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REPORT ON THE DESIGN OF A HAND THROWN AVALANCHE CONTROL CHARGE --ETC(U)
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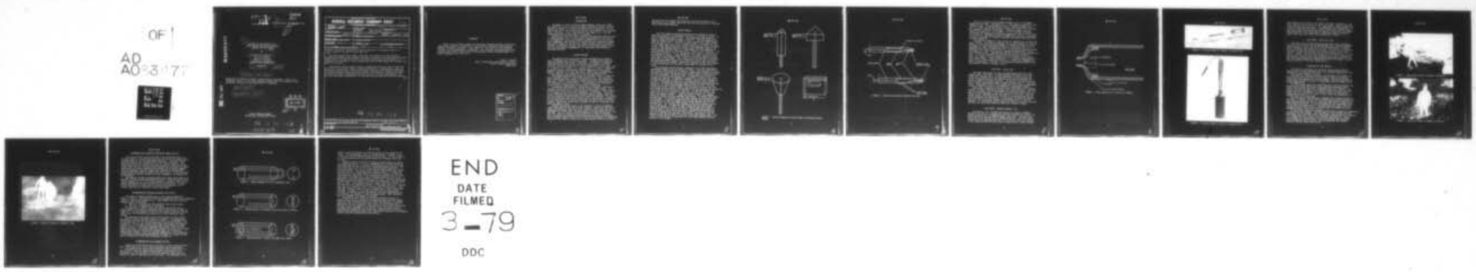

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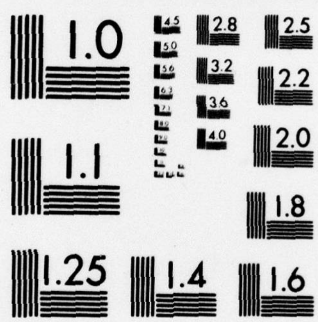
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NWC Technical Memorandum 3183

REPORT ON THE DESIGN OF A HAND THROWN AVALANCHE CONTROL CHARGE FOR THE USFS

by

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JUNE 1977

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*Premature Detonation with Selected Explosive Materials for Avalanche Control, by Carl F. Austin et al, NWC TS 74-219, May 1974

The Naval Weapons Center (NWC), China Lake, was tasked by the USFS Missoula Equipment Development Center, Missoula, Montana, to develop a two pound avalanche control charge which can be hand thrown with a two minute delay and has the potential to be launched from a helicopter. Later communication from the USFS reduced the required time delay to 90 seconds.

Specifically, NWC was asked to design a package which would be easy to throw and would stick in place where thrown; design an efficient H. E. configuration; insure environmental acceptability; utilize off-the-shelf components where feasable and design any other components needed; fabricate a number of test devices; conduct safety tests to determine hazards, environmental effects, dud rate, and field performance of the devices; and present recommendation for both hand thrown design and helicopter delivery.

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FOREWORD

This is an informal report of the Naval Weapons Center describing continuing studies in support of the Missoula Equipment Development Center, Missoula, Montana. This report is not part of the permanent records of the Department of Defense. The studies described were conducted under USDA Forest Service Development Center Reimbursement of Funds Agreement No. 62-18-77.

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4 May 1977

INTRODUCTION

On October 7, 1976, the Naval Weapons Center, China Lake, (NWC), was tasked by the USFS Missoula Equipment Development Center, Missoula, Montana, to develop a two pound avalanche control charge which can be hand thrown with a two minute delay and has the potential to be launched from a helicopter. Later communication from James Lott of the USFS reduced the required time delay to 90 seconds.

Specifically, NWC was asked to design a package which would be easy to throw and would stick in place where thrown; design an efficient H. E. configuration; insure environmental acceptability; utilize off-the-shelf components where feasable and design any other components needed; fabricate a number of test devices; conduct safety tests to determine hazards, environmental effects, dud rate, and field performance of the devices; and present recommendation for both hand thrown design and helicopter delivery.

DESIGN CRITERIA

The design of the charge must include considerations of safety, cost, convenience and environmental impact. A tamper-proof method of insuring adequate fuse length is required. The problem of premature detonation due to electrostatic discharge was assumed to have been solved by the staple shunt and will not be addressed in this report (see C. F. Austin, M. R. Osburn, C. C. Halsey, and C. L. Wilson, "Premature Detonation Studies with Selected Explosive Materials for Avalanche Control", NWC Pub. TS 74-219, May 1974). Other safety considerations include protection from impact due to falling and low dud rate.

The charges presently being used for avalanche control in most ski areas represent design for the lowest possible cost. Any new design which incorporates more safety or convenience factors must necessarily cost more. Since a large number of these charges are thrown each year this additional cost must be kept to a minimum and is not warranted unless offset by added safety or operational convenience.

Convenience considerations include ease of assembly, handling and throwing, and the ability of the charge to remain where thrown. The charges are carried by ski patrol personnel in backpacks, inside jackets, or in pockets and so must be of convenient size and shape. Since the actual throwing takes place under extremely adverse weather conditions, any field assembly required should be as simple as possible. The charges will be thrown into soft, newly fallen snow, so the problem of charges rolling away down hill after the throw does not seem to be a significant problem. Deep burial could pose a problem in event of a high dud rate after helicopter launch.

Another significant factor to be considered is the environmental impact resulting from the use of such a charge. Ideally all the charge should be consumed by the blast or any remaining parts should be biodegradable in a short time. Another aspect to be considered here is the dud rate. This of course should be minimized in order to keep down cost, to prevent the charges from getting into the hands of terrorists and to prevent hazards to skiers as a result of the presence of unexploded charges on the slopes as these could be considered attractive nuisances

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and could lead to attempts by novices to reinitiate the delay train. Additionally, the charges should not make dark colored marks in the snow which would enhance melting.

DESIGN PROCESS

The first stage of the design process was to develop an overall shape which would (1) be convenient to carry, (2) be easy to throw, (3) not roll when thrown onto a slope. Four shapes were considered and models of each were made as shown in Figure 1. (The fuse channels are shown by dashed lines.) Initially it was conceived that these charges would be cast from H. E. with no protective case. For shapes A, B and C, the handle would screw into a plastic base plate cast into the charge itself. These designs would be similar to the charges already in use and would not represent much of an improvement with the exception of being somewhat easier to throw and not as likely to roll downslope. The structural strength of all of the shapes, and of shape D in particular, was somewhat in doubt. It was feared that the moment imparted by the throw would cause enough stress to develop around the handle-to-charge joint that it would break. This concern led to the decision to enclose the protruding handle designs in a protective plastic case into which the handle could be screwed. Shape B was rejected at this point because of the inconvenience of carrying a large number of charges of this shape.

The protruding handle designs, comparable to the WWII spud-masher handgrenade seemed to be the easiest to throw. Given this decision the next stage of the design was to develop a tamper-proof method of insuring adequate fuse length (90 seconds) and a better method of protecting the cap from accidental ignition by shock. A reasonable solution was to include the fuse and cap assembly in the handle in order to facilitate storage and handling. In the first attempt, fuse was simply wrapped in a spiral wrap around the handle in a recessed section (cross section A, Figure 2). Although no tests were made, concern was expressed about the possibility of spit-across between adjacent turns of fuse. This was avoided by turning a spiral channel into the handle to accept the fuse with enough plastic material left between turns to eliminate the possibility of spit-across (cross section B, Figure 2). In the test models, the channel was cut at a pitch of 3 turns per inch and was 1/4" wide and deep. This design allowed the required length of fuse to be wrapped around the handle and also prevented spit-across. To prepare the handle, the fuse was first inserted into the inner channel at the threaded end of the handle. A cap was crimped onto the fuse and the fuse was then pulled back until the cap seated and was flush with the face of the threaded end. The fuse was then wrapped in the spiral channel and fed out the other end. A sleeve was then fitted over the fuse wrapped handle and cemented in place in order to protect the fuse as well as insuring that it could not be cut short. The handle was designed so that the burning time of the fuse was 90 seconds if the fuse was cut just as it emerged from the end of the handle. Any pigtail left for connecting the ignitor would, of course, extend this burning time. The trials of the test device resulted in burning times ranging from 105 seconds to 130 seconds.

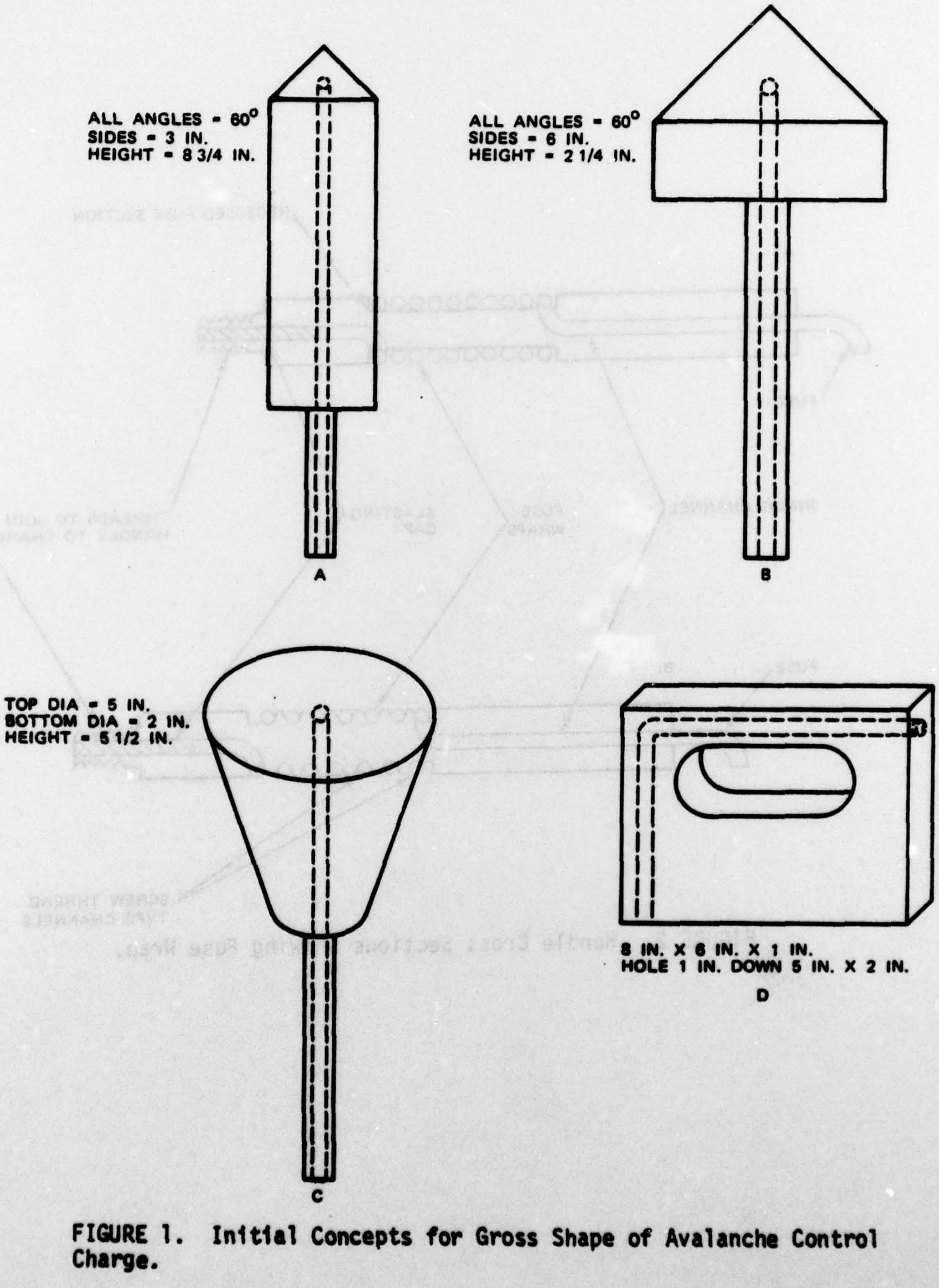

FIGURE 1. Initial Concepts for Gross Shape of Avalanche Control Charge.

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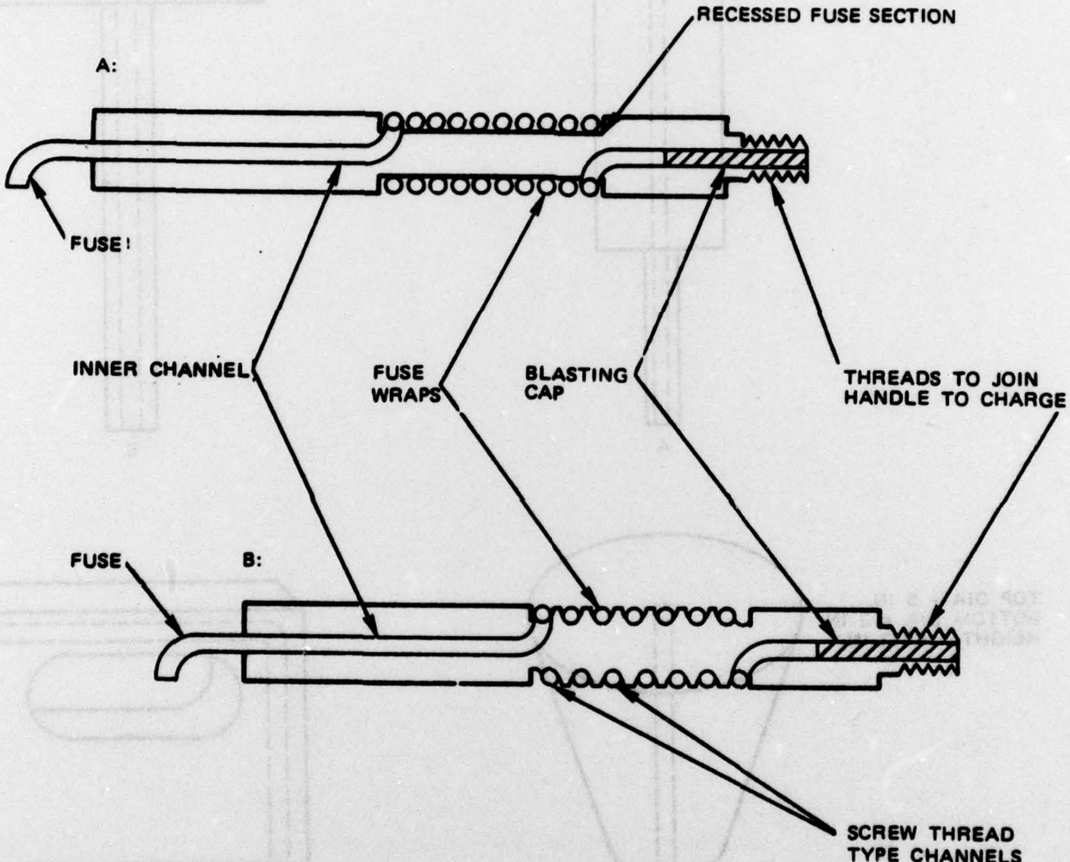

FIGURE 2. Handle Cross Sections Showing Fuse Wrap.

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The H. E. portion of the charge was made up in 2 1/2" diameter schedule 40 PVC pipe. Two pounds of H. E. was found to require a 6 3/4" length of pipe. A fitting made up from a 2" bushing cemented over a 3/4" to 2" bell reducer and turned by lathe to fit into the 2 1/2" pipe was cemented to one end of the pipe. A seat was tuned in the bell reducer to accept the 1 1/4" diameter x 1 1/4" long PBX N-5 booster. The booster was protected from the environment by a disc of 10 mil mylar (see Figure 3). NWC chose to machine commercially available components in order to approach as closely as possible the request that we use off-the-shelf materials.

Although this method of lathe turning of commercially available PVC pipe, fittings, and stock was adequate for our test charges, it would be impractical for producing large numbers of charges for field use since the amount of labor involved would make the cost prohibitive. It is suggested that both the handle and the H. E. portion be injection molded. This would save labor and also with a properly designed mold, should save material as well. Considerable opportunities for using less material exist in fluting the handle and reducing the thickness of the H. E. case. This would also be a weight saving which might allow a man to carry more charges. Another advantage of the injection molded design is that a softer plastic could be used and thus reduce the fragmentation hazard to personnel in the area. A transparent plexiglass model of the test charge is shown in Figures 4 and 5.

FIELD TEST - China Lake

The final test design for the protruding handle was first field tested at NWC, China Lake. A handle assembly with fuse and cap was fired with a booster only in an enclosed space in order to test the effect of the mylar gap in the explosive train and to determine the amount of debris left after the blast. The test of the explosive train was successful and several pieces of handle material up to 1" long were found. Approximately 70% of the assembly was sufficiently pulverized to present no physical hazard or environmentally unacceptable debris.

Other tests conducted at the NWC in the conjunction with personnel of MEDC, Missoula, used two prototypes built from plexiglass. The first test was successful, but in the second, the protective sleeve over the handle was not cemented in place and came off in the throw. When the charge landed, the plexiglass at the base of the charge broke and the handle separated from the charge. The blasting cap detonated properly, but since the cap was not coupled to the charge, the H. E. did not detonate. All subsequent charges tested were made of polyvinal chloride and only one, which was thrown on rocky soil cracked on impact.

FIELD TESTS - Mammoth Mountain, Cal.

On March 10, 1977, the NWC team tested six charges at Mammoth Mountain, California in cooperation with USFS personnel and several ski patrol personnel from the Mammoth Mountain Ski Area. The tests were conducted in the Red Lake area of Mammoth Mountain. The first charge thrown failed to detonate and after a thirty minute wait was recovered. It was found that the fuse had failed to ignite prior to being thrown.

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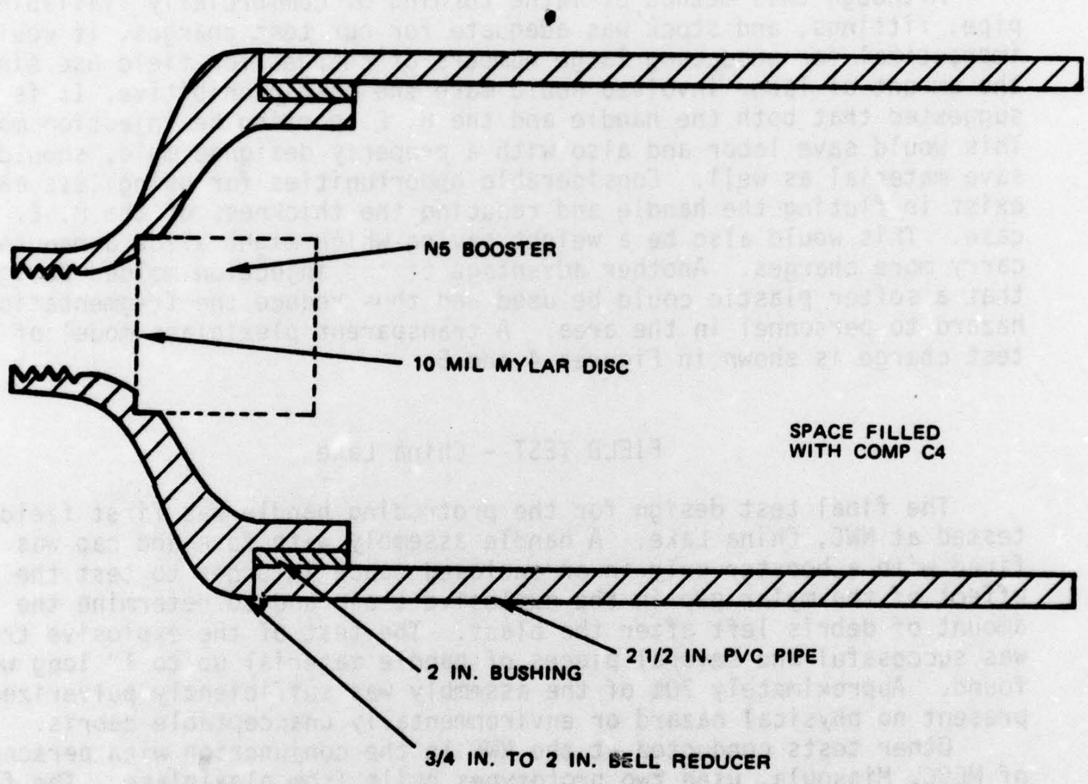

FIGURE 3. Cross Section of H.E. Portion of Charge.

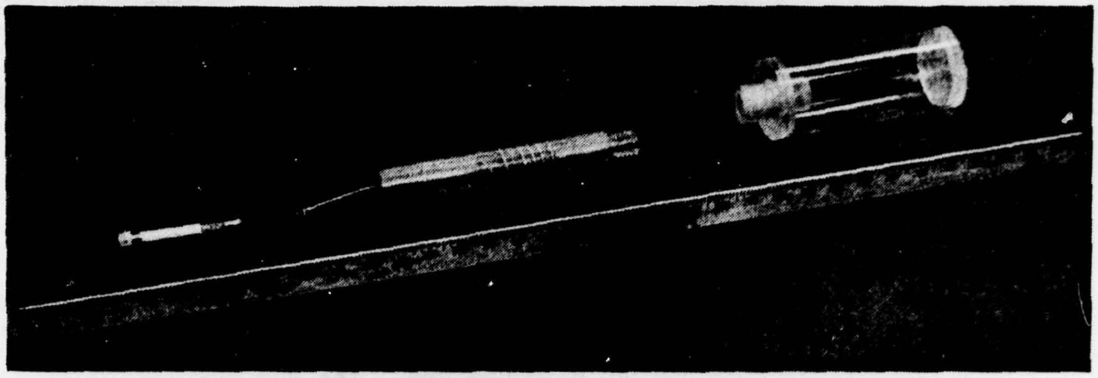

FIGURE 4. Plexiglass Model of Charge in Exploded Form.

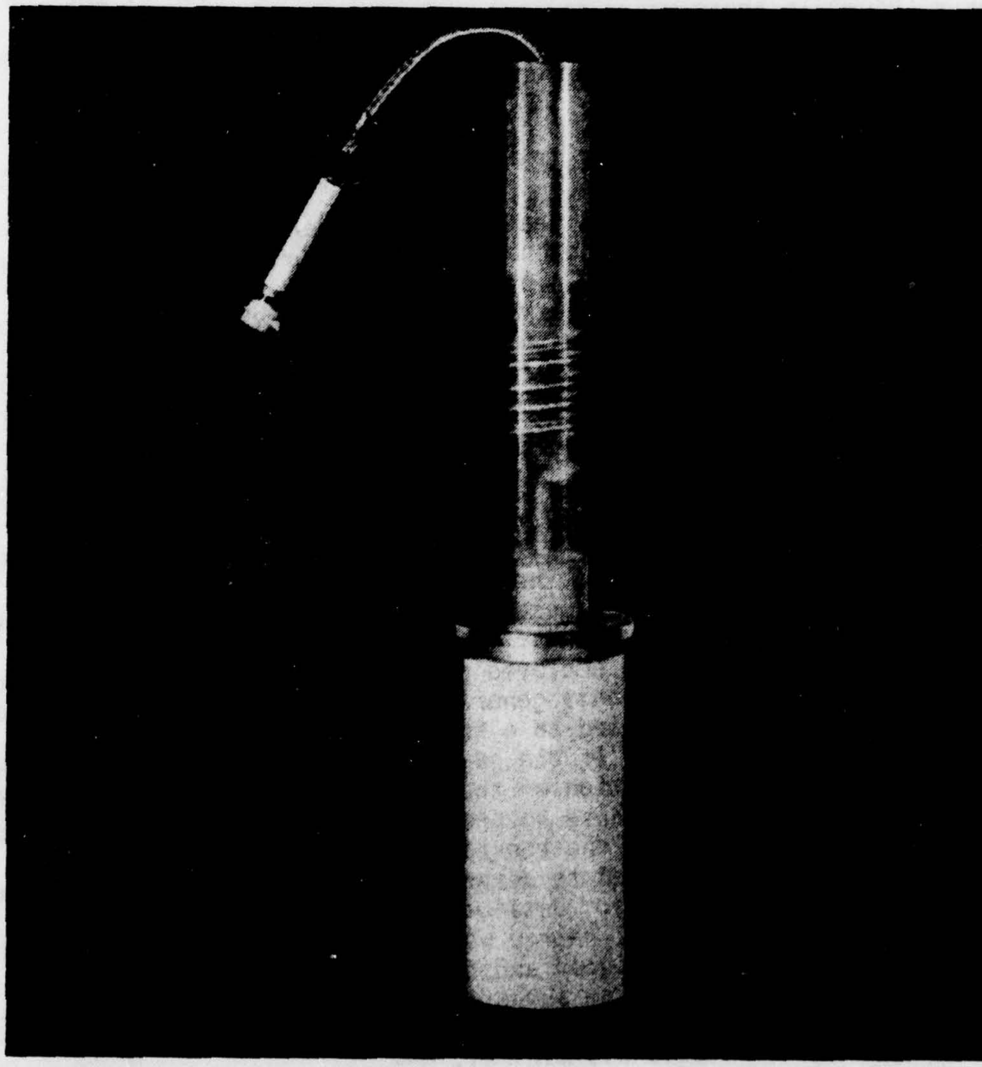

FIGURE 5. Plexiglass Model of Charge in Assembled Form.

The charge was fitted with a new igniter and thrown successfully. All other charges were successful on the first attempt. Weather conditions during the test were not severe. The temperature was approximately +20° F with 10 to 20 mph winds and some light blowing snow. Figures 6 and 7 show the charges being thrown and the results of the blast. The charges were thrown onto level ground and no attempt was made to determine whether they would roll after being thrown onto a slope.

FIELD TESTS - Snow Bird, Utah

The final tests of the protruding handle device were conducted at Snow Bird, Utah in March 1977 by NWC and MEDC USFS, Missoula personnel and by members of the ski patrol of the Snow Bird Resort. In these tests six charges were thrown with one dud. The dud was not recovered; the belief is that the dud again was caused by failure of the fuse igniter. Weather conditions were severe with temperatures of -3° F and winds of 40 knots with considerable blowing snow. Four of the charges were thrown in areas where it was impossible to check the results, but the final charge impact was examined and no debris was found. Figure 8 shows the results of the last charge thrown.

DISCUSSION OF TEST RESULTS

The tests all confirmed that the mylar insert between cap and booster did not affect the detonation. All fourteen charges were fired successfully with the mylar in place.

The problem of impact breakage of the prototype test charges only occurred when they were thrown on bare ground. None of the charges thrown into snow appeared to suffer any damage. Breakage should not be a significant problem if a plastic is used which does not become brittle at low temperatures.

No loose surface debris was found from any of the full charges even though the prototypes which were fired contained considerably more plastic material than the final recommended charge will contain. This question of remaining debris will require further study after the final product design is determined. The question of marks on the snow will depend upon the type of H. E. used. In our tests with Composition C-4, no marks were left on the snow.

The prototype charges employed a threaded joint between the handle and the H. E. charge. If this general design were placed into production this joint should be modified to a snap-lock type joint to simplify use under adverse conditions. If the gap between the cap and booster which results from the detent action of the joint were kept under a few mils, a snap-lock joint should cause no problem with the transmission of the detonation from the cap to the booster.

No tests were conducted to determine lethal blast ranges or fragmentation hazards of the test charges. Detailed tests of the prototype would be meaningless since the final charge would almost certainly be of a different H. E. composition and a thinner and different case material. Since no surface debris was found from any of the full charges and the charge cases and handles were frangible. NWC concluded that the fragment hazard of the test models was minimal.

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FIGURE 6. Charge Being Thrown at Mammoth, California.

FIGURE 7. Results of Charge at Mammoth, California.

FIGURE 8. Results of Charge at Snowbird, Utah.

RECOMMENDATIONS REGARDING PROTRUDING HANDLE DEVICES

The fuse enclosure system set forth in the preceeding pages is a reliable method of insuring that the fuse will not be cut shorter than a minimum length by the field deployment personnel. The handle design which NWC used was not intended to be a final design however. This handle contained significantly more material than an injection molded handle would require. Flutings could be molded into the handle to remove excess material without affecting the strength of the handle assembly. The only breakage of the PVC handle which occurred in the NWC tests occurred when the charge was thrown onto rocky ground. Since the actual production model would be thrown onto snow, breakage is not expected to be a problem.

The shape of the NWC protruding handle test models might need to be modified in order to make them easier to carry. A shorter charge with a larger diameter (3" to 3 1/2") would probably be easier to pack into ski jackets and pockets and the handle could also be shortened. The NWC design involved an 8" handle but this could be shortened to 5 1/2" without affecting the required 90 second fuse length.

RECOMMENDATIONS REGARDING SNOWBIRD TYPE DEVICE

The simple cylindrical charge used at this time by Snowbird is shown in Figure 9. This device is certainly inexpensive and as environmentally clean as a hand thrown charge can be. The problems with this device as presently used are two-fold:

1. There is no control over the length of fuse actually used.
2. The fuse is subjected to a sharp bend.

The objection to item 2, which can lead to fuse failure due to flexure when cold, is easily overcome by casting the charges as shown in Figure 10. A curved channel is cast into the charge to protect the fuse bend as well as eliminating the possiblity of fuse breakage at sharp corners.

The problem of fuse length must be left subject to local control but could be largely overcome as shown in Figure 11. The charge would be designed such that the fuse would be too short to be retained if cut at the first bend. If cut at the second bend, the burning time would be reasonable. In fact such a design could enable the thrower to choose either a short or a long delay depending upon whether the third fuse channel was used. This design obviously reduces the control over minimum fuse timing gained by the protruding handle type, but it would be substantially cheaper. Also, the external appearance of the charge with a long dangling fuse should encourage use of proper fuse length through ease of inspection at the time the charges are made up.

RECOMMENDATION FOR AIRBORNE DELIVERY

Charges can be delivered from an aircraft in either of two distinct ways. Each method has its own unique advantages and disadvantages.

The charges can be hand thrown after being ignited while still in the aircraft. When the charges are delivered in this manner from a helicopter, care must be taken to throw then downward rather than up or outward in order to keep them out of the rotors. The advantage of this

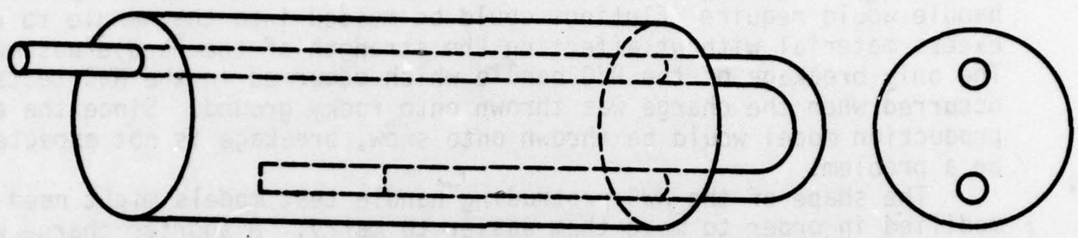

FIGURE 9. Charge Presently in use at Snowbird, Utah.

FIGURE 10. Improved Design To Eliminate Fuse Failure due to Flexure.

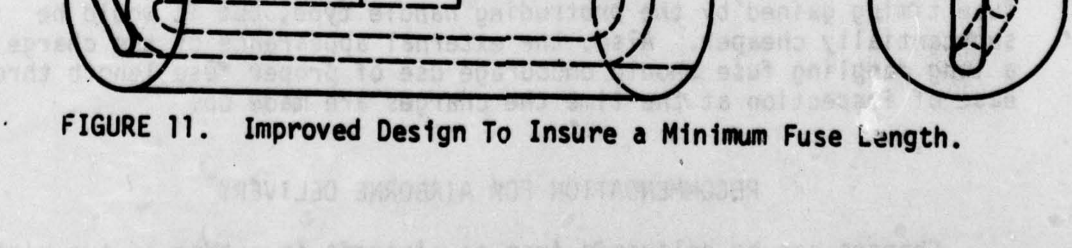

FIGURE 11. Improved Design To Insure a Minimum Fuse Length.

method is that the thrower has positive control of the charge at all times. The disadvantage is that an ignited charge is present in the aircraft for the time between ignition and delivery. In very rough air it is quite possible for an ignited charge to be dropped within the aircraft.

Another alternative method of airborne delivery employs a mortar-like launching device. It is not recommended that ignited charges be delivered from this device because if the charge should hang up it may not be possible to get it out of the mechanism before detonation. A preferred method is to use an arming wire attached between the igniter and the aircraft. This method would probably result in a higher dud rate because of the added complexity. With this method, care must be taken that the arming wire is not inadvertently pulled prior to launch. The arming wire should have a manual release attached to the firing mechanism in case the charge hangs up by the wire. The wire should also be short enough that there is no chance of it tangling in the helicopter skid or rotor. As the arming wire will remain with the aircraft, it will not be an environmental problem. If the target were ice or crusted snow the use of impact to cause initiation would be attractive. With soft snow, however, impact is not of interest due to the high dud rate expected. In general, it has been the experience of those people involved in airborne launch of explosives, that arming mechanisms are not practical for charges of under 30 pounds weight. NWC, therefore, does not recommend this method of delivery.

Regardless of what method of airborne helicopter delivery is chosen, tests need to be performed to determine how the harder impact resulting from airborne delivery will affect the dud rate. A sturdier charge may have to be designed specifically for airborne delivery in addition to the less expensive, light weight and less sturdy charge used for hand thrown deployment on the ground. Also, the higher cost of occasional helo operations may warrant more expensive and reliable or sophisticated detonation system. This could be an electronic or pyrotechnic "handle" just for vehicular/aircraft delivery.

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