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MAR 78   G D'ANDREA, R CULLINAN, P CROTEAU

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FEASIBILITY STUDY OF FILAMENT WOUND CARTRIDGE CASES.

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10 G. D'Andrea,
R. Cullinan
P. Croteau

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BENÉT WEAPONS LABORATORY
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The feasibility of fabricating a 60mm composite cartridge case by the filament winding process has been demonstrated. Fabrication procedures for the manufacturing of this type of case are presented in this report.

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INTRODUCTION

The combustible cartridge case, as proposed for use in such weapons as the 60mm automatic cannon, has, on occasions, shown (a) the disadvantage of being structurally incapable of with standing the stresses during the loading cycle, and (b) intolerance to burning residue products, and high chamber surface temperature.

This report introduces a novel cartridge case made of fiber-glass-epoxy material which is expected to be free of these problems.

This approach appears feasible in that: (a) there should be no automatic loading and/or extraction problems as the fiberglass composite has a specific strength 3 times higher than conventional gun steels, with a specific modulus similar to the steels, (b) the fiberglass will act as a thermal insulator against any hot gases or burning residue left in the chamber from a previous round and/or high chamber surface temperature, and (c) the approach is also practical since the proposed case can be easily manufactured.

FABRICATION

The procedures for tailoring the composite's properties to a specific application are well understood. Automatic winding machinery, computer controlled, has been used to fabricate a total of four 60mm cartridge cases made of prepreg "S" glass/epoxy. All cases were wound on a hard coated aluminum (6061) mandrel which was machined to the dimensions shown in Figure 1. The curing cycle of the resin called for 1 hour at 200°F and 2 hours at 350°F.

Figure 2, which is a computer printout, shows a schematic of the mandrel's geometry (A) which is imput to the computer program GEOD. It also shows (B) the angle of wrap of the helical winding as it traverses the length of the mandrel. This data is important in determining the strength properties of the case at various points along its length.

GEOD is the computer program that provides the proper program (C) for the Winding Machine. Given the mandrel's geometry, GEOD outputs the helical winding program that will provide the proper geodesic (non-slip) filament path.

Case 60-1

The first case wound was fabricated to meet the dimensions shown in Figure 3. This case was thin walled like the disposable cartridge case it was to replace. Four helical patterns (8 layers) were required to meet the 0.085 in. wall.

Most of the case was left in the "as wound" condition with finish machining required at the base (where case slips into steel stub) and the nose (where the helical wrap on a smaller diameter causes excessive build-up) to meet the requirements of Figure 3. A later decision was made to go with a thicker walled case, therefore, this sample could not be used. It was, however, cut in half along its length so that a better view of the dome build-up was obtained.

Although lightweight, fiberglass case could never match the weight of the ultra-light disposable case, and this was never one of the requirements. Sample 60-1, which was fabricated and machined to the approximate geometry of the disposable case weighed over 500 gms while the disposable case weighs ~ 250 gms. Since ultra light-weight was not a criteria, it was decided that the fiberglass case be made thicker walled. This was done to reduce the clearance between the case and the chamber wall from ~ .070 in. to ~ .004 in. This effect would greatly reduce the deflection of the fiberglass case which in return would minimize the stress concentration at the shoulder where the case fits into the steel stub case. In addition, the new clearance would assure that the fiberglass case would stay within its plastic zone upon pressurization. Both of these conditions would assure easy extraction of the case.

Case 60-2

This case was wound to meet the thicker-walled dimensions shown in Figure 4. Four helical patterns were again used but in order to meet the thick-wall dimension of .143 in., eight additional hoop layers were wound on the body of the case from the base end to a point ½ in. down the dome.

This case was machined similar to 60-1, with finish machining at the base and dome sections only. Some hand finishing was required to obtain the smooth contour on the dome.

The O.D. dimensions shown in Figure 4 were to provide for the .004 radial clearance between the case and the expected chamber dimensions. This case was matched with a steel stub case and the assembly was inserted into the chamber of a 60mm tube. The case assembly did not seal and it hung up at the top of the dome. It was thought that the hand finishing on this dome did not remove enough material and was therefore oversize.

It was decided at this time to fabricate an oversize fiberglass case that would be machined entirely on a numerically controlled (NC) lathe. This would assure exact control and assure that the case met specifications especially in the area of domes.

Case 60-3

This sample was wound oversize to provide enough material for NC machining of the entire case to the dimensions shown in Figure 4. Six helical patterns were wound along with an additional 6 hoop layers on the body of the case.

A machining program was prepared and the case was finish machined on a NC lathe. This case was matched with a steel stub and inserted into the chamber. This assembly also did not seal in the chamber and again the hang-up was at the top of the dome.

The case was then given a detailed inspection on a comparator and found to be within the tolerances of Figure 4. A detailed examination of the tube's machining operations finally ascertained the problem. Extremely generous radius tolerances (1.0 in. on the converging radius and 1.0 in. on the diverging radius) resulted in a chamber converging and diverging radii of 2.50"R. A look at Figure 4, which illustrates the case's matching dimensions at these locations shows why this case and #60-2 did not seal. The O.D. of the case was remachined to 2.88"R at the converging radius and 3.00"R at the diverging radius. The remachined case with another stub case was inserted in the chamber and resulted in a perfect fit.

Case 60-4

This final fiberglass case was wound exactly as #60-3. It was NC machined to the dimensions shown in Figure 5 and this case, with a steel stub case fit exactly in the chamber.

Figure 6 is a view of the finish machined case (60-4) with the hard-coated Aluminum mandrel. Still attached to the mandrel are the "as wound" fiberglass end caps. Figure 7 shows the simulated projectile, fiberglass cartridge case, and the steel stub case. The steps shown at the base of the cartridge case slide into two mating shoulders inside the stub case. This concept calls for bonding these surfaces with a high strength adhesive after loading.

An overall assembled view of the projectile, cartridge case, and steel stub case is shown in Figure 8. This finished round is to be tested in the test firing of the MCAAAC gun system.

CONCLUSIONS

The feasibility of fabricating a composite cartridge case by the filament winding process has been demonstrated. Future work should include:

A. The study of the interaction between the cartridge case and gun barrel chamber. This study could be an extension of the work done by Frankford Arsenal on the "Three Dimensional Finite Element Analysis on the 20mm Cartridge Case, M204 and M139 Gun" (Oct 1975) and "Application of NASTRAN in Non-Linear Analysis of the Cartridge Case Neck Separation Malfunction" (Oct 1975). The study will investigate the deformation and stresses that are developed in the cartridge case as it is seated in the barrel chamber, and the displacements and stresses caused by a subsequent pressure loading.

B. The study of fabrication procedures to wind repeatable geodesic paths for optimum structural properties.

C. Test firings to ascertain the structural integrity of the composite cartridge case.

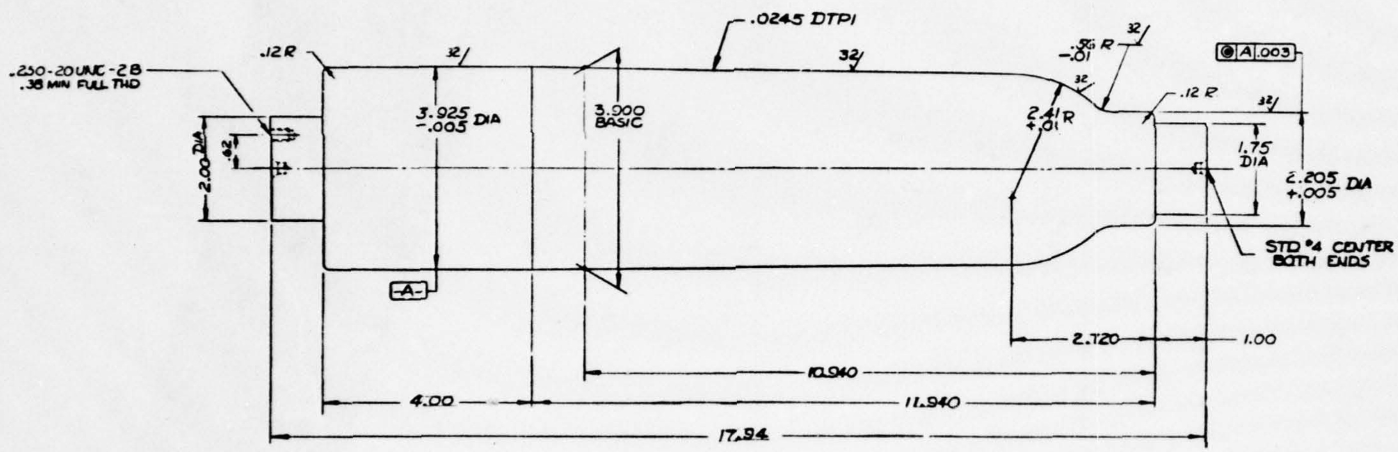

Figure 1. Drawing of mandrel used in fabricating fiberglass cases.

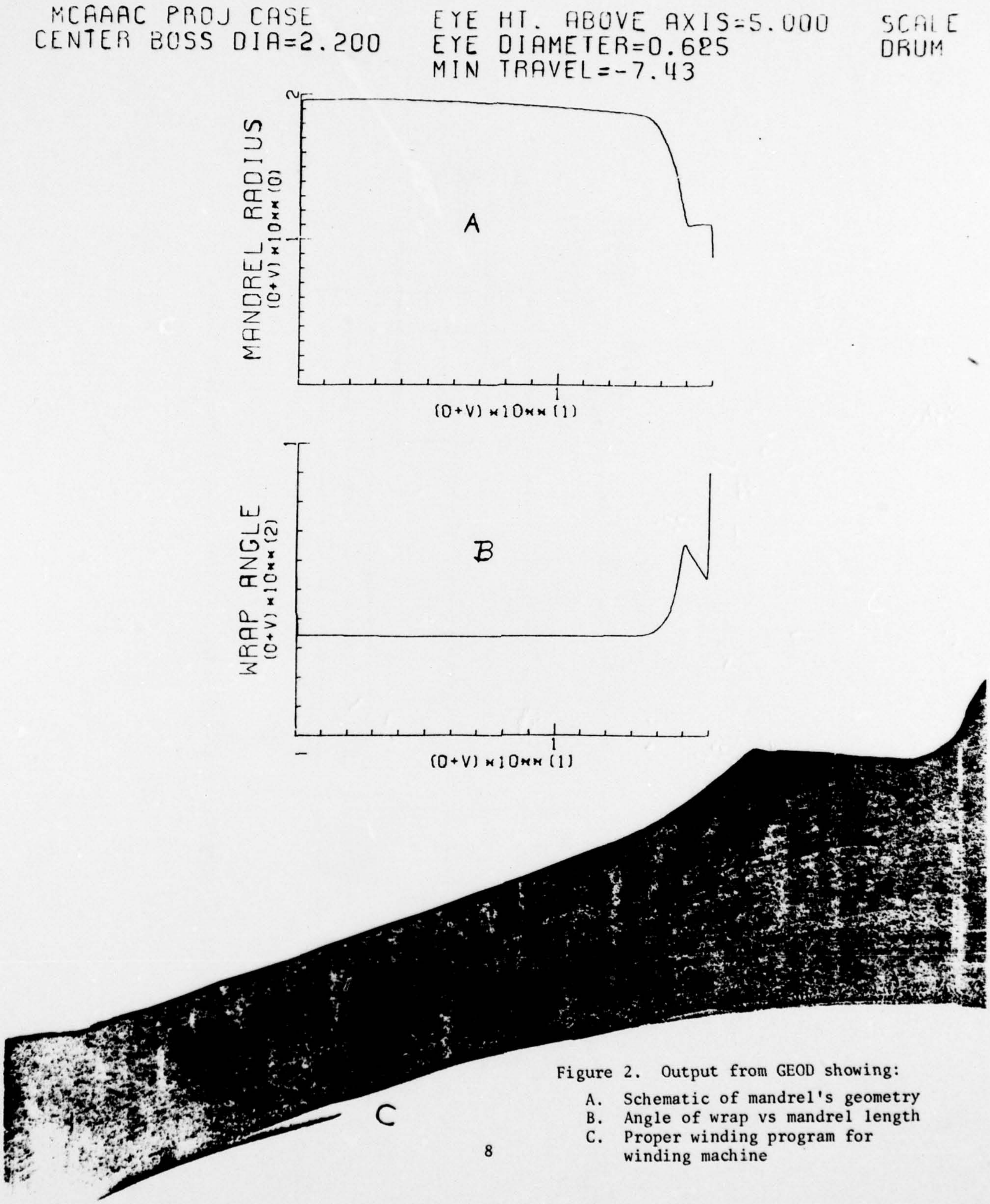

Figure 2. Output from GEOD showing:

A. Schematic of mandrel's geometry
B. Angle of wrap vs mandrel length
C. Proper winding program for winding machine

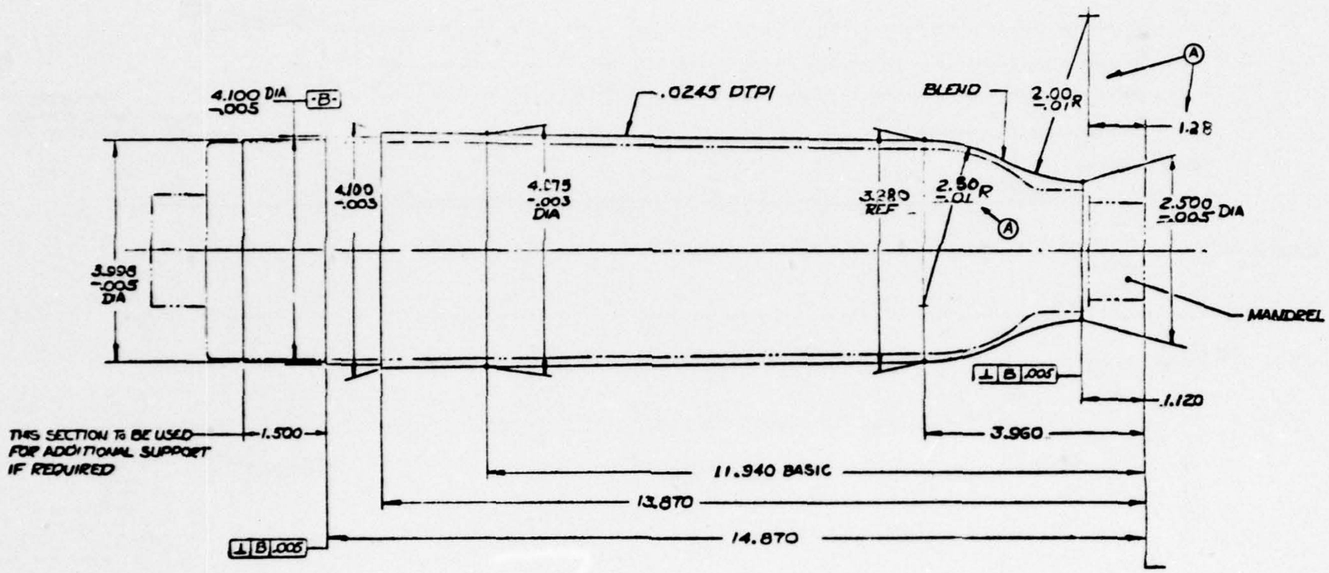

Figure 3. Machining drawing for case 60-1.

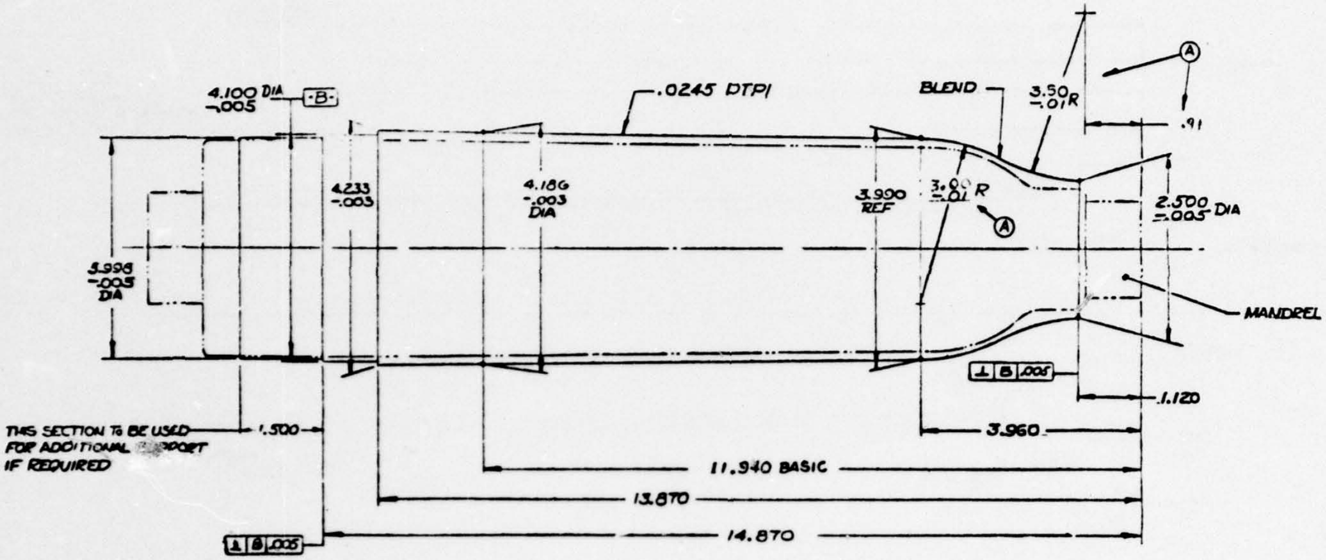

Figure 4. Machining drawing for case 60-2.

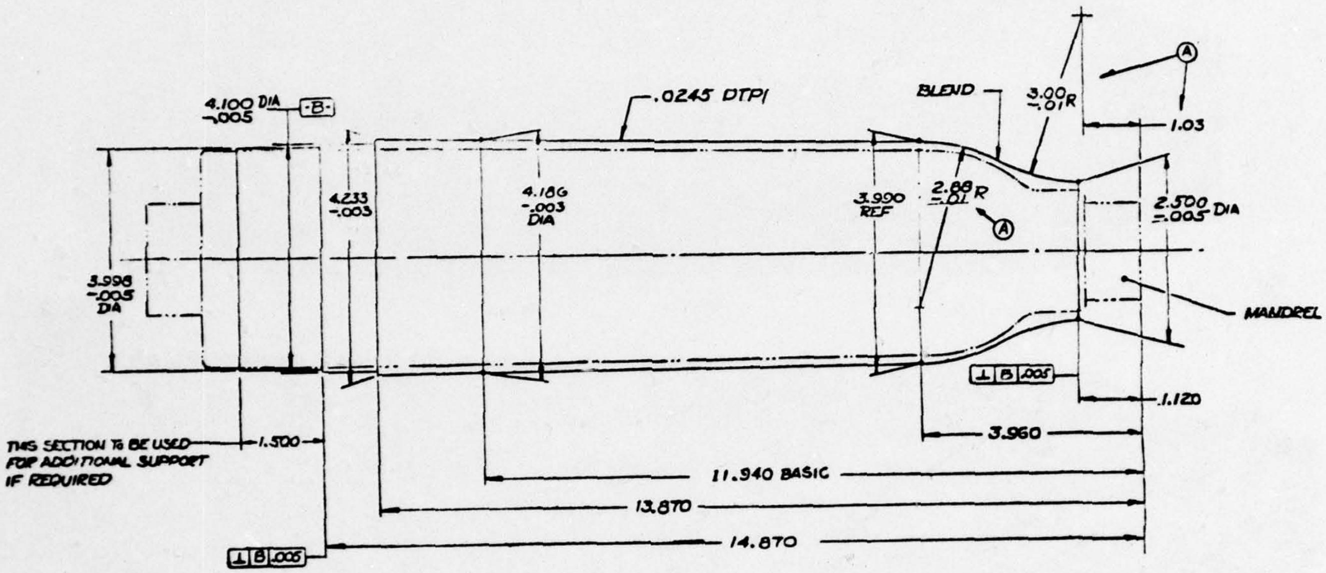

Figure 5. Final machining drawing for cases 60-3 and 60-4.

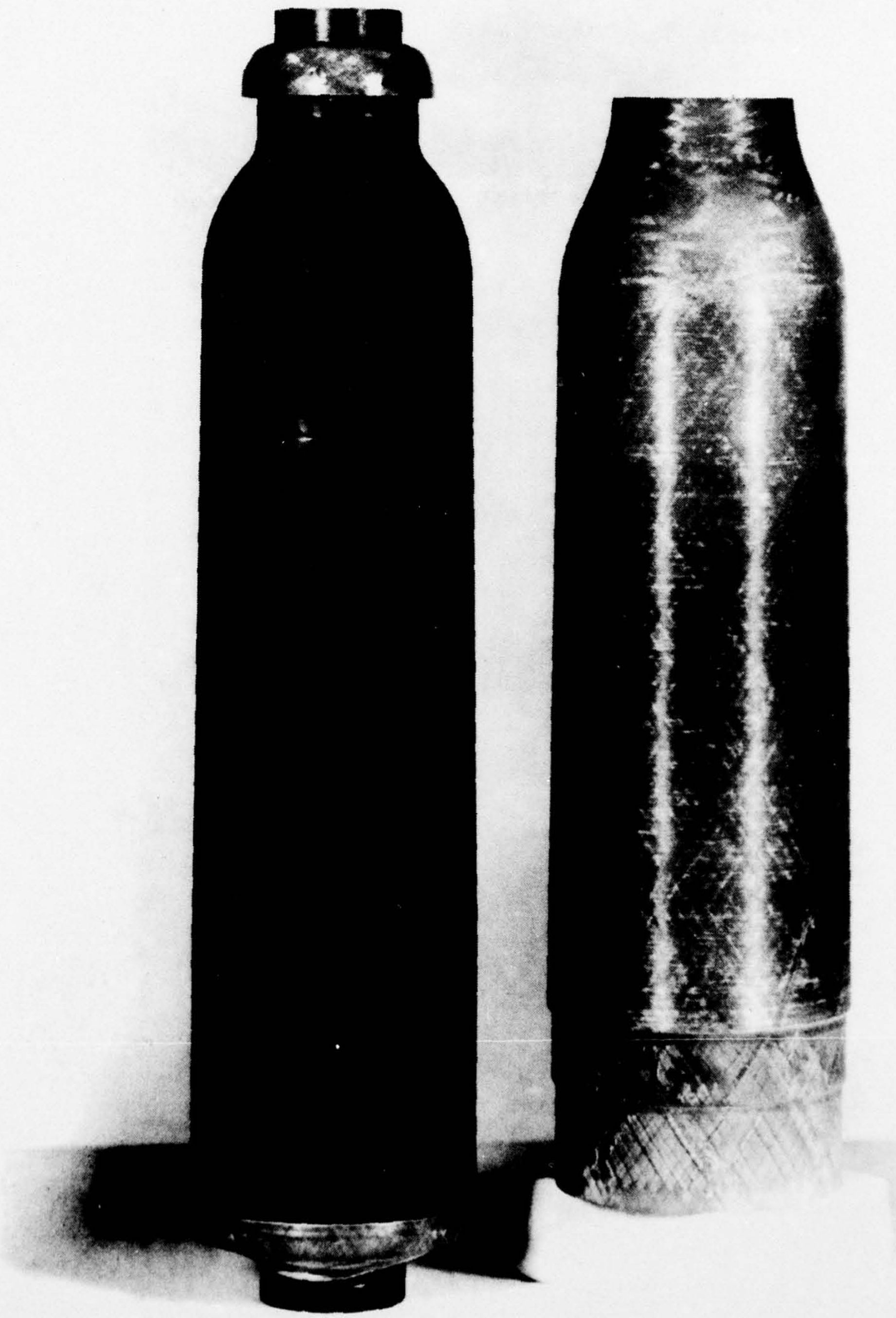

Figure 6. Finish machined case 60-4 with the mandrel.

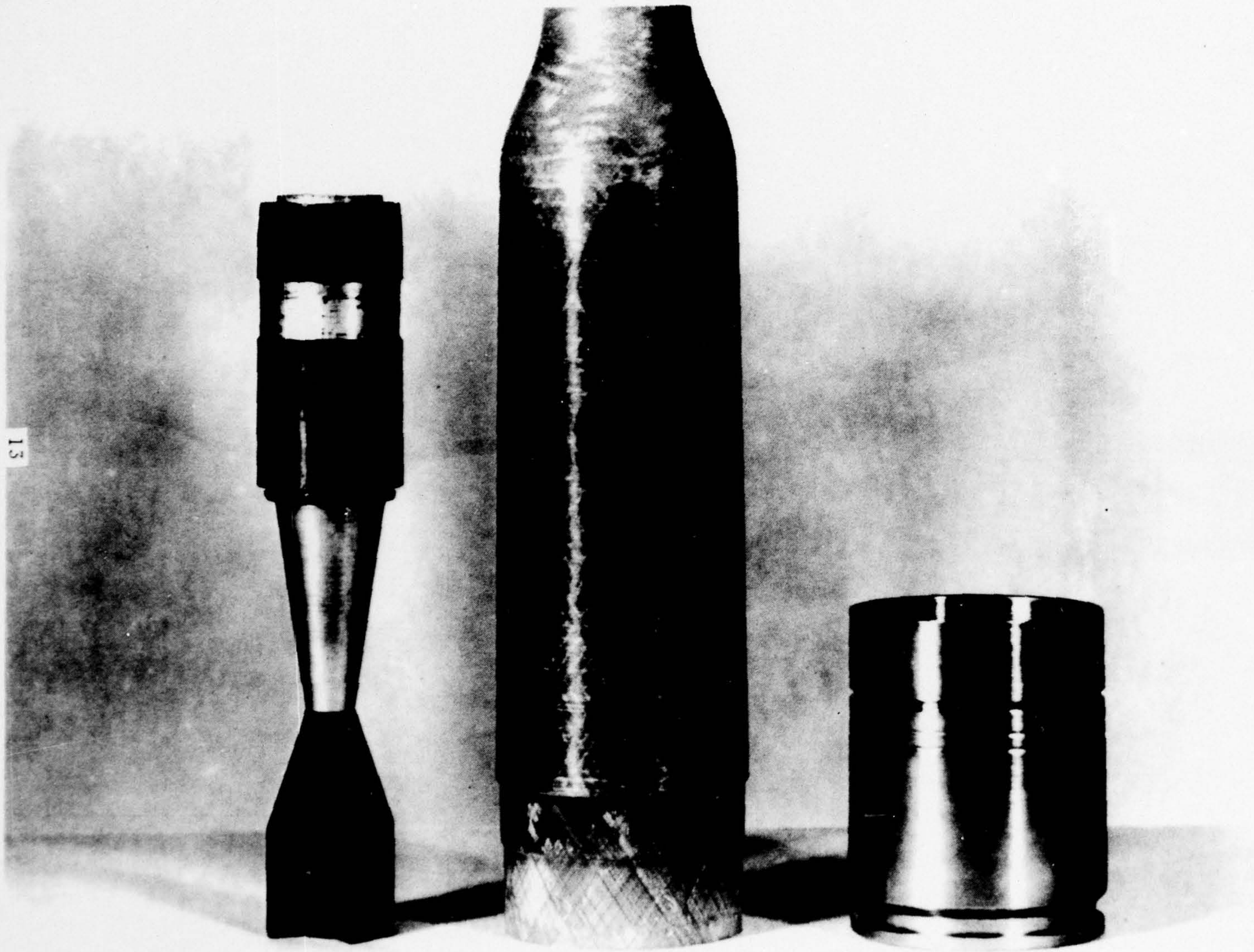

Figure 7. View of the simulated projectile, fiberglass case, and the steel stub case.

Figure 8. Assembled view of projectile, cartridge case, and stub case.

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