26 Copy

NASA TECHNICAL MEMORANDUM

NASA TM X-53117

AUGUST 27, 1964

NASA TM X-53117

DEVELOPMENT OF TECHNIQUE FOR EXPLOSIVE FORMING TORUS TANK SUMP SEGMENTS OF ALUMINUM ALLOY 7039

by O. M. TOMMIE, JR. AND E. R. COLEMAN
Manufacturing Engineering Laboratory

NASA

George C. Marshall Space Flight Center, Huntsville, Alabama

TECHNICAL MEMORANDUM X-53117

DEVELOPMENT OF TECHNIQUE FOR EXPLOSIVE FORMING TORUS TANK SUMP SEGMENTS OF ALUMINUM ALLOY 7039

By

O. M. Tommie, Jr.
E. R. Coleman

ABSTRACT

31726

This report covers the details of MSFC efforts to establish explosive forming parameters for the production of Torus Tank sump segments. A description of the tooling, preform configuration and developed techniques is included. All explosive tests were conducted at the explosive forming facility in the Manufacturing Engineering Laboratory.

Author

NASA-GEORGE C. MARSHALL SPACE FLIGHT CENTER

NASA-GEORGE C. MARSHALL SPACE FLIGHT CENTER

TECHNICAL MEMORANDUM X-53117

August 27, 1964

DEVELOPMENT OF TECHNIQUE FOR EXPLOSIVE FORMING TORUS TANK SUMP SEGMENTS OF ALUMINUM ALLOY 7039

By

O. M. Tommie, Jr.
E. R. Coleman

METHODS RESEARCH AND TECHNOLOGY DIVISION
MANUFACTURING ENGINEERING LABORATORY

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

TECHNICAL MEMORANDUM X-53117

DEVELOPMENT OF TECHNIQUE FOR EXPLOSIVE FORMING TORUS TANK SUMP SEGMENTS OF ALUMINUM ALLOY 7039

SUMMARY

Test results have established the feasibility of explosively forming parts to the configuration of Torus Tank sump segments using Aluminum alloy 7039.

The preform should be fabricated from a single blank and the weld quality inspected before any explosion forming is conducted.

The information contained within this report demonstrates the need of good welding technology in the fabrication of preforms for use in explosive forming Torus Tank sump segments.

The numerous fractures occuring within the weld area during the explosive forming tests may be the result of two basic conditions. The first of these is the quality of the weld as evidenced by the random location of the fracture under identical forming procedures. The second condition is the location of the weld relative to points of severe contour and thus highest region of stress.

One major problem encountered in the development of the process was the formation of an inward bulge at the center of the part. This condition proved to be a processing problem, however, which was remedied by selective charge location.

INTRODUCTION

The basic configuration of the Torus Tank may be seen in Figure 1. The shape of the tank poses many manufacturing problems, one of which is the fabrication of the propellent drainage sump segments.

It was the intent of this program to establish the feasibility of explosively forming these sump segments and to develop the necessary procedures.

Process development was confined to fabrication of the intermediate sump segments. It was noted that the geometry of all of these segments was identical with the exception of trim line location. A single explosive forming die was designed, therefore, which would produce all of the intermediate segments by providing sufficient excess stock for varying the trim lines. Forming of the end segments and flaring of the sump drain outlet was contracted to the Republic Aviation Company, Farmingdale, Long Island, New York.

The material used in fabrication of the sump segments was .125 inch thick 7039 Aluminum alloy.

TEST PROCEDURE

A. General

Tests were conducted on a total of 17 preforms. Fourteen of these preforms were fabricated by rolling in two parts requiring two weld seams. The other three were rolled from a single blank requiring one weld seam. The two configurations are illustrated in Figures 2a and 2b.

The two part preform was given initial consideration due to the apparent difficulty of rolling in one piece. Of the 14 preforms fabricated from two parts, 6 were made from Aluminum alloy 2219 to be used for die tryout and for determining proper charge size, location and configuration. The remaining 8 were fabricated from Aluminum alloy 7039 with the objective of forming a satisfactory segment from which a flared opening could be drawn for producing the center segments.

Consistent fracturing at the weld seams indicated that this approach to the fabrication of a two part preform would not be entirely satisfactory, and further study led to the development of a technique for fabricating the preform from a single piece. This permitted the weld seam to be located in an area of least stress. The three preforms of this configuration were constructed from Aluminum alloy 7039.

Figures 3 through 7 depict the general procedure for the forming operation. The preform is positioned in the split die insert, which is mated by dowel pins and pulled tight by four - .625 inch diameter bolts. After the insert is placed in the retainer, the cavity between the preform and die is sealed by placing zinc chromate tape around the preform edge. A vacuum of 29 inches of Hg is drawn, the explosive charge positioned in the preform and the setup lowered into the

water tank. The charge is then detonated forcing the preform into the die cavity. This procedure is repeated as required to form the part. Full contact between die and part could be detected by tapping lightly with a wooden mallet.

Data pertinent to all tests are tabulated in Table I.

B. Details of Tests on Two Part Preforms.

The first three tests resulted in complete fracture of the weld seams. A typical failure is shown in Figure 8. Based on these results, it was decided to reinforce the welds for subsequent tests of the two part preforms. This was done by bonding doublers of 2.5 inch x .050 inch x 36 inch Aluminum 2219-0 over the inside weld beads. The adhesive used was a new high strength epoxy-modified polyurethane, Narmco 7344.

Test No. 4 produced slightly better results with a 5 inch fracture occuring in only one of the weld seams near one end of the part. The fracture is shown in Figure 9.

Test No. 5 resulted in a 6 inch fracture on the opposite weld seam and near the opposite end of the part as shown in Figure 10. An inward bulge was also noted in both parts at a point which represents the bottom of the part. The bottom of the part is designed for no curvature in the vertical plane. Preliminary analysis indicated that the bulge was the result of welds fracturing. However, Test No. 6 formed the part to the die with the exception of this characteristic bulge and was accomplished without fracture of the welds. Successive shots were unsuccessful in removing the bulge. The eighth attempt to remove the bulge resulted in fracture of the weld seams. Further analysis at this point concluded that the occurrence of the bulge was a process problem which could be remedied by proper sequencing of the shots. It was further decided that enough information had been gathered using AL 2219 material and tests would proceed using Aluminum alloy 7039 material.

Tests No. 7 and 8 represented the first attempt to form the AL-7039 parts and resulted in failure of the weld. The tests indicated that the doublers used to reinforce the welds would not be adequate and that the weld quality must be improved and/or the weld seams relocated to an area of reduced stress. It was also concluded that in-process anneals would be necessary. Based on the foregoing analysis, action was started for obtaining the one part preforms described in paragraph A. Meanwhile, tests proceeded on the two part preforms already on hand.

Test No. 9 was performed without the aid of doublers for weld reinforcement. A Neopene rubber pad 6 inch x $\frac{1}{4}$ inch x 36 inch was attached to the inside weld beads in an effort to protect the weld area against direct shock. The preform was annealed prior to any explosive shots to remove the effect of cold working introduced in the fabrication process. After the first shot, which formed the part to within $\frac{1}{4}$ inch of die, the part was removed and annealed. An acceptable part was produced after applying two additional shots. This represented the first successful forming of the part and indicated that good welds on preforms are mandatory and that in-process annealing may be necessary to relieve the stresses caused by cold working. Figure 11 shows the finished part.

Test No. 10 was set up to follow the same pattern as Test No. 9 based on the satisfactory results obtained from that test. Both weld seams had small fractures after the first shot. The fractures were repaired and the part annealed. The next shot fractured the part beyond repair.

The part for Test No. 11 had doublers bonded to inside weld beads which broke loose after the first shot. The weld seams did not break, however, and the part was removed and annealed. One of the weld seams split beyond repair on the second shot. The welds had not been X-ray inspected but results indicated poor weld quality.

Test No. 12 produced an acceptable part following the sequence set forth in Table I. The doublers used over the welds were effective only on the first shot since the low temperature adhesive used for bonding melted out during the annealing process. The ball charge used on the first shot appears to be ideal for preventing the characteristic bulge noted previously.

Tests No. 13 and 14 completed work on the two part preforms with both parts resulting in failure. Again the failures were attributed to poor weld quality.

C. Details of Tests on One Part Preforms.

The weld seam on the preform for Test No. 15 was X-ray inspected and found to be of good quality. An acceptable part was formed requiring a sequence of 5 charges of size and configuration shown in Table I. After approximately 80 per cent forming, the part was removed from the die and annealed prior to final sizing. The final sizing operation formed the part to within .025 inches of the die. The finished part may be seen in Figure 12.

Test No. 16 resulted in failure of the weld seam as was expected. The weld seam on the preform had initially been X-ray rejected. Rather than scrap the part, an additional pass was made over the weld seam in a futile attempt to improve the weld. The part fractured on the second shot.

Test No. 17 concluded the test series with the production of a fourth acceptable part. This part required in-process repair to the weld seams due to 4 small fractures occurring on the third shot which formed the part approximately 80 per cent. This part was also annealed before final sizing.

CONCLUSIONS AND RECOMMENDATIONS

The feasibility of explosive forming Torus Tank sump segments of Aluminum alloy 7039 has been demonstrated. From an analysis of the test data, it is concluded that a preform of the one part configuration should be used and all welds inspected before explosive operations. The size, location and configuration of the charges as well as the sequence of the shots will follow that developed for test No. 9. The preforms should be annealed prior to the explosive operations as well as an in-process anneal after the part has been formed approximately 80 per cent.

Subsequent to the explosive operations and prior to trimming, the part should be solution heat treated and aged.

Manufacturing process data sheets describing the procedures required for fabricating the torus sump preforms and explosive forming the sump segments were generated. These procedures were released to the Manufacturing Development Division for use in fabricating the production parts required in the torus tank program. (See Appendix)

TABLE I. EXPLOSIVE FORMING DATA SHEET

Test No.	Shot No.	Charge Type	Charge Size	Charge Configuration	Preform	Remarks
1	1	Primacord	36"-200-Gr/Ft.	Line Charge Central to Two Sides & 7" from Back Side	Alum. 2219	Part Split Full Length of Weld Seam on One Side & 3 Places on Opposite Side
2	1	Primacord	30"-100-Gr/Ft.	Line Charge Central to All Sides	Alum. 2219	Weld Seam Split on Both Sides
3	1	Primacord	30"-50-Gr/Ft.	Line Charge Central to All Sides	Alum. 2219	Weld Seam Split on Both Sides
4	1	Primacord	4 Ft-50-Gr/Ft. Total	(2) Oblong Charges Positioned 6" from Each End	Alum. 2219	This Part has Doublers Bonded to Inside Weld Seams - Part Formed Approx. 80%. Doublers Pulling Loose
4	2	Primacord	3 Ft-50-Gr/Ft.	Line Charge Central to All Sides		One Weld Seam Split for 5" Length - Part Formed Within 1/8" of Template Contour

Note: The first three parts were originally X-ray rejected due to porosity in weld seams.

TABLE I. EXPLOSIVE FORMING DATA SHEET (Cont'd)

Test No.	Shot No.	Charge Type	Charge Size	Charge Configuration	Preform	Remarks
5	1	Primacord	4 Ft-50-Gr/Ft. Total	(2) Oblong Charges Positioned 5" from Each End	Alum. 2219	This Part has Doublers Bonded to Inside Weld Seams - Formed Approx. 80% - Welds O. K.
5	2	Primacord	4 Ft-50-Gr/Ft. Total	(2) Oblong Charges Positioned 6" from Each End		One Weld Seam Split for 6" Length
6	1	Primacord	30"-50-Gr/Ft.	Line Charge Central to Sides	Alum. 2219	Doublers Bonded to Weld Seams - Partial Forming- One Doubler Came Loose
6	2	Primacord	30"-50-Gr/Ft.	Line Charge		Partial Forming - Both Doublers Broke Loose
6	3	Primacord	32"-50-Gr/Ft. Total	(2) 5" Dia. Circles 8" from Each End Inside Part		Top Cap & Charge Did Not Detonate

TABLE I. EXPLOSIVE FORMING DATA SHEET (Cont'd)

Test No.	Shot No.	Charge Type	Charge Size	Charge Configuration	Preform	Remarks
6	4	Primacord	32"-50-Gr/Ft. Total	(2) 5" Dia. Circles 8" & 18" from End		Top Cap & Charge Did Not Detonate
6	5	Primacord	16"-50-Gr/Ft.	(1) 5" Dia. Circles 8" from Top		Part Checks to Die Contour by Tapping with Hammer - Except Back Face
6	**6**	Primacord	30"-100-Gr/Ft.	Line Charge Central		Straight Surface of Back Face Still Not to Die Surface
6	7	Primacord	12"-100-Gr/Ft.	Line Charge 4" from Back Face		This Shot Did Not Correct the Bulge Condition of Back Face
6	8	Primacord	12"-100-Gr/Ft.	Line Charge 4" from Back Face		Bulge Condition Still in Back Face of Part-Weld Seams Fractured

TABLE I. EXPLOSIVE FORMING DATA SHEET (Cont'd)

Test No.	Shot No.	Charge Type	Charge Size	Charge Configuration	Preform	Remarks
7	1	Composition C-4	10-Gram	Ball Charge Positioned 18" From Each End, Central To Two Sides and 6" From Side Opposite Welds	Alum. 7039	(2) Weld Seams With Doublers Bonded To Inside Surface Very Little Forming From This Shot
7	2	Primacord	20" of 100 Grain	Line Charge 6" From Side Away From Welds and Central To Other Two Sides		Both Weld Seams Broke
8	1	Primacord	35"-50 Grain	Line Charge Central Location Length of Part	Alum. 7039	Two Weld Seams With Doublers Bonded To Inside Seam - Partial Forming, Doublers Coming Loose - Weld Seams O.K.
8	2	Primacord	35"-50 Grain	Line Charge Central To Two Sides and 4" From Side Opposite To Weld Seams		Taped Rubber Strips Over Two Doublers. One Weld Seam Split Length of Part Except 2" Each End.

TABLE I. EXPLOSIVE FORMING DATA SHEET (Cont'd)

Test No.	Shot No.	Charge Type	Charge Size	Charge Configuration	Preform	Remarks
9	1	Primacord	35"-50 Grain	Line Charge Central To Two Sides and 4" From Side Opposite Weld Seams	Alum. 7039	Two Weld Seams, No Doublers-Rubber Pad Taped To Seams. This Part Was Annealed Again After Fab. and Welding - Part Formed Within 1/4" of Template. Will Be Annealed Before Next Shot
9	2	Primacord	50"-50 Grain	Two 5" Circles 6" From Each End and Central To Sides - One 20" Straight Charge Central To Sides and Midway Between Circle Charges		Rubber Pads Taped To Seams - All Areas of Part Are to Die Except Side Away From Weld Seams. Checked By Tapping with Hammer.
9	3	Primacord	30"-50 Grain	Line Charge Central To Two Sides and 4" From Side Away From Weld		Rubber Pads Taped To Seams - Part Formed To Die O.K.-Checks O.K. To Templates

TABLE I. EXPLOSIVE FORMING DATA SHEET (Cont'd)

Test No.	Shot No.	Charge Type	Charge Size	Charge Configuration	Preform	Remarks
10	1	Primacord	35"-50 Grain	Line Charge Located Central To Two Sides And 4" From Side Opposite To Weld Seams	Alum. 7039	Two Weld Seams - No Doublers-Rubber Pads Taped To Seams-This Part Was Annealed Again After Fab. and Welding. - Partial Forming Fractures in Both Weld Seams Approx. 1" - Long Part Will Be Repaired and Then Annealed
10	2	Primacord	50"-50 Grain	Two 5" Circles 6" From Each End and Central To Sides-One 20" Length Central To Sides and Midway Between Circle Charges		Both Weld Seams Split
11	1	Primacord	30"-50 Grain	Line Charge Central To Two Sides and 4" From Side Away From Weld Seams	Alum. 7039	Two Weld Seams With Doublers Bonded To Inside Surface - Part Has Partial Forming-One Doubler Came Off and Other is Loose-Part Will Be Annealed Before Next Shot.

TABLE I. EXPLOSIVE FORMING DATA SHEET (Cont'd)

Test No.	Shot No.	Charge Type	Charge Size	Charge Configuration	Preform	Remarks
11	2	Primacord	22"-50 Grain	Line Charge Central To Two Sides and 4" From Side Opposite To Weld Seams		Rubber Pads Taped To Inside Surface of Weld Seams-One Weld Seam Split
12	1	Composition C-4	5 Gram	Ball Charge Central To Both Ends and Two Sides and 5" From Side Opposite Welds	Alum. 7039	Two Weld Seams With Doublers Bonded To Inside Surface - Partial Forming. Part Will Be Annealed Before Next Shot
12	2	Primacord	22"-50 Grain	Line Charge Central To Two Sides and 4" From Side Away From Weld Seams		Rubber Strips Taped To Weld Seams. Part Formed Approx. 80%-Will Be Annealed Before Next Shot
12	3	Primacord	26"-50 Grain	Line Charge Central To Two Sides and 4" From Side Opposite To Weld Seams		Rubber Strips Taped To Inside Surface of Weld Seams. Part Formed Approx. 85%
12	4	Primacord	26"-50 Grain	Line Charge Equal Distance From Sides		Rubber Strips Taped To Inside Surface of Weld Seams. Part Formed To Die Template-Check O. K.

TABLE I. EXPLOSIVE FORMING DATA SHEET (Cont'd)

Test No.	Shot No.	Charge Type	Charge Size	Charge Configuration	Preform	Remarks
13	1	Primacord	30"-50 Grain	Line Charge Central To Two Sides and 6" From Side Opposite Weld Seams	Alum. 7039	Two Weld Seams With Doublers Bonded To I. D. Partial Forming
13	2	Primacord	52"-50 Grain	Two 5" Circles Central To Sides and 6" From Each End. One 22" Long Piece Central To Sides and Midway Between Circle Charges		Part Formed Approx. 80%. Will Be Annealed Before Next Shot
13	3	Primacord	50"-50 Grain	Same Charge Configuration and Location As Shot No. 2		Both Weld Seams Split
14	1	Primacord	22"-50 Grain	Line Charge-Central To Two Sides and 4" From Side Opposite Weld Seams	Alum. 7039	Two Weld Seams With Doublers Bonded To I. D. Weld Seam Split On One Side

TABLE I. EXPLOSIVE FORMING DATA SHEET (Cont'd)

Test No.	Shot No.	Charge Type	Charge Size	Charge Configuration	Preform	Remarks
15	1	Composition C-4	10-Gram	Ball Positioned 18" From Each End, Central To (2) Sides & 16" From Side Opposite To Weld Seam	Alum. 7039	One Weld Seam With Doubler Bonded To Inside Surface Part Partially Formed
15	2	Primacord	20"-50-Grain	Line Charge Located Central Length of Part		More Pronounced Forming
15	3	Primacord	36"-100 Grain	Line Charge Length of Part, Central To (2) Sides & 7" From Side Opposite Weld Seam		Part Formed Approx. 50%
15	4	Primacord	36"-100 Grain	Line Charge Same Position as Shot No. 3		Part Formed Approx. 80%. Will Now Be Annealed Before Final Sizing
15	5	Primacord	4'6"-50 Grain	(2) 6" Circles 6" From Each End & Central To Sides (1) 18" Straight Piece Between Circle Charges		Rubber Strip Taped To Weld Seam Replacing Doubler Removed and Annealed - Part Formed to Die. Checks Within .025 of Template

TABLE I. EXPLOSIVE FORMING DATA SHEET (Cont'd)

Test No.	Shot No.	Charge Type	Charge Size	Charge Configuration	Preform	Remarks
16	1	Primacord	26"-100 Grain	Line Charge-Central To Two Sides and 4" From Side Opposite Weld Seams	Alum. 7039	One Weld Seam With Rubber Strip Taped To I. D. This Part Was X-Ray Rejected and Had Another Pass Made on Weld - Formed Approx. 80%
16	2	Primacord	26"-100 Grain	Line Charge-Same Charge and Location as Shot No. 1		Rubber Strip Taped To I. D. Of Weld Seam. Weld Seam Split
17	1	Composition C-4	10-Gram	Ball Charge Positioned 18" From Each End, Central To Sides	Alum. 7039	One Weld Seam - No Doubler Rubber Pad Taped To Seam - Partially Forming
17	2	Primacord	30"-50 Grain	Line Charge Central To Two Sides & 4" From Side Opposite Weld Seam		Good Forming
17	3	Primacord	30"-100 Grain	Line Charge Positioned Same As Shot No. 2		Part Formed Approx. 80%. Weld Seam Has (4) Small Fractures - Will Be Repaired and Annealed Before Next Shot

TABLE I. EXPLOSIVE FORMING DATA SHEET (Cont'd)

Test No.	Shot No.	Charge Type	Charge Size	Charge Configuration	Preform	Remarks
17	4	Primacord	50"-50 Grain	Two 5" Circles 6" From Each End and Central To Sides-One 20" Length Central Between Circle Charges		Part Formed To Die Template Check-The 20" Charge Did Not Detonate

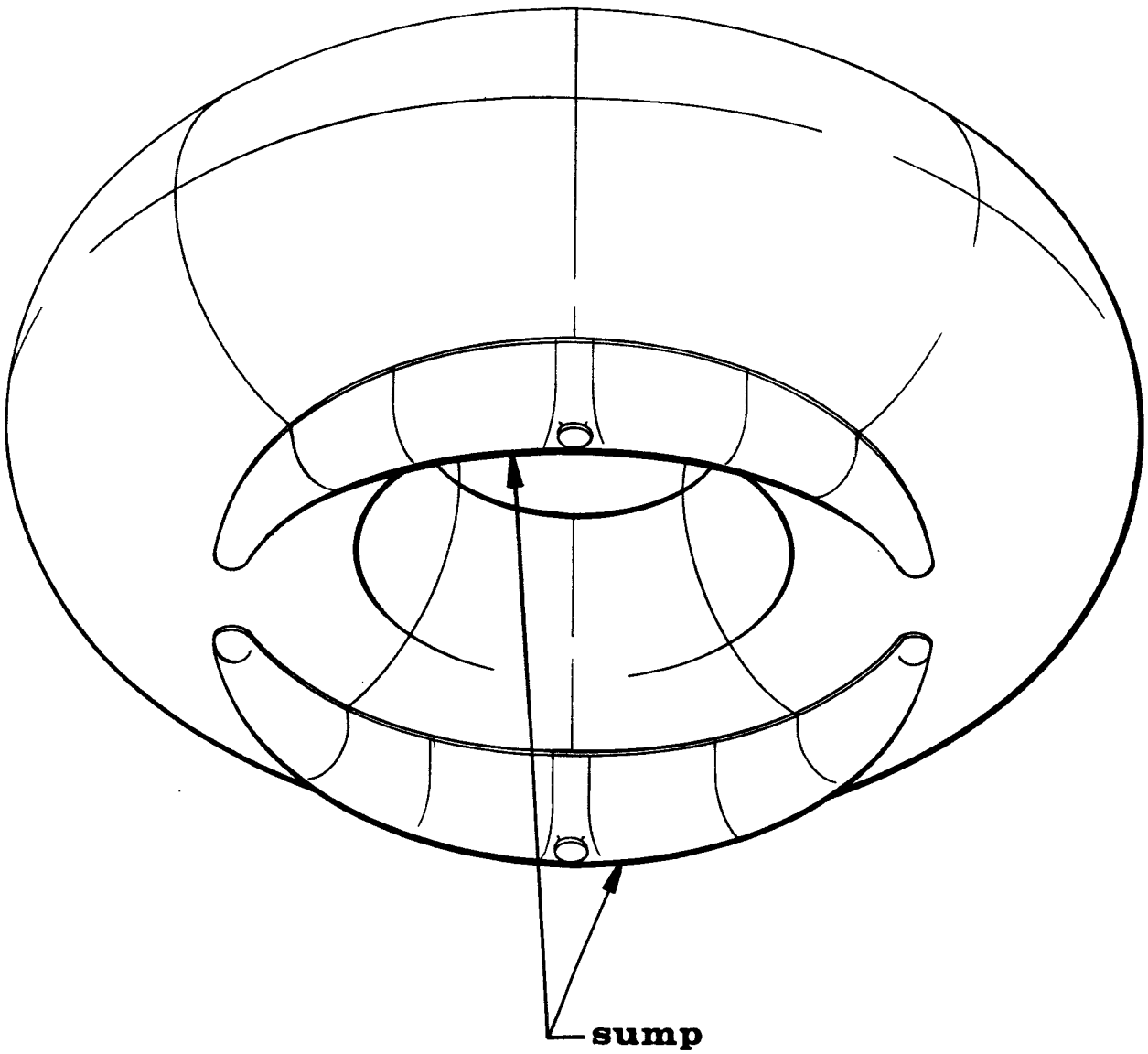

FIGURE 1. GENERAL CONFIGURATION OF TORUS TANK

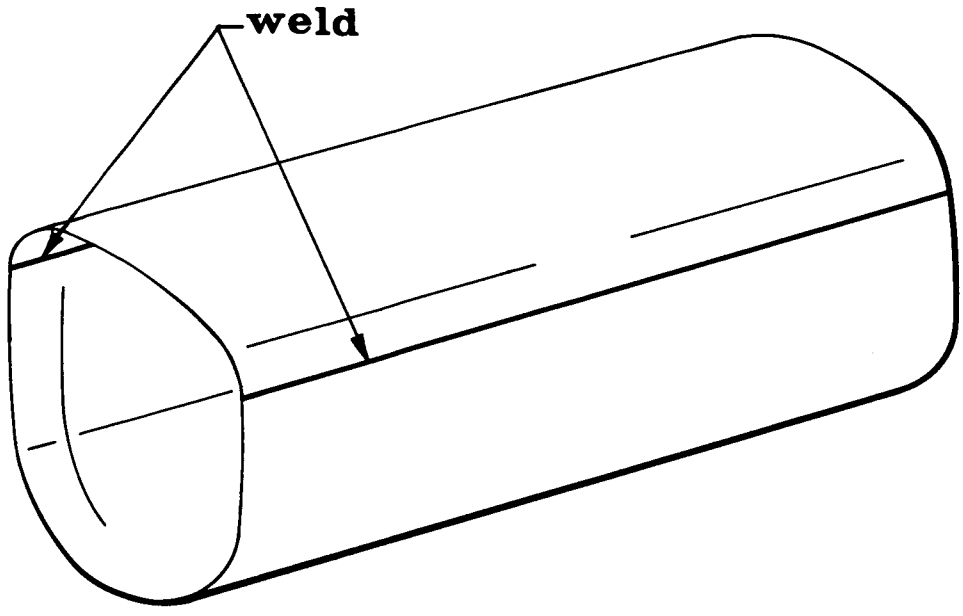

FIGURE 2a. TWO PART PREFORM CONFIGURATION

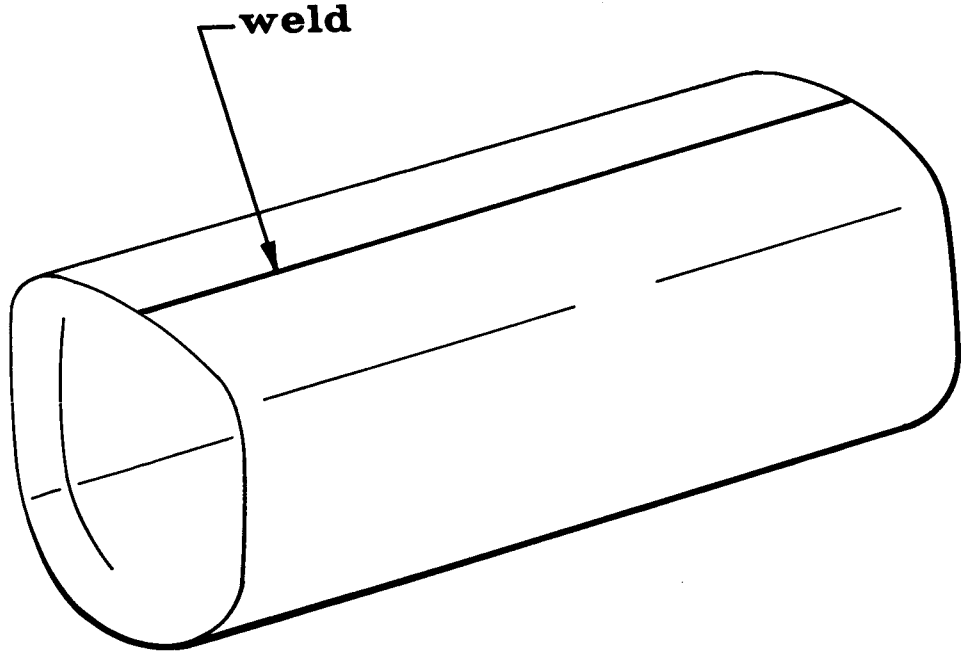

FIGURE 2b. ONE PART PREFORM CONFIGURATION

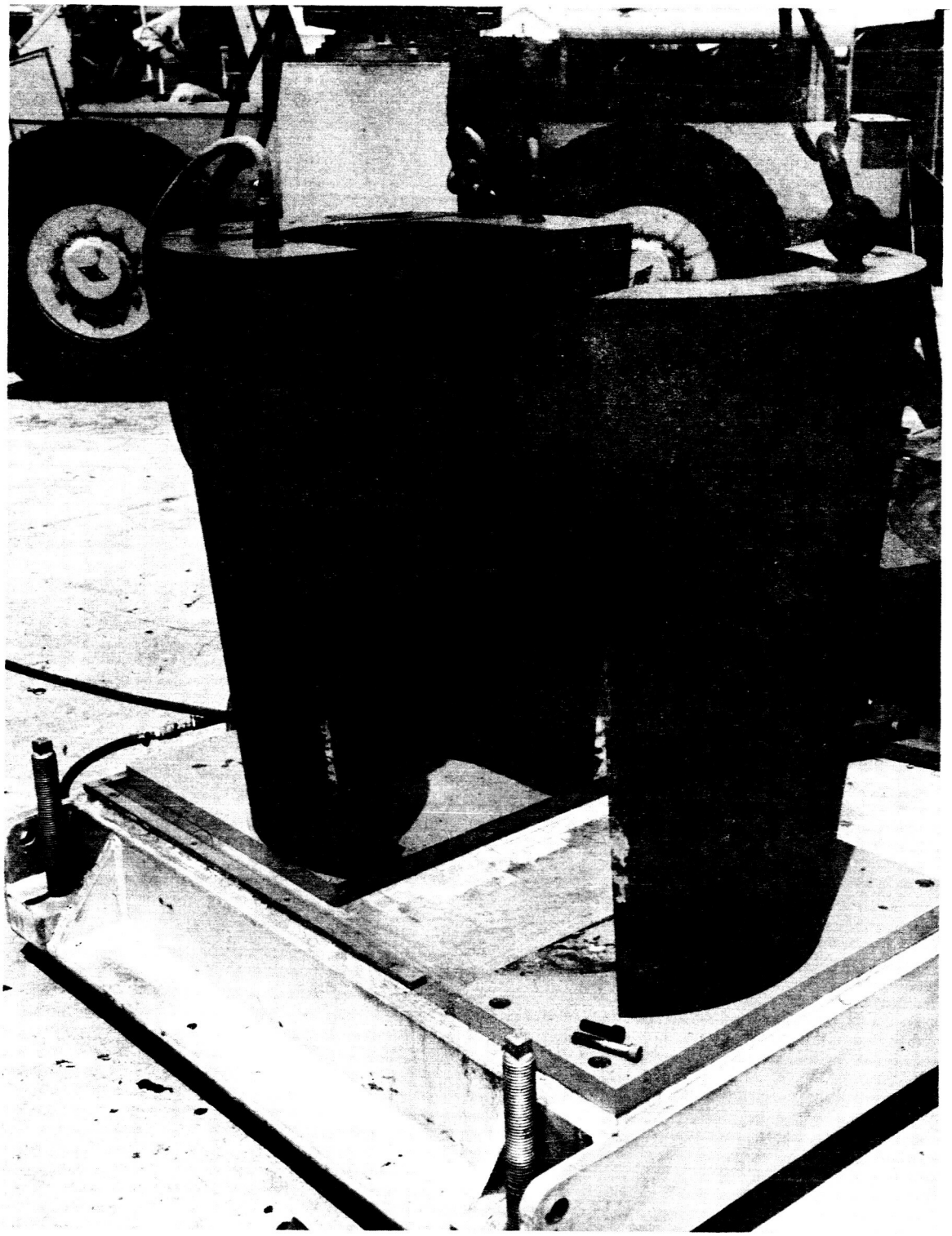

FIGURE 3. DIE INSERT AND AIR BEARING

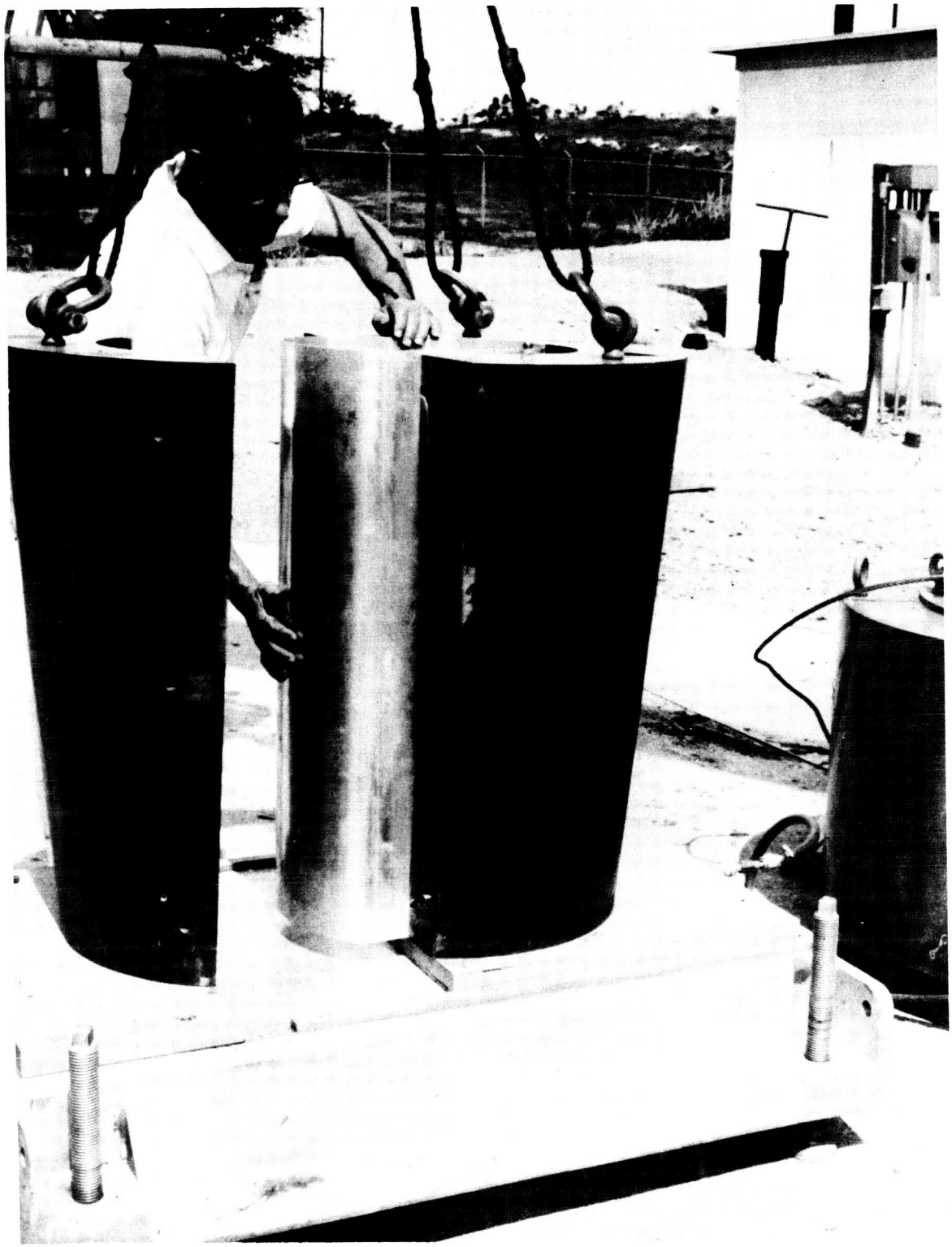

FIGURE 4. POSITIONING PREFORM IN DIE INSERT

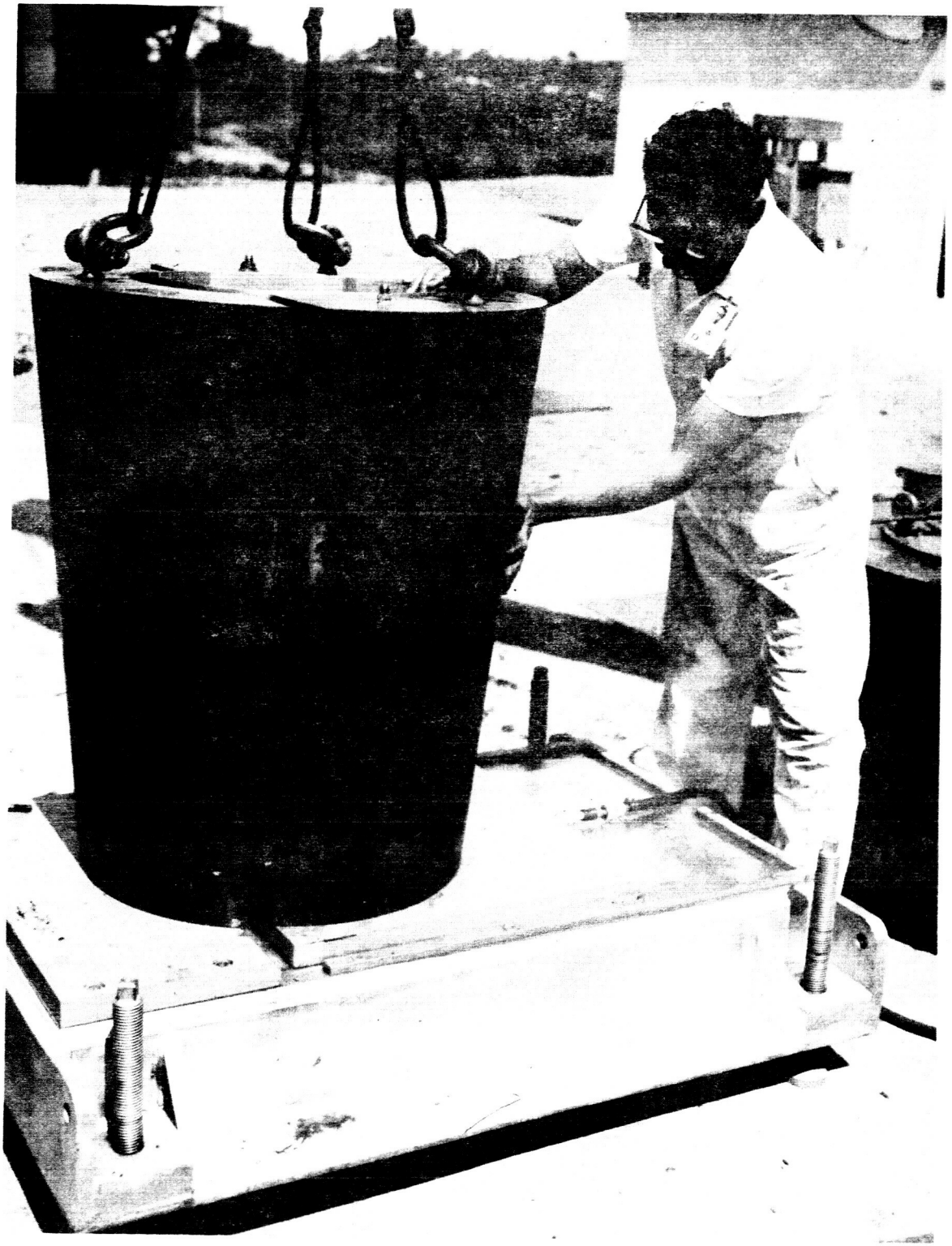

FIGURE 5. CLOSING DIE INSERT

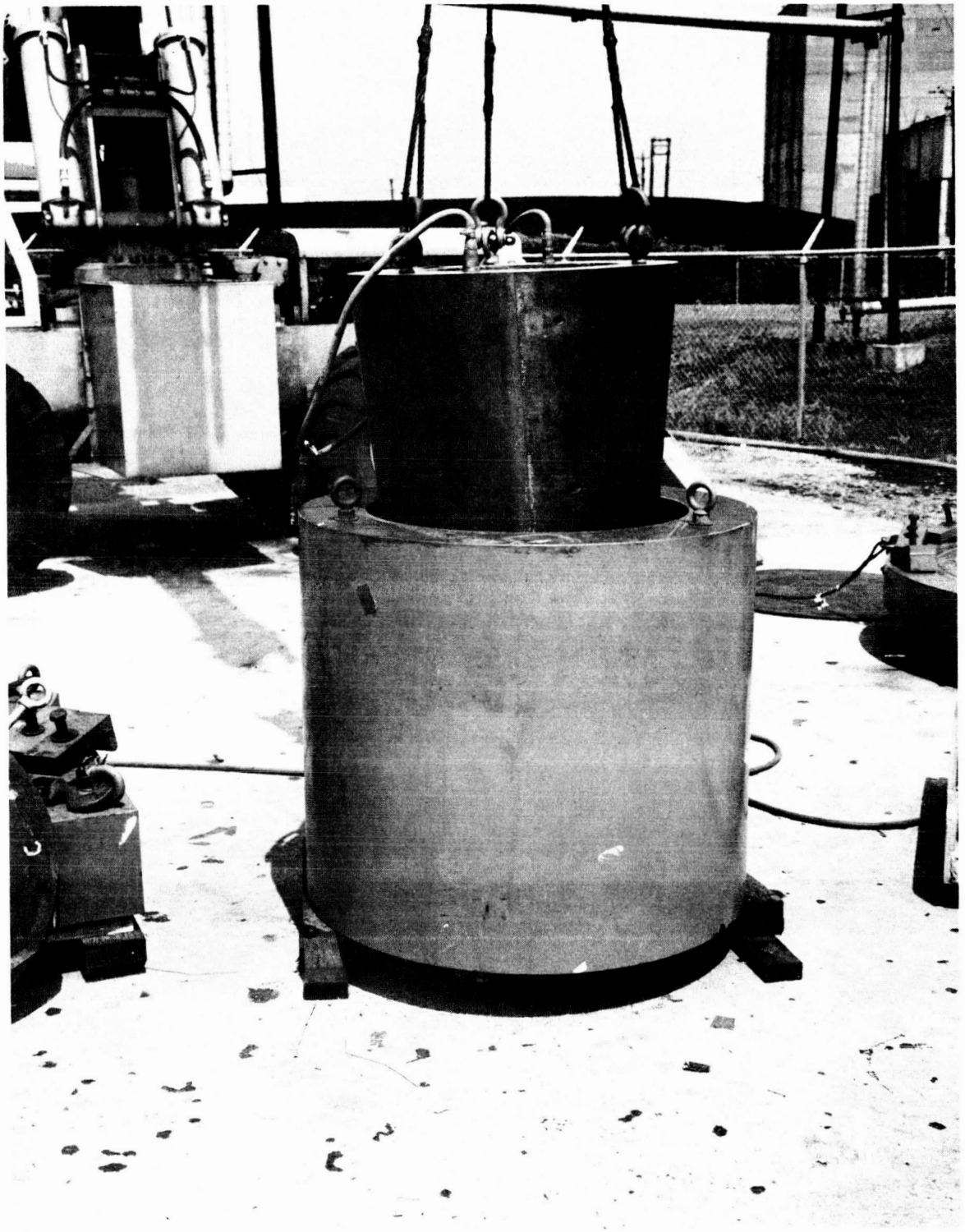

FIGURE 6. PLACING INSERT IN RETAINER

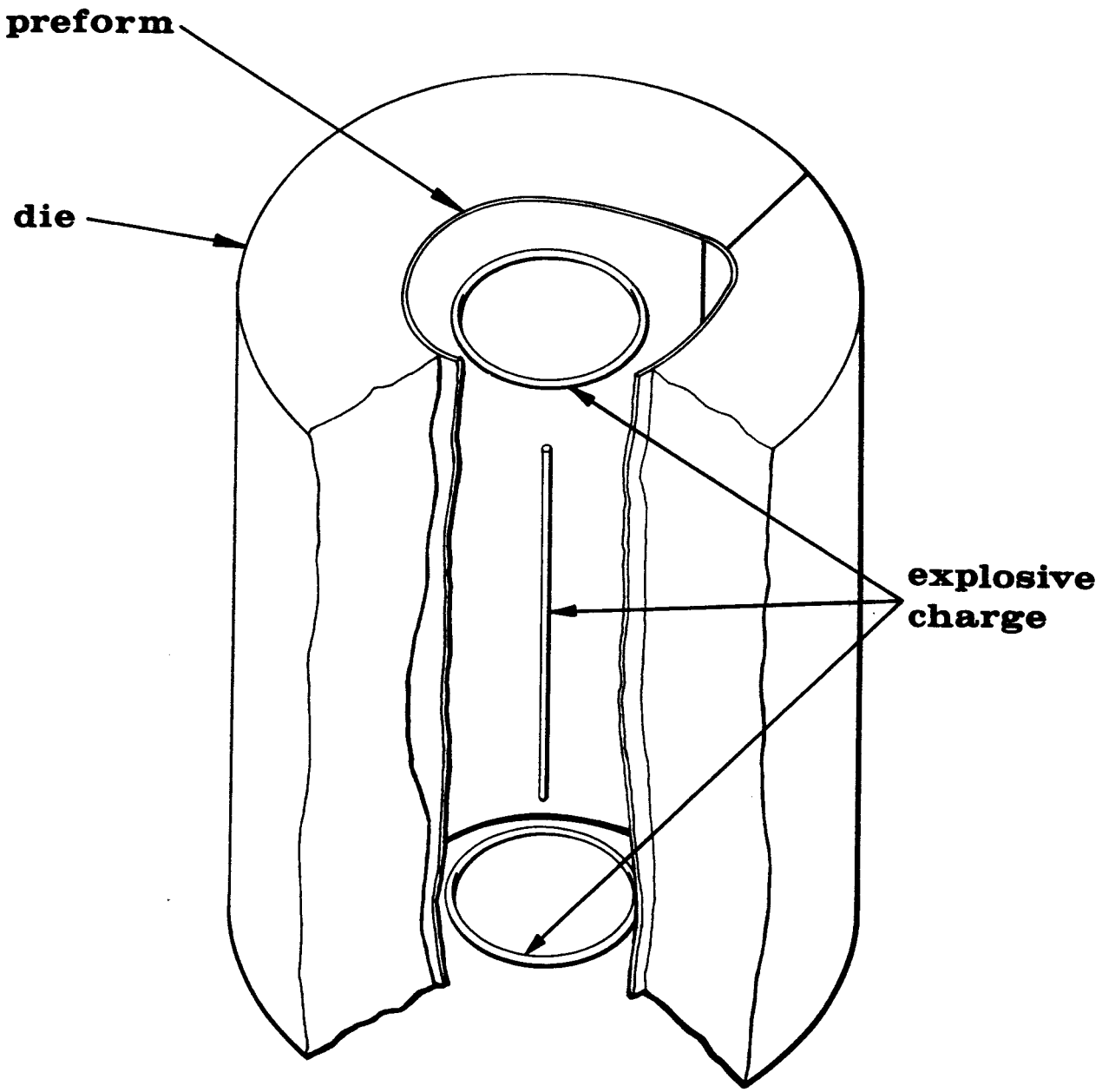

FIGURE 7. POSITIONING OF EXPLOSIVE CHARGE

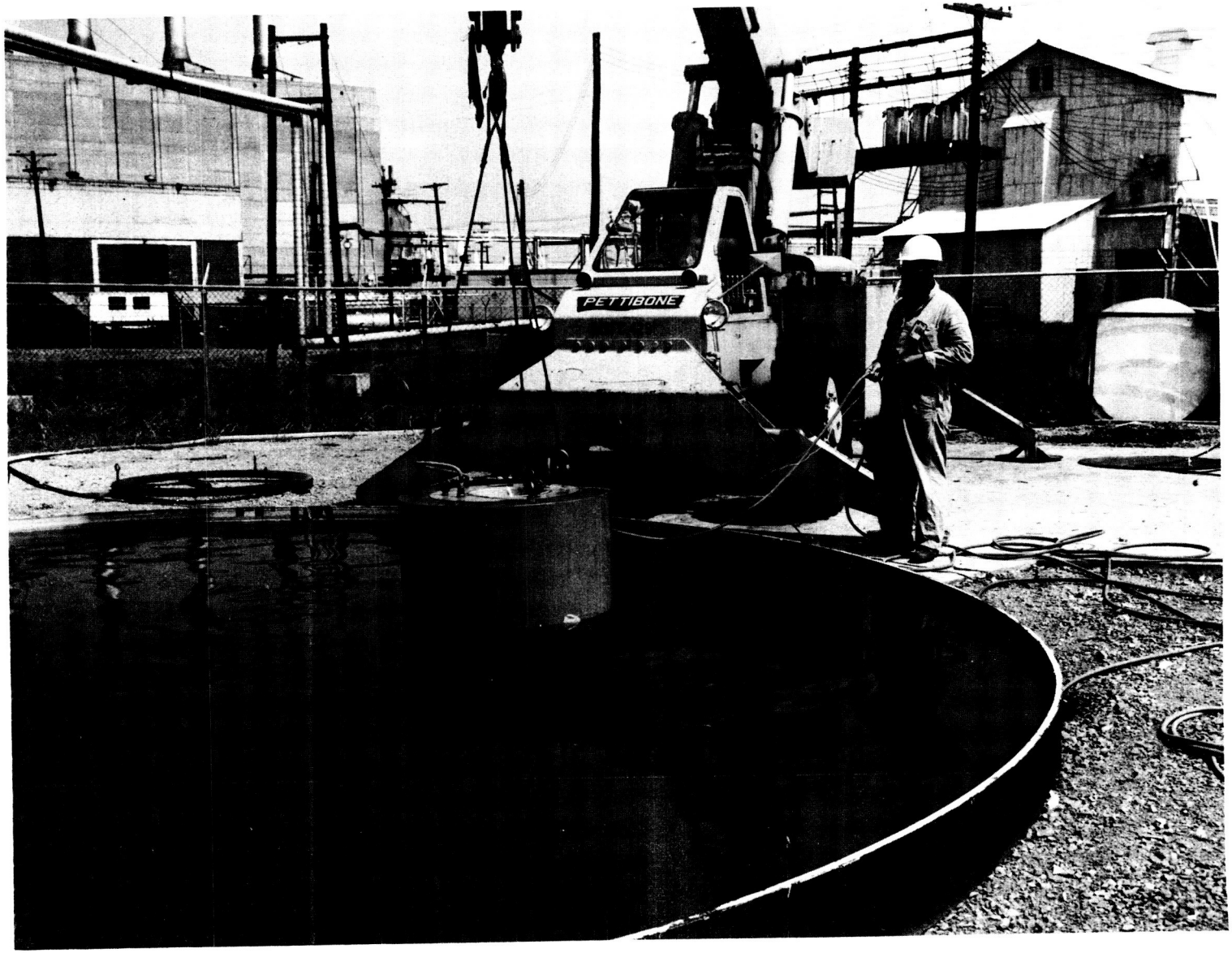

FIGURE 8. LOWERING ASSEMBLY IN WATER

FIGURE 9. RESULT OF FIRST FORMING EFFORTS

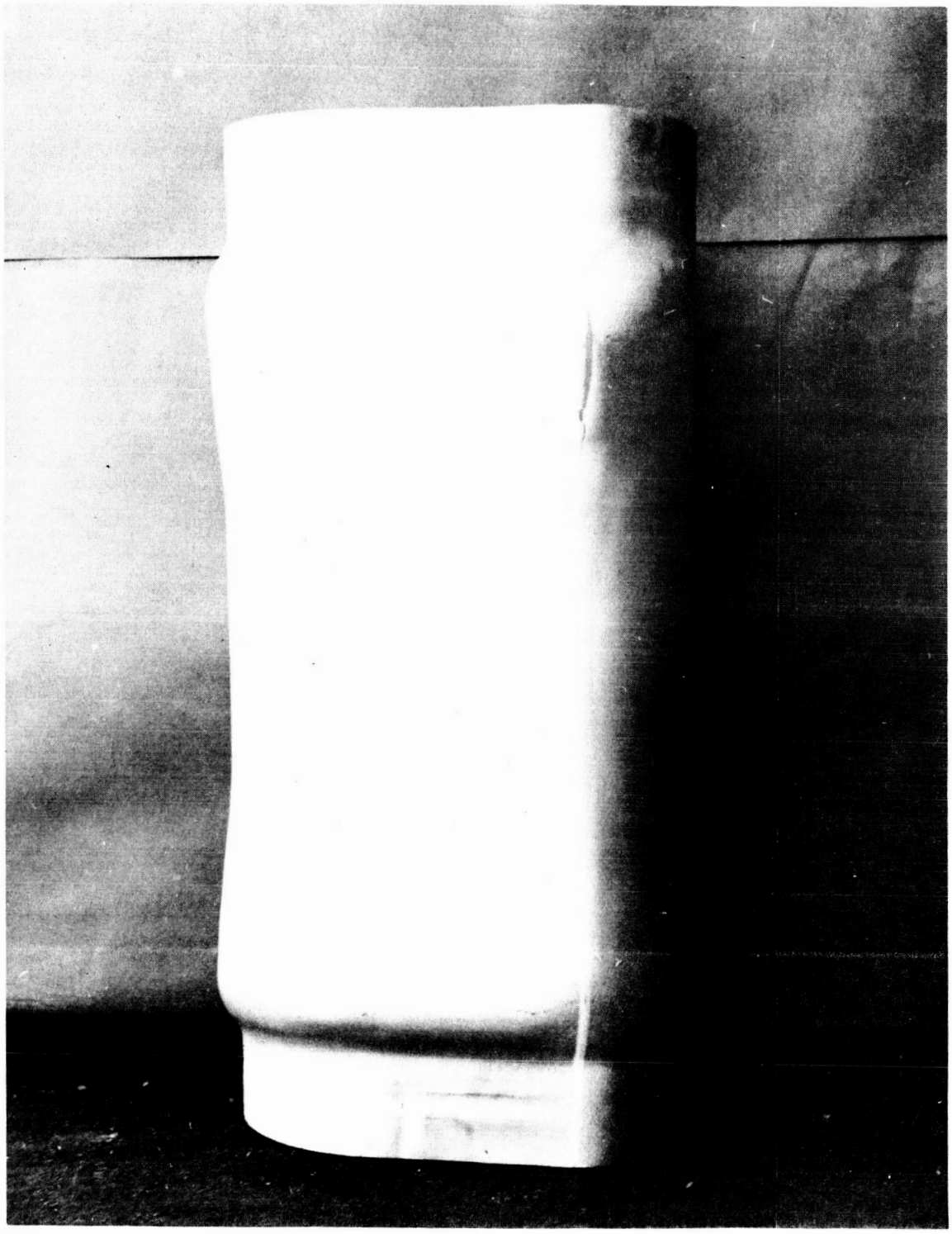

FIGURE 10. RESULTS OF FIRST ATTEMPT TO USE DOUBLERS FOR WELD REINFORCEMENT

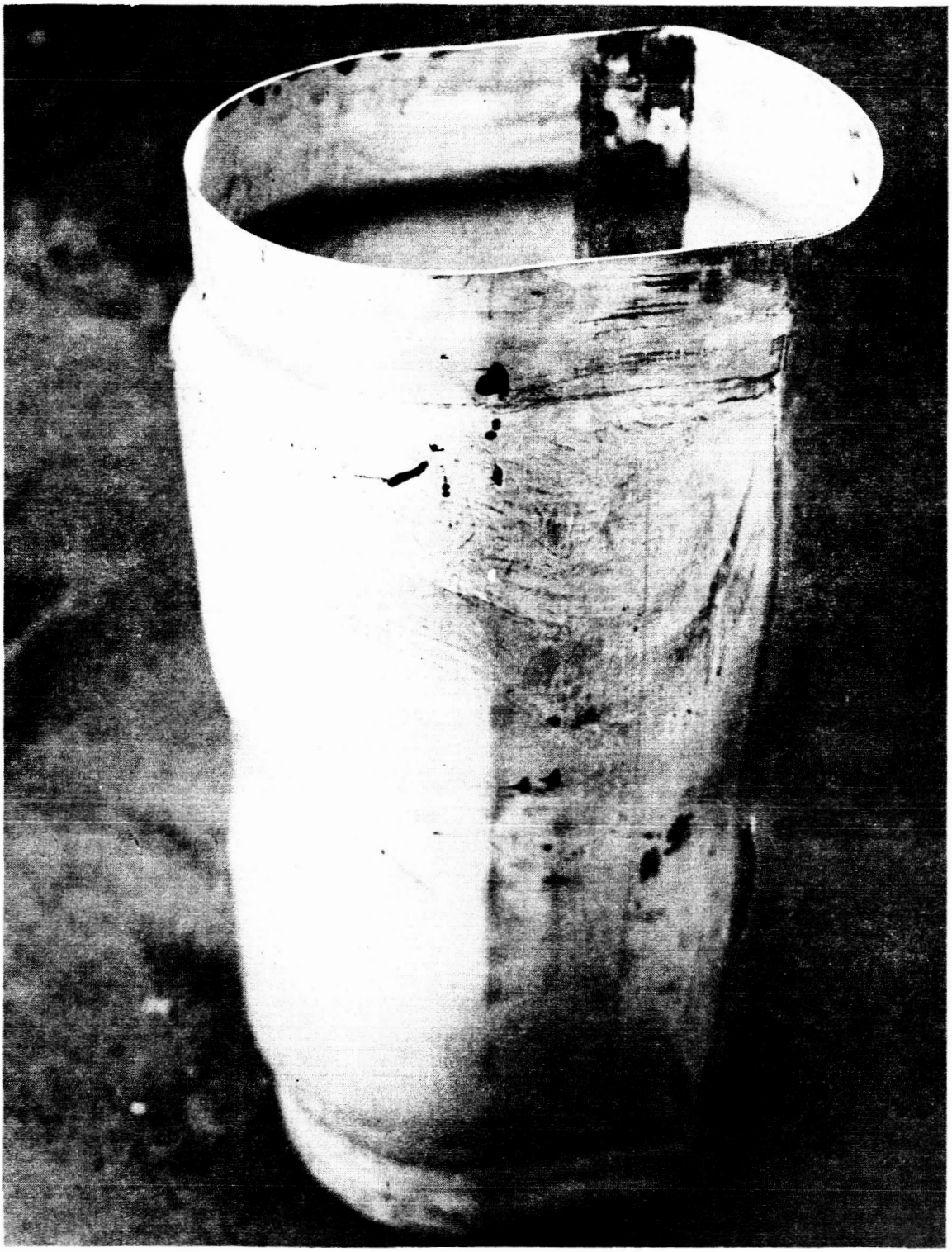

FIGURE 11. FRACTURED PART SHOWING BULGE

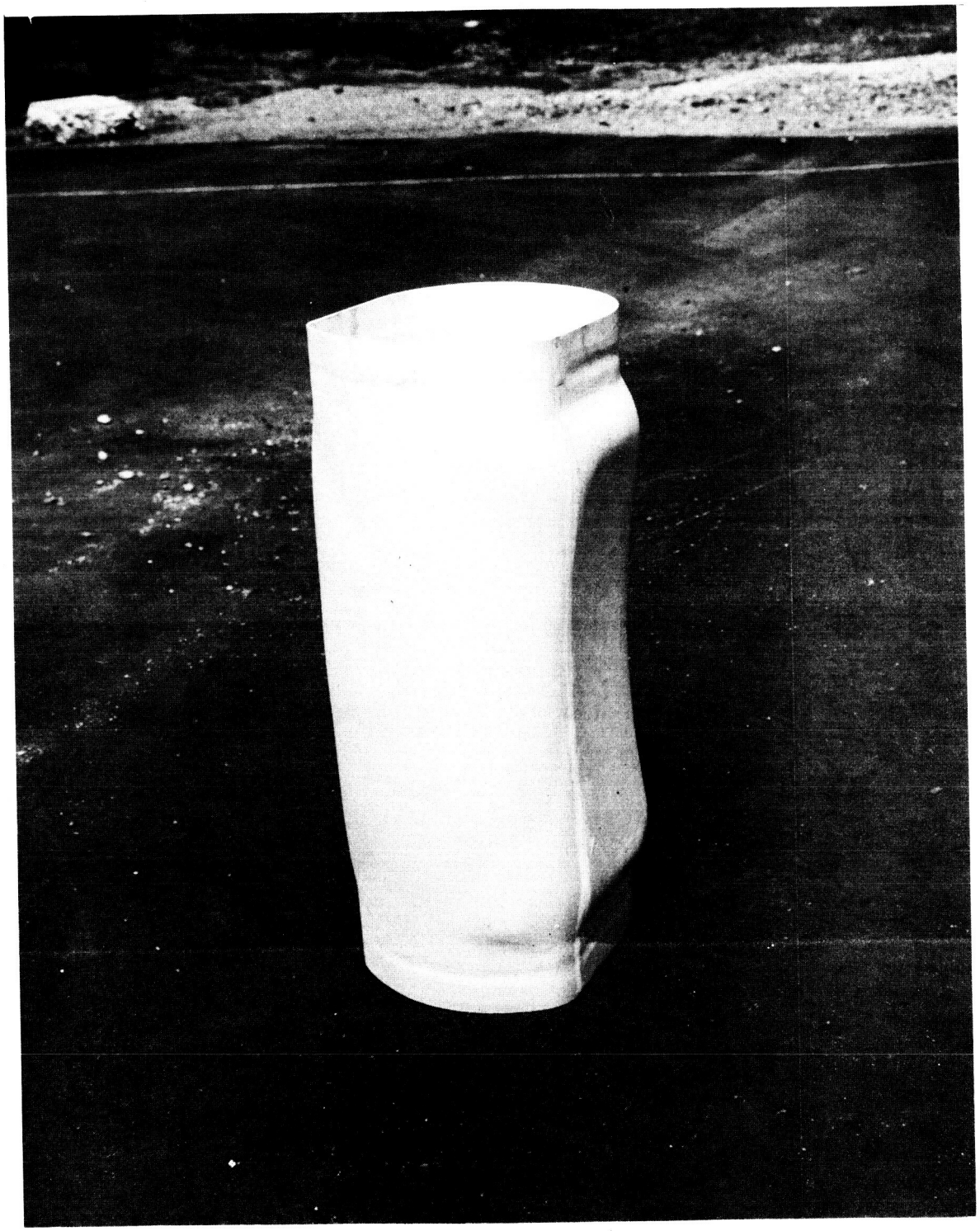

FIGURE 12. FINISHED PART MADE FROM TWO PART PREFORM OF 7039 ALUMINUM ALLOY

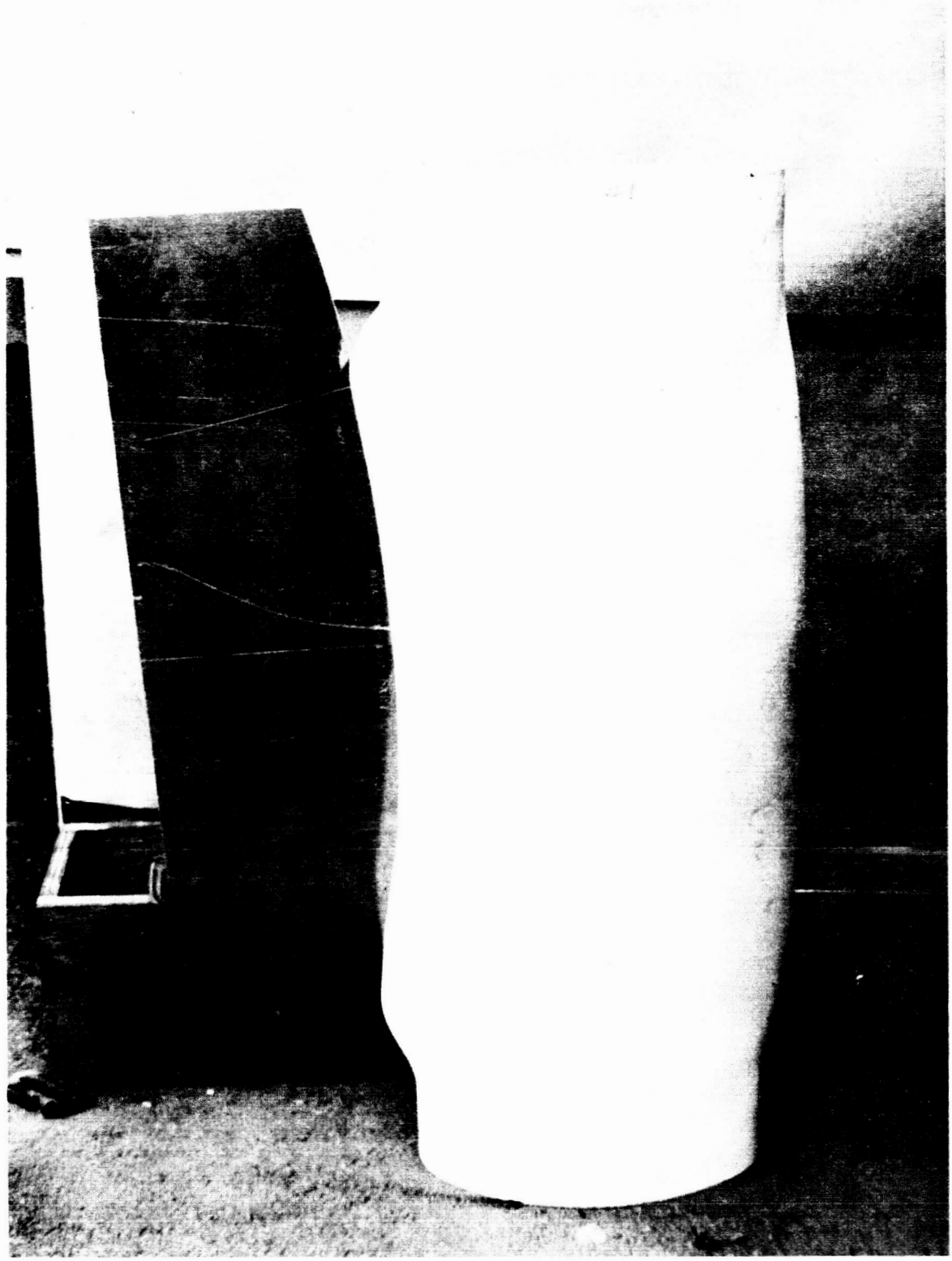

FIGURE 13. FINISHED PART MADE FROM ONE PART PREFORM OF 7039 ALUMINUM ALLOY SHOWING TEMPLATE CHECK

TITLE

APPENDIX A

EXPLOSIVE FORMING TORUS SUMP SEGMENTS

ABSTRACT

This document presents the process data necessary for explosive forming intermediate torus sump segments at Manufacturing Engineering Laboratory facilities, MSFC. All parts are formed from one die for subsequent trimming to the configuration of individual parts.

APPROVAL	CONCURRENCE
PROJECT ENGINEER E. Coleman	R-ME-D Otto K. Eisenhardt 7-28-64
SECTION CHIEF for P. H. Schuerer	R-ME-M J. P. Orr 7-22-64
BRANCH CHIEF W. A. Wilson 7-15	R-ME-T W. Franklin

NOTE: THIS DOCUMENT REFLECTS MANUFACTURING PROCESS DATA UTILIZED BY THE MANUFACTURING ENGINEERING LABORATORY AND SHALL NOT BE REFERENCED ON THE ENGINEERING DRAWINGS NOR CHANGED WITHOUT THE JOINT APPROVAL OF R-ME-D, R-ME-M, AND R-ME-T

REVISION SYMBOL AND DATE	APPLICABLE PART NUMBER
ORIGINAL ISSUE DATE: July 30, 1964	MPD IDENTIFICATION NUMBER: MPD 34001

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL

MANUFACTURING PROCESS DATA
EXPLOSIVE FORMING TORUS SUMP SEGMENTS

1. SCOPE

1.1 This manufacturing process data covers the tooling, process sequence and explosive charge weight, configuration and placement for forming torus sump segments from preformed tubes.

2. EQUIPMENT AND MATERIALS

2.1 Equipment - Tooling

a. MR&D-SK-400 - Explosive Form Die

b. MR&D-SK-702 - Air Bearing Plate

c. 12½-ton Pettibone Crane

d. Hand tools - 3/8" Straight Allen Wrench
3/8" Socket and Ratchet Wrench

e. Contour template

2.2 Material

a. Aluminum Preform - MR&T-SK-766

b. Zinc Chromate Tape

c. Missile tape

3. PROCESS SEQUENCE

a. Receive preform - Visual check that the weld bead on the outside surface is shaved to within ±.015" of parent metal thickness.

b. Tape two 3/16" x 6" x 35" rubber strips to the weld seam on the inside of the preform. Use double backed tape. Tape all edges with green missile tape to preclude water getting under the strip.

c. Use 12½-ton Pettibone Crane to position die form inserts on the air bearing plate.

d. Separate split inserts by removing four bolts and actuating the air bearing to move one section back approximately 12 inches.

e. Wipe die surfaces clean and position preform in the larger of the two split sections. Actuate the air bearing and bring the sections together. Align the sections with Dowel pins and secure with four bolts.

f. Seal for vacuum by the use of zinc chromate tape and missile tape. Before positioning the die in the pressure ring, make certain that vacuum pump gage shows 29 inches.

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL

g. Position die in pressure ring. Demolition Personnel shall set the wire grid for positioning of the charge at this time. Change the lifting cables from the inserts to the pressure ring. Remove slack from cables before positioning charge.

h. Position charge for the first shot (Demolition Personnel). This shall consist of a 30" length of 50 grain primacord located centrally between the two straight sides and 4" from the side which is opposite to the weld seam. At this time, recheck vacuum gage. If gage shows 29", attach cap to primacord. Signal for crane operator and lower die assembly into tank.

i. After crane operator leaves the pit area, a Demolition man will hook the cap wires to the firing circuit. When the Demolition man returns to the safety area, he will turn over his key to the firing circuit to his co-worker. As he leaves the pit area, red warning lights and bells will be turned on.

j. Detonate charge - shut off vacuum pump.

k. After Demolition Personnel have checked the area, the die shall be removed from the tank and positioned on 4" x 4" wood blocks. Lifting cables shall then be changed from the pressure ring to the die inserts and the inserts set on the air bearing plate.

l. Disassemble inserts and remove part.

m. Anneal the part in preparation for final sizing shot.

n. Repeat operations b through g.

o. Position charges for final shot (Demolition Personnel). Two 5" diameter circles of 50 grain Primacord shall be positioned an equal distance from the sides and 6" from each end. One 18" length of 50 grain primacord shall be positioned an equal distance from the sides between the circular charges. Recheck vacuum gage. Attach three caps to charges. Lower die into tank.

p. Repeat operations i through l.

q. Check part contour with templates

r. Clean surface

s. Inspect

t. Send to storage

CODE IDENT NO	DWG SIZE	MPD 34001
	A	SHEET 3 of 3

TITLE

APPENDIX B

FABRICATING TORUS SUMP TANK PREFORMS

FOR EXPLOSIVE FORMING

ABSTRACT

This manufacturing process data presents the equipment, material and manufacturing sequence necessary for the fabrication of torus tank sump preforms. The preforms will be used for explosive forming torus sump segments at the Manufacturing Engineering Laboratory facilities of MSFC.

APPROVAL	CONCURRENCE
PROJECT ENGINEER E. Coleman	R-ME-D Otto K. Eisenhardt 7-28-64
SECTION CHIEF for P. H. Schuerer O. M. Dommie, Jr.	R-ME-M J. P. Ort 7-22-64
BRANCH CHIEF W. A. Wilson 7-15	R-ME-T W. Franklin

NOTE: THIS DOCUMENT REFLECTS MANUFACTURING PROCESS DATA UTILIZED BY THE MANUFACTURING ENGINEERING LABORATORY AND SHALL NOT BE REFERENCED ON THE ENGINEERING DRAWINGS NOR CHANGED WITHOUT THE JOINT APPROVAL OF R-ME-D, R-ME-M AND R-ME-T

REVISION SYMBOL AND DATE	APPLICABLE PART NUMBER
ORIGINAL ISSUE DATE: July 30, 1964	MPD IDENTIFICATION NUMBER: MPD 34002

R-ME-M cca	MANUFACTURING PROCESS DATA	SHEET 1 OF 3
MSFC	MANUFACTURING ENGINEERING LABORATORY	NASA

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL

MANUFACTURING PROCESS DATA
FABRICATING TORUS SUMP TANK PREFORMS
FOR EXPLOSIVE FORMING

1. SCOPE

1.1 This manufacturing process data covers the material, equipment and process sequence for fabricating torus sump preforms.

2. EQUIPMENT AND MATERIAL

2.1 Equipment

a. Sheet Metal Shear

b. Press Brake

c. Roll Form (Slip Roll)

2.2 Material

a. Aluminum - 7039-W - Flat sheet - .125" thick

3. PROCESS SEQUENCE

a. Receive material - visual inspect surfaces for nicks and scratches.

NOTE

Surfaces must be protected through all handling and fabrication operations.

b. Shear to Size 36" x 60"

c. Deburr and break sharp edges

d. Anneal flat blank before forming

e. Form one piece segment as shown on Sketch MR&T-SK-766

f. Prepare mating edges for welding.

g. Weld preform

NOTE

All welding either tack or final to be performed according to acceptable techniques for this alloy.

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL

h. Shave outside of weld bead as called out on Sketch MR&T-SK-766

i. X-ray and repair if required

j. Anneal welded preform

k. Inspect

l. Deliver to explosive forming area in south end of Building 4702.

CODE IDENT NO	DWG SIZE	MPD 34002
	A	SHEET 3 of 3

APPROVAL NASA TM X-

DEVELOPMENT OF TECHNIQUE FOR EXPLOSIVE FORMING TORUS TANK SUMP SEGMENTS OF ALUMINUM ALLOY 7039

By

O. M. Tommie, Jr.
E. R. Coleman

The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC security Classification Officer. This report, in its entirety, has been determined to be unclassified.

This report has also been reviewed and approved for technical accuracy.

O. M. TOMMIE, JR.
Author

E. R. COLEMAN
Author

J. P. ORR
Chief, Methods Research and Technology Division

for W. R. KUERS
Director, Manufacturing Engineering Laboratory