ERDE 10/M/68

UNLIMITED

MINISTRY OF TECHNOLOGY

EXPLOSIVES RESEARCH
AND DEVELOPMENT ESTABLISHMENT

TECHNICAL MEMORANDUM No. 10/M/68

The Testing of Safety Spectacles, Lenses, Goggles and Visors

Part 2

L.D. Cole
R. Pape

WALTHAM ABBEY
ESSEX

ERDE 10/M/68 WAC/190/08

MINISTRY OF TECHNOLOGY

EXPLOSIVES RESEARCH AND DEVELOPMENT ESTABLISHMENT

TECHNICAL MEMORANDUM No. 10/M/68

The Testing of Safety Spectacles, Lenses, Goggles and Visors

Part 2

by

L.D. Cole and R. Pape

Approved: E.G. WHITBREAD
SE

Approved for Circulation: L.J. BELLAMY
DIRECTOR

7th October 1968

WALTHAM ABBEY,
ESSEX

CONTENTS

Reference: WAC/190/08

1. SUMMARY

Fifteen types of spectacles, goggles and visors have been tested for resistance to glass fragments driven by explosive charges, six types to the explosion of bare detonators and six types to glass flasks burst by nitrogen pressure.

The heavy duty acetate visor with a resin impregnated forehead guard offered the best protection against explosively driven glass fragments and is recommended for use against the explosion of not more than 10 grammes of explosive in glass apparatus. For protection of the eyes only, goggles with a double lens system with a rear lens of cellulose acetate are recommended for use against the explosion of not more than 5 grammes of explosive in glass apparatus as are clip-on spectacles with C.R.39 lenses worn over ordinary spectacles. None of the systems examined was capable of withstanding the jet from a detonator held "end-on" and it is recommended that if it is necessary to examine detonators "end-on" they should be viewed by means of a mirror system and eye protection worn in addition.

Glass fragments from flasks burst by nitrogen pressure are much less damaging than those driven by exploding tetryl.

2. INTRODUCTION

A further series of tests has been carried out in a similar manner to that described by (Mrs.) Williams (1) with a variety of spectacles and goggles and a modified heavy duty visor fitted with a new type of forehead guard. Her report is now to be regarded as Part 1 in this series. In general, the method utilising glass fragments driven by a charge of tetryl has been followed but two changes were made as follows:

2.1 Full face models made from Plasticine were used in place of models of the portions of the eyes and nose. This enabled a check to be made on the overall direction of the fragments.

2.2 Since it was thought that the batch of Cordtex being used was not always initiating the tetryl pellet, the latter was initiated directly from a No. 8 Briska detonator placed in a Tufnol bush attached to the pellet. The charge was so arranged that only a small portion of the bush protruded above the top of the artillery shell (Fig. 1). No fragments of the detonator or bush were found in any of the models.

A series of tests was also carried out on goggles and visors using No. 8 Briska detonators held sideways and "end-on" to the lenses.

/It .....

It had been suggested that glass fragments arising from laboratory explosions other than detonations would be larger and, though having lower initial velocities, would be more damaging. The authors were of the opinion that (Mrs.) Williams (1) had demonstrated this to be false but undertook further experiments to clarify this.

The tests using tetryl driven glass fragments and fragments from bursting flasks were carried out at a distance of 38 cm as before but those using detonators alone were carried out at a distance of 23 cm.

3. SCOPE OF THE PRESENT INVESTIGATION

Since the investigations reported by (Mrs.) Williams (1) a number of further varieties of safety goggles and spectacles have been received at ERDE. These include the high impact foundry goggles, goggles with double lens systems of glass and cellulose acetate, spectacles fitted with C.R.39 lenses, and an acetate visor fitted with a modified forehead guard made from a resin impregnated fibre. The main interest has centred around the ability to afford protection against explosivly driven glass fragments.

RAE Aberporth reported that tests on certain safety goggles showed that while they would withstand penetration by fragments from an exploding detonator held parallel to the lenses at a distance of 23 cm (9 inches), they were penetrated when the detonator was held "end-on" at the same distance. The authors considered the test distance to be unrealistic but retained it for the sake of comparison in testing other safety goggles and the heavy duty acetate screen.

4. EXPERIMENTAL DETAILS AND RESULTS

The arrangement of the charge in the artillery shell is shown in Fig. 1; the charge was held in place by means of adhesive tape. The Plasticine face models were mounted on wooden stands and placed symmetrically around the charge (Fig. 2). Preliminary experiments showed that the maximum amount of damage occurs around the area of the eyes when the models are mounted with the eyes at 5 cm (2 inches) above the horizontal line of the charge.

Tests Nos. 2 and 4 (see Table 1) correspond to Tests Nos. 3 and 6 in ERDE 7/M/60 (Reference 1). Test No. 1 is less severe than Test No. 2 and Test No. 3 is an intermediate step between Nos. 2 and 4. Test No. 5 has been used at ERDE in demonstrations on eye protection devices and differs from No. 4 only in the size of beaker used. The results of the two tests are very similar and those of Test No. 5 have been included because of the number of trials which have been carried out on foundry goggles.

/Tests .....

Tests Nos. 6 and 7 (Table 2) with bare detonators differ from Tests Nos. 1 to 5 in that they employ simpler face models and were carried out singly (i.e., on one model at a time). The detonator was suspended horizontally or vertically above the model (Figs. 17 and 22). The distance of 23 cm was chosen to conform with tests carried out at RAE Aberporth (2). The models were placed horizontally on the floor so that one lens received the major effect.

Test No. 8 is the same as Test No. 7 in ERDE 7/M/60 except that full face models were used. In addition one flask was burst in the centre of a large wooden box lined with hardboard. The box was approximately a cube of 75 cm (30 inches) side and the fragments reaching the wall would have approximately the same terminal velocity as those reaching the face models. The glass particles were collected so that an estimate of size distribution could be made. A 10-gramme tetryl charge was exploded within a 50 ml beaker within the same box for comparison.

The results for the tests using explosively driven glass fragments are summarised in Table 1 and illustrated in Figs. 3 to 16. The results for tests using detonators only are summarised in Table 2 and Figs. 17 to 32.

The heavy duty acetate visor (Type 15) has stood up to repeated attacks from explosively driven glass fragments and the reinforced forehead guard deflector has not been penetrated though there were several cuts and a number of glass fragments embedded in it (see Fig. 16). Double lens systems employing rear lenses of cellulose acetate (Types 9, 10A and 10B) all withstood the attack of glass fragments driven by 10 grammes of tetryl and the rear lens remained undamaged whether the front lenses were made of glass (Figs. 4 to 7) or cellulose acetate (Fig. 9). Clip-on spectacles fitted with C.R.39 lenses (Type 8, Fig. 3F) protected ordinary spectacles against damage by glass particles driven by 10 grammes of tetryl. Spectacles with C.R.39 lenses (Types 4 and 8) withstood the attack of glass particles driven by 5 grammes of tetryl.

Each of the protective devices used in the detonator trials (see Table 2) showed that they would withstand fragments from an exploding detonator held parallel to the lens but would not withstand them from a detonator held "end-on".

Bursting a flask within the box by nitrogen pressure resulted in some cuts on the surface of the hardboard but no fragments were found embedded in the hardboard nor was it penetrated. The glass fragments were collected from the box; these varied in size from very tiny fragments to pieces approximately 2 cm^2 in area. On firing the tetryl pellet within the beaker inside the box, the box was blown apart and the hardboard lining showed that the fragments were concentrated in a narrow band right round the box. A large number of very tiny fragments were embedded in the hardboard and a great many had cut right through. It was impossible to collect any glass fragments from this explosion but the largest fragments would appear to have been of the order of cubes of 1 mm side.

/The .....

The face protection devices chosen for testing against the effects of the bursting flasks were of two types:

4.1 Types which had failed to withstand glass fragments driven by 2.5 grammes of exploding tetryl.

4.2 Types which had withstood glass fragments driven by 10 grammes of exploding tetryl.

The results are summarised in Table 3 and illustrated in Figs. 33 to 37. With the exception of the safety goggles with toughened glass lenses (Type 20 Fig. 33) and the 10.2 cm (4-inch) visor (Type 21 Fig. 34) all the eye protection devices withstood glass fragments from a bursting flask.

5. CONCLUSIONS

The value of a double lens system in goggles, when the rear lens is of cellulose acetate, has been clearly demonstrated in the results on Types 9, 10A, 10B and 12A (Figs. 4, 5, 6, 7 and 9). Cellulose acetate is preferred to glass for the front lenses because it suffers from scarring only. If optical considerations favour the use of glass front lenses then laminated glass is preferred to toughened glass because the former tends to hold together even when severely cracked. The tests on Types 12A, 12B and 12C goggles illustrate the advisability of following the manufacturer's instructions to mount the lenses in contact, with the thinner lens in front (see Figs. 9, 10 and 11).

Of the lenses tested, those made from C.R.39 (Types 4 and 8) gave the most encouraging results. Clip-on spectacles with these lenses protected ordinary spectacles against glass fragments driven by 10 grammes of tetryl, while standard spectacles fitted with C.R.39 lenses also withstood the effects of glass fragments driven by 10 grammes of tetryl although pitting of some lenses was observed when 5 grammes of tetryl was used. It must be emphasized that the clip-on spectacles should cover the whole lens including the frame of the ordinary spectacles. It is the opinion of the authors that goggles combining C.R.39 front lenses with cellulose acetate rear lenses should give excellent eye protection.

Foundry goggles using a single curved polycarbonate lens (Type 13) are much less reliable than the same goggles using a double planar lens system of cellulose acetate. Eye damage was recorded on one shot and on a number of other occasions glass fragments were embedded in the lenses.

Spectacles and goggles which withstand glass fragments driven by explosive charges protect the eyes only and the full face models show extensive damage to the nose, brow and cheeks. For this reason the heavy-duty cellulose acetate visor has much to recommend it particularly when fitted with the resin impregnated fibre forehead guard (Type 15). Their

/ability .....

ability to withstand several attacks by explosively driven glass fragments has been amply demonstrated and the area of protection extends from below the chin to the top of the head.

Tests Nos. 6 and 7 show that foundry goggles fitted with double planar lenses of cellulose acetate and the heavy duty acetate visor will each withstand fragments from an exploding detonator held parallel to the lens at a distance of 23 cm (Figs. 18 and 21) but will not withstand the "jet" from a detonator held "end-on" (Figs. 19, 20 and 23). Lining the visor with CA adhesive tape does not prevent penetration when the detonator is held "end-on" (Fig. 24). The C.R.39 and toughened glass lenses with acetate screens show similar behaviour (Figs. 25 and 28). The Woolwich type detonator goggle was satisfactory against a detonator fired "side-on" (Fig. 29) but the double lens was penetrated by a detonator fired "end-on" with severe spalling (Fig. 30; Fig. 31 shows the rear of the lens) and severe penetration of the eye (Fig. 32).

Tests at ERDE on glass safety screens show that the "jet" from an exploding detonator will cause extensive damage to 25 mm (1-inch) thick laminated glass with some spalling at a distance of 23 cm. It is doubtful if any form of wearable goggles, spectacles or visor would withstand the "jet" from an exploding detonator even at distances considerably greater than 23 cm. If it is necessary to examine detonators "end-on" it is essential to use a mirror system as well as eye protection and it is clearly important when manipulating detonators outside a heavy safety screen to avoid pointing them towards the face.

The results from the trials with bursting flasks coupled with the experiment with the exploding tetryl inside the box give a clear indication that explosively driven glass fragments are much more severe than those arising from burst flasks [approximately 180 psi (1.2 MN/m^2)]. Test No. 8 again demonstrates the unsuitability of toughened glass for eye protection (see Fig. 33). Although the 10.2 cm (4-inch) visor was of the same thickness as the full anti-splash visor the former (Fig. 34) was holed in the first attempt by the bursting flask while the latter (Fig. 36) survived four such bursts. It was felt that the rigid metal frame of the 10.2 cm (4-inch) visor was a contributory factor. This was also shown in the trials with the goggles with the large single thin acetate lens (Fig. 35); the mounting was again flexible and it survived four tests. The hole punctured in the brittle forehead guard of the heavy-duty visor again demonstrated the value of the resin impregnated fibre guard. (Compare Fig. 37 with Fig. 16.)

/6. .....

6. RECOMMENDATIONS

Where the numbers of specimens available for testing are limited it is the practice to allow a two-fold safety margin in recommending explosive limits for protective devices. In the case of the heavy-duty visor, over the last 8 years, at least 50 have been successfully tested against glass fragments driven by 10 grammes of exploding tetryl so that particular recommendation (6.2) can be made with confidence.

It must be stressed that these recommendations relate to possible unforeseen explosions, they are a minimum standard and the protection used must be increased by a substantial amount if an explosion is produced deliberately or is very probable.

6.1 Toughened glass should NOT be used as an eye protection against high or low velocity fragments.

6.2 The heavy-duty visor with resin impregnated fibre forehead guard should be worn whenever possible and is recommended for use against the explosion of 10 grammes of explosive in glass apparatus.

6.3 Foundry goggles with a double lens system of cellulose acetate make a suitable, easily portable eye protection device and are recommended for protecting the eyes against the explosion of 5 grammes of explosive in glass apparatus.

6.4 C.R.39 clip-on spectacles are recommended for protecting ordinary spectacles against the explosion of 5 grammes of explosive in glass apparatus providing the frames of the ordinary spectacles are completely covered.

6.5 C.R.39 spectacles are recommended for use against the explosion of 5 grammes of explosive in glass apparatus.

6.6 If detonators are to be examined "end-on" they should be viewed by a mirror system, and eye protection worn in addition.

7. ACKNOWLEDGEMENTS

The authors wish to thank Dr. R.M.H. Wyatt for much valuable help and discussion, and Mr. E.G. Whitbread for his continued active interest in this work.

/8. .....

BLANK PAGE

8. REFERENCES

1. (Mrs.) H.D. Williams ERDE, Technical Memorandum No. 7/M/60

2. Lt. Cdr. Samson, RAE, Aberporth. Notes on trial to test the effectiveness of safety goggles against number 33 detonators. 28.3.61

/TABLE 1 .....

TABLE 1

Testing of Eye Protection Dev:
Explosively Driven Glass

Type	Type of Protection	Fig. No.	Type of Frame	Type of Lens	Material of Lens	Test 1 1 g of Tetryl in 50 ml Beaker
1	Safety Spectacles with side-wings	3D	Metal and polymer with gauze wings	Curved	Triple-armour plate	1.1 Practically undamaged
2	Safety Goggles with elastic head band worn over Ordinary Spectacles		PVC moulded in nickel mesh Polymer	Planar Planar	PVC Glass	1.1 Slightly marked 1.1 Undamaged
3	Safety Goggles with elastic head band worn over Ordinary Spectacles		Moulded PVC Polymer	Planar Planar	PVC Glass	1.1 Slightly marked 1.1 Undamaged
4	Safety Spectacles	3E	Polymer	Curved	C.R.39	1.1 Undamaged - -
5	Safety Spectacles	3C	Polymer with side wings	Planar	Toughened glass	1.1 Badly cracked; eyes not affected

For decimal notation in the columns listing

A

TABLE 1

Protection Devices Against
Driven Glass Fragments

Test 1 of Tetryl in 50 ml Beaker	Test 2 2.5 g of Tetryl in 50 ml Beaker	Test 3 5 g of Tetryl in 50 ml Beaker	Test 4 10 g of Tetryl in 50 ml Beaker	Test 5 10 g of Tetryl in 100 ml Beaker
ractically ged	1.2 Cracked but no splintering; eyes not affected	1.3 Badly cracked; hole in one lens	-	-
lightly damaged	1.2 Cracks in lens 1.2 Undamaged	1.3 Badly torn 1.3 Sha+tered	-	-
lightly damaged	1.2 Cracks in lens 1.2 Undamaged	1.3 Badly torn 1.3 Shattered	-	-
damaged - -	1.2 Slightly marked - -	1.3 Pit in one corner of one lens otherwise only slightly marked; eyes not affected 2.1 Slightly marked 3.1 Pit in one corner of one lens, otherwise only slightly marked	1.4 Badly cracked but eyes not affected 2.2 Badly cracked but eyes not affected -	- - -
dly d; eyes fected	2.1 Badly cracked with one hole in one lens	3.1 Severely cracked	-	-

lumns listing the test see end of Table

/TABLE 1 (contd.) .....

B

TABLE 1 (contd.)

Type	Type of Protection	Fig. No.	Type of Frame	Type of Lens	Material of Lens	Test 1 1 g of Tetryl in 50 ml Beaker	2.5
6	Safety Spectacles	3B	Polymer	Curved	Toughened glass	1.1 Badly cracked; slight spalling of fragments; eyes not affected	2.1 I small spall insid
7	Rimless Spectacles	3A	Thin metal supporting bands	Curved	Acrylic	1.1 Both lenses deeply crazed, one cracked; eyes not affected	1.2 C torn lens hole lens
8	Clip-on Spectacles worn over Ordinary Spectacles	3F	Thin metal frame with metal clips Polymer	Curved Planar	C.R.39 Glass	- -	
9	Safety Goggles with rubber head band	4 (1.1) 5 (2.1)	Moulded PVC with soft PVC nose flap Screwed caps to retain lenses	Front lens planar Rear lens planar	Toughened glass Cellulose acetate	-	1.1 I shat glas Rear unda not
10A	Safety Goggles with rubber head band	6 (1.3)	Moulded PVC with soft PVC nose flap. Screwed caps to retain lenses	Front lens planar Rear lens planar	Laminated glass Cellulose acetate	- -	1.1 I badly Rear unda

A

TABLE 1 (contd.)

Test 1 1 g of Tetryl in 50 ml Beaker	Test 2 2.5 g of Tetryl in 50 ml Beaker	Test 3 5 g of Tetryl in 50 ml Beaker	Test 4 10 g of Tetryl in 50 ml Beaker	Test 5 10 g of Tetryl in 100 ml Beaker
.1 Badly cracked; light spalling of ragments; eyes ot affected	2.1 Badly cracked; small fragments spalled from inside of lens	3.1 Severely cracked	-	-
.1 Both lenses eeply crazed, ne cracked; eyes ot affected	1.2 One corner torn from one lens; small holes in both lenses	-	-	-
-	-	1.1 Slightly marked	1.2 Scarred but no cracks 1.3 Increased scarring; cracks and hole in one lens	-
-	-	1.1 Undamaged	1.2 Undamaged 1.3 Crack in one lens appears to have been caused by hit on frame	
-	1.1 Front lens shattered; some glass fell out Rear lens undamaged; eyes not affected	-	2.1 Front lens shattered; one lens cap cut; lenses on floor Rear lens undamaged; eyes not affected	-
- -	1.1 Front lens badly cracked Rear lenses undamaged	1.2 Front lens further cracked Rear lenses undamaged	1.3 Front lenses almost powdered; held together by adhesive. Rear lens undamaged; slight crack in one screwed cap	

/TABLE 1 (contd.) .....

B

Type	Type of Protection	Fig. No.	Type of Frame	Type of Lens	Material of Lens	Test 1 1 g of Tetryl in 50 ml Beaker
10B	Safety Goggles with rubber head band	7 (1.3)	Moulded PVC with soft PVC nose flap. Screwed caps to retain lenses	Front lens planar Rear lens planar	Laminated glass Cellulose acetate	-
11	Safety Spectacles	8	No frames, metal ear-pieces only	Single curved lens including nose bridge	Acrylic 1.5 mm thick	-
12A	Safety Goggles with elastic head band	9 (3.2)	Moulded PVC with screwed caps to retain lenses	Front lens planar Rear lens planar	Cellulose acetate 1.25 mm thick Cellulose acetate 2 mm thick	-
12B	Safety Goggles with elastic head band	10	Moulded PVC with screwed caps to retain lens	Front lens planar Rear lens planar	Cellulose acetate 2 mm thick Cellulose acetate 1.25 mm thick (Reversal of recommended order)	-

A

TABLE 1 (contd.)

Test 1 1 g of Tetryl in 50 ml Beaker	Test 2 2.5 g of Tetryl in 50 ml Beaker	Test 3 5 g of Tetryl in 50 ml Beaker	Test 4 10 g of Tetryl in 50 ml Beaker	Test 5 10 g of Tetryl in 100 ml Beaker
-	-	-	2.1 Front lens badly cracked but held together by adhesive. One screwed cap cut; lenses on floor. Rear lens undamaged; eyes not affected	
-	1.1 Several small holes punched in lens. Some pieces of lens and one ear piece broken off. Eyes not affected	-	-	-
-	-	-	1.1 Front lens scarred. Rear lens undamaged 2.1 Screwed cap cut; one set of lenses on floor; front lons scarred; rear lens undamaged. Eyes not affected.	3.1 Front lens scarred. Rear lens undamaged. 3.2 Screwed cap cut; lenses on floor; front lens scarred; rear lens undamaged. Eyes not affected
-	-	-	-	1.1 Front lens scarred. Rear lens undamaged

/TABLE 1 (contd.) .....

B

TABLE 1 (contd.)

Type	Type of Protection	Fig. No.	Type of Frame	Type of Lens	Material of Lens	Test 1 1 g of Tetryl in 50 ml Beaker	2.
12C	Safety Goggles with elastic head band	11	Moulded PVC with screw caps to retain lenses	Front lens planar Rear lens planar	Cellulose acetate 1.25 mm thick Cellulose acetate 2 mm thick	-	
				(Lenses separated by rubber washer, not recommended by manufacturer)			
13	Safety Goggles with elastic head band	12 (1.3) 13 (4.1) 14 (5.1)	Moulded PVC with screw caps to retain lenses	Curved	Polycarbonate 1.75 mm thick	-	1.1 sca poi one cor mar 2.1 sca not
14	Heavy duty visor with spark guard, head harness and elastic head band	15 (1.1)	Brittle polymer forehead guard	Visor	Cellulose acetate 3 mm thick	-	

A

TABLE 1 (contd.)

Test 1 1 g of Tetryl in 50 ml Beaker	Test 2 2.5 g of Tetryl in 50 ml Beaker	Test 3 5 g of Tetryl in 50 ml Beaker	Test 4 10 g of Tetryl in 50 ml Beaker	Test 5 10 g of Tetryl in 100 ml Beaker
-	-	-	-	1.1 Front lens cut to ribbons. Rear lens undamaged. Eyes not affected
-	1.1 Lenses scarred; sharp point at rear of one lens with corresponding mark in eye 2.1 Lenses scarred; eyes not affected	1.2 Lenses further scarred; small glass particles embedded in lenses. No further eye damage 2.2 Lenses further scarred. Eyes not affected	1.3 Lenses further damaged; cuts in frame. No further eye damage 2.3 Lenses further scarred, small glass particles embedded in lens. Eyes not affected	3.1 Lenses scarred. Eyes unaffected 4.1 One screw cap cut, lens on floor and torn. Eyes not affected 5.1 Small glass particles embedded in lenses; minute marks in eye 6.1 Lenses scarred. Eyes not affected
-	-	-	-	1.1 Deflector cut, visor scarred but not penetrated. Face undamaged 2.1 Nuts holding visor to deflector cut, visor scarred but not penetrated. Face undamaged

/TABLE 1 (contd.) .....

B

TABLE 1 (contd.)

Type	Type of Protection	Fig. No.	Type of Frame	Type of Lens	Material of Lens	Test 1 1 g of Tetryl in 50 ml Beaker
15	Heavy duty visor with spark guard and elastic head band	16 (1.5)	Resin impregnated fibre fore-head guard	Visor	Cellulose acetate 3 mm thick	-

The decimal notation in the columns listing the tests

1.1 Means the first test to be carried out on th

2.1 Means the first test to be carried out on th

1.5 Means the fifth test to be carried out on th

A

TABLE 1 (contd.)

Test 1 1 g of Tetryl in 50 ml Beaker	Test 2 2.5 g of Tetryl in 50 ml Beaker	Test 3 5 g of Tetryl in 50 ml Beaker	Test 4 10 g of Tetryl in 50 ml Beaker	Test 5 10 g of Tetryl in 100 ml Beaker
-	1.1 Visor scarred, slight cuts in spark guard; no penetration 1.4 Visor further scarred. More cuts in spark guard; some glass fragments embedded in spark guard	1.2 Visor further scarred. More cuts in spark guard	1.3 Visor further scarred. More cuts in spark guard 1.5 Visor further scarred, no penetration. More glass fragments embedded in spark guard, no penetration. Face and head undamaged	

listing the tests is as follows:-

e carried out on the first pair of spectacles (or goggles or visor etc.)

e carried out on the second pair of spectacles etc.

e carried out on the first pair of spectacles etc.

/TABLE 2 .....

B

TABLE 2

Testing of Eye Protection Devices Against Exp

Type	Type of Protection	Fig. No.	Type of Frame	Type of Lens	Material o
12	Safety Goggles with elastic head band	17(1.1) 18(1.1) 19(1.2) 20(1.2)	Moulded PVC with screw cap to retain lens	Front lens - planar Rear Lens - planar	Cellulose ac 1.25 mm thic Cellulose ac 2 mm thick
14	Heavy-duty Visor with forehead guard, head harness and elastic head band	21(1.1) 22(1.2)	Brittle polymer spark guard	Visor	Cellulose ac 3 mm thick
16	Heavy-duty Visor (as 14) lined with Sellotape	23(1.1) 24(1.1)	Brittle polymer spark guard	Visor	Cellulose ac thick lined adhesive tap
17	Safety Goggles with additional Cellulose acetate screens	25(1.1) 26(1.1) 27(1.2)	Moulded PVC	Planar 1st screen 2nd screen	C.R.39 Cellulose ac 1.25 mm thic Cellulose ac 2 mm thick
18	Safety Goggles with additional cellulose acetate screens	28(1.2)	Moulded PVC	Planar 1st screen 2nd screen	Toughened gl Cellulose ac 1.25 mm thic Cellulose ac 2 mm thick
19	Detonator goggles Drawing RD 1796A	29 30 31 32	Metal	Two planar lenses 3 mm (0.1 inch) thick with 3 mm (0.12 inch) separation in each eyepiece	Laminated gl

For decimal notation in the columns listing the

A

TABLE 2

ction Devices Against Exploding Detonators

Lens	Material of Lens	Test 6 No. 8 Briska Detonator held Parallel to Lens	Test 7 No. 8 Briska Detonator held "Head-on" to Lens
- planar planar	Cellulose acetate 1.25 mm thick Cellulose acetate 2 mm thick	1.1 Several pit marks on front lens of right eye-piece. No penetration; eyes not affected	1.2 Holes in outer lens of left eye-piece. Inner lens broken into several pieces. Left eye penetrated
	Cellulose acetate 3 mm thick	1.1 Several pit marks. No penetration; eyes not affected	1.2 Several pit marks and one penetration. Left eye penetrated.
	Cellulose acetate 3 mm thick lined with CA adhesive tape	-	1.1 Several pit marks and one penetration. Eye penetrated
	C.R.39 Cellulose acetate 1.25 mm thick Cellulose acetate 2 mm thick	1.1 Pit marks in the top screen. No penetration; eyes not affected	1.2 Several minor and one major penetration of first screen. One major penetration of second screen. Optilite lens cracked and splintered with one large hole. Splinters penetrated eye and face
	Toughened glass Cellulose acetate 1.25 mm thick Cellulose acetate 2 mm thick	1.1 A few pit marks in the outer screen. No penetration; eyes not affected	1.2 Outer screen penetration 4 mm x 6 mm. Inner screen penetration 7.5 mm x 10 mm. Glass lens disintegrated. Glass splinters in eye.
nses h) thick 12 inch) each	Laminated glass	1.1 Several pit marks on front lens of left eye piece. No penetration; eyes not affected	1.2 Complete penetration of both lenses of right eyepiece. Right eye severely penetrated

the columns listing the test (see Table 1)

/TABLE 3 .....

B

TABLE 3

Testing of Eye Protection Devices Agains

Type	Type of Protection	Fig. No.	Type of Frame	Type of Lens	Mat
20	Safety Goggles	33	Moulded rubber, flexible	Planar	Toughe 2.9 m
21	Half Visor with forehead guard and head harness	34	Aluminium band round visor	Visor	Cellu thick
22	Safety Goggles	35	Moulded rubber, flexible	Curved lens covering both eyes	Cellu 0.75
23	Anti-splash Visor	36	Metal head band	Visor	Cellu 1 mm

For decimal notation in the column listi

A

TABLE 3

Devices Against Bursting Glass Flasks

	Material of Lens	Test 5 10 g of Tetryl in 100 ml Beaker	Test 8 Bursting 500 ml Glass Flask
	Toughened glass 2.9 mm thick	-	1.1 One lens holed and shattered
	Cellulose acetate 1 mm thick	-	1.1 Hole cut in visor near frame; frame dented
ring	Cellulose acetate 0.75 mm thick	-	1.1 Lens scratched 1.2 Further scratches 1.3 Some surface cuts, one right through; eyes not affected 1.4 Further surface cuts; eyes not affected
	Cellulose acetate 1 mm thick	1.1 Badly torn; eyes penetrated	2.1 Some surface scratches 2.2 Further scratches 2.3 Some surface cuts 2.4 One starred cut right through; face and eyes undamaged

column listing the tests (see Table 1)

/TABLE 3 (contd.) .....

B

TABLE 3 (contd.)

Type	Type of Protection	Fig. No.	Type of Frame	Type of Lens	Material
13	Safety Goggles with elastic head band		Moulded PVC with screw caps to retain lenses	Curved	Polycarbona thick
14	Heavy-duty Visor with forehead guard, head harness and elastic head band	37 (3.3)	Brittle polymer spark guard	Visor	Cellulose a 3 mm thick

A

TABLE 3 (contd.)

Lens	Material of Lens	Test 5 10 g of Tetryl in 100 ml Beaker	Test 8 Bursting 500 ml Glass Flask
	Polycarbonate 1.75 mm thick	3.1 Lens scarred; eyes not affected 4.1 One screw cap cut, lens on floor; eyes not affected 5.1 Small glass particles embedded in lens; minute marks in eye	6.1 Slight surface scratches on one lens 6.2 Further slight scratches
	Cellulose acetate 3 mm thick	1.1 Spark deflector cut, visor scarred; no penetration; no damage to face or eyes 2.1 Nuts holding visor to deflector cut; visor scarred but not penetrated; no damage to face or eyes	3.1 Slightly scratched 3.2 Further scratches 3.3 Further scratches; hole in spark deflector 3.4 Further scratches

S.No. 41/68/RR

A

ERDE 10/M/68

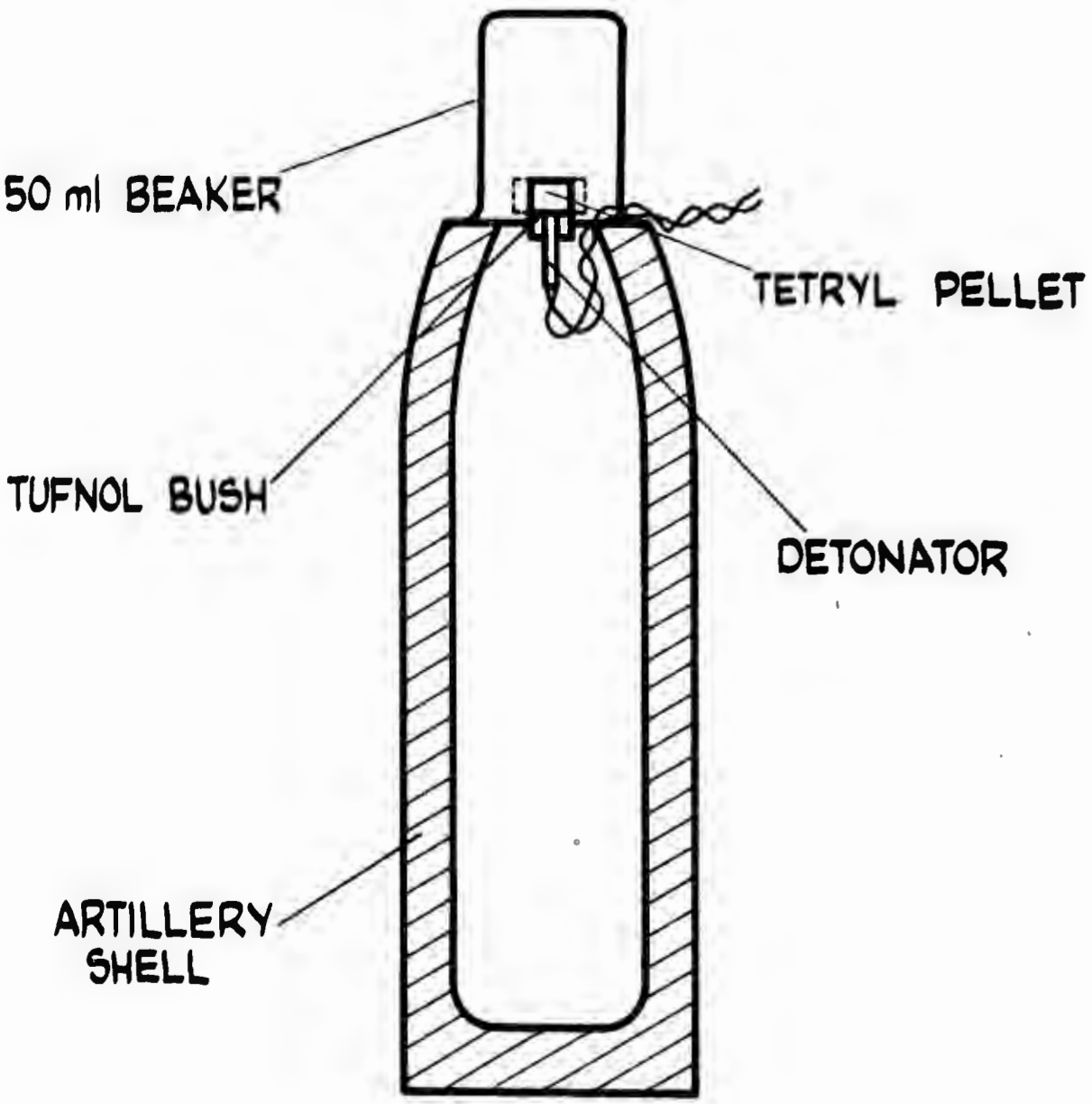

FIG. 1 METHOD OF MOUNTING CHARGE AND BEAKER.

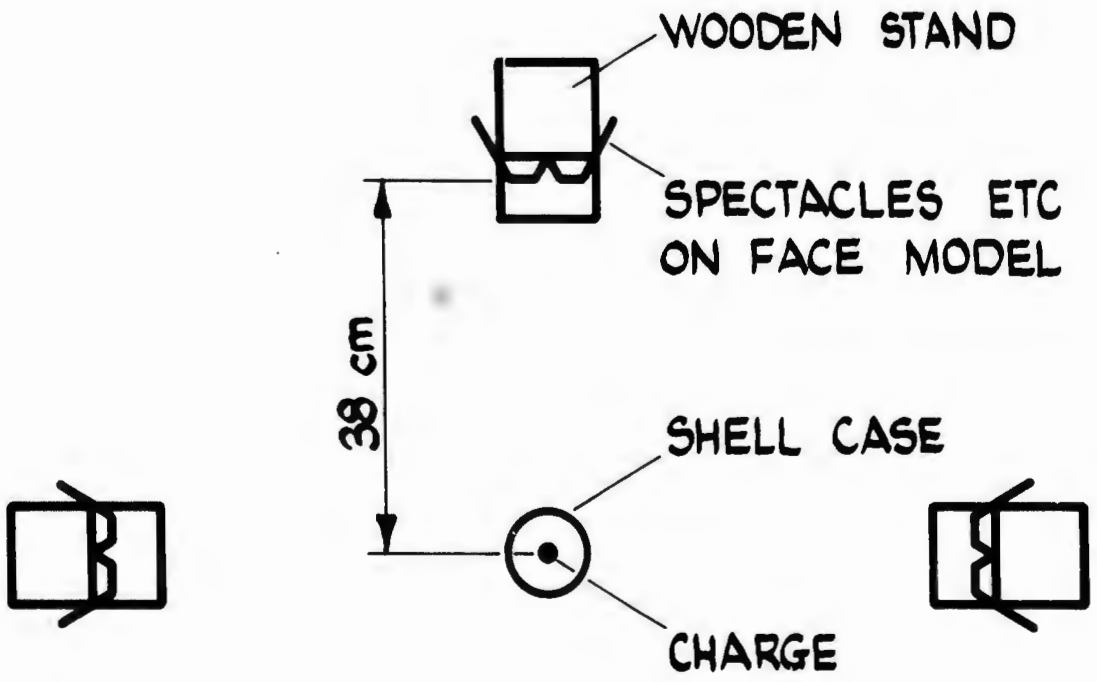

FIG.2 SYMMETRICAL ARRANGEMENT OF FACE MODELS AROUND EXPLOSIVE CHARGE.

ERDE 10/M/68

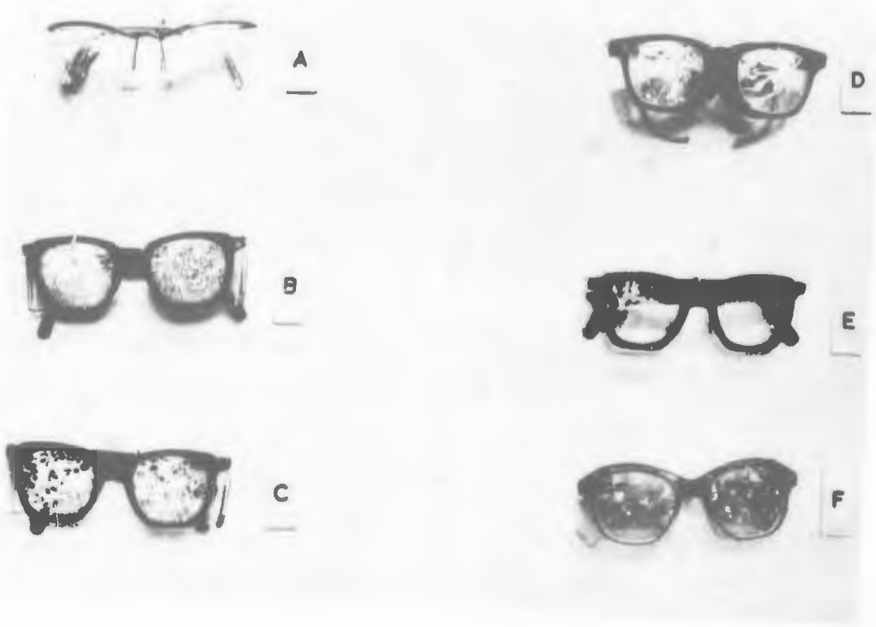

FIG. 3

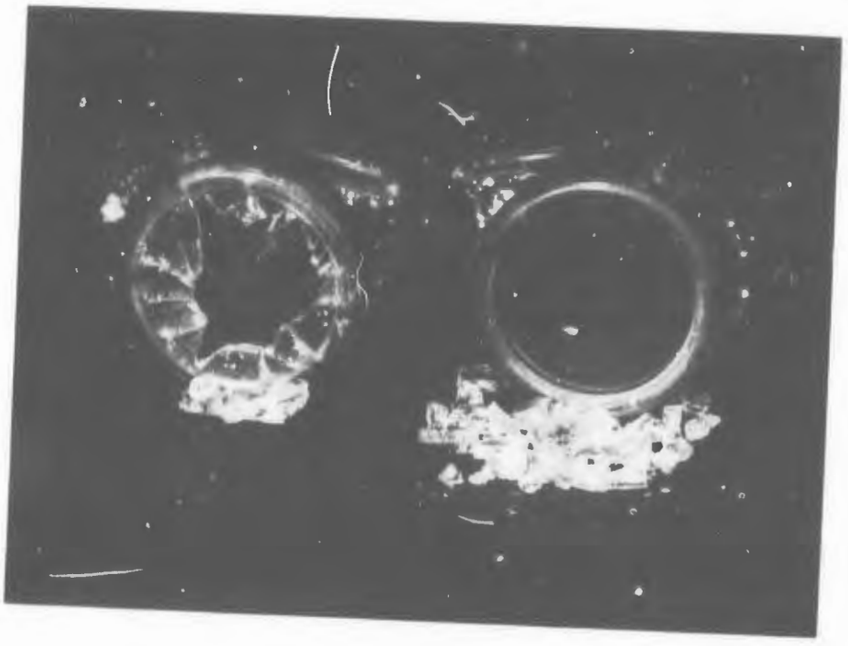

FIG. 4

ERDE 10/M/68

FIG. 6

FIG. 8

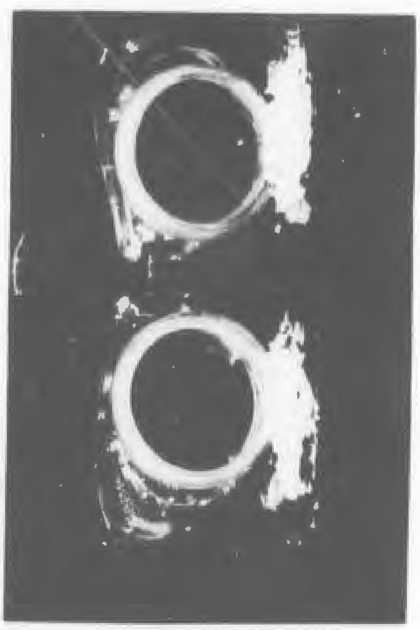

FIG. 5

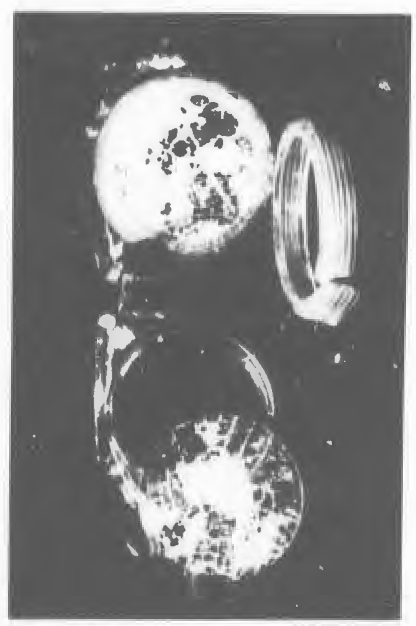

FIG. 7

ERDE 10/M/68

FIG. 10

FIG. 12

FIG. 9

FIG. 11

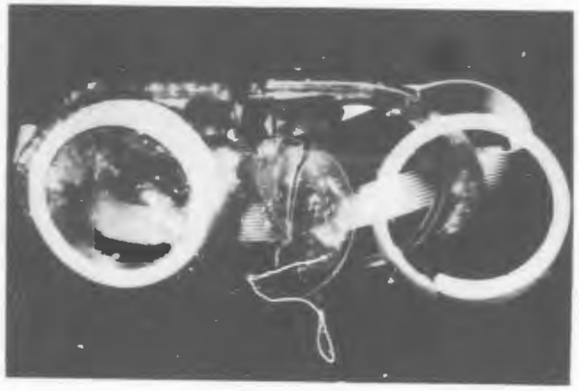

FIG. 13

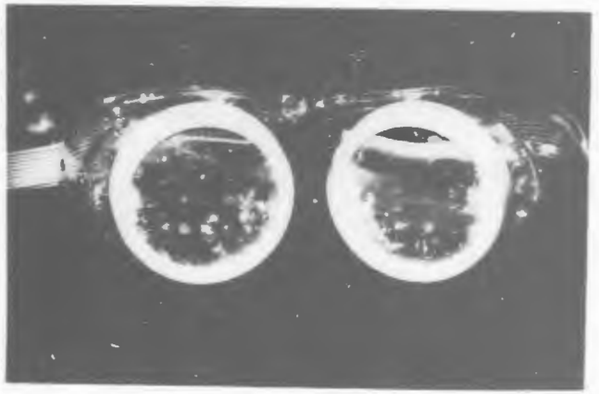

FIG. 14

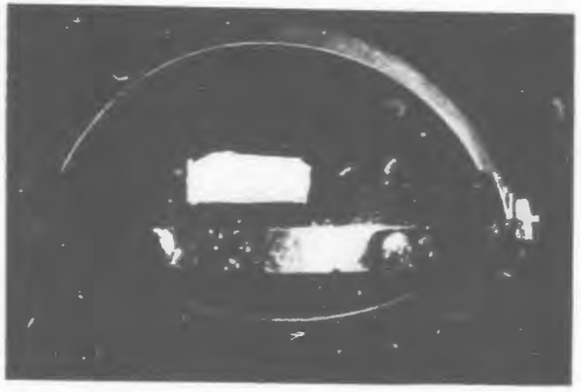

FIG. 15

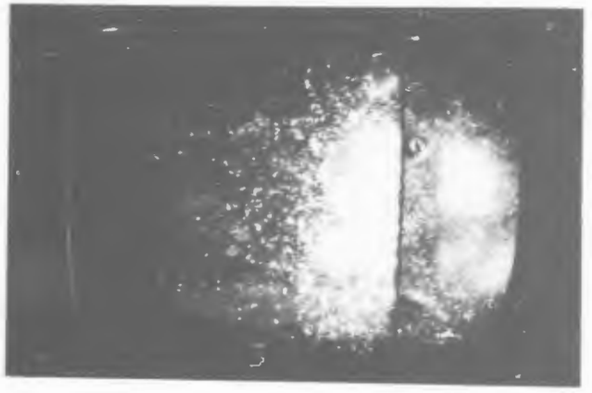

FIG. 16

ERDE 10/M/68

FIG. 18

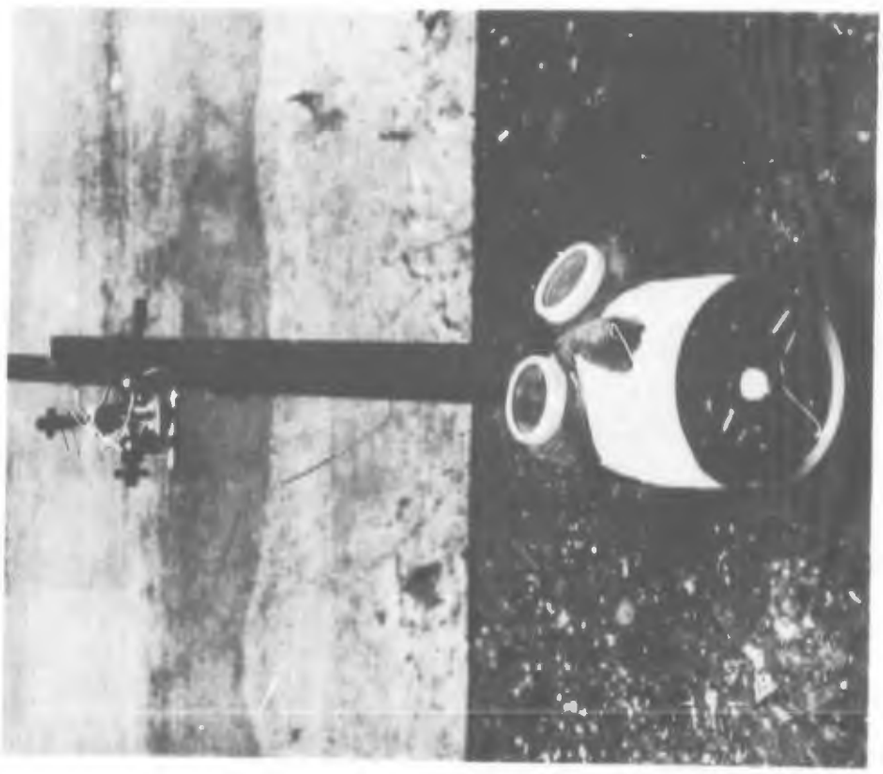

FIG. 17

ERDE 10/M/68

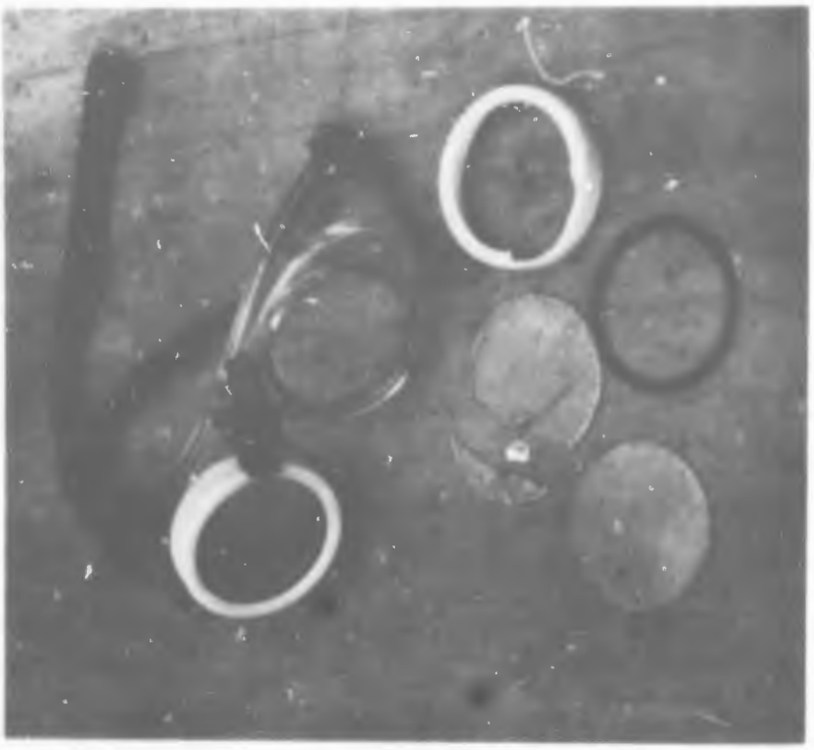

FIG. 20

FIG. 19

ERDE 10/M/68

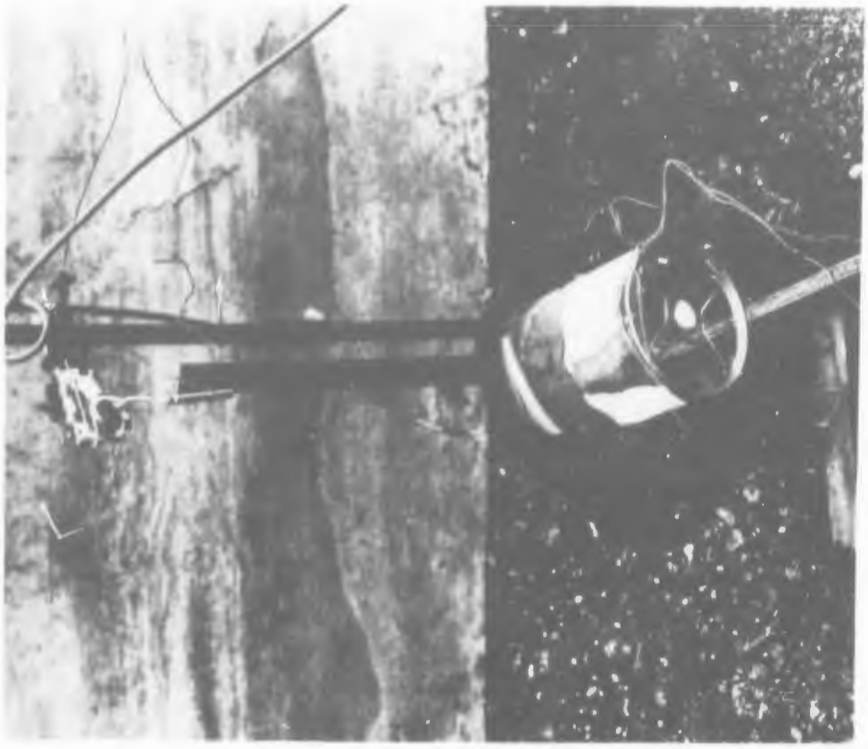

FIG. 22

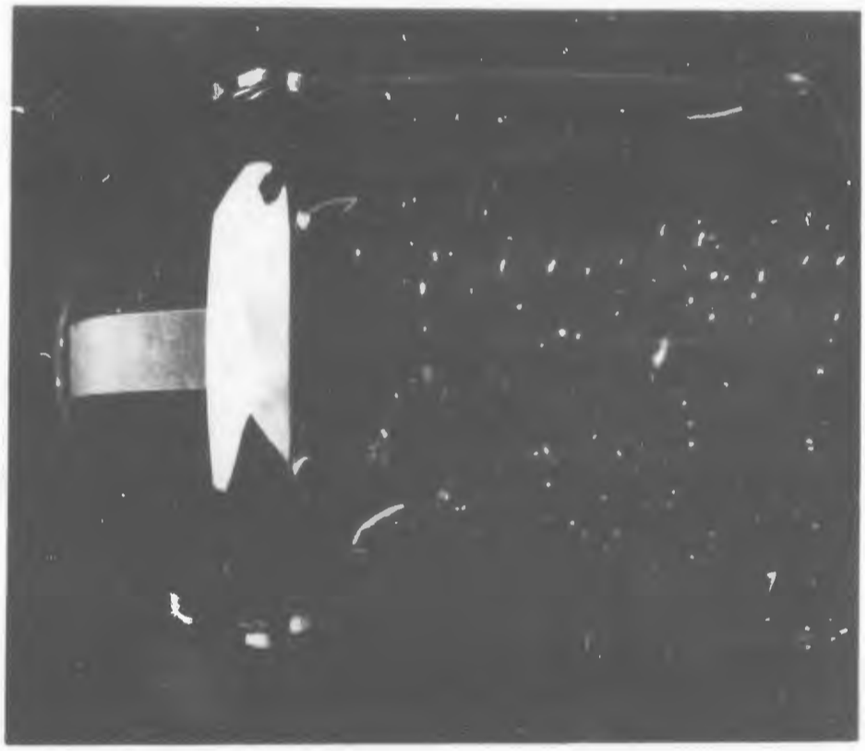

FIG. 21

FIG. 23

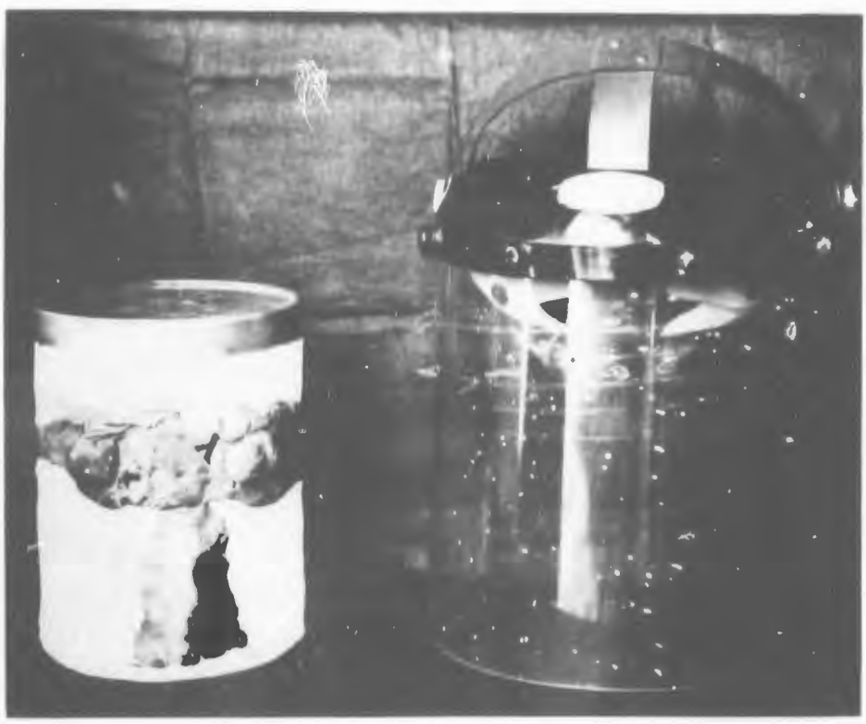

FIG. 24

ERDE 10/M/68

FIG. 25

FIG. 26

ERDE 10/M/68

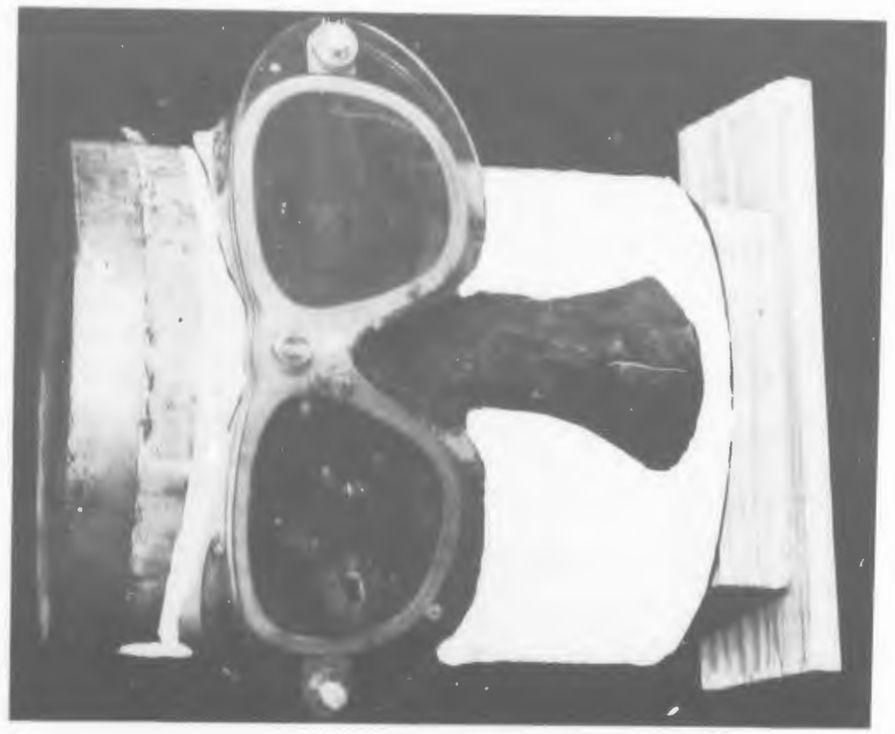

FIG. 28

FIG. 27

ERDE 10/M/68

FIG. 29

FIG. 30

ERDE 10/M/68

FIG. 31

FIG. 32

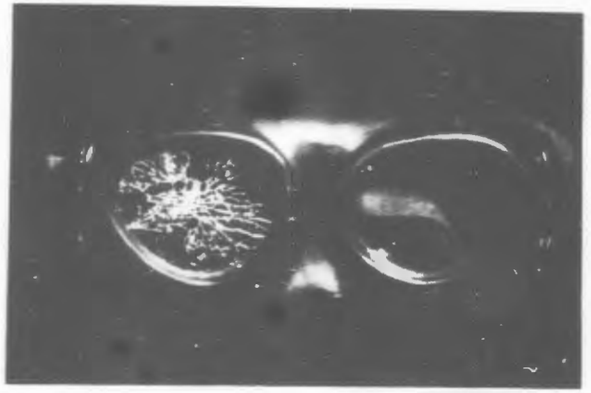

FIG. 33

FIG. 34

FIG. 35

ERDE 10/M/68

FIG. 37

FIG. 36