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EXPLOSIVE CHARGES FOR USE IN UNDERWATER ACOUSTIC TRIALS.(U)

JAN 79 D J DAVIS, R H WELDON, K A HEADLAND

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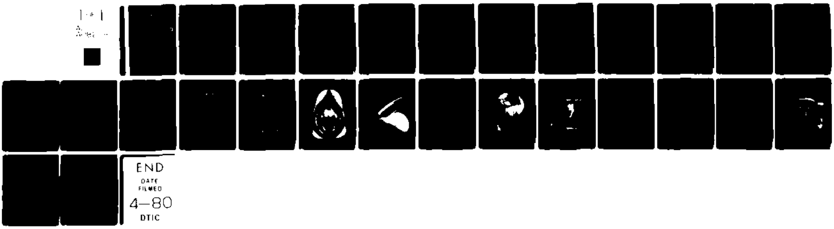

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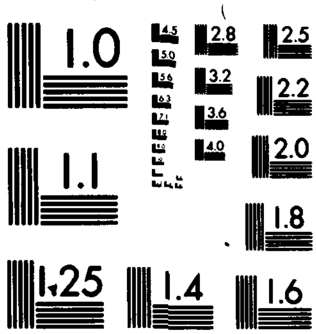

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DEFENCE SCIENCE AND TECHNOLOGY ORGANISATION

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11 Jan 77

S U M M A R Y

An explosive device, consisting of fuze, booster and main charge, has been developed for generation of acoustic signals at various underwater depths. The signal arises from the fuze, or fuze plus booster, or from all three components. The concept has potential for quantity production of an inexpensive SUS charge but further development to improve reliability is required.

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An explosive device, consisting of fuze, booster and main charge, has been developed for generation of acoustic signals at various underwater depths. The signal arises from the fuze, or fuze plus booster, or from all three components. The concept has potential for quantity production of an inexpensive SUS charge but further development to improve reliability is required.

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1. INTRODUCTION

This paper describes explosive charges which were required for the generation of acoustic signals at various depths in the ocean. The short time scale for their development and manufacture necessitated fabrication from readily available materials, acceptance of some design limitations and a restricted degree of testing of sub-assemblies. The charges, required to detonate at a range of depths from 180 to 1000 m, were of three sizes:- a small charge, called the fuze; a Type B charge, consisting of 31 g of explosive together with the fuze; and a Type A charge, consisting of 0.81 kg of high explosive together with the Type B charge as booster.

Design of the charges had to meet the following requirements:-

(a) units were to be inexpensive

(b) the fuze was to be a separate item

(c) material of the same external diameter was to be used as containers for the two components of the Type B charge and three components of the Type A charge

(d) water-impervious explosives were to be used in Type A and Type B charges since the assemblies were not required to be watertight.

Facilities were not available to test Type A and Type B charges during development either in local waters or in hydrostatically pressurised tanks.

Sea trials were carried out with the first versions of Type A and Type B charges and led to modifications for further trials. Thus this report is divided into two parts to describe Mark I and Mark II versions of the charges used.

Part 1.

Mark I Assembly

2. DESIGN

The fuze was based upon a detonantless initiator (developed by Materials Research Laboratories, Maribyrnong) and has been described elsewhere (1, 2). It contained a 10 grain column of RDX, pressed in a heavy container and, above this, a rubber diaphragm which, upon impact, acted as a piston to adiabatically compress the air above the explosive. The generated heat ignited the explosive which burnt to detonation. This initiator (used in WREPOC Mark II (2)) was housed in a fuze body with an aluminium shear disc which was designed to fail at the hydrostatic pressure of a prescribed depth. Entrant water then provided a pressure pulse to the initiator. Details of the fuze are given in figure 1.

The primary charge contained 31 g of explosive NOBEL 852 and this served both as the main filling for the Type B charge and as the booster for the Type A charge.

The main charge was 0.81 kg of plastic explosive (P.E.3).

The container, into which components could be easily inserted, was an appropriate length of commercial plastic (polyvinyl chloride) tubing commonly used for irrigation purposes. It was purchased in lengths of 6.1 m, 53.3 mm I.D., and 2.0 mm wall thickness.

The assembly of the Type A charge is shown in figure 2 and of the Type B charge in figure 3.

3. EXPERIMENTAL TESTS ASSOCIATED WITH CHARGE DESIGN

3.1 Watertightness of fuze

Units were tested in a vessel containing water pressurised to and held at 4480 KPa for five minutes. The basic form of the original fuze design was retained but the means by which the shear washer was clamped in the fuze body was modified to a simple flange turned over onto a keeper ring in order to reduce manufacturing costs (figure 1). Ingress of water at the turnover face and around threads of the initiator was prevented by potting with an epoxy resin and, further, all metal surfaces were coated with "Loctite Plastic Gasket." All units so treated proved to be adequately sealed.

3.2 Functioning of Fuze

Previous work, carried out on the failure pressures of aluminium shear discs under hydrostatic pressure (3), showed that discs ranging from 28 to 14 gauge material in conjunction with a shear washer of 38 mm would cause the fuze to operate at depths close to those required. The findings of the previous work can be seen in Table 1. It was decided to use these gauges:

TABLE 1. FUZE OPERATING DEPTH FOR VARIOUS DISC THICKNESSES (ALUMINIUM)

Disc Gauge No. (S.W.G.)	Required Depth (m)	Nominal Operating Depth (m)
28	183	177
26	244	241
24	305	296
22	366	353
20	457	469
18	670	676
16	853	871
14	1035	1008

In preliminary tests a 28 gauge disc was used and it was found that high disc shear pressures were required to operate the initiator. Inspection of the disc after shearing, or in cases where the disc had failed to shear at more than the expected shear pressure, showed that the edges of the disc had either pulled out from between the shear washer and the keeper ring or had crinkled. See figures 4 and 5.

Three tests were carried out using assemblies in which a film of "Araldite" was placed between the shear disc and keeper ring prior to turning over the fuze body flange. Cure time was 24 hours. In all cases it was found that shearing occurred at a pressure consistent with earlier tests (3).

Further comparable tests were then carried out using 14 gauge shear discs and it was found that fuze operated at 11 550 KPa (equivalent to a depth of 1149 m).

The results of the tests indicated that the fuze would function over the required range but units containing 14 discs would operate at greater depths than were needed.

3.3 Effects of pressure upon main charge

Tests were carried out using charges (P.E.3, 0.81 kg) hand tamped into comparable containers which had end caps. Four holes drilled in each end cap allowed entry of water, thereby equalising pressure inside and outside the container. The caps were held in position by plastic adhesive tape enabling ease of inspection of the charge after testing. A steel booster housing and dummy fuze were placed in the body to simulate the Type A charge.

The assembly was placed in a vessel containing water and pressure was slowly increased to 4482 KPa (equivalent to a depth of 445 m) and held at that level for two minutes.

Upon removal it was found that no damage had occurred to the body and that the end caps were undamaged and still in position. The explosive charge had been compressed by about 1.5 to 2.3 mm where the steel booster housing had been in contact with the surface of the charge. This indicated the necessity of excluding air pockets from the charge during its production as the presence of voids would permit charge deformation under pressure and perhaps also permit the presence of water-filled gaps in the explosive train.

3.4 Effects of pressure upon primary charge

The gaps referred to above could be between the primary charge and main charge and between primary charge and initiator. The primary charge was considered adequate to initiate the P.E. 3 even though a water-filled gap was present but it was thought advisable to assess the effect of a water-filled gap between initiator and primary charge.

A schematic of the test used is shown in figure 6. The detonantless initiator was functioned by an electric detonator placed against its pressure-sensing end. A modified version of the fuze body was used to house the initiator and a charge (Nobel 852, 31 g) was packed into a plastic sample container which was held axially in a section of body tubing by a booster housing. A gap between initiator and charge was created by placing washers between the fuze body and container. Five tests were made. The first was in air and the remaining four in water.

Test 1 : complete detonation; air gap = 3.175 mm.

Test 2 : failure; water gap = 6.35 mm, charge forced through container, booster housing undistorted.

Test 3 : low order explosion; water gap = 3.175 mm, some charge undetonated, booster housing slightly distorted.

Test 4 : high order explosion; polythene container reversed so that its thinner end (base) was offered up to the initiator, water gap = 3.175 mm.

Test 5 : complete detonation; same as Test 4 but with a 12.7 mm hole in base of polythene container covered with 25.4 mm diameter brown paper. Result shown in figure 8.

3.5 Propagation of detonation

A charge (P.E. 3, 0.81 kg) was hand-tamped into a length of plastic tubing (50.8 mm diameter) and a mild steel cylinder, bored out axially to accept a 25.4 mm diameter plastic sample container rested above it. A primary charge (Nobel 852, 31 g) was tamped into this container and placed in the steel cylinder so as to be in contact with the surface of the P.E. 3. The complete unit was positioned on top of a mild steel witness block (127 mm diameter, 104.8 mm high) and the Nobel 852 charge detonated with a No. 108 electric detonator. Figure 8, showing the witness block after the test, indicates complete detonation of the main charge.

4. ASPECTS OF CHARGE DESIGN

The tubing chosen for the main body had a diameter of 53.3 mm in accord with the 38.1 mm diameter of the shearing disc and the profile of the chamber leading to the initiator. The length of the tube for each type of charge was specified by the length of the tamped 0.81 kg of P.E. 3 filling and/or the 31 g of Nobel 852 packed into a polythene container, together with the fixed dimensions of the fuze.

The end caps were designed to mate with the tubing, were of the same material, and could be cemented to the body. The charges were not required to be watertight and the bodies were designed to permit intake of water at both ends to equalize water pressure within and without the body. One end cap had four holes (2.39 mm diameter) drilled on 31.8 mm P.C.D. and the other, at the fuze end, had one hole (38.1 mm diameter) punched at its centre. All holes were sealed with plastic tape to prevent ingress of foreign material during storage and transport.

Intimate contact between all components in Type A and Type B charges was ensured by (a) designing the fuze body so that the initiator protruded approximately 3.18 mm when screwed fully home, (b) making the bodies of the Type A and Type B charges 6.35 mm shorter than the overall length of the components placed therein.

In preliminary tests the booster charge was packed in a plastic container. In charges to be used for trials the Nobel 852 composition was pressed directly in the booster housing and 39.7 g was necessary to fill the cavity. A 50.8 mm diameter manila board disc was cemented over one end of the steel spacer, while the other end was sealed, after filling, with a 50.8 mm diameter brown paper disc. This latter end was to be placed against the initiator when the units were assembled for operation. Each spacer was coated by dipping in shellac, both to protect the steel from rust during storage and transport, and to form an inhibitor between the steel and Nobel 852. Details of the booster charge are shown in figure 3.

It was desirable that H.E. charges should not be transported as complete units, i.e. with H.E. and initiator in intimate contact. It was decided to replace a section of the Types A and B charge during transport with a wooden block and to arm each charge before launch by removing the wood block and inserting the appropriate section of the charge. On the Type A charge the fuze was replaced with a wooden block of comparable dimensions, and on Type B charge, the space occupied by the Nobel 852 was replaced; thus all fuzes were transported as separate items.

As each charge would have to be armed prior to launch, it was necessary to have one end cap removable. Tests showed that plastic adhesive tape appeared to be unaffected by prolonged immersion in water, or by water pressure. On units assembled for sea trials, only one end cap was cemented to each body, the other was removable, being held in position during transit and after launch with plastic adhesive tape. This tape, which was red, had a two-fold purpose; to secure the end cap in position and to act as a "filling band" to indicate a filled store.

The fuzes were designed to operate at eight different depths. To identify the depths a two figure number was marked on the shear disc of each fuze. This number multiplied by 100 gave the nominal operating depth of the fuze as follows:-

TABLE 2. STORE OPERATING DEPTH IDENTIFICATIONS

Number on Disc	Nominal Operating Depth in Feet (m)	
06	600	(183)
08	800	(244)
10	1000	(305)
12	1200	(366)
15	1500	(457)
22	2200	(670)
28	2800	(853)
34	3400	(1036)

5. TRIALS

Observers reported that:

(a) the fuze operated satisfactorily on all occasions

(b) a deviation of ± 20% occurred in the time taken from launch to fuze operation for a given thickness of shearing disc (perhaps due to differences in rate of sinking but, more probably, to variation in the depth at which the fuze operated)

(c) if the booster operated then so did the main filling of Type A charges

(d) there was a 30% failure for both Type A and Type B charges.

Part 2

Mark II Assembly

6. DESIGN

As a result of trials of the Mark I Assembly it was decided that:

(1) no changes were required to the case material

(2) the performance of the main charge was satisfactory

(3) it would be preferable to use a solid pellet of Nobel 852 rather than a pressed charge to minimise the possibility of separation of this charge and the initiator

(4) precise operation of the fuze required that attention be given to the hardness and thickness of the shearing disc, the sharpness of the edge of the shear washer and the means of securing the shearing disc assembly to the fuze body.

7. EXPERIMENTAL TESTS ASSOCIATED WITH CHARGE DESIGN

A test unit was produced consisting of a fuze in which special attention was given to the sharpness of the shearing edge of the shear washer and to the hardness of the shear disc. A booster charge was made from two tetryl pellets each 38.1 x 12.7 mm sealed in a container. The fuze and booster housing were screw-threaded so that the pellets were in intimate contact with the initiator (see figure 9). The modified booster charge is shown in figure 10. The unit functioned correctly on test.

Another test unit was constructed in which the booster charge consisted of two 38.1 x 12.7 mm tetryl pellets paper-wrapped and coated with shellac. This charge was assembled into a pocket in the main P.E.3 charge (see figure 11). The unit was fired after placing it on a steel witness plate with the result shown in figure 12.

8. TRIALS

Only fuzes and Type A charges were used. The booster and main charge assemblies were produced by hand tamping the P.E.3 into the plastic tube and inserting the tetryl booster into a cavity at the centre of the top of the main charge. The charges were closed as in Mark I assemblies with perforated plastic end caps held on by tape. A wooden block was used as an inert fuze for transit purposes. The complete assembly of the Type A charge, Mark II, is shown in figure 11. Observers reported that:

(a) 80% of all fuzes operated. The energy output was comparable in all cases and all units operated within ± 5% of the mean drop time of 3 minutes. This drop time was twice that of the Mark I version, the slow rate of fall probably being due to the removal of the heavy booster housing.

(b) 80% of the Type A charges failed. It is believed that this was related either to saturation of the pellet with water or presence of water at the initiator/booster charge interface.

9. CONCLUSIONS

Underwater charges can be developed to become inexpensive local production items but further work is necessary to overcome deficiencies in the fuzing and boosting system.

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2	Davis, D.J.	"The W.R.E. Point Charge Mk II. (W.R.E.P.O.C. Mk II)". W.R.E. Tech. Note CPD89, April, 1964.
3	Furby, B.E.	"The Failure Pressures of Commercially Pure Aluminium Shearing Discs under Hydrostatic Loading". W.R.E. Tech. Note CPD90, June, 1964.

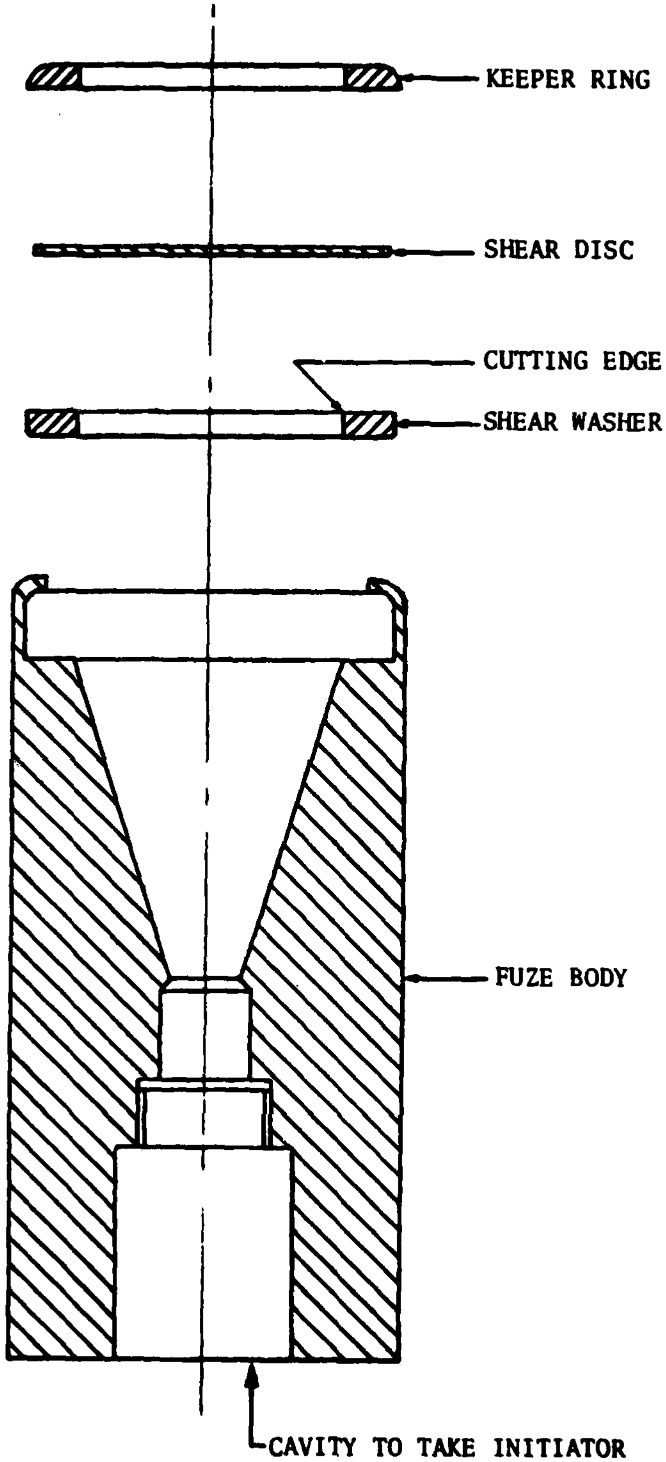

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Figure 1. Exploded View of Fuze Design

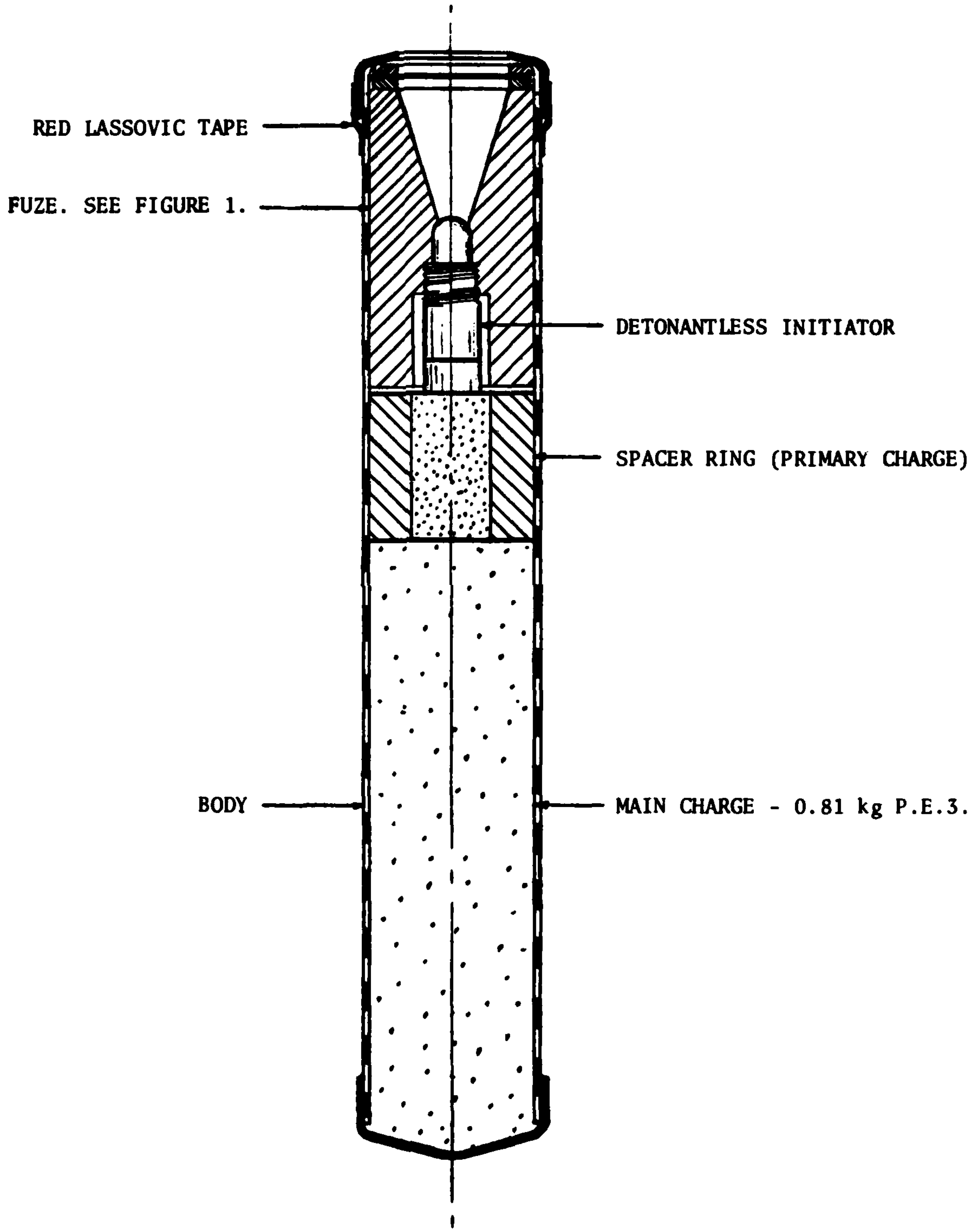

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Figure 2. Type A Charge Mk I Assembly

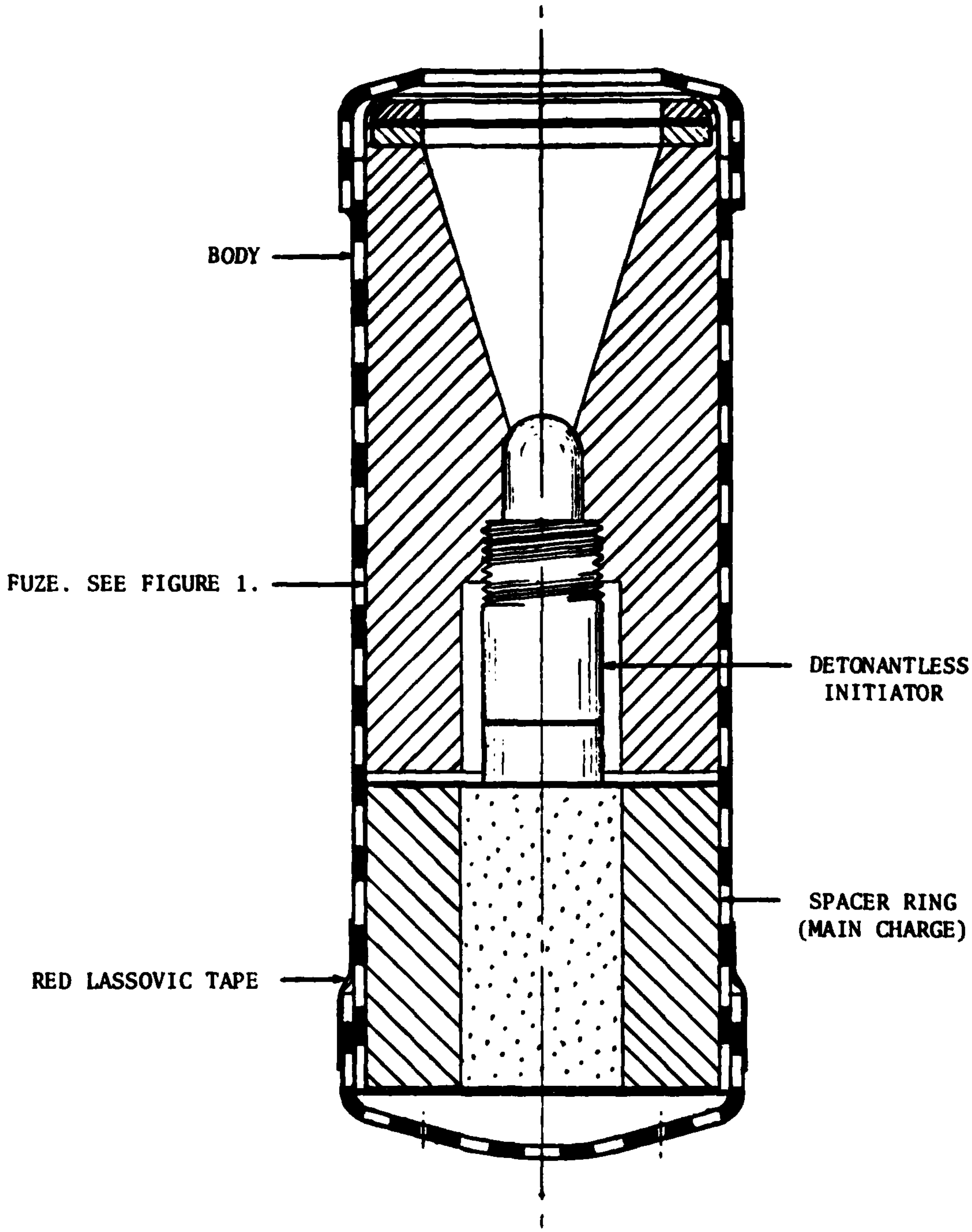

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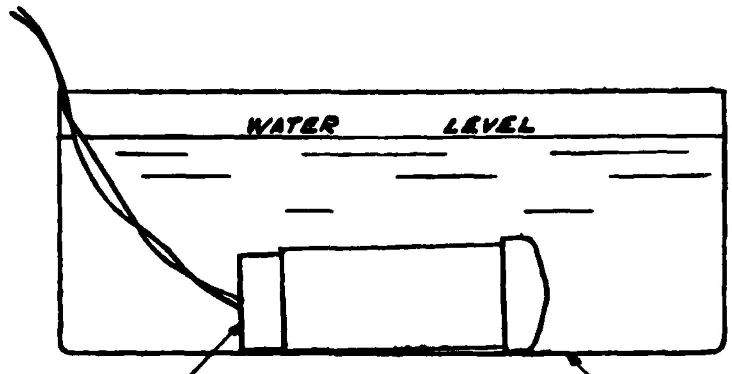
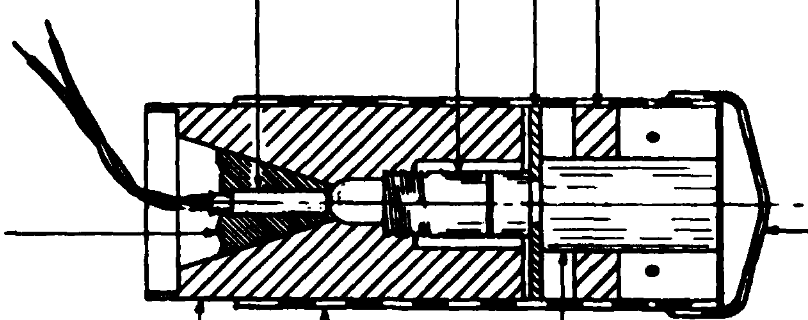
Figure 3. Type B Charge Mk I Assembly

Figure 4. Fuze Body After Pressurising Showing Sheared Disc

Figure 5. Sheared Disc After Removal from Fuze Body



(a) Test Layout



(b) G.A. of Test Piece. Scale 1:2

Figure 6. Layout of Gap Test in Water

Figure 7. Fuze Body After Gap Test in Water

Figure 8. Witness Block After Explosion of Type A Charge, Mk I Assembly

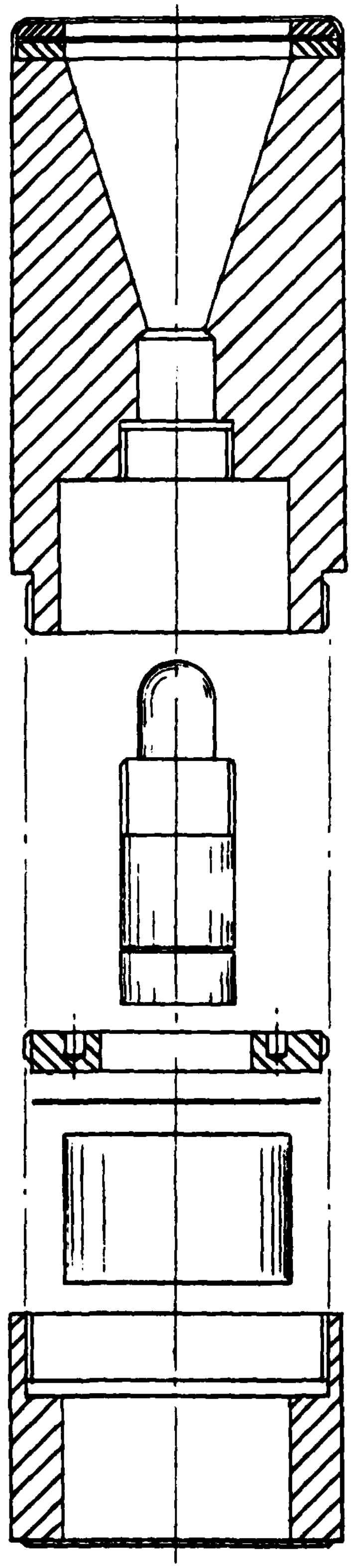


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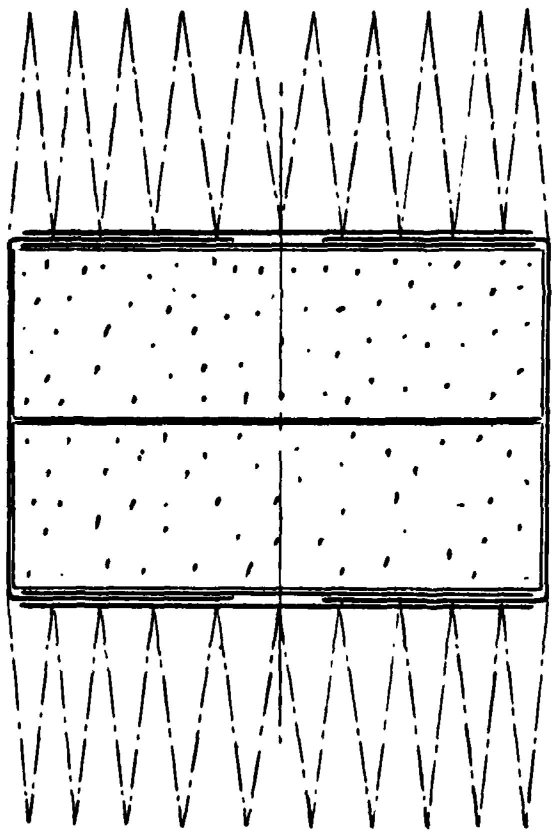
Figure 9. Modified Fuze Design.



Scale 2:1

Figure 10. Booster Charge Mk II Assembly

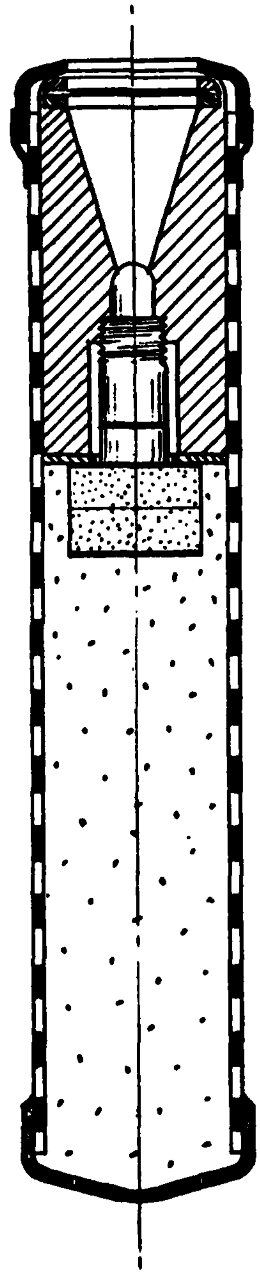


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Figure 11. Type A Charge Mk II Assembly

Figure 12. Witness Block After Explosion of Type A Charge, Mk II Assembly

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