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2.75-INCH ROCKET LAUNCHER ICE PROTECTION TESTS, DECEMBER 1975 TO FEBRUARY 1976

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A series of 2.75-inch icing test firings was carried out at US Army Missile Command, Redstone Arsenal, Alabama during the winter of 1975-1976. The existence of a launcher icing problem was verified. Several passive protection devices were tested. A final solution was not found, but the groundwork for future efforts was laid.

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I. INTRODUCTION

Adverse weather conditions have historically hampered aircraft operation. This is particularly significant in the case of military ai craft operating in close support of troops engaged on the ground. Future Army aircraft (i.e., AAH, UTTAS, ASH) will be required to operate in conditions where aircraft icing will occur. Future helicopter weapon systems will be required to function in the same environment. The Army's current attack helicopter, the AH-1G Cobra, could conceivably operate for short periods of time in conditions where ice would accumulate on rocket launcher pods.

At the present time there is no fielded method of providing ice protection for the Army 2.75-inch rocket launchers. From December 1975 through February 1976, a series of ground test firings were conducted at Redstone Arsenal, Alabama. The tests, while having some possible application to current launchers, were conducted in support of the lightweight launcher request for proposal. Testing verified the existence of a launcher icing problem and explored several protection concepts.

II. GENERAL SETUP AND TEST METHOD

All of the firings were conducted at Redstone Arsenal, Test Area 1 (Figure 1). The rocket launchers were suspended from a standard M156 mount, which was mounted on the side of a heavy steel building. The launcher was enclosed in a plywood box insulated with celatex panels. The front and back doors of the box swing open for firing. The front door is designed to act as a witness screen during firings. The wall and front door, when open, are approximately 24 inches from the centerline of the launcher. This simulates the distance from the inboard store station to the fuselage on the AH-1G Cobra.

Cooldown was accomplished with a conditioning unit that blew CO_2 into the "box." The unit is thermostatically controlled to maintain a set temperature. After experiencing trouble with the control unit, CO_2 was sprayed directly into the box. This method allowed a very rapid buildup of ice.

Ice was built up with an atomizing water spray directed onto the forward bulkhead. Limited flight tests with unprotected launchers indicate that most of the ice buildup will occur on the front end of the launcher.

Except where otherwise noted, all rocket firing tests were conducted with 1/2 inch of ice on the forward bulkhead of the launcher.

Because of limited time and funding, data collection was kept to a minimum. Data were acquired from visual inspection of witness panels and the launcher, still photographs, and two 400-frame per second documentation movie cameras. One movie camera was set up as near the flight path as possible, looking at the launcher face. The second camera was set to the side of the launcher to cover the first 10 to 20 feet of flight. This arrangement gave the broadest data with the funds available. Load cell data were not included as it was not considered vital to the results.

III. TESTS

A. Test 1 – Unprotected Launcher

It was not known if ice could actually hold a rocket in a launch tube after the rocket is ignited. To test this, a single rocket was loaded into the center tube (tube No. 1). After the initial cooling, water was sprayed onto the launcher. On the first attempt, ice would not accumulate to the desired 1/2 inch, therefore, the firing test was postponed. Even with less than 1/2 inch of ice accumulation, the unfired rocket was firmly held in the tube. Removing the rocket, for safety, was difficult.

When the test was rescheduled, the range personnel insisted on placing tape around the rocket just forward of the fin and nozzle assembly. This was to prevent ice from building up around the fins. It was feared that if the rocket left the launcher, the fins might be frozen shut, thus causing a dangerously erratic flight. One-half inch of ice was built up on the upper face of the M200 launcher, but the ice thinned out around the center tube (Figure 2). However, the rocket was held in the tube when fired. The launcher was damaged severely and several tubes were rendered useless (Figure 3). Later examination showed that the rocket had moved forward approximately 1/2 inch, i.e., enough to clear the detent.

The test demonstrated that ice can hold a rocket in a launcher. At the very least, the launcher will be damaged severely. Calculations show that, under certain conditions, a helicopter will be impossible to control if a rocket is held after ignition. Multiple hangfires would compound this situation. Discussions with Cobra pilots confirm this conclusion.

B. Test 1A – Bare Launcher Control Test

A single rocket was prepared with tape, similar to the round used in test No. 1. The rocket was then loaded and fired without applying any ice. There was no problem with the launch. This test showed that the tape did not hold the original rocket in the launcher.

C. Test 2 – Styrofoam Dust Cover

The 2.75-inch rocket Project Managers Office provided the Ground Equipment and Materials Directorate with several launcher dust covers from a previous effort. These were made of beaded styrofoam. They consisted of a 1/2-inch thick face and a 1-1/2-inch thick spacer. The spacer had a hole pattern similar to the hole pattern of a 19-round launcher. The cover fit very tightly inside the lip of the M200 bulkhead. To insure that it was secured in place, 2-inch mistick tape was used (Figure 4).

One rocket was fired from the center tube. It cleared the launcher and flew a normal trajectory. The dust cover was completely destroyed.

This test proved the feasibility of providing some ice protection to the launcher. This type cover would not be satisfactory as a final solution. It was destroyed with the first rocket. If a partial load of rockets is retained, the ice protection is gone, leaving the launcher vulnerable to later ice buildup. Debris is also a problem. Several large pieces of ice were found forward of the launcher (Figure 5). These were of sufficient size to possibly cause damage to the helicopter tail rotor, if they struck it.

D. Test 3 – Polyethylene Foam (Etha-foam) Plugs

The need to provide protection to individual tubes was recognized early. To explore this approach, foam plugs were fabricated. These were placed in each tube to exclude water and ice. When the rockets are fired they will push the plugs out of the tube ahead of the warhead. Material used for the plugs was expanded polyethylene foam, sold commercially as Etha-foam by Dow-Corning. Foam density is 1.8 to 2.6 pounds per cubic foot. The plugs were cut from 2-inch thick stock. Plug diameters were from 2.91 to 2.95 inches. This provides a nominal 0.07-inch interference fit (Figure 6). The plug will not vibrate out in flight. The plugs are light and do not pose a threat to the aircraft.

For test 3, six rockets with M151 (10 pounds) inert warheads were loaded into an M200 launcher with the plugs installed (Figure 7). After applying 1/2 inch of ice to the front of the launcher, all the rockets were successfully fired and flew normal trajectories.

Film data showed that the plugs tend to spring away from the rockets. Ice debris did not seem to be very great.

There was one unforeseen result. The plugs covering empty tubes were pushed through the length of the launcher and out the back end (Figure 8). The firing arm tore through the plugs as they left the aft end of the launcher.

E. Test 3A - Etha-foam Plugs, No Ice

To provide a control, the launcher was again prepared with six rockets and plugs. Six inert rockets were placed at random in the launcher, and no ice was applied.

At firing, the plugs from the loaded tubes were shoved out ahead of the rockets. The plugs in the tubes loaded with inert rockets were shoved back until stopped by the fuze of the warhead (Figure 9). With the plugs now recessed in the tube, later icing could build up in front of the plugs. Although this condition was not tested, it is suspected that the launcher would be damaged if rockets were fired from this condition.

Several methods to prevent the plugs from being pushed back were discussed, but never tested. Some of these methods were:

1) A shoulder made of a hard material, larger than the tube inside diameter.
2) A taper on the plug.
3) Increase the length of the plug so that it is resting against the warhead.

Time of installation is the biggest drawback to the plugs. The current design requires in excess of 3 man minutes to install 19 plugs. Future designs could reduce this significantly.

F. Test 3B - Etha-foam Plug, 2 Inches of Ice

As a maximum test, the foam plugs were again installed. Two inches of ice were applied to the forward bulkhead. The new light-weight launcher specification requires that the launcher be able to tolerate 2.0 inches of ice in areas where ice is neither prevented from building up nor removed. This is based on information found in AR-70-38. Three rockets were loaded and fired (Figure 10).

The data film of the firing shows that the entire cover of ice was removed by the first rocket. The two later rockets were fired without obstruction. There are indications that the first rocket actually impaled the plug while breaking out.

Although the rocket cleared the launcher without problems, the size of the ice fragments is unacceptable (Figure 11). The fragments were large enough to damage a tail rotor.

G. Test 4 - LAU 61A/A Fairing

For a quick solution to launcher icing, a standard "off the shelf" item, the Air Force LAU 61 fairing, was tested as a protection device. The fairing offers an additional benefit of reducing drag caused by the rocket pods.

While building up ice, it was noticed that the ice did not accrete rapidly and did not adhere very well to the surface of the fairing. It was possible to build up only approximately 1/4 inch of ice with the box temperature at approximately 0°F.

Three rockets were ripple fired. The data films indicate that all three were needed to completely remove the fairing. The first rocket seems to have punched a relatively small, clean hole through the fairing. As the rocket nozzles cleared the hole, the backblast peeled away most of the ice. The fragments were small. It is apparent that the adhesion between the ice and fairing was very weak.

Possibly, an "ice-phobic" coating applied to the fairing might prevent ice from building up. The US Army Cold Regions Research and Development Laboratory is studying such chemicals for helicopter blade application.

The fairing presents two problems. As with the dust cover, the protection is removed with the early rockets from the pod, thus leaving the launcher vulnerable to later icing. The fairing itself produces large pieces of debris. Discussions with pilots indicate that the size of the fragments is unacceptable (Figure 13).

One possible direction of development would be to design a fairing that would break up in a satisfactory manner. An ice shedding or ice-phobic coating would be applied to the outside. To provide supplementary protection, plugs would also be installed.

H. Test 5 – Ring Plug for M229 (17 Pound) Warheads

All previous tests had been conducted with M151 warheads (i.e., 10-pound warheads). The M229, or 17-pound warhead, is longer than the M151 and protrudes beyond the end of all current launchers. To keep water and ice out of the launch tube, a seal around the warhead is required. This seal, or "plug," was a strip of Etha-foam that wrapped around the warhead near the launcher bulkhead. Dimensions for the strip were: length – 3.8 inches; thickness – 0.30 to 0.35 inch; a taper cut across the width – 9 to 10°. This angle matches the taper of the warhead where it passes through the bulkhead. The plugs are flush with the bulkhead when installed (Figure 14).

One live round was loaded into the center tube for the test. Six inert rockets with inert M229 heads were placed in tubes surrounding the live rocket. Ice was applied in the usual manner. By the time 1/2 inch of ice was built up, the seven protruding warheads had "grown" together (Figure 15). Ice fragments tended to be large and possibly dangerous to the aircraft (Figure 16).

Data films show that part of the ice ramained with the rocket, at least during the initial 20 feet of flight. There were some indications that the trajectory was influenced by the ice. Future launchers should be designed to completely enclose the longest rocket/warhead combination. This will preclude the preceding problems.

I. Test 6 — O-ring Gasket Seals

Some of the new members of 2.75-inch warhead family are quite long. In particular, the illumination head protrudes past the bulkhead of the M200 launcher. The warhead presents a flat cylinder at the bulkhead.

To simulate this condition, an M158 was prepared with a bulkhead added to the forward end. (An M158 is an early short-tube version of the M158A1, a seven tube launcher designed without a skin.) A 17-pound warhead will present a flat cylinder at the bulkhead of this launcher.

To keep ice out of the launch tube, a standard rubber O-ring was fitted around the warhead, then pushed tight against the bulkhead.

Tube No. 1 was loaded with a live rocket and a M229 warhead. Tube No. 2 is an outside tube. The other six tubes were loaded with inert rockets and warheads (Figure 17) and more than 1/2 inch of ice was applied (Figure 18). There was no evidence of runback inside the tubes.

The firing did not produce a large amount of debris. Data films show that a large amount of ice remained on the rocket at least during the first 20 feet of flight.

Since the illumination round does not require an accurate trajectory, it could probably tolerate the ice accretion. Other warheads requiring more accurate flight could not tolerate the ice coating.

J. Test 7 — Heater Bulkhead

It was recognized that for a launcher to be operable in sustained icing condition a means of preventing buildup is necessary. A heater assembly on the bulkhead has been proposed. To date, a heated bulkhead has not been tested. To install the heater, a thermally low-conductive bulkhead will be required. To seal the tubes and prevent damage to the foil used in the heater, a frangible backing is required (Figure 19). Use of such an approach on current helicopters would involve a modification to the aircraft electrical system.

A masonite bulkhead and a 1/2-inch thick styrofoam backing were fabricated and tested. There were two design goals: (1) to test the components for possible use with a heater assembly, and (2) to look for a way to protect each tube with a rapidly installed device.

For the final test in this series, the masonite/styrofoam combination was installed on the M200 (Figure 20). One-half inch of ice was applied. Three rockets were loaded and fired.

Debris was similar to that observed for the plug firing. The styrofoam was broken out of some of the tubes that were not fired. Data films show that the rocket backblast broke out the backing (Figure 21).

The test demonstrated an approach that would allow rapid installation. However, a stronger foam is required, perhaps polyurethane. This general approach could be used as an alternative to plugs or used with a heater.

IV. CONCLUSIONS

The test series demonstrated several passive ice protection concepts. In general, they appear to be functional where ice is not expected to build up more than 1/2 inch. Heavier ice will require an active device, i.e., not allow the ice to build up. These tests indicated the importance of excluding ice and water from the launch tube. If this is done, the rocket will leave the launcher without damage.

During the entire series of tests the witness screen was never damaged by ice. The celatex panels are more susceptible to damage than aluminum aircraft skin. It appears that ice fragments pose little threat to the fuselage.

The large pieces of ice, especially those produced in test 3B, pose a hazard to the tail rotor. Ice must never be allowed to build beyond 1/2 inch in thickness.

The effect on the warhead fuzes was not tested. Impact on the fuze, while breaking through the ice, could be detrimental. This is an area for a follow-on investigation.

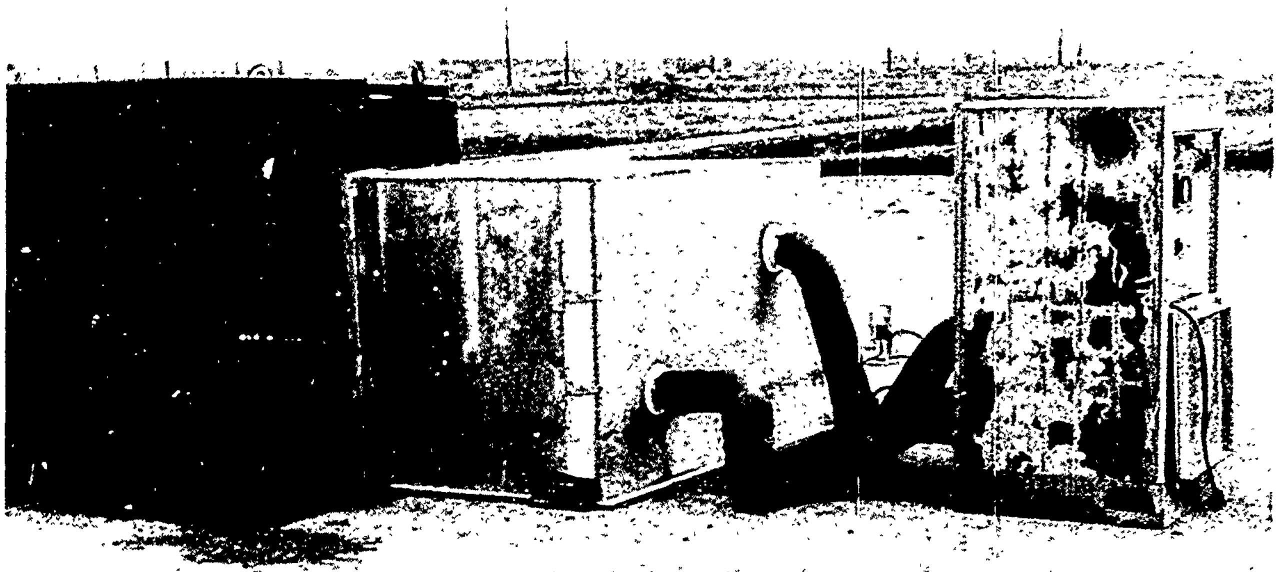

Figure 1. Icing test setup.

Figure 2. Ice on unprotected launcher.

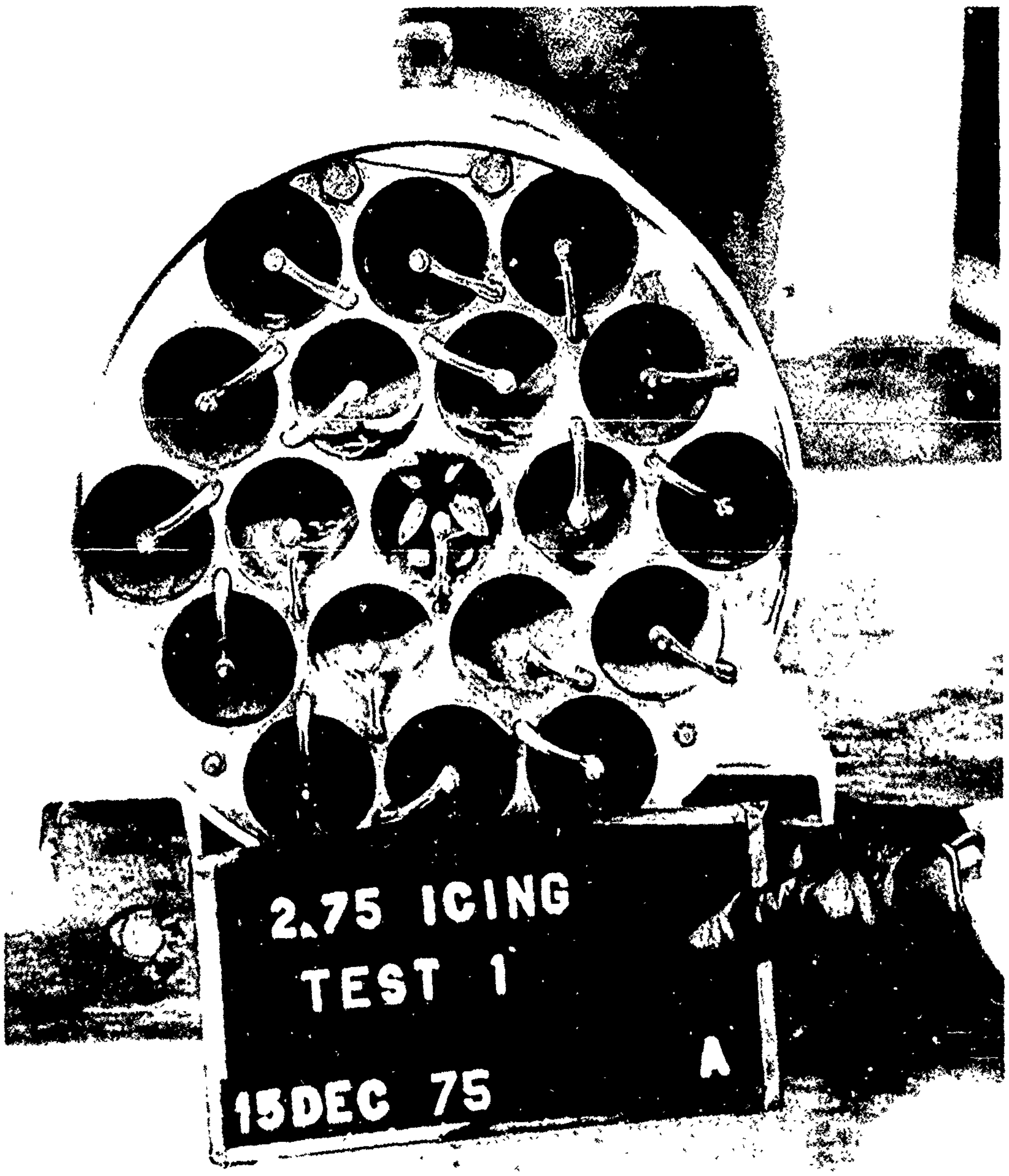

Figure 3. Aft end of unprotected launcher after firing.

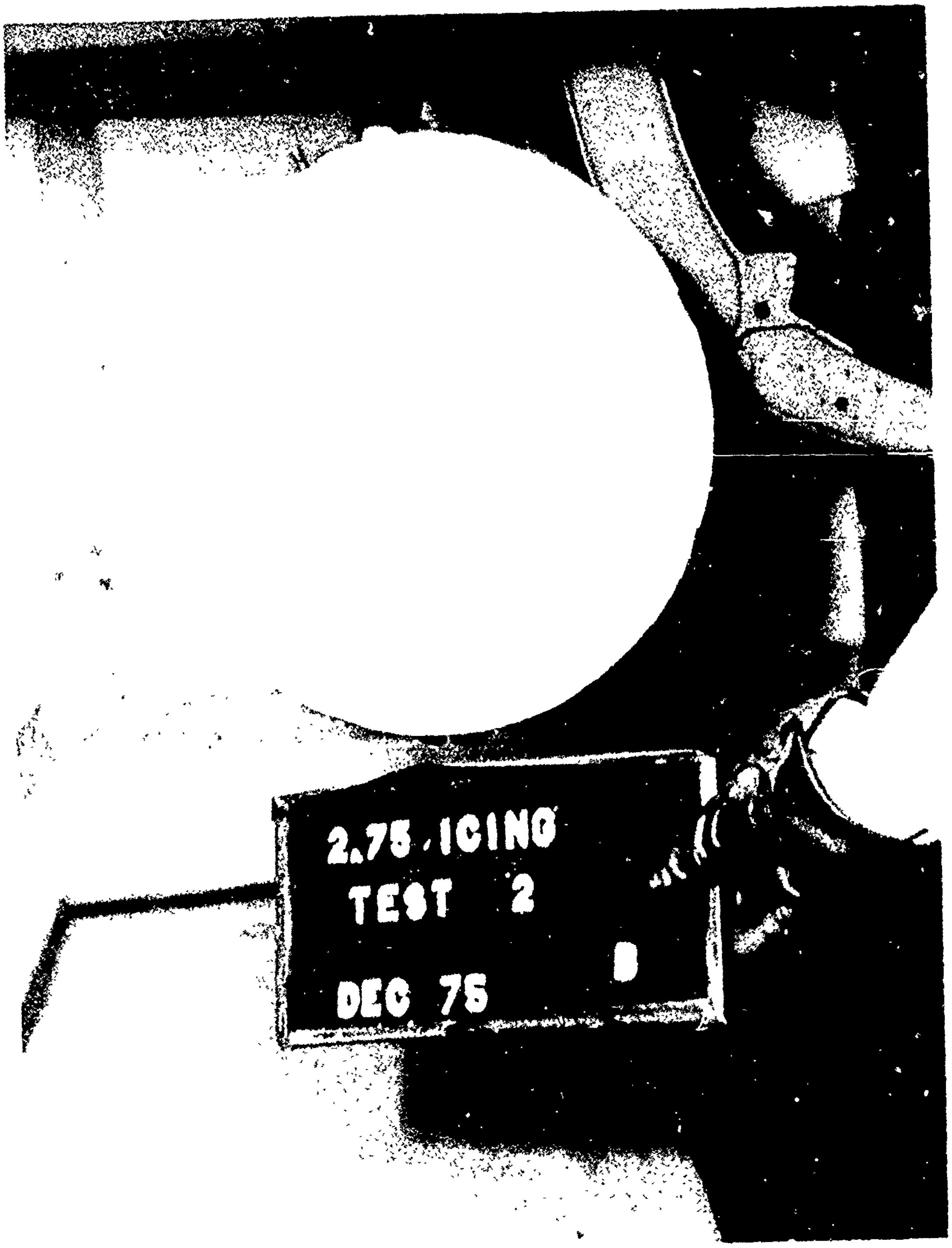

Figure 4. Dust cover installed.

Figure 5. Ice fragment from dust cover.

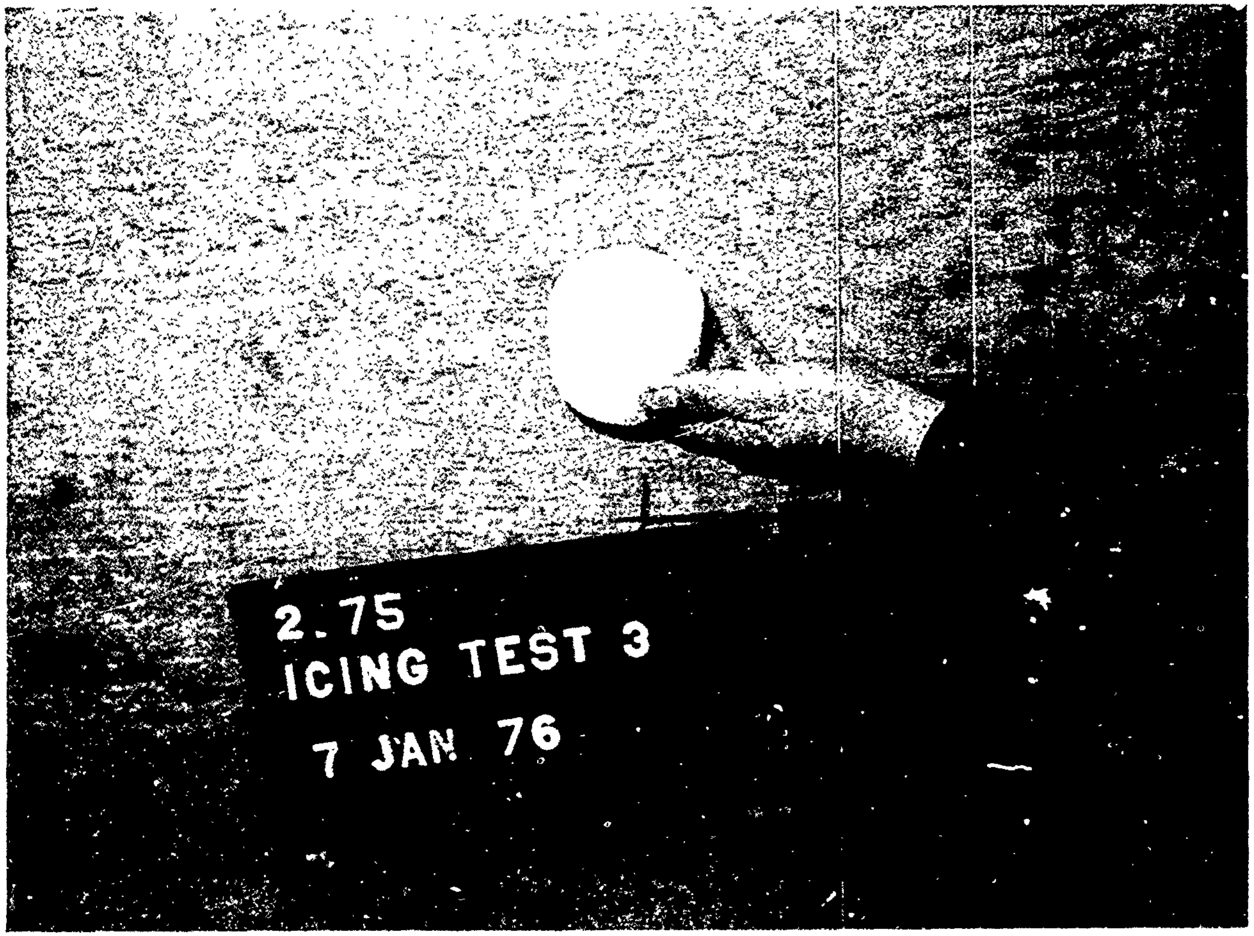

Figure 6. Etha-foam plug.

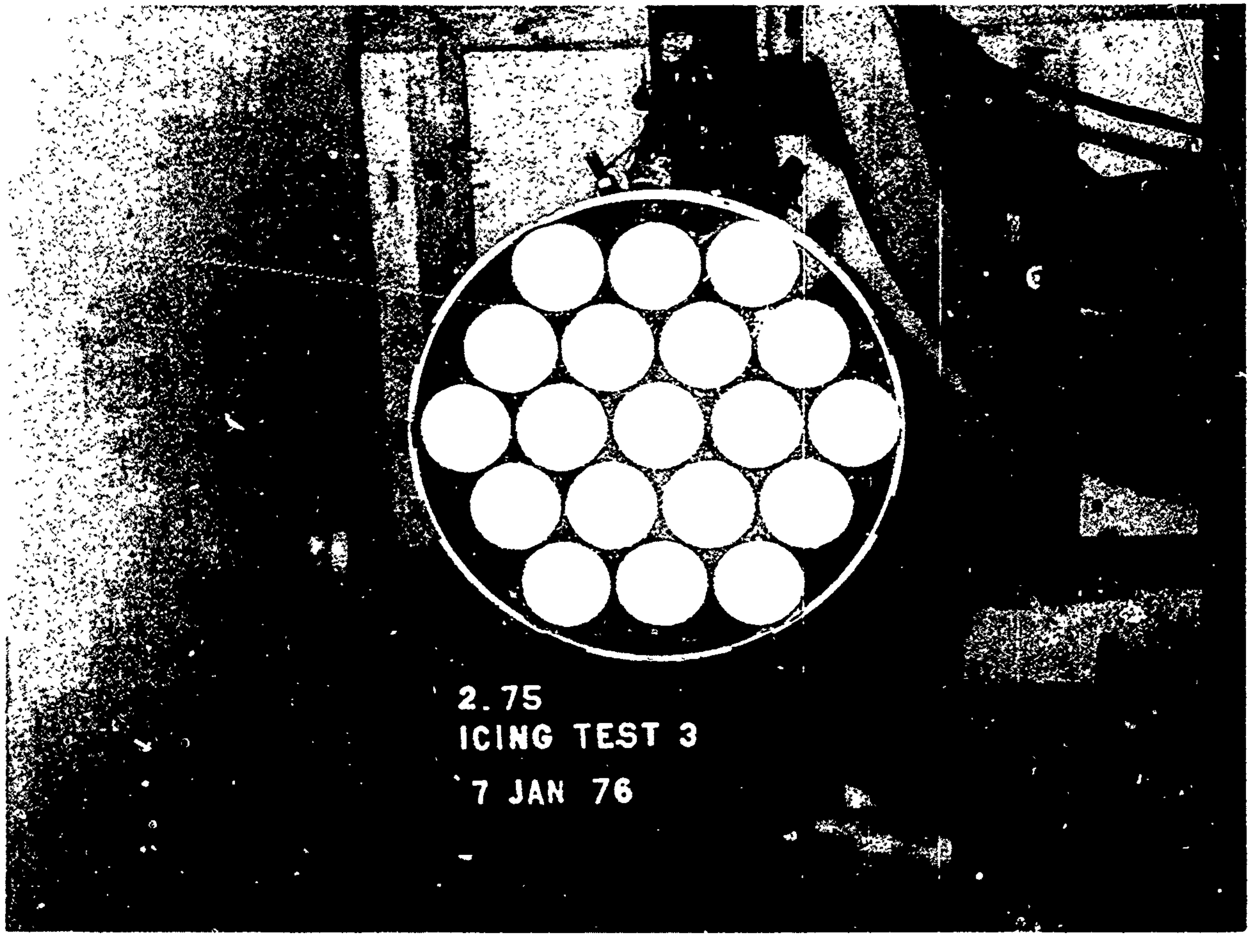

Figure 7. Etha-foam plugs installed.

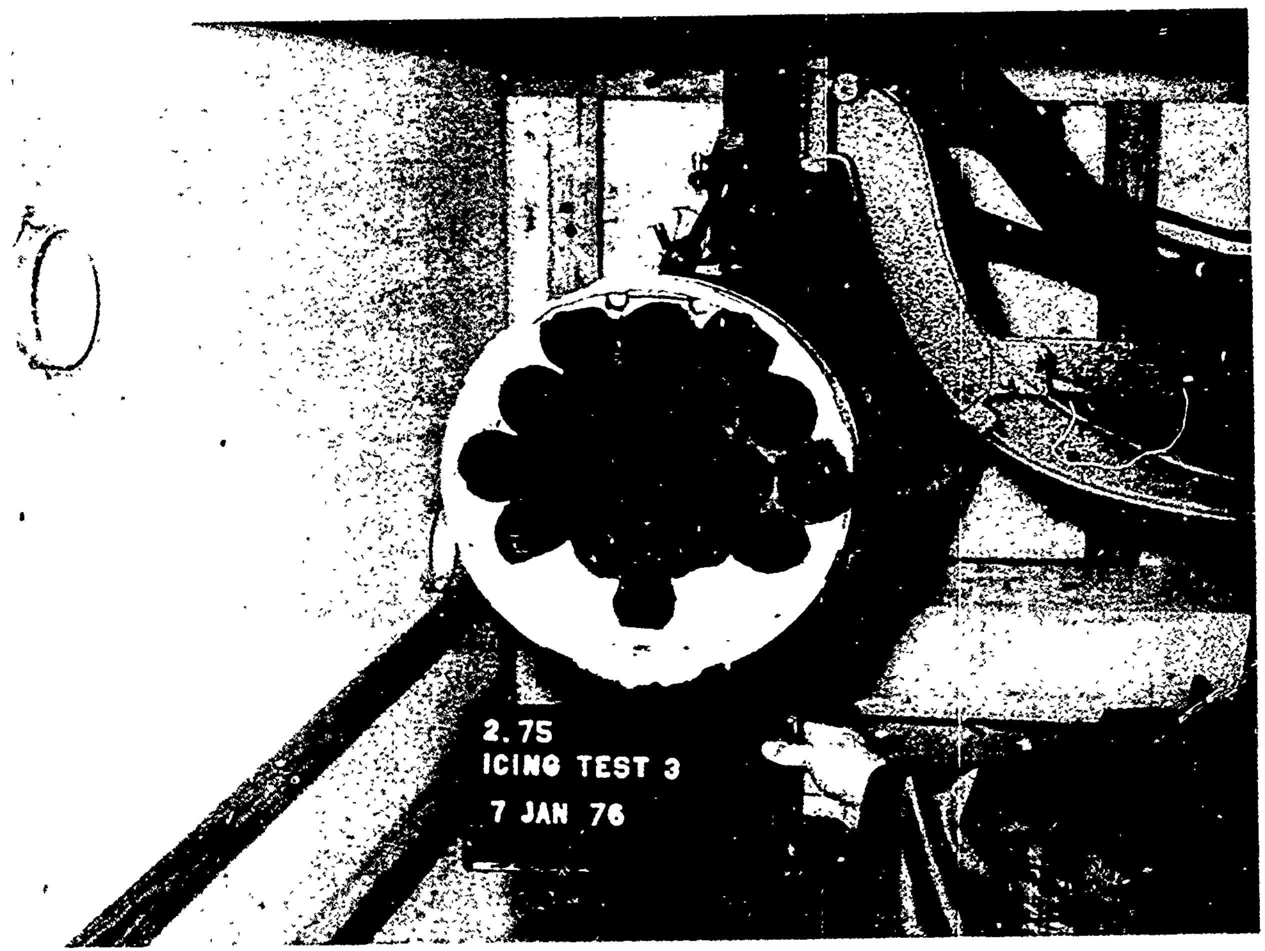

Figure 8. Launcher after plug test firing, with ice.

Figure 9. Launcher with plugs after firing, without ice.

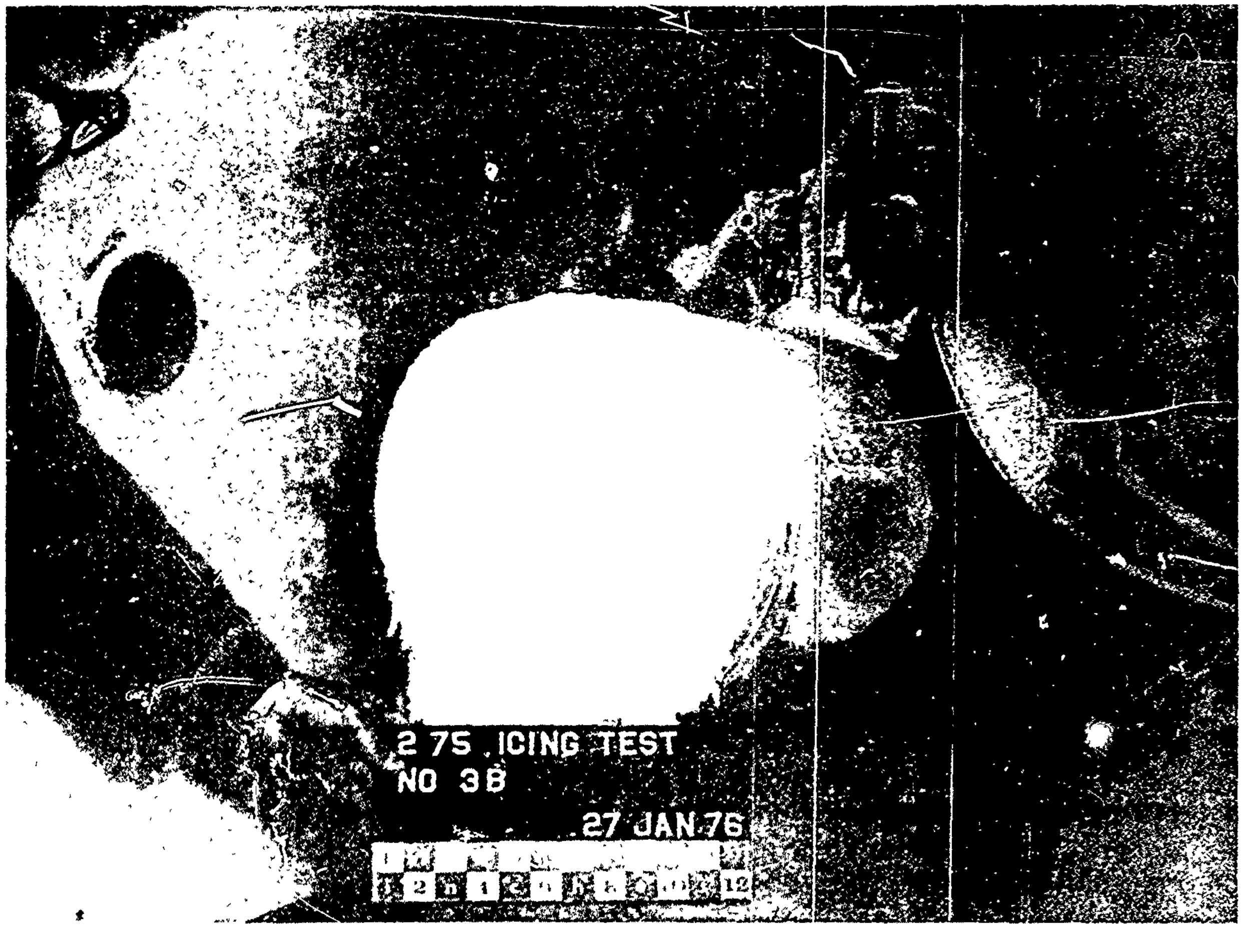

Figure 1 . Launcher, plugs installed, with 2 inches of ice.

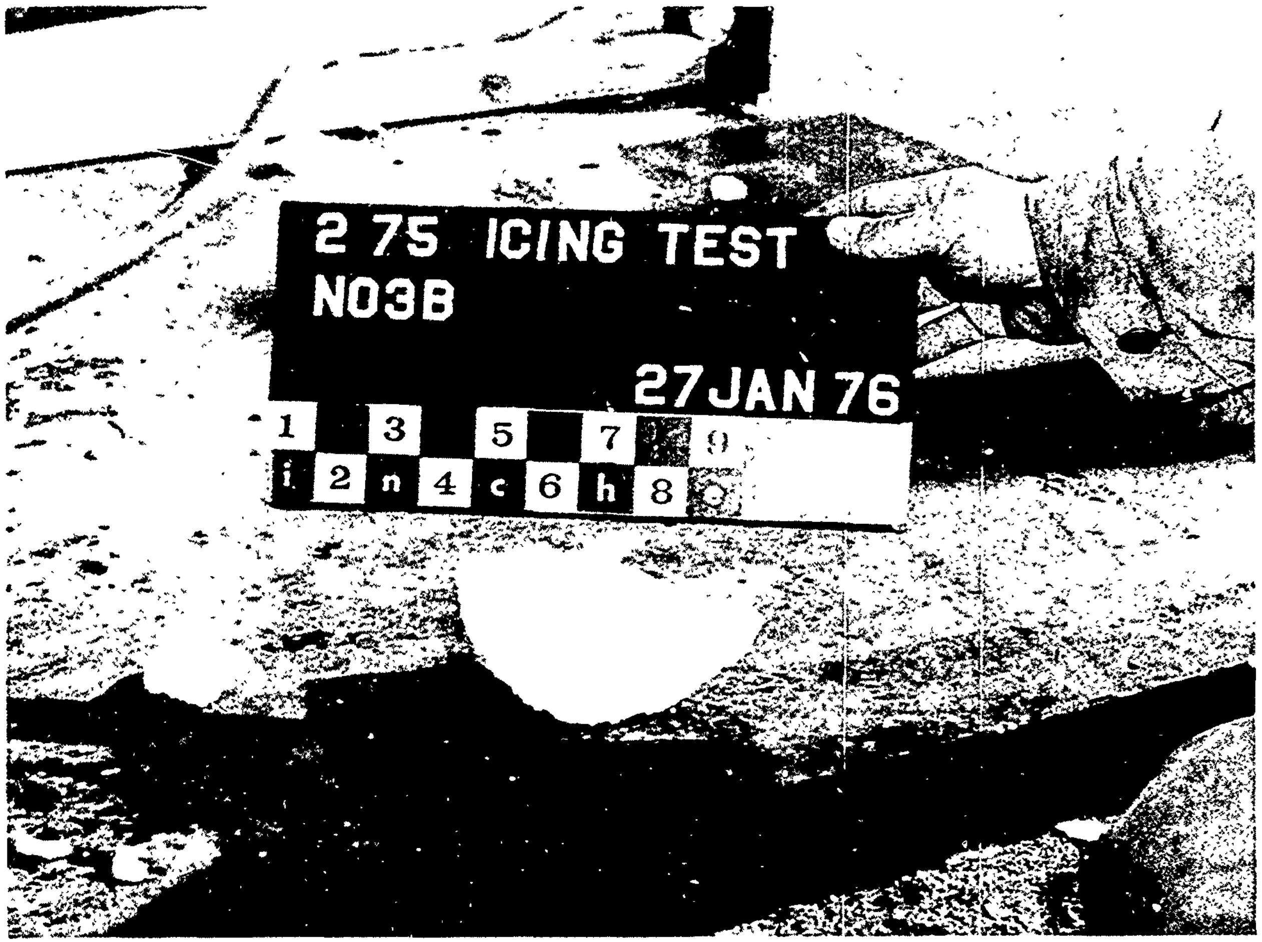

Figure 11. Ice fragment from 2-inch ice test.

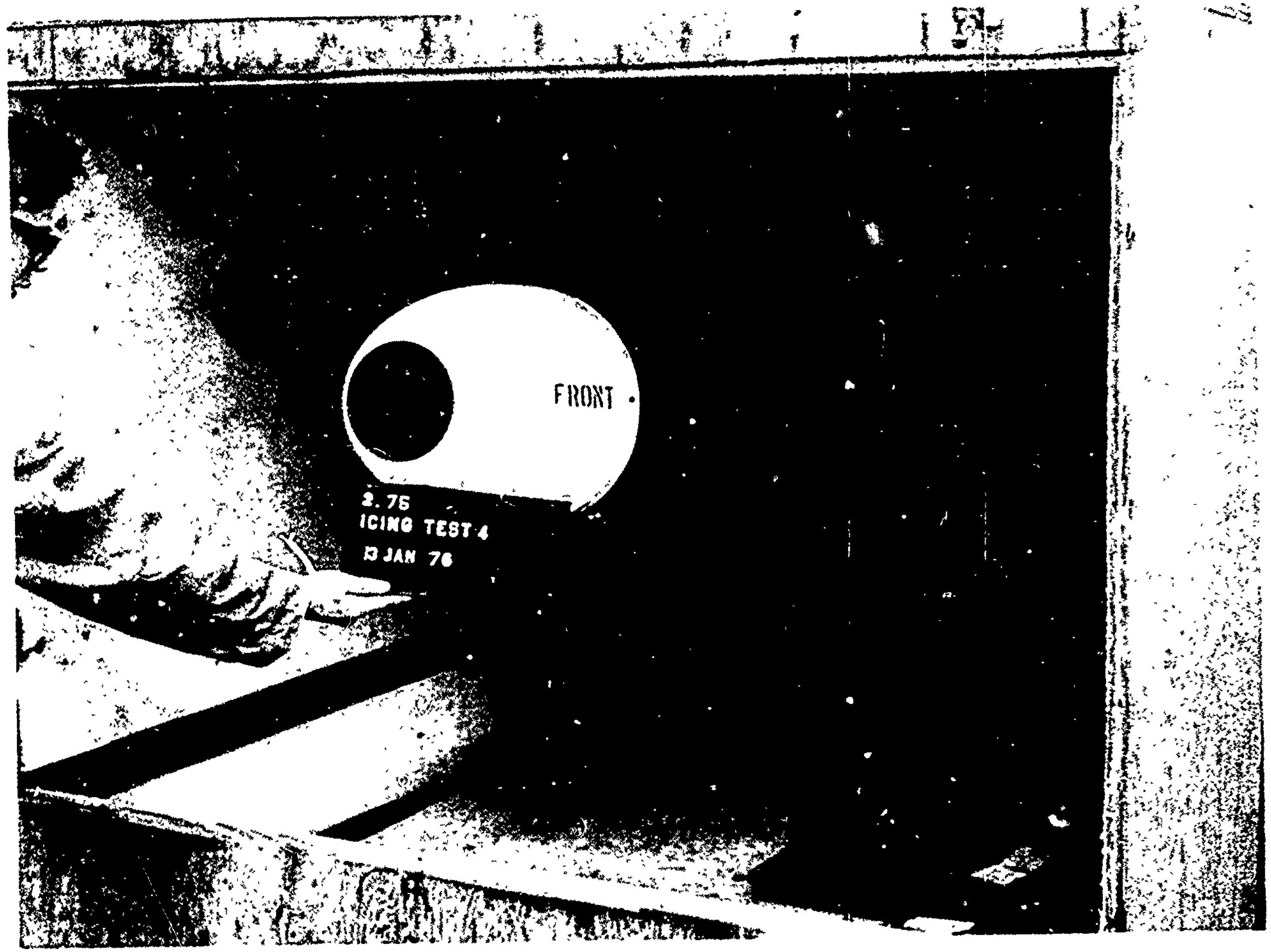

Figure 12. LAU 61A/A fairing.

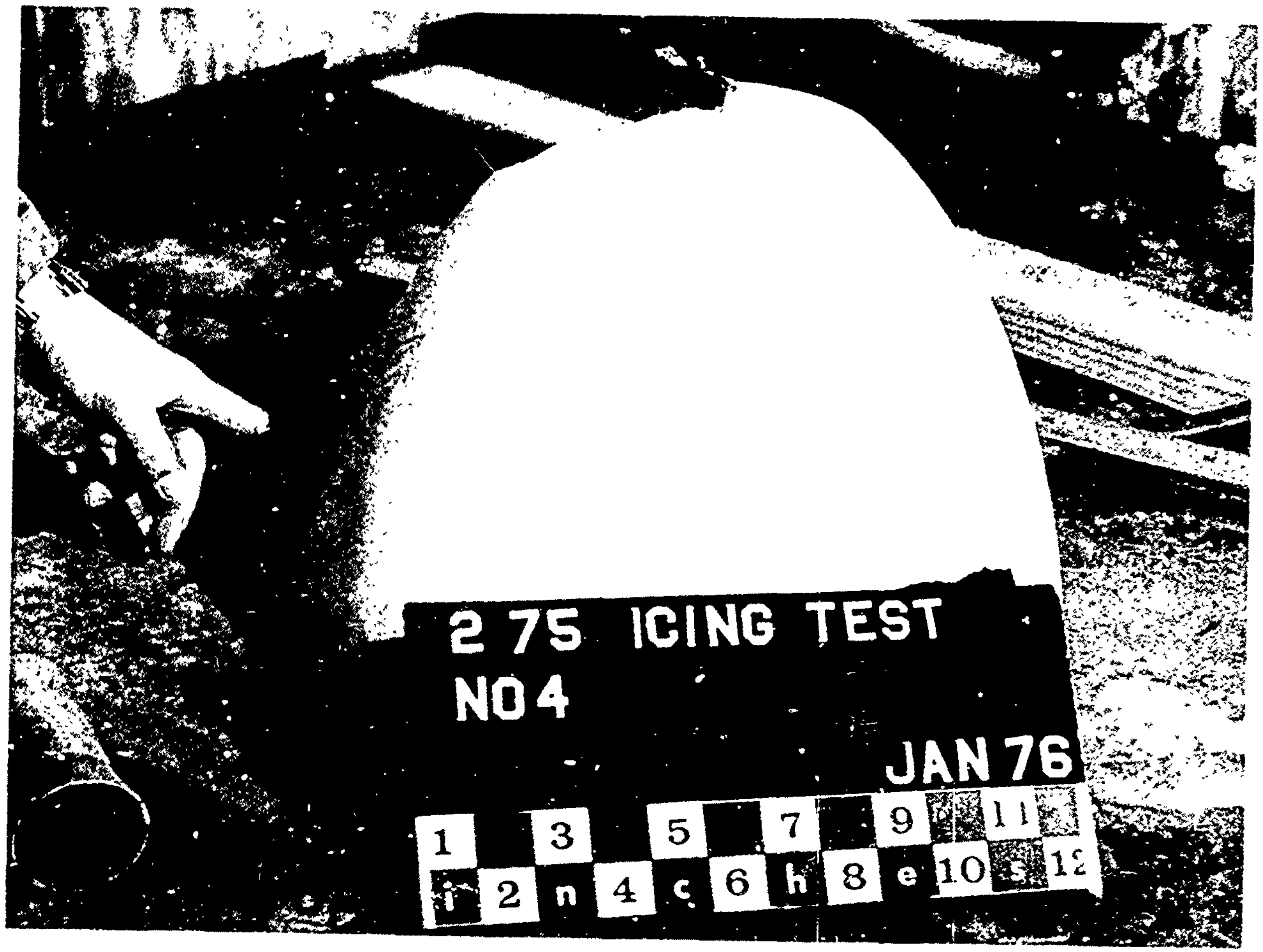

Figure 13. Fairing fragment.

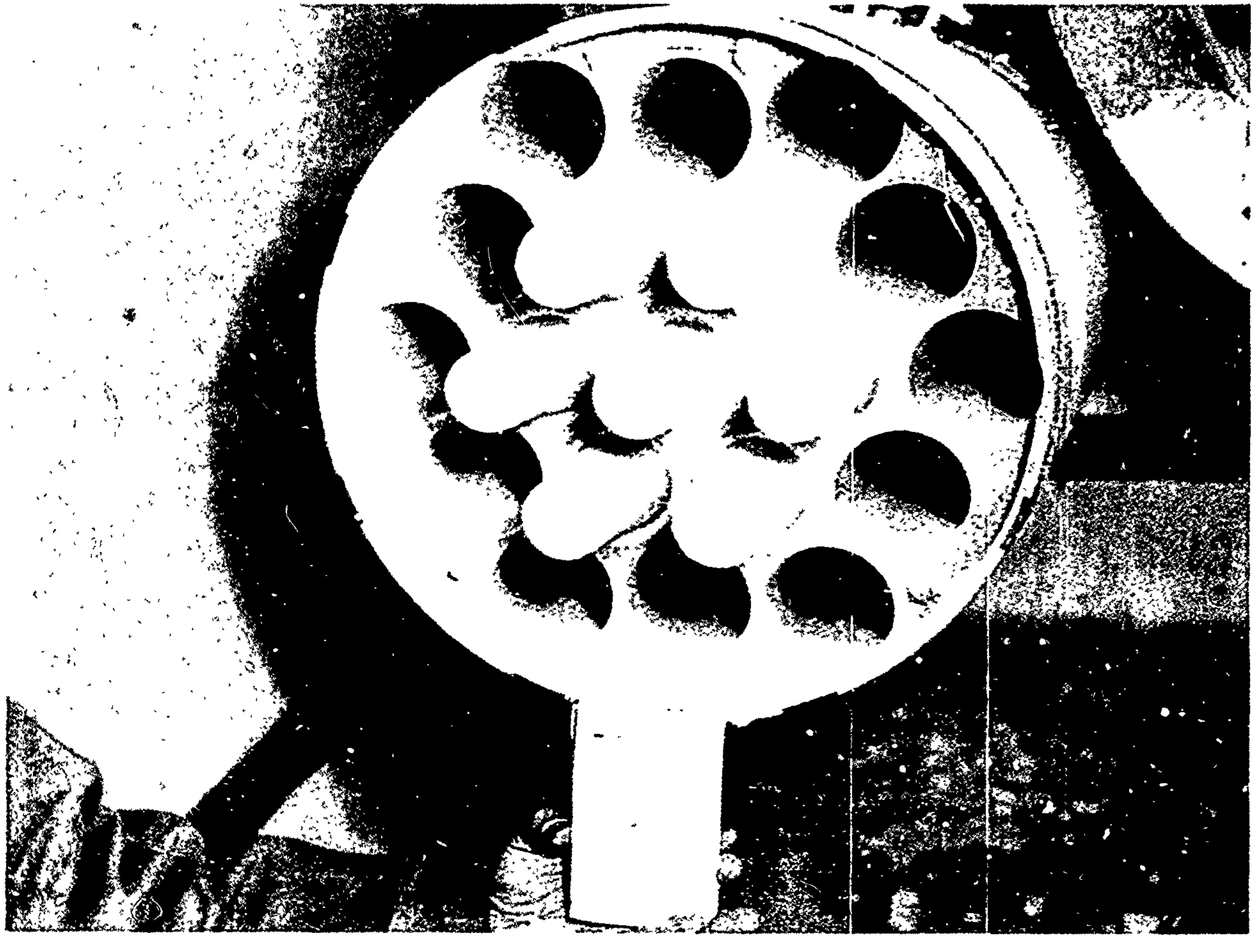

Figure 14. Ring plugs installed with 17-pound warheads.

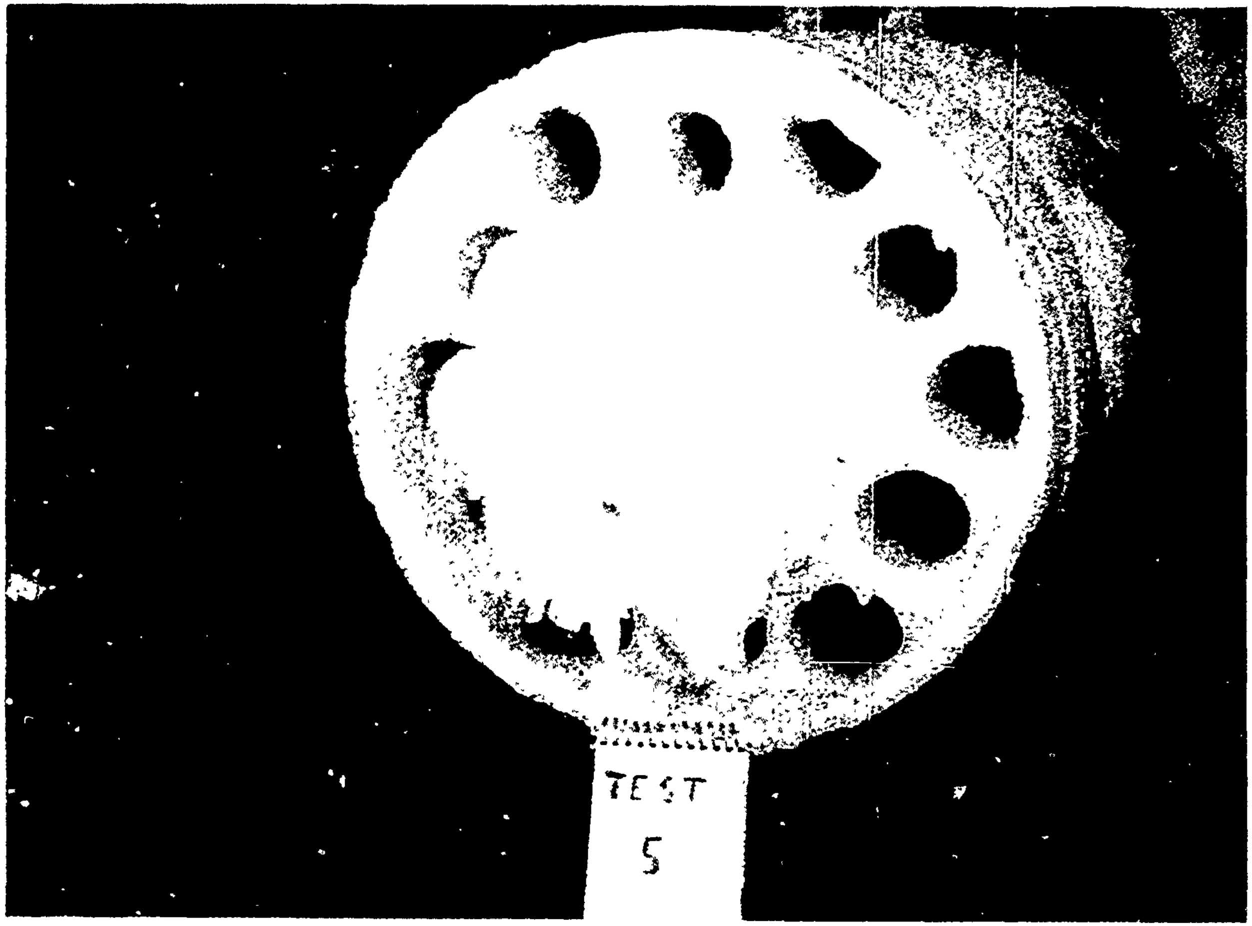

Figure 15. Ring plugs, 17-pound warhead, 1/2 inch of ice.

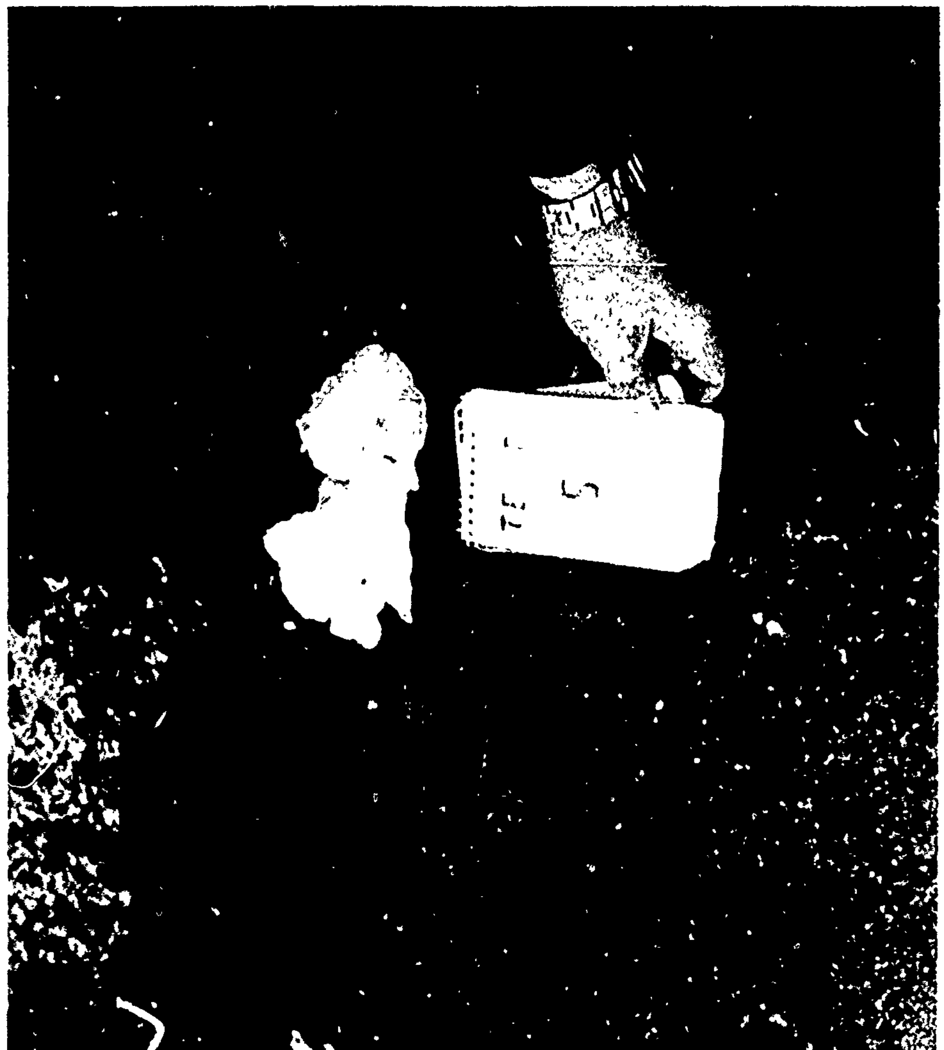

Figure 16. Ring plug test ice fragment.

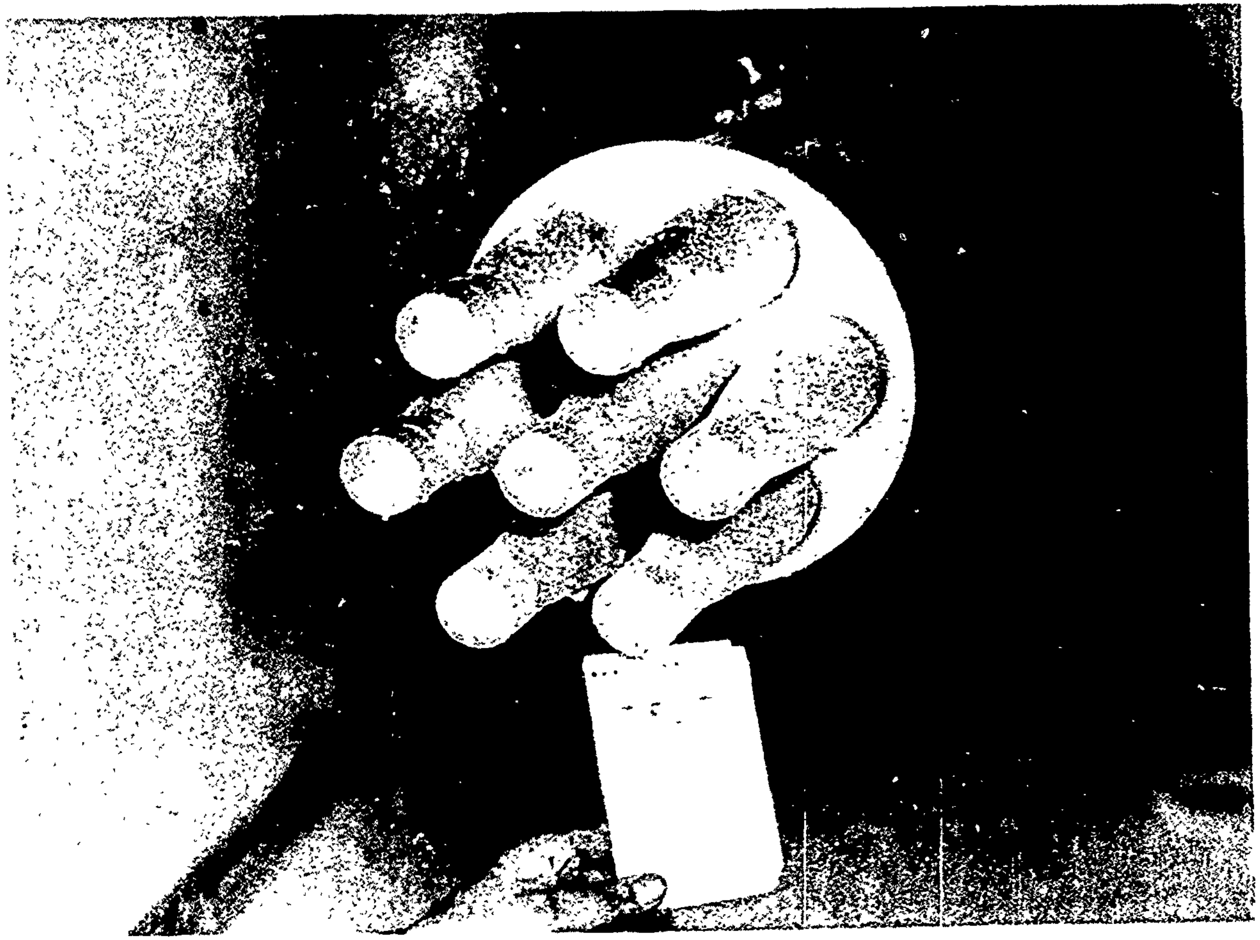

Figure 17. Long warhead simulation with O-rings.

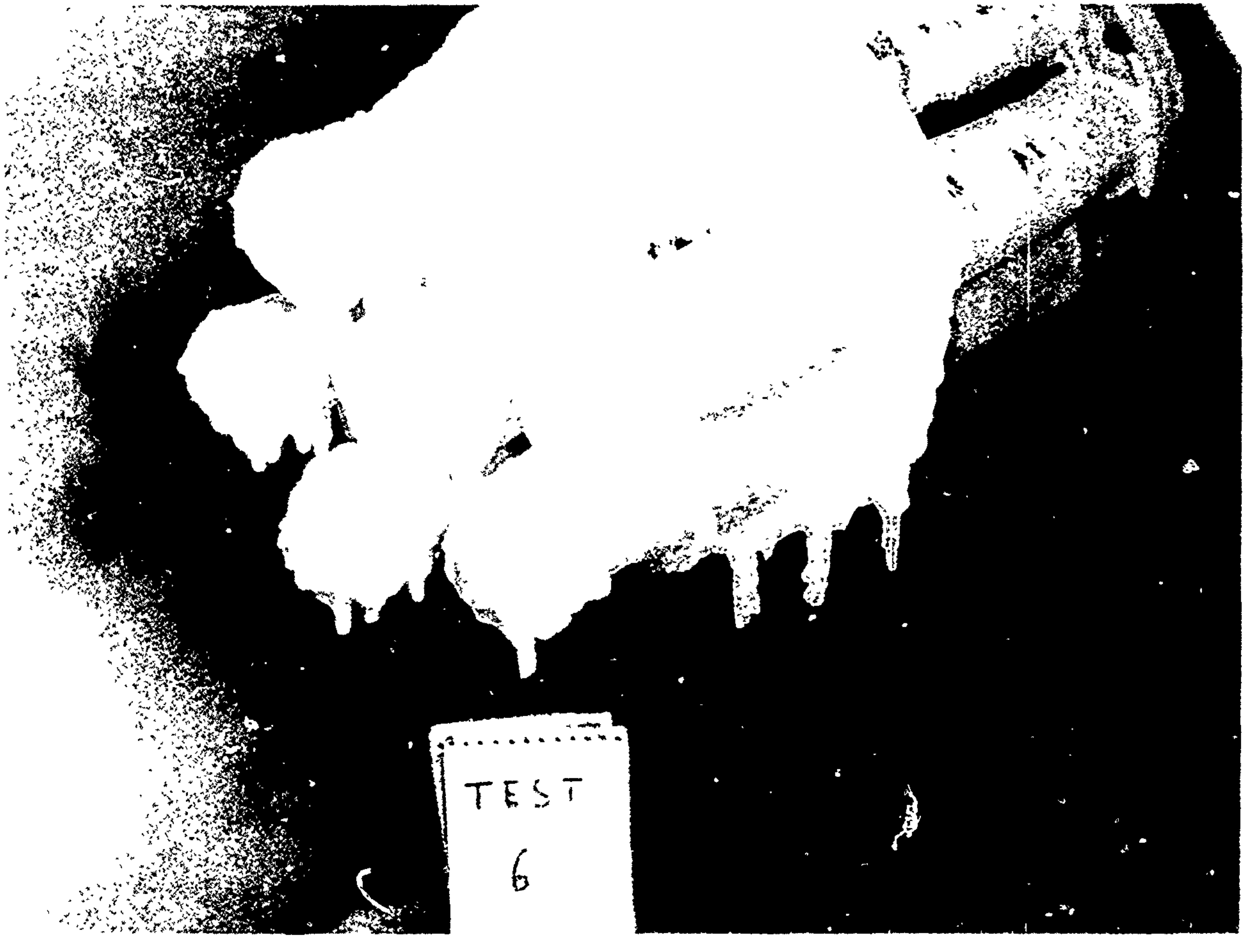

Figure 18. Long warhead simulation, 1/2 inch of ice.

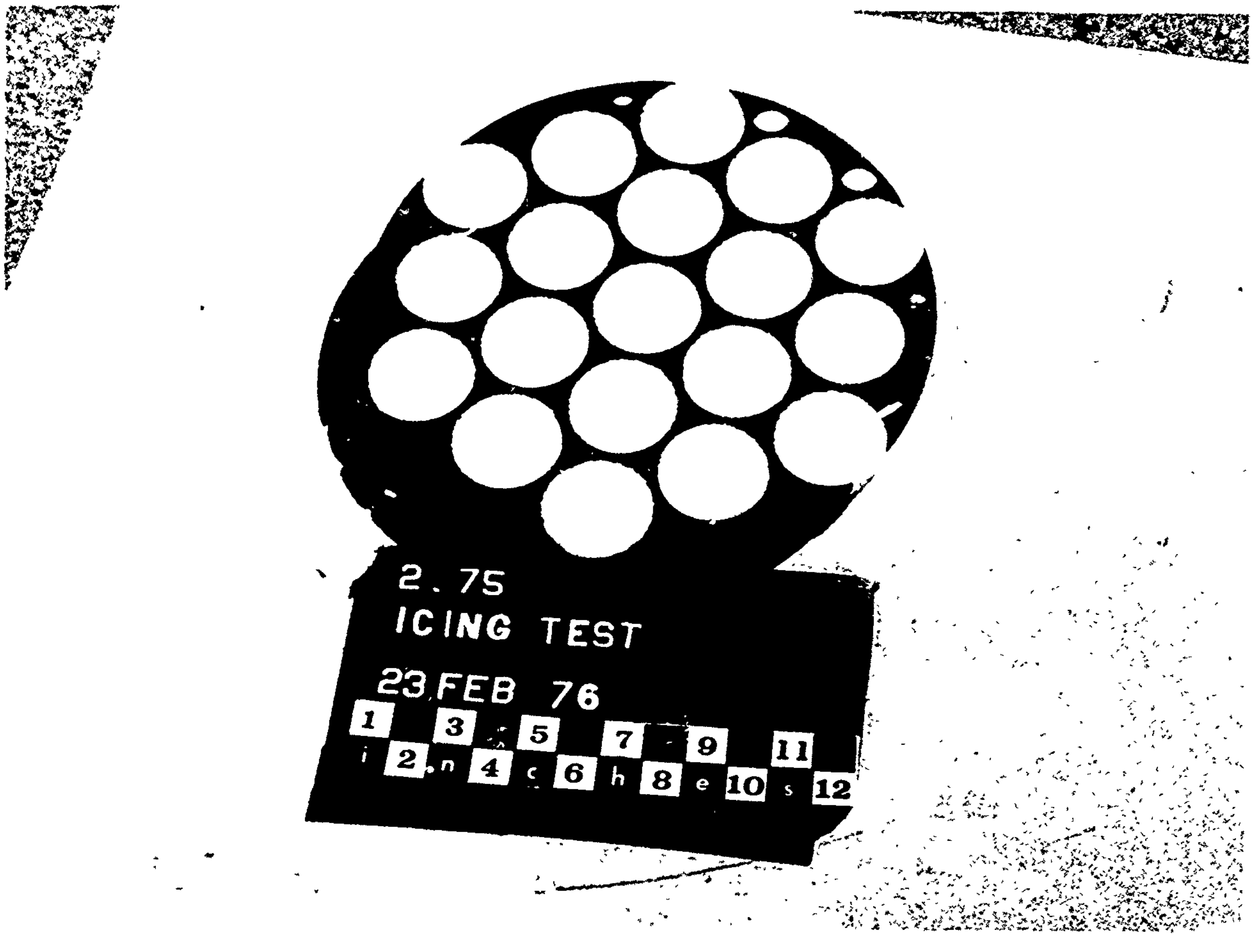

Figure 19. Heater bulkhead with styrofoam backing.

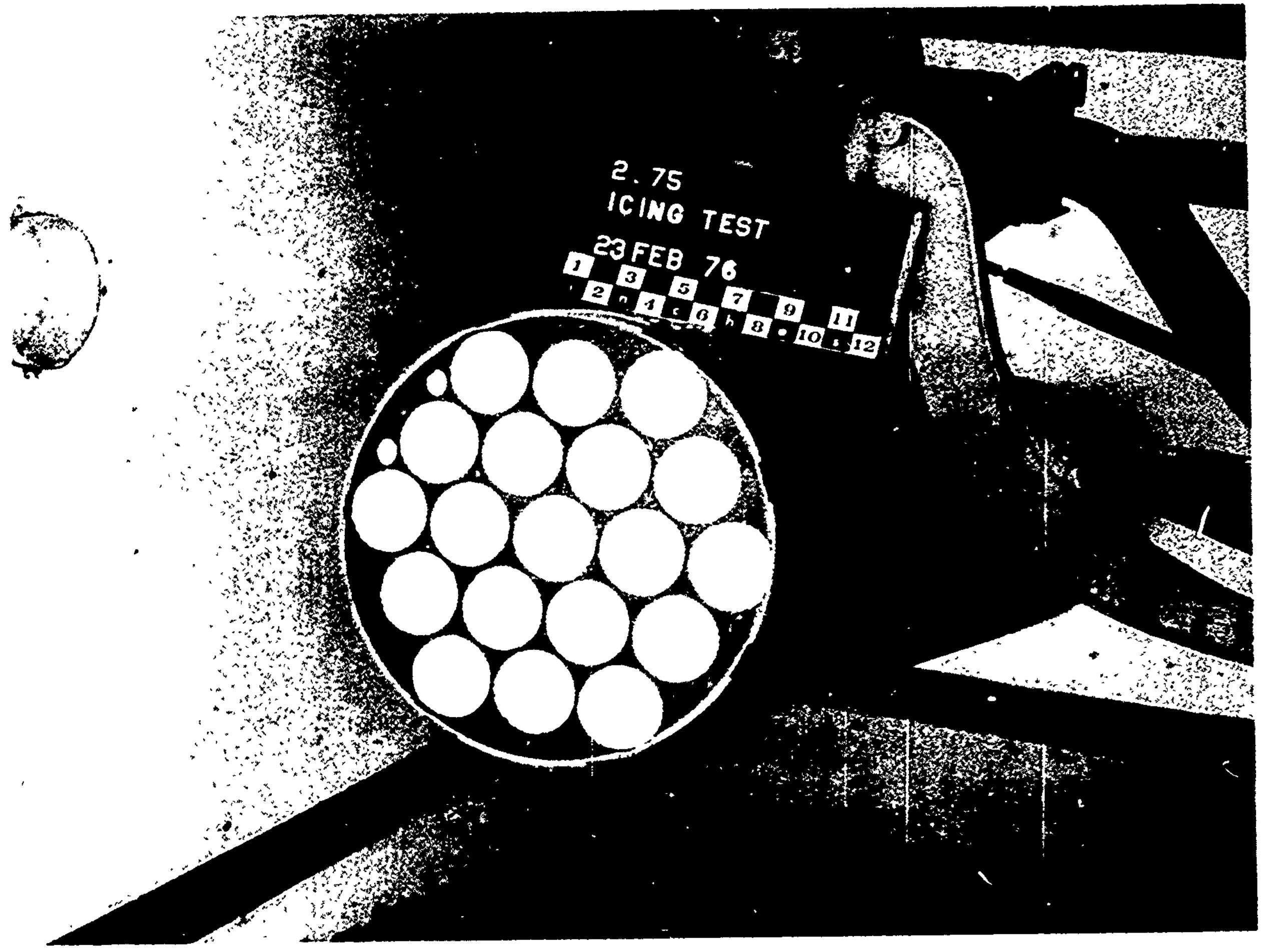

Figure 20. Heater bulkhead installed.

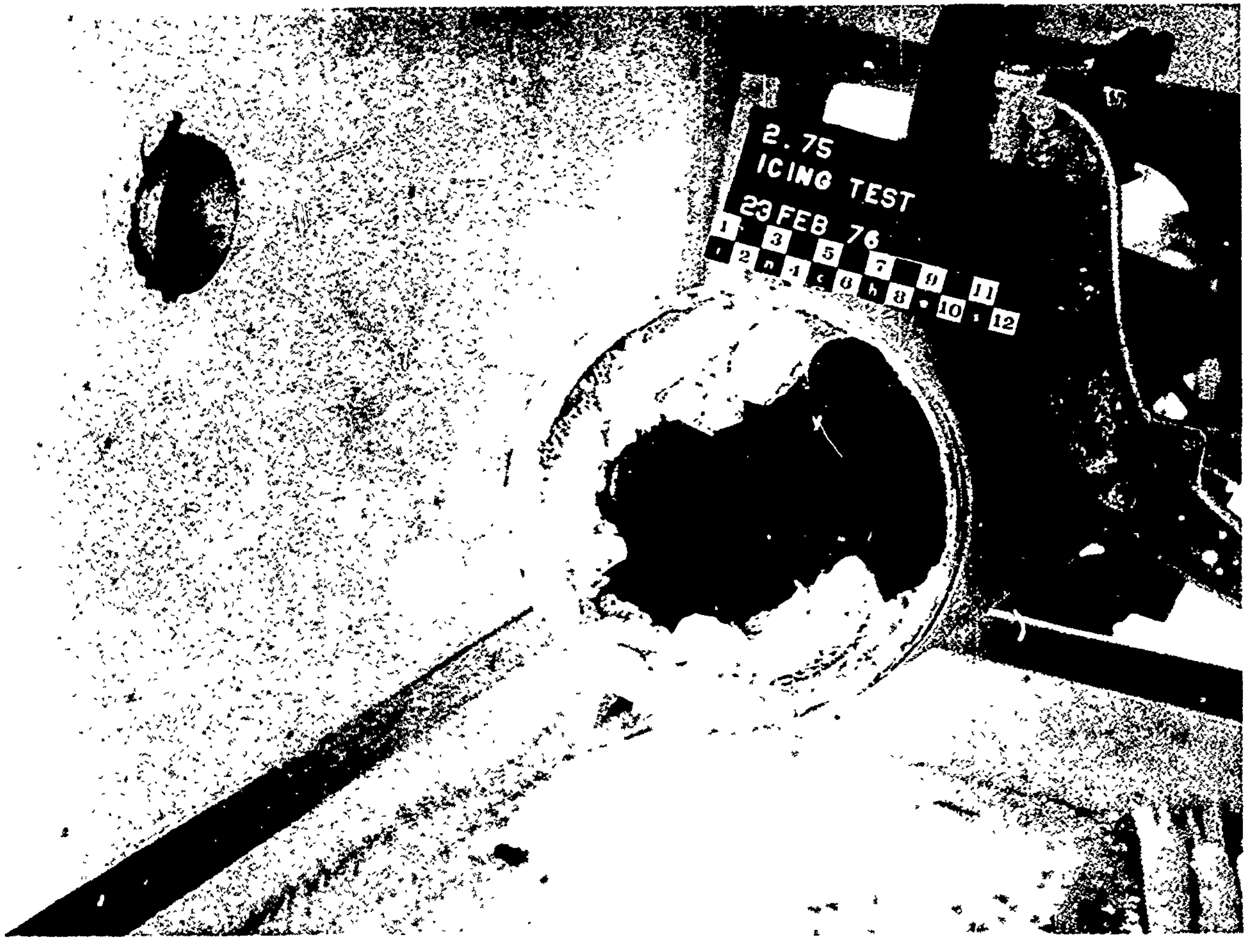

Figure 21. Heater bulkhead, after firing.

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