

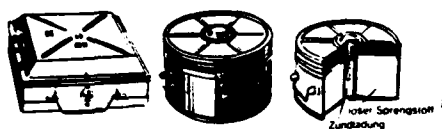


Figure 8: Soviet antitank mine TM-38 (left) and  
TM-41 (right)

1. explosive grain; 2. primer charge

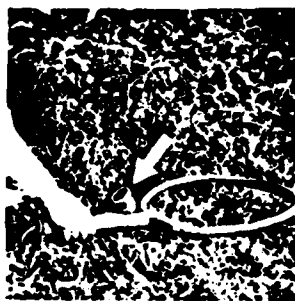


Figure 9: Japanese mine detector with visual  
display (arrow)

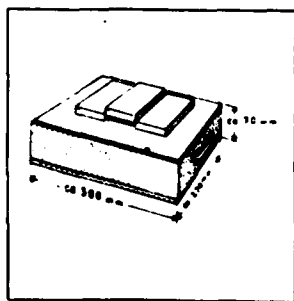


Figure 10: Soviet wooden box mine TMD-B; hardly  
detectable with electric mine detectors.

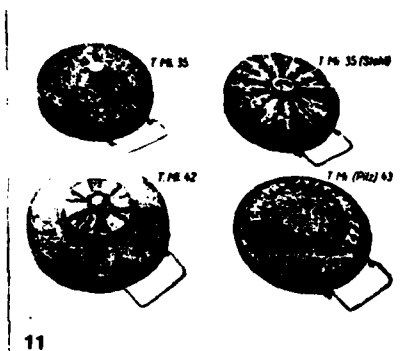


Figure 11: German standard mines in World War II

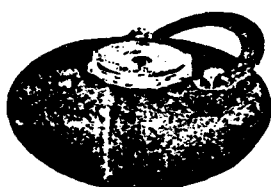


Figure 12: German Topfmine A 4531 (pot-shaped mine)

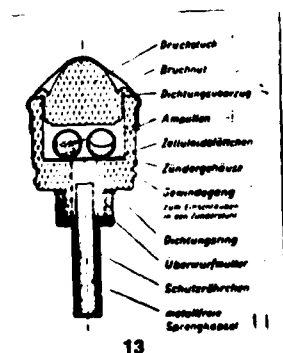


Figure 13: Pot mine fuze SF 1 (cross-section)

- 1.pressure element; 2.fracture groove;
- 3.sealant; 4.ampules; 5.celluloid platelet;
- 6.fuze housing; 7.threading;
- 8.seal ring; 9.counter nut; 10.protective sleeve;
- 11.non-metallic detonator.



Figure 14: Glass mine (open), with Schuco lever fuze



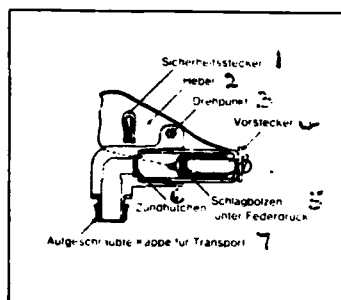


Figure 15: Schuco lever fuze (cross-section)  
1.safety plug; 2.lever; 3.pivot point; 4.safety pin; 5.spring-loaded striker; 6.stab primer; 7.screwed-on cap for transport.



Figure 16: Italian bakelite antitank mine Pignone Type II

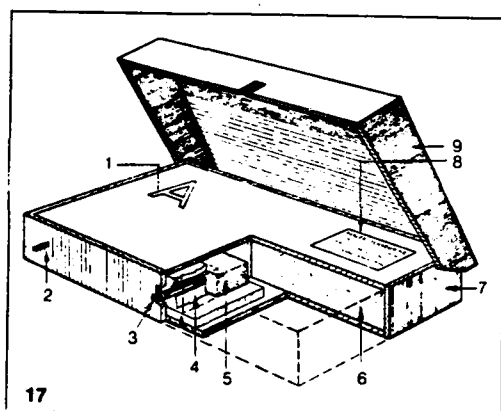


Figure 17: German wooden box instantaneous antitank mine Type A

1. type designation; 2.wood dowel, which is sheared off by pressure on the cover; 3.pull fuze 42; 4.wooden spacer; 5.initiator charge of approx. 700 g; 6.main explosive charge, approx. 6 kg of picric acid, wrapped with water repellent paper; 7.lower box with explosive; 8.label; 9.cover.

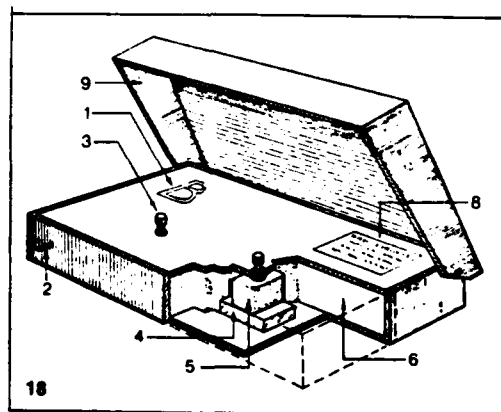


Figure 18: German wooden box instantaneous antitank mine Type B

same explanation as for Figure 17 above, but item 3 is a Buck fuze.

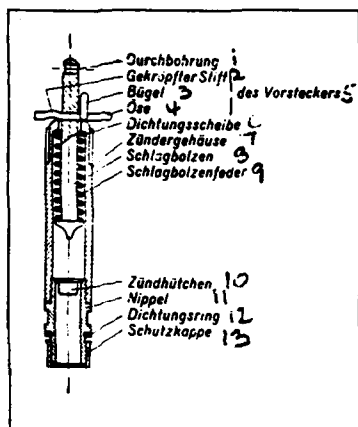


Figure 19: Pull Fuze 42 (cross-section)

This fuze made of bakelite was also used in the instantaneous antitank mine A

- 1.boring; 2.crimped pin; 3.clamp;
4. eyelet; 5...of safety pin; 6.seal;
- 7.fuze housing; 8.striker; 9.striker spring;
- 10.stab primer; 11.nipple;
- 12.seal ring; 13.protective cap.

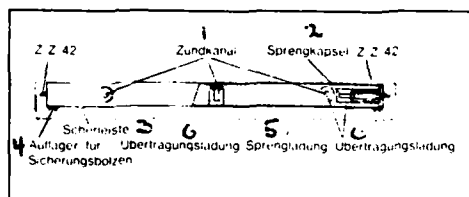


Figure 20: Riegelmine 43 (crossbar mine)(cross-sect.)

The upper and lower section of the mine box is shown with a dashed line.

- 1.activation well; 2.detonator; 3.shear edge;
- 4.support for safety pin; 5.explosive charge;
- 6.booster;

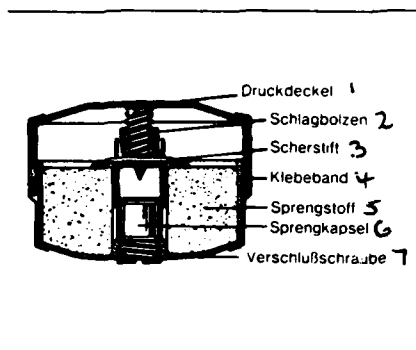


Figure 21: German Schuetzen-Dosenmine (cylindrical antipersonnel mine)(cross-section)

- 1.pressure cover; 2.striker; 3.shear pin;
- 4.adhesive tape; 5.explosive;
- 6.detonator; 7.locking bolt.

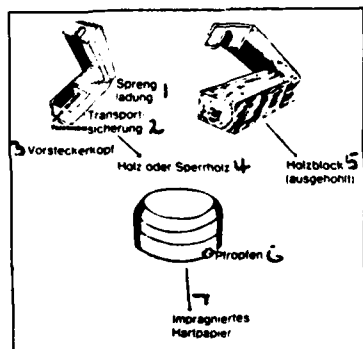


Figure 22: Soviet Antipersonnel Mines  
PMD-6 (left); PMD-7 (center); PMK-40 (right)

- 1.explosive; 2.transport safety;
- 3.safety pin head; 4.wood or plywood;
- 5.hollowed woodblock; 6.plugin;
- 7.impregnated kraft paper.

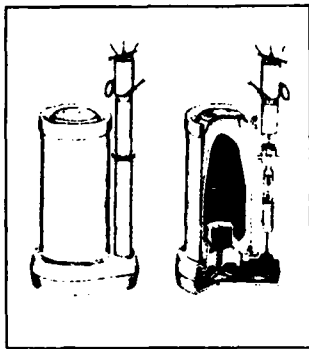


Figure 23: French Bouncing Mine

This mine was used by the Dutch Army as a slightly modified version with the designation MIN 3



Figure 24: British Bouncing Mine

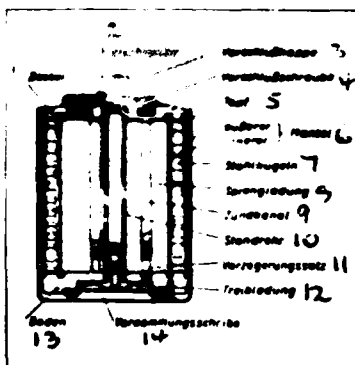


Figure 25: German S-Mine 35 (cross-section)

weight 4 kg, explosive approx. 280 g, height 13 cm.

1.cover; 2.filler plug; 3.locking cap;  
4.locking bolt; 5.can; 6.outer and inner  
sleeve; 7.steel balls; 8.explosive charge;  
9.activation well; 10.standpipe; 11.delay  
element; 12.propellant charge; 13.base;  
14.tamping plate.

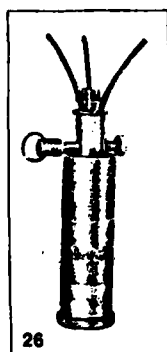


Figure 26: S-Mine Fuze 35



Figure 27: Soviet Fragmentation Bouncing Mine (drawing)



1. MUW fuze without detonator
2. explosive grain (loose)
3. fragmentation
4. detonator
5. fuze train
6. ejection charge



Figure 28: US Fragmentation Bouncing Mine M-16



Figure 29: French Fragmentation Bouncing Mine Mle 53



Figure 30: British Version of a Fragmentation Bouncing Mine

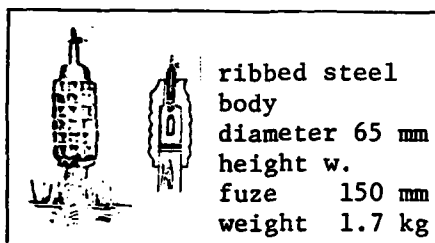


Figure 31: Soviet Stick-mounted Fragmentation Mine POMZ-2 (drawing)  
Required pressure for functioning of the mine: approx. 1 kg



Figure 32: US Fragmentation Mine M 3

The length of this mine is 13.5 cm with a very strong steel body.

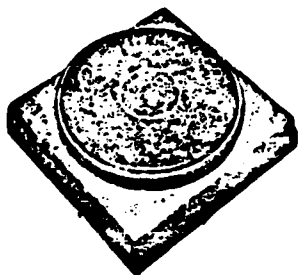


Figure 33: Belgian Antitank Mine PRB III

The mine body consists of a mixture of TNT/Hexogen. The fuze housing is made of bakelite; the mine has a mechanical fuze mechanism.

33



Figure 34: Italian Antitank Mine SH 55 (Minelba)

The mine has a plastic case; fuze functions in accordance with an air chamber principle so that short-time high pressure do not activate the fuze; the mine with fuze has a high profile.

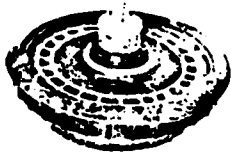


Figure 35: Fuze of the Italian Antitank Mine SH 55

During testing it was found that the complex plastic body swells when left in moist ground for extended periods of time, and the fuze would no longer be functional.

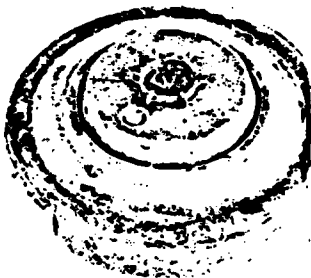


Figure 36: French Antitank Mine Alsetex

This mine was fielded by the West German Army as antitank mine DM 11.  
Overall weight: 7.4 kg; diameter: 30 cm;  
height: 9 cm.

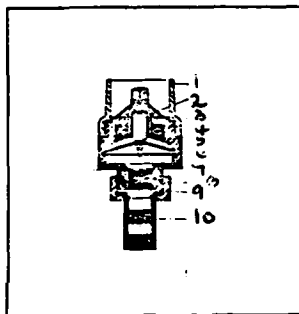


Figure 37: German Fuze Design for Antitank Mine DM 11

1.shock absorber; 2.predetermined breaking cone; 3.striker pin; 4.fuze housing;  
5.pressure ring; 6.striker spring;  
7.primer; 8.counter nut; 9.rubber seal;  
10.detonator

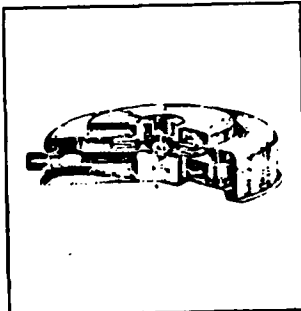


Figure 38: US Antitank Mine M-6 with fuze M 600

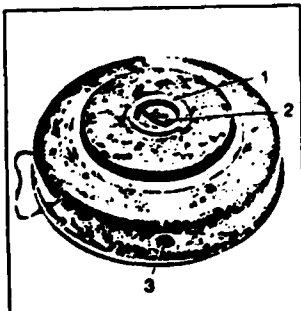


Figure 39: US Antitank Mine M-15 with fuze M 603

1.fuze; 2.armed lever; 3.second, additional activation well.

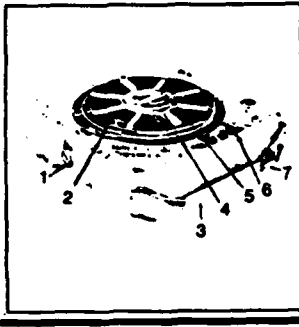


Figure 40: Non-metallic US Antitank Mine M-19 with Fuze M-606

1.activation well plug; 2.pressure cover;  
3.carrying strap; 4.safety lever in dis-  
armed position; 5.safety clip (transport);  
6.clip pull cord; 7.carrying cord.

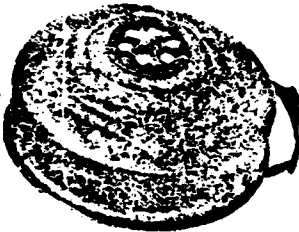


Figure 41: British Antitank Mine Mk-7

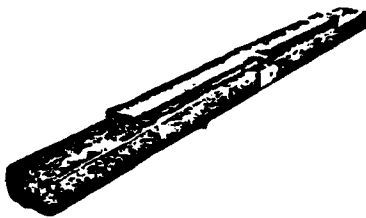


Figure 42: British Crossbar Mine

Overall weight: 11 kg  
Length: 120 cm  
Width: 10.8 cm  
Height: 8.1 cm  
Explosive: 8.4 kg

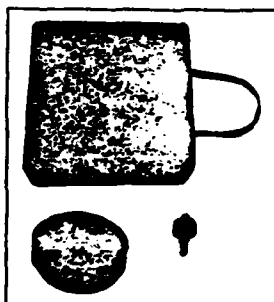


Figure 43: Belgian Antitank Mine PRB-ATK-3TS;  
disassembled into mine body, pressure  
cover and non-metallic 30 TS fuze



Figure 44: Soviet Antitank Mine TM-46  
with clearly visible safety pin



Figure 45: Czech Antitank Mine Ba 54

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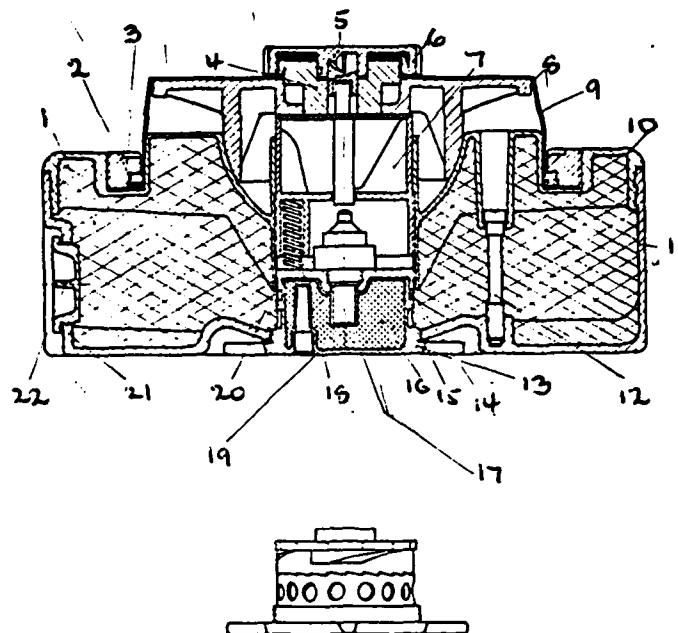


Figure 46: German Non-metallic Antitank Mine

1.explosive:approximately 8 kg TNT; 2.locking ring; 3.threaded ring; 4.pressure body; 5.curved slide element; 6.locking handle; 7.delay mechanism; 8.tilt cover; 9.rubber calotte; 10.upper mine section; 11.lower mine section; 12.three nylon mounting bolts; 13.bottom bolt; 14.disassembly lock; 15.seal ring; 16.booster charge; 17.DM-46 fuze with detonator; 18.fuze receptacle; 19.booster cover plate; 20.three support springs (Delrin); 21.seal ring; 22.locking bolt for filler opening.



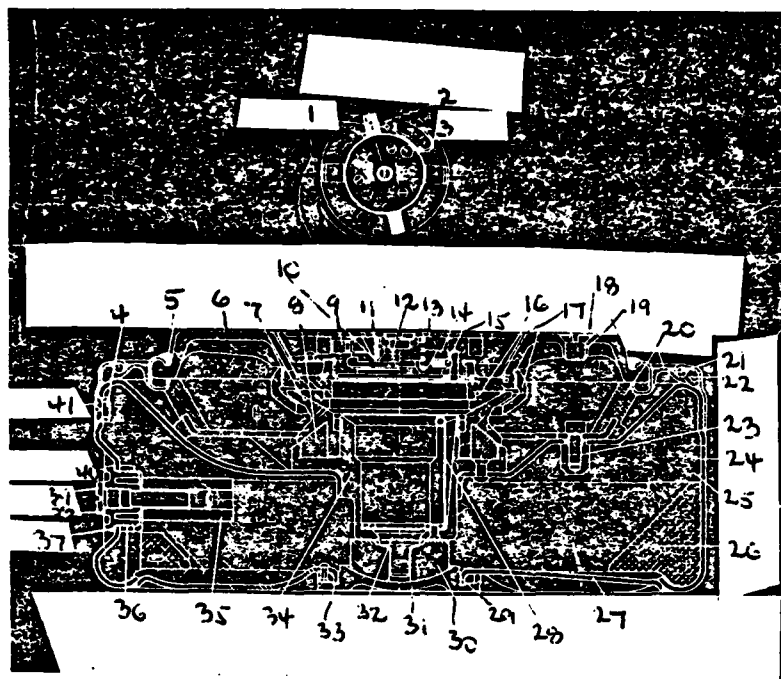


Figure 47: German Antitank Mine II

1.safety splint; 2.switch ring; 3.armed; 4.inserted with lacquer (dope); 5.casting mass; 6.cover; 7.guide cone; 8.buffer; 9.locking pin; 10.pressure element; initial position; 11.pressure spring; 12.shear pin with ring; 13.cap cover; 14.functional position of pressure element, armed; 15.ball lock; 16.ball race; 17.catch ring; 18.assembly bolts; 19.inserted with lacquer; 20.rubber support; 21.wire ring; 22.rubber; 23.inserted with lacquer (dope); 24.upper housing (Al Mg Si 1); 25.TNT (in accordance with End Item Specification 1375-801; 26.fill ring; 27.base; 28.locking spring; 29.inserted with lacquer (dope); 30.Tetryl in accordance with Preliminary End Item Specification 1375-804; 31.base bolts (forged); 32.cap; 33.seal ring; 34.receptacle; 35.same as 30 above; 36.same as 29 above; 37. seal ring; 38.seal ring; 39.locking bolt; 40.locking bolt, combustion safety (Delrin); 41.filler plug.

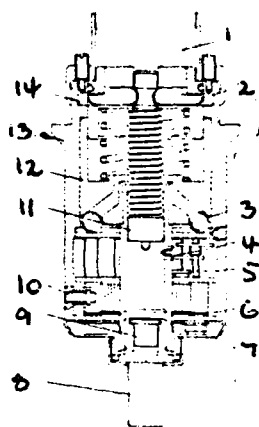


Figure 48: AZ-2 Fuze

1.plastic ball; 2.locking pins; 3.steel balls; 4.switching pin;  
5.timing mechanism; 6.indicator; 7.window; 8.detonator;  
9.primer; 10.spring-loaded bolt; 11.striker; 12.push sleeve;  
13.fuze housing; 14.ring.



Figure 49: French Flat Charge  
Mine Mle. 48-55

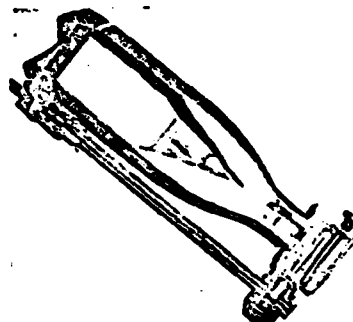


Figure 50: French Antitank Mine  
Mle STRIM with Shaped Charge

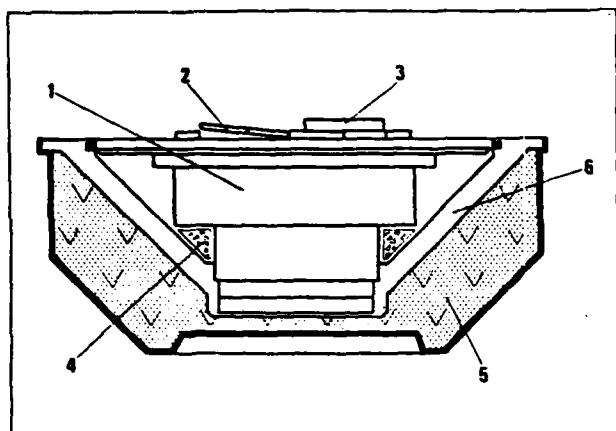


Figure 51: Swedish Antitank Mine FFV 028

1.fuze mechanism; 2.transport safety;  
3.arming lever; 4.charge for removal  
of fuze system and possible camouflage  
layer; 5.shaped charge; 6.casing of  
non-magnetic metal. Height 11 cm,  
diameter 25 cm, overall weight 7.5 kg.

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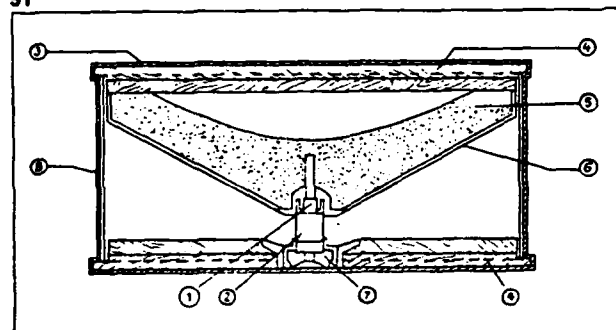


Figure 52: Hungarian Antitank Mine with  
Shaped Charge

1.detonator; 2.pressure cap; 3.canvas  
cover; 4.plywood; 5.shaped charge;  
6.paper cover; 7.pressure element;  
8.cardboard.

52

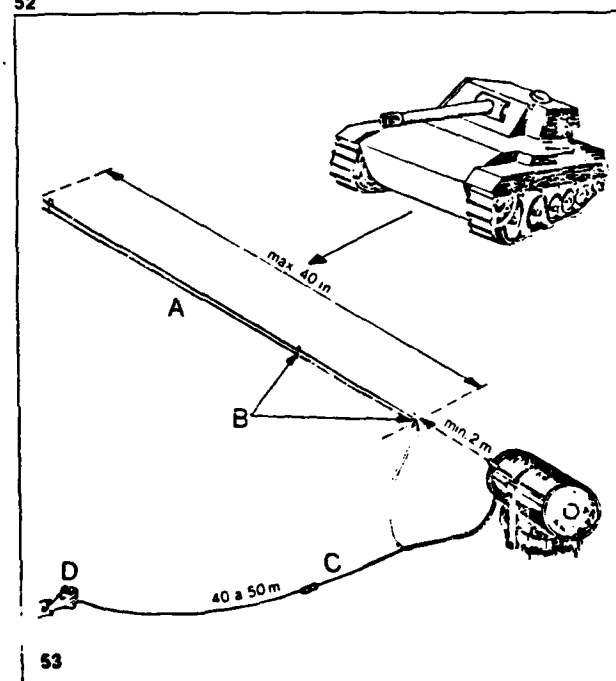


Figure 53: Installation Schematic of  
a Remote Antitank Mine

A.contact wires; B.mounting clamps;  
C.lead wire for command initiation;  
D.trigger device for observer.

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Figure 54: German Antitank Mine II "New" (Pz-Mi DM21) with improved pressure element

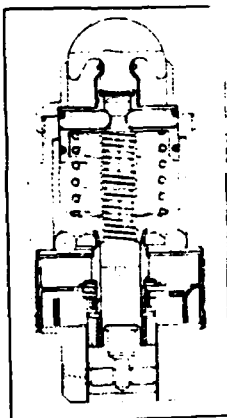


Figure 55: Modified Fuze for Antitank Mine II "New"



Figure 56: Scatterable Italian Antitank Mine MATS

This mine has a low metal content and functions with a pneumatic fuze device. (on the right, the transport safety mechanism)



Figure 57: Helicopter with Make-shift Wooden Slide for Quick-laying of Mines



Figure 58: Soviet Antitank-Mine Laying Device

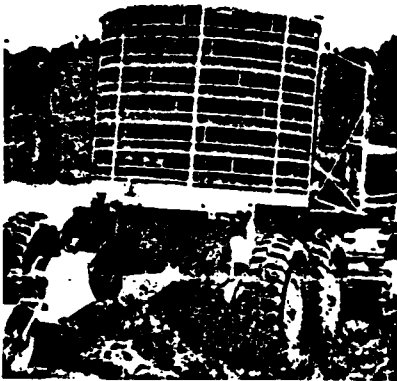


Figure 59: US Mine-Laying Device for Concealed Laying of Mines

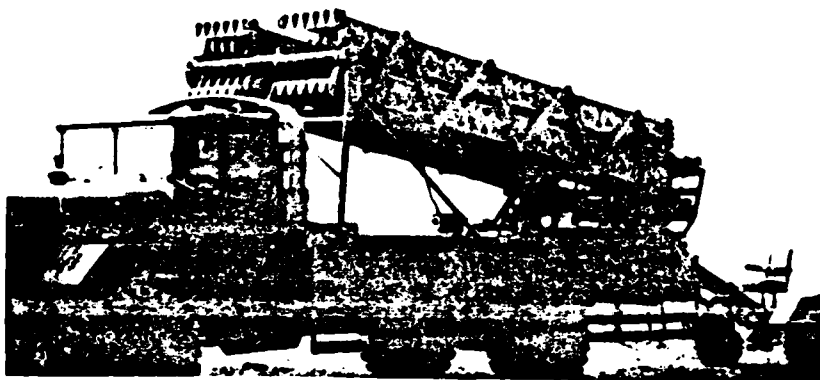


Figure 60: German Trial Mine-Laying Device

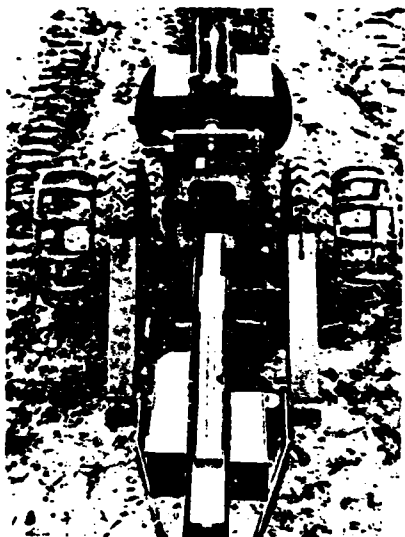


Figure 61: British Mine-Laying Device  
for the Crossbar Mine

This device automatically arms  
the mines. Mines can be laid  
exposed or concealed.

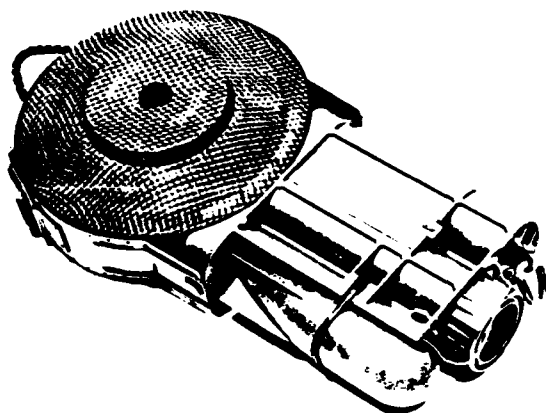


Figure 62: German/Dutch River-Bed Mine

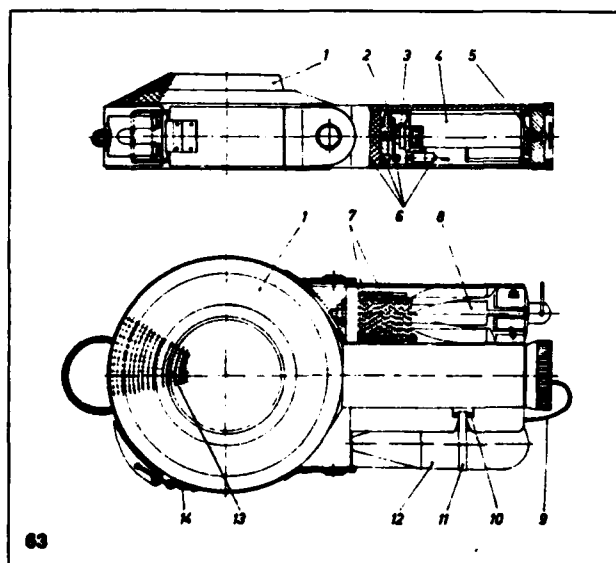


Figure 63: River-Bed Mine with Dutch No.26  
Antitank Mine as Explosive Charge

1.standard antitank mine; 2.mechanical  
safety mechanism; 3.clock mechanism;  
4.battery; 5.key for actuation of clock;  
6.fuze contact with detonator; 7.holding  
and anchor rope; 8.folding anchor;  
9.coaxial cable; 10.sugar cartridge;  
11.holding tape; 12.float (fish);  
13.cover net; 14.bracket with locking clamp.

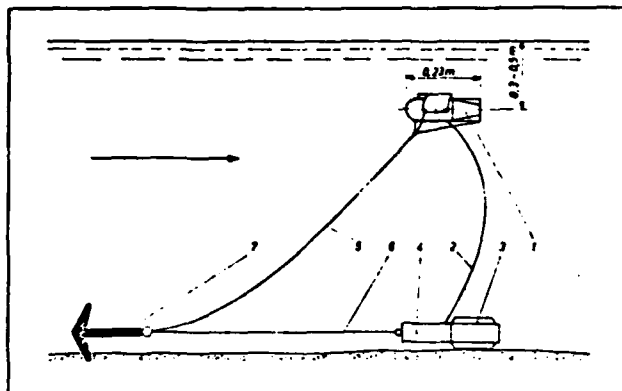


Figure 64: Laying Schematic for River-Bed Mine

1.float; 2.coaxial cable; 3.antitank mine; 4.additional housing with fuze mechanism; 5.holding rope; 6.anchor rope; 7.folding anchor.

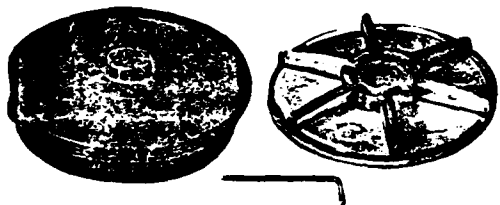


Figure 65: Belgian Antipersonnel Mine PRB-AP-BAC-H 28  
Mine Body, Pressure Cover and Safety Pin

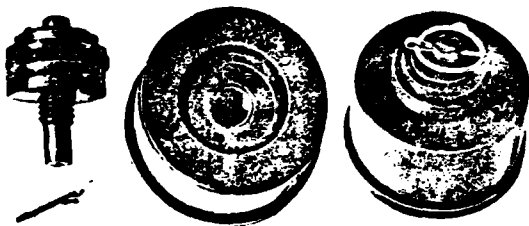


Figure 66: Belgian Antipersonnel Pressure Mine PRB-AP-M 35  
diameter: 6.5 cm  
height 6.0 cm

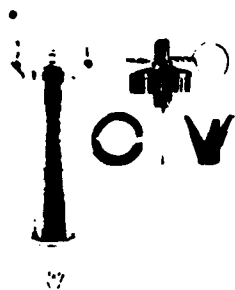


Figure 67: British Low-Metal Antipersonnel Mine (AP 6 Mk 1) also referred to as "carrot"

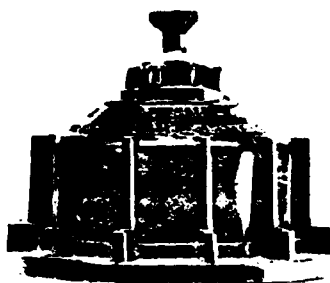


Figure 68: French Non-metallic Antipersonnel Mine Mle 51

diameter: 7.0 cm  
height: 5.2 cm  
overall weight: 85 g, 40 g of which is Trotyl

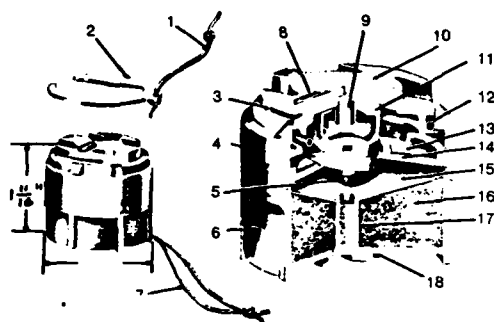
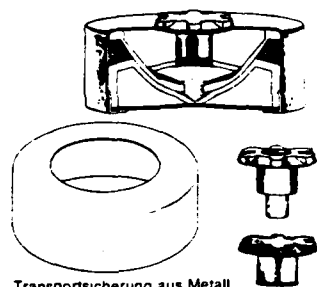


Figure 69: US Antipersonnel Mine M-14 (non-metallic)

1.pull cord; 2.safety clamp; 3.groove for safety clamp; 4.fuze body; 5.striker component; 6.mine body; 7.carrying cord; 8.indicator arrow; 9.blocking bolt; 10.pressure plate; 11.lock ring; 12.seal; 13.star disc; 14.Belleville spring; 15.bulkhead; 16.main charge; 17.detonator mount; 18.detonator seal.



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Figure 70: Swedish Antipersonnel Pressure Mine LIAB

This mine was fielded by the West German Army as antipersonnel mine DM 11.

height: 3.5 cm  
diameter: 8 cm  
overall weight: approx. 200 g

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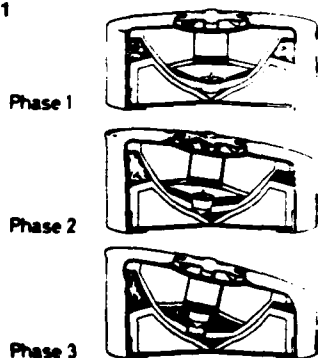


Figure 71: Fuze of Antipersonnel Mine DM 11

Operational phases of the belleville spring under a given load.



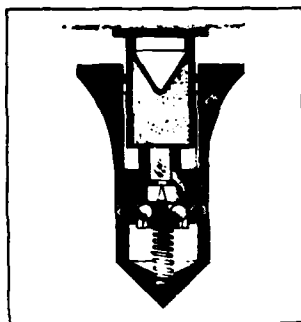


Figure 72: Canadian Antipersonnel Mine M 25 "Elsie" with Shaped Charge



Figure 73: British Scatterable Antipersonnel Mine "Dingbat"  
Mine body and detonator slide (left); mine partially armed (center); mine operational, safety pin removed (right).

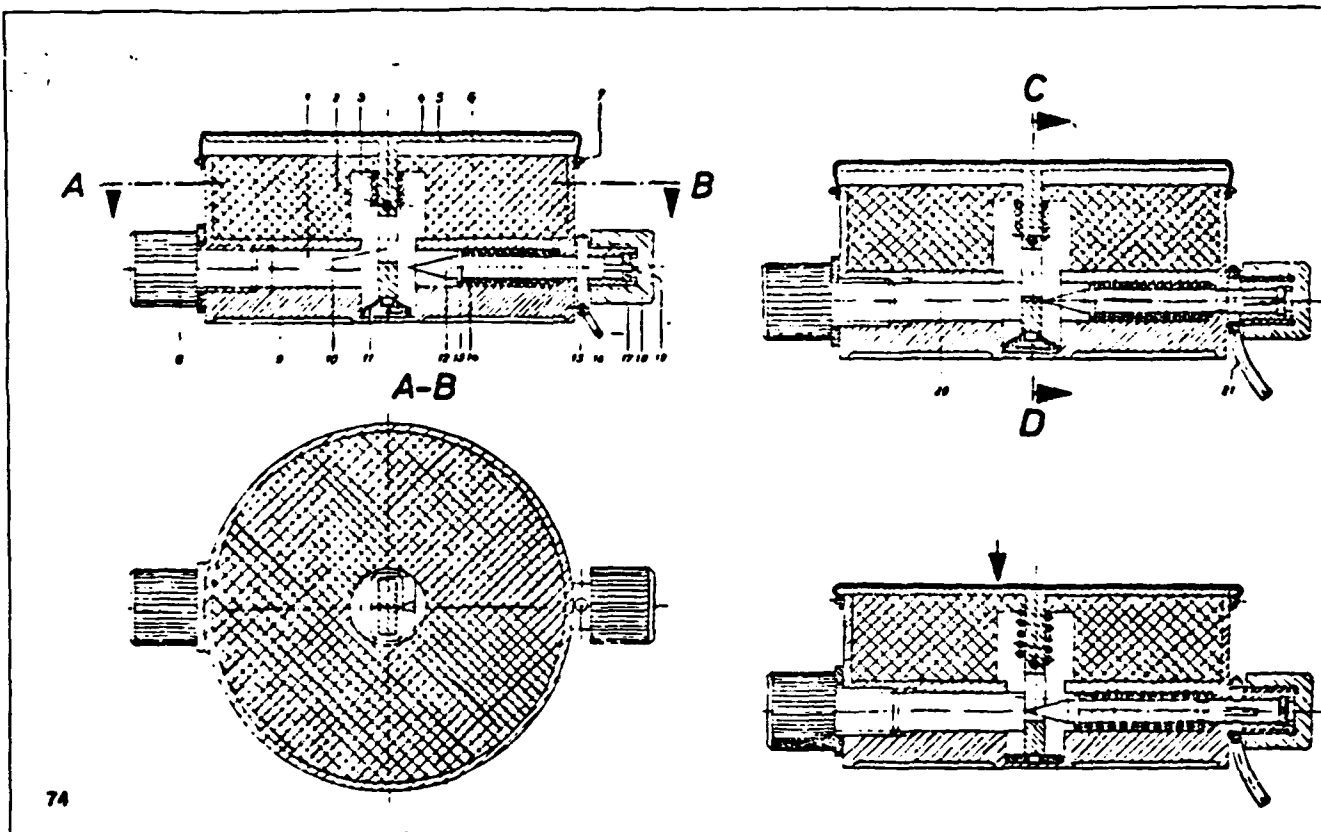
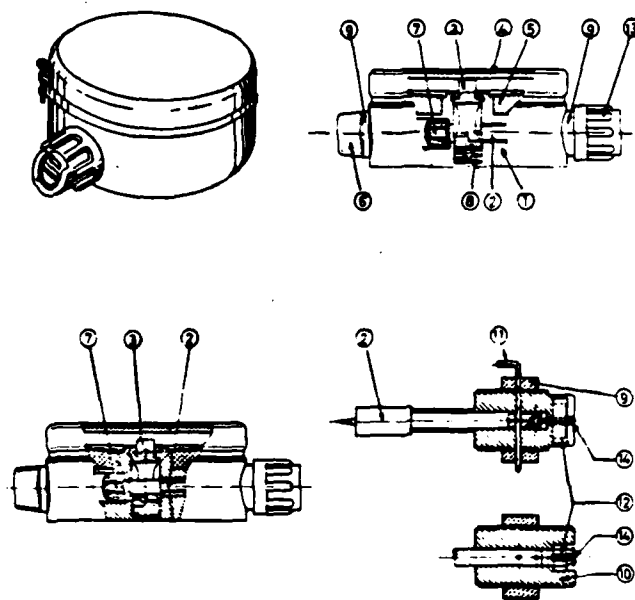


Figure 74: Soviet Antipersonnel Mine PMN 6(also used in the GDR)

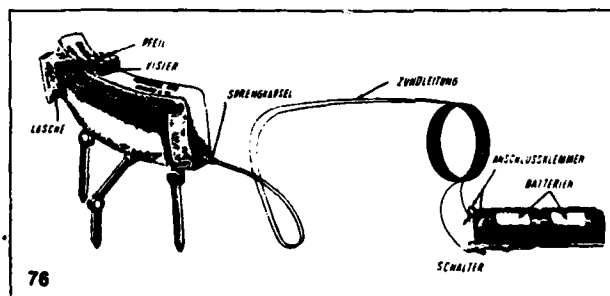
- 1.fuze well; 2.support for pressure spring; 3.pressure spring; 4.rubber coating;
- 5.pressure plate; 6.explosive (240 g TNT); 7.Nylon ring; 8.threaded plug with seal for fuze well; 9.mine body; 10.boring in neck; 11.pressure spring; 12.striker;
- 13.support for pressure spring at striker; 14.pressure spring for striker;
- 15.safety pin; 16.ring of safety pin; 17.lead platelet; 18.protective cap;
- 19.steel wire; 20.fuze; 21.nylon thread for mine anchor.



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Figure 75: Soviet Antipersonnel Mine PMND-2-65

1.fuze block; 2.striker; cross-section b: prior to expiration of time delay, shown with solid line; after expiration of time delay, shown with dashed line; cross-section c: after initiation; 3.striker locking plunger; 4.pressure cover; 5.explosive; 6.threaded plug with pivot handle for detonator; 7.detonator; 8.pressure spring; 9.seal; 10.threaded plug for striker; 11.safety pin; 12.lead platelet; 13.protective cap; 14.cutting wire.



1.arrow; 2.sight; 3.strap;  
4.detonator; 5.fuze circuit;  
6.terminals; 7.batteries;  
8.switch.

Figure 76: US Antipersonnel Fragmentation Mine M-18 Claymore  
(with predetermined directional effect)

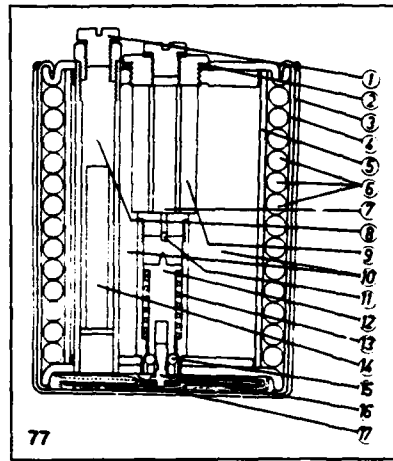


Figure 77: German Antipersonnel Fragmentation Mine DM 31  
This is an improved version of the former Fragmentation Mines 35 and 42.

1.locking bolts; 2.seal rings; 3.mine can; 4.outer case; 5.inner case;  
6.steel balls; 7.activation well; 8.activation well; 9.primer charge;  
10.explosive charge; 11.primer; 12.striker; 13.striker spring; 14.propellant  
charge; 15.retainer balls; 16.retainer splint; 17.trigger wire.

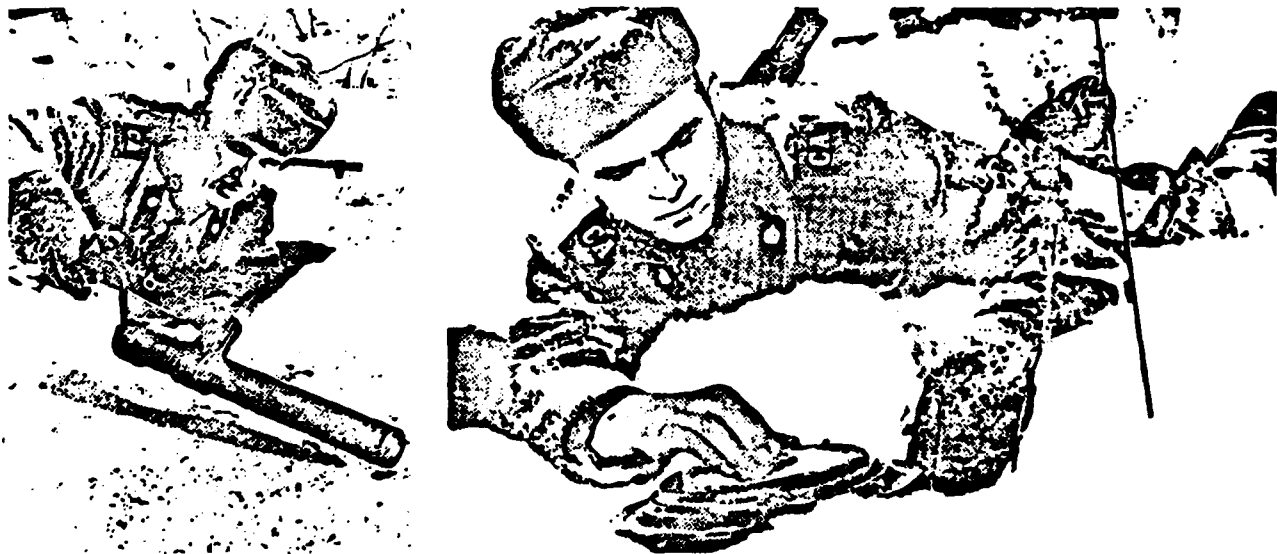


Figure 78: Winter Training in Mine Detection of Soviet Engineer Troops  
On the left: Club-shaped electronic mine detector with acoustic signal;  
On the right: Engineer during disarming of a TM 46 mine.