AD-A046 106 WATERVLIET ARSENAL N Y F/G 19/6

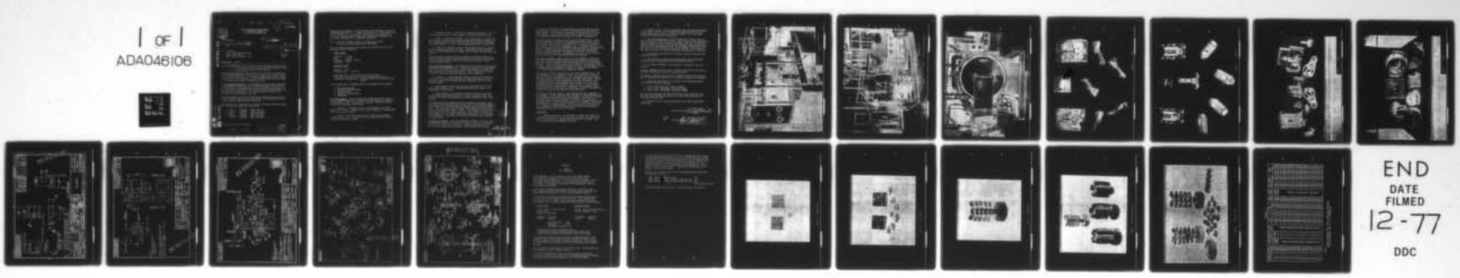
APPLICATION OF CERAMIC SHELL INVESTMENT CASTING PROCESS TO THE --ETC(U)

OCT 74

UNCLASSIFIED NL

1 OF 1

ADA046106



END

DATE FILMED

12-77

DDC

NTIS 10167

(1) File

19 AUG 1975

DEPARTMENT OF THE ARMY
WATERVLIET ARSENAL
WATERVLIET, NEW YORK 12189

AD A046106

SARWV-RDS-AP

(11) 25 Oct[redacted]74

SUBJECT: (9) Final Technical Report,

DDC
NOV 8 1977
A

(12) 25p.

TO: Commander
U. S. Army Armament Command
ATTN: AMSWE-PPW-PB
Rock Island, Illinois 61201

PROJECT NO.: 6706769

PROJECT TITLE: (6) Application of Ceramic Shell Investment Casting Process to the Production of Castings Now Being Produced by the Solid Mold Investment Casting Process,

Statement of the Problem: This project was initiated to determine the potential advantages of the Ceramic Shell Process over the Solid Mold Investment Casting Process in the areas of dimensional control, surface finish, size, and configuration. The Solid Mold Process had been used at the Watervliet Arsenal for twenty-five years.

Background and Introduction: The Watervliet Arsenal became interested in the potential offered by the Solid Mold Investment Casting Process in 1943 and set up an experimental foundry to explore the process. In 1944 Watervliet Arsenal became the first arsenal to produce production castings for gun components. From 1944 through 1969 thousands of castings for various weapons were made.

The Ceramic Shell Process used today had its beginning during the later fifties, and for many years each foundry had its own formula for the ceramic slurry it used to produce the shell.

The following five components were choosen to be made using this Ceramic Shell Process to evaluate the areas above:

1.	Clamp*	B8769489	105mm, M68 Gun
2.	Sleeve*	C7238349	105mm, M2A2 How.
3.	Sear*	C7238384	105mm, M2A2 How.
4.	Bracket*	F8766064	90mm, M67 Rifle
5.	Breech*	F8768203	90mm, M67 Rifle

AD No. ___
DDC FILE COPY

*Component drawings are attached

371 050

Approach to the Problem: Several ceramic slurry formulas are available from companies such as E. I. DuPont de Nemours & Co., Nalco Chemical Co., Stauffer Chemical Co., and others. After reviewing literature and talking to representatives of different companies, we decided to use the "Ludox" formula by E. I. DuPont de Nemours Co.

NOTE: Ludox HS collodial silica is a suspension of silica in water containing approximately 30% solids.

The slurry formula that we used in making up the shells for the five components was the following:

ZIRCON SLURRY

Ludox HS - 2.5 gal.
Water - 1.0 gal.
Zircon No. 3 Powder - 100 lbs.
Surfactant - 10cc

MOLOCHITE SLURRY

Ludox HS - 8 gal.
Molochite 200 - 100 lbs.

First two coats - zircon slurry with zircon stucco.
Third coat - molochite slurry with 60-90 molochite stucco.
Fourth and following coats - molochite slurry with 30-60 molochite stucco.

The following types of equipment had to be procured for the project:

1. Wax injection press
2. Autoclave dewaxing system
3. Fluidized beds
4. Slurry turn table mixers
5. Humidifier

50 Ton Wax Machine: Specifications were written for the 50 ton wax injection press (Figure 1). A contract for the machine was awarded to Leyden Hydraulics Inc., Melrose Park, Illinois. Listed are some of the important features of this press:

1. Injection - Capacity of 10 lbs. per injection with a total capacity of 157 lbs. - pressure from 50 psi to 2000 psi - system purged after every injection cycle.

2. Platen - Consists of an area of 28" x 28" with a clamping pressure up to 50 ton. Platen has T-slots to hold die halves and is capable of being water cooled.

3. Hydraulic System - Consists of a 45 gallon tank with a 7-1/2 HP motor provided with oil filter, magnetic clean-out and cooling coil.

4. Nozzle - Electrically heated. It is controlled by a solid state proportional control, has universal movement to facilitate alignment of die, automatic shut-off when retracted from die to prevent wax leakage, adjustable height 1" to 7-1/4", and controlled speed rate into the die.

5. There is an emergency button to return the machine to a neutral position during any part of the cycle. The machine is also equipped with a special parting device to prevent the die from sticking to the top platen.

This wax injection press gives the capability of obtaining closer dimensional control pattern to pattern, better control of the wax because of its consistant mixing action, and the ability of making a wider range of pattern sizes.

Autoclave Dewaxing Systems: Specifications were written for the autoclave dewaxing system (Figures 2 & 3). Contract was awarded to Casting Supply House, Inc., New York, New York. Actual manufacture of the system was done by Welding and Steel Fabrication Co., Inc., Tonawanda, New York. Listed are some of the important features of this autoclave:

1. Autoclave - 150 psi operating pressure, designed in accordance with Sec. VIII of the 1968 ASME CODE, with hydraulic opening of the door after pressure is released from the system and a 36" I.D. x 48" straight length.

2. Steam Supply - Boiler type 150 psi rating with electric fired water tube, rating of 37 HP 1,238,686 BTU/HR and steam capacity of approximately 1200 lbs/hr.

3. Safety Factors - An electrical interlock prevents activation of the system if the mechanical lock is not in a safe position. The autoclave and boiler have automatic blow off of pressure if they reach 165 psi.

The complete autoclave dewaxing system is mounted on a singular steel base that measures 12 feet long by 7 feet wide. The autoclave dewaxing system gives us an efficient means of removing the wax from the ceramic shell. Previously this operation had to be performed by placing the shells into a furnace at 1600° - 1800°F. This caused an instant ignition of the wax and in turn caused dense black, oily smoke in the area for approximately 10 to 15 minutes depending on the amount of wax that had to be burned out. This means of burn out also caused severe cracking on larger shells.

Discussion of Results: The Clamp, B8769489, (Appendix I) was the first component made using the Ceramic Shell Process. The first information that we had to obtain was the amount of shrinkage we would have to allow for in making the wax patterns. With the Solid Mold Process,

White Section
Buff Section
AVAILABILITY CODES
Letter on file
A

shrinkage was figured at 1 to 2% depending on how the part was gated. After a couple of runs on the Clamp, we determined an approximate 3% shrink factor. This increase in shrinkage is due mainly to the shell being made of a stable material that does not expand during firing. For detailed information on casting of this Clamp, see Appendix 1.

The Sear, C7238384, (Figure 4) was the second component made. We had ten (10) patterns per set up or 30 components per heat and used the same ceramic slurry mix for this component as we did for the Clamp and will also use for all other components cast. We obtained good surface finish, obtained class A soundness and met dimensions of the casting drawing. Further study was made into the function of the component and it was determined that by changing the 2.113-.005 dimension to 2.090 ± .015 and the 3.300 + .02 dimension to 3.300 ± .02 we would be able to cast both, thus eliminating machining operations.

The Sleeve, C7238349, (Figure 5) was the third component to be cast. The shell consisted of nine components and was poured, two shells per heat. The finish, soundness and most dimensions of the casting drawing were met. During the centerless grinding operation to hold the 1.248 - .003 dia., one of the casting dimensions was lost. The component drawing is being studied to determine if a change in tolerance can be made. This will be accomplished under production funding.

The Bracket, F8766064, (Figure 6) was the fourth component cast. The wax patterns for this component were made on a contract by Hitchiner Mfg. Co., Milford, New Hampshire. This arrangement was made because we did not have the 50 ton wax machine completely operational. Making up a gating system to obtain soundness for a part of this size and configuration involved considerable hand working of the waxes. We were able to obtain a good surface finish and met x-ray and magnetic particle inspection requirements. Dimensions were a problem. Wall thickness was met, but to meet other dimensions requires straightening fixtures for both the wax patterns and the castings.

The Breech, F8768203, (Figure 7) was the fifth and final component to be processed. As with the other four components, shrink dimensions had to be calculated and drawings for the die made. A contract to make the die and 20 wax patterns was awarded to Tempcraft Tool & Mold Co., Cleveland, Ohio. The patterns were received in a damaged condition but fortunately the 50 ton wax injection press was in operation and we were able to make the needed patterns. The heavy sections of the casting were acceptable in finish and soundness, but there were problems in completely filling the .110 wall thickness.

Conclusions:

1. Dimensional Control - We were able to obtain good control on the smaller components. On the two larger castings, the Bracket and Breech, we had problems holding dimension because of warpage. This can be controlled by straightening fixtures.

2. Surface Finish - All five components cast provided exceptionally good surfaces. On the Sear, C7238384, the surface on the 2.113-.005 would be acceptable as cast for a working surface. On a solid mold casting this would have to be machined.

3. Size and Configuration - We encountered no problems in making any of the five different wax patterns. We did find out that when making larger wax patterns like the Bracket F8766064, some sort of holding or sizing fixtures should be used to prevent warpage of the patterns before they are set up for ceramic coating. We had trouble being able to cast the .115 + .01 wall thickness on the Breech F8768203. This thickness will have to be cast to a thicker dimension and machined to finish size.

4. Less decarb was found on the castings than those made with the Solid Mold Process.

5. Wax pattern to casting is possible within three working days compared to five working days with the Solid Mold Process.

6. The Clamp, B8769489, is being made as a production item, not in-house.

The Sear, C7238384, and the Sleeve, C7238349, need minor corrections in tooling to make them available as production items.

The Bracket, F8766064, and the Breech, F8768203, need extensive future work to determine the feasibility as acceptable castings for production.

7. During the initiation of the project, the following castings were made for prototype castings:

a. 12 ea. Poppet CPR-9746 152mm Gun XM150
b. 30 ea. Lever WTV-C24684 60mm Motar XM225
c. 60 ea. Foot WTV-C23903 60mm Mortar XM225

The first two prototype Foot were machined at a cost of $125.00 each. The cost of the castings were $24.05 and $22.00 machining cost, or a savings of $78.95 each.

8. Presently we are reviewing drawings on the 20mm Auto Gun Dual Feed System.

Project Officer: A. L. Palladino for
L. C. JOHNSON

mb

Approved: Edward L. Hebenstreet
EDWARD L. HEBENSTREET
Chief, Application Engr. Div.

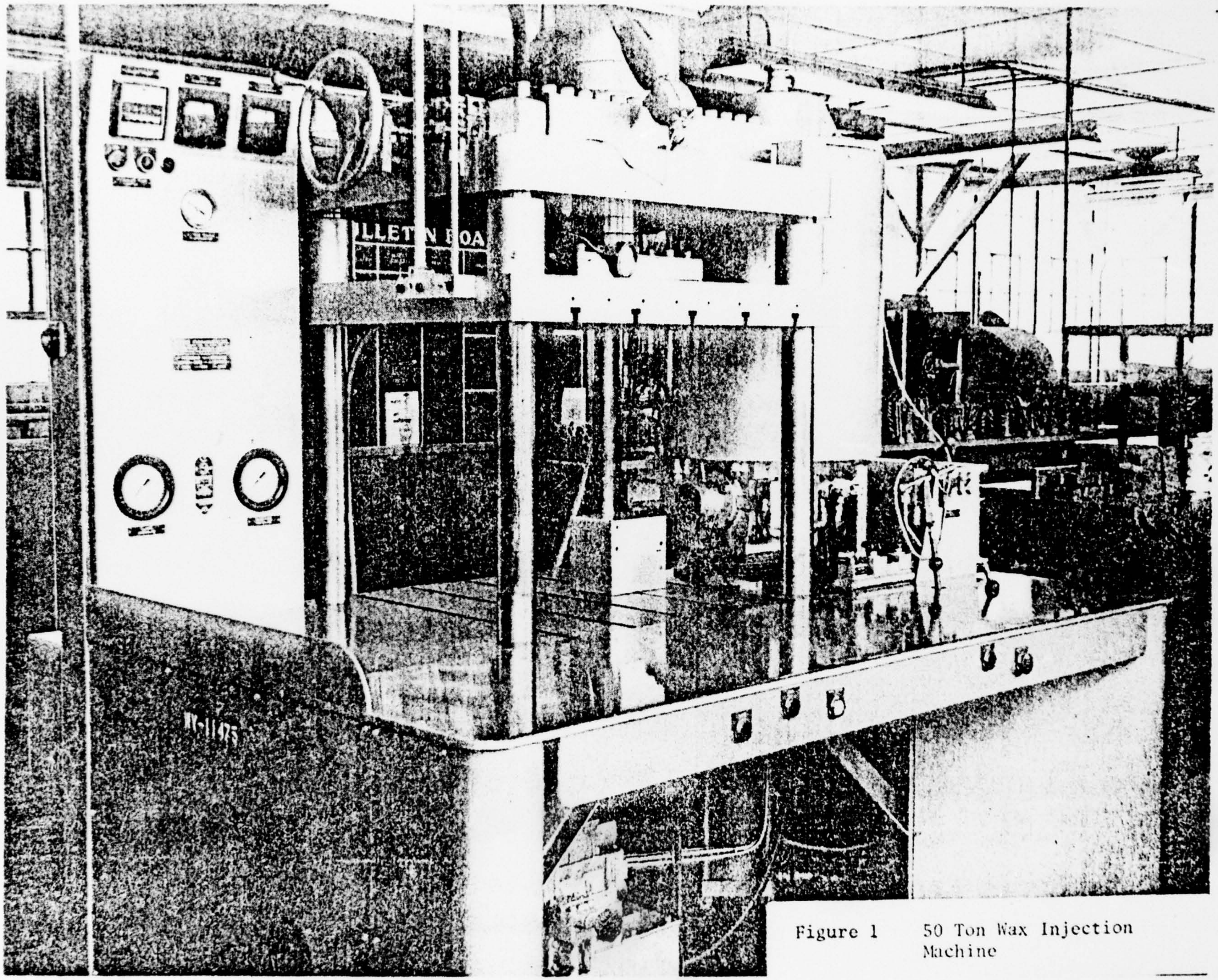


Figure 1   50 Ton Wax Injection Machine

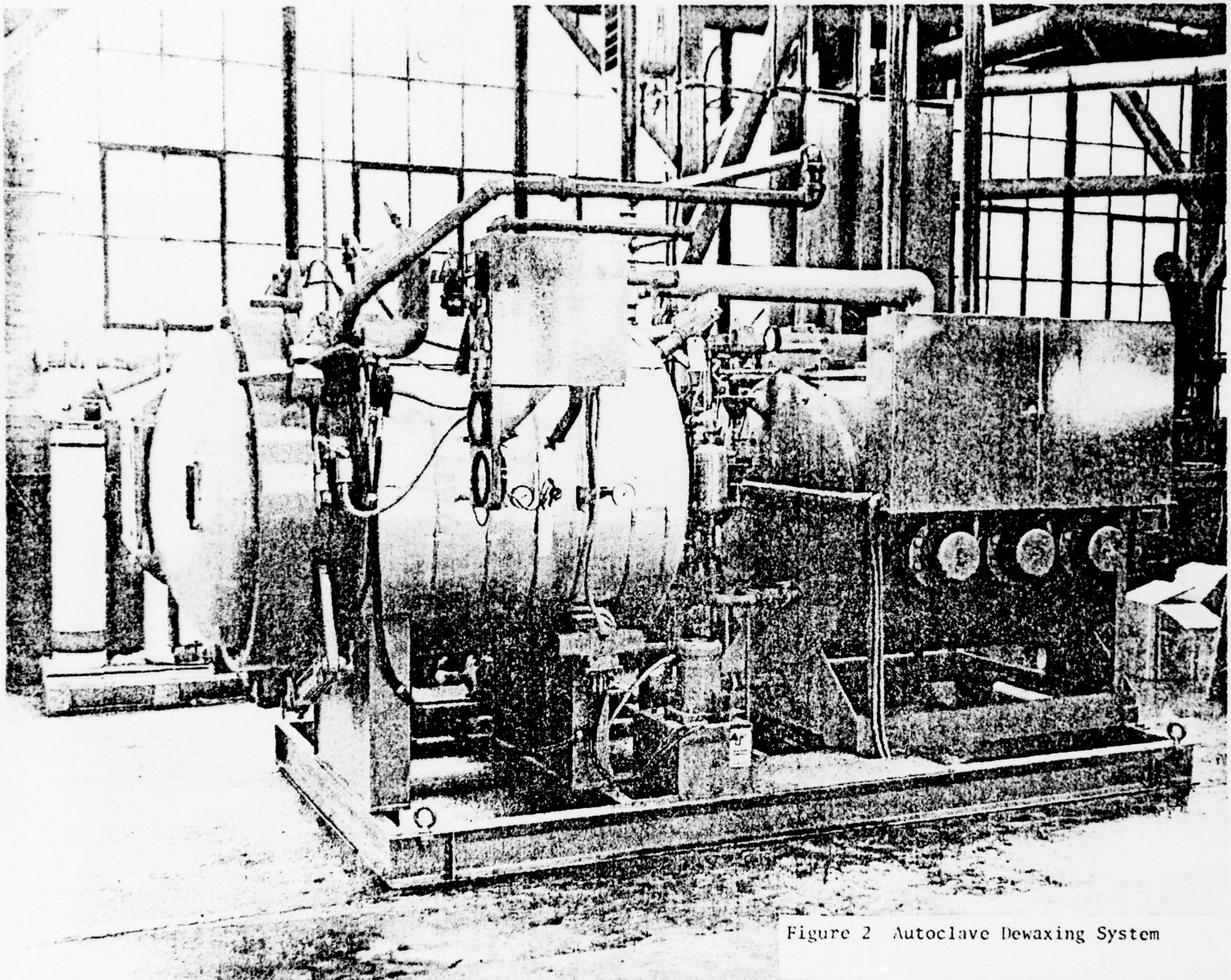


Figure 2 Autoclave Dewaxing System

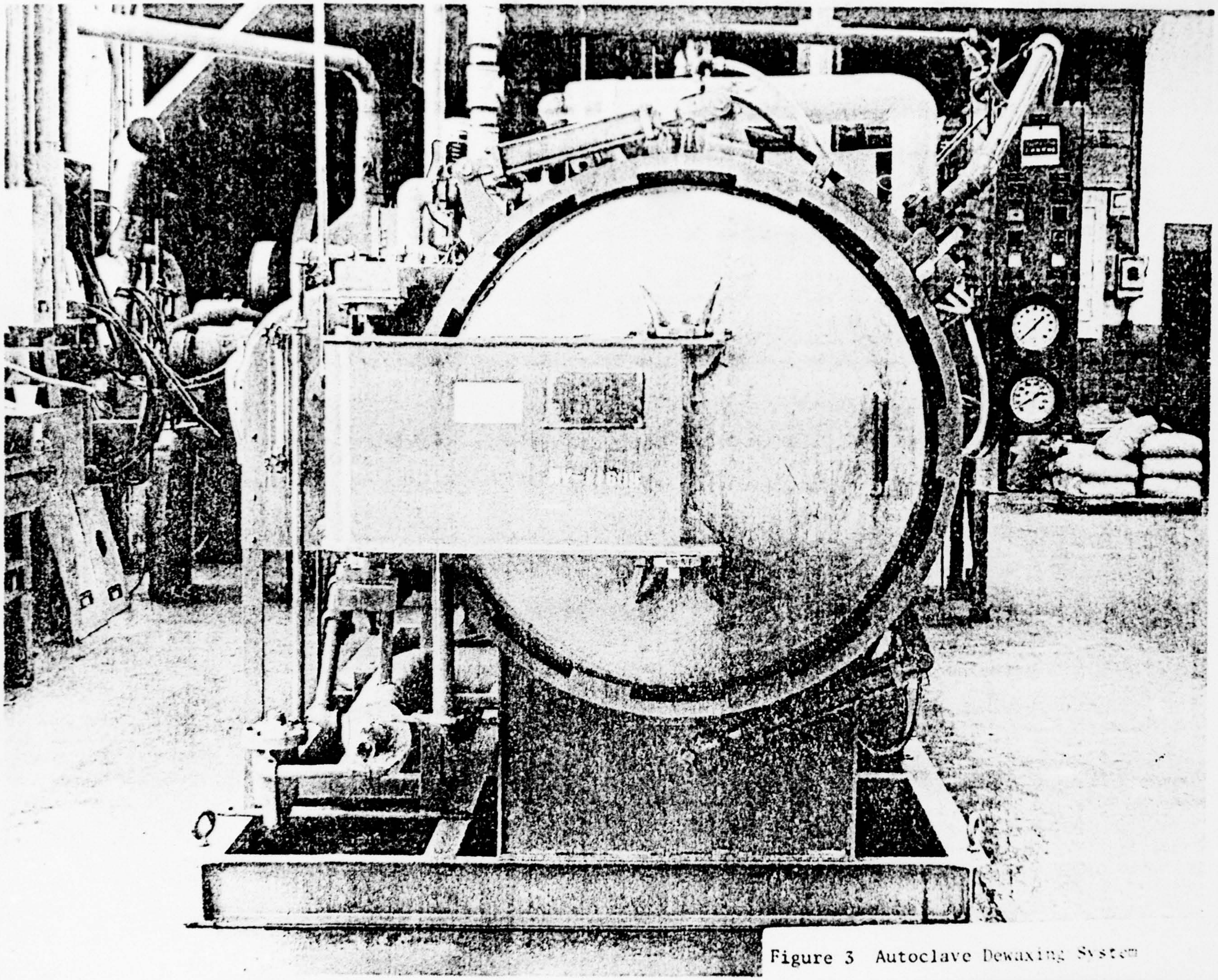


Figure 3 Autoclave Dewaxing System

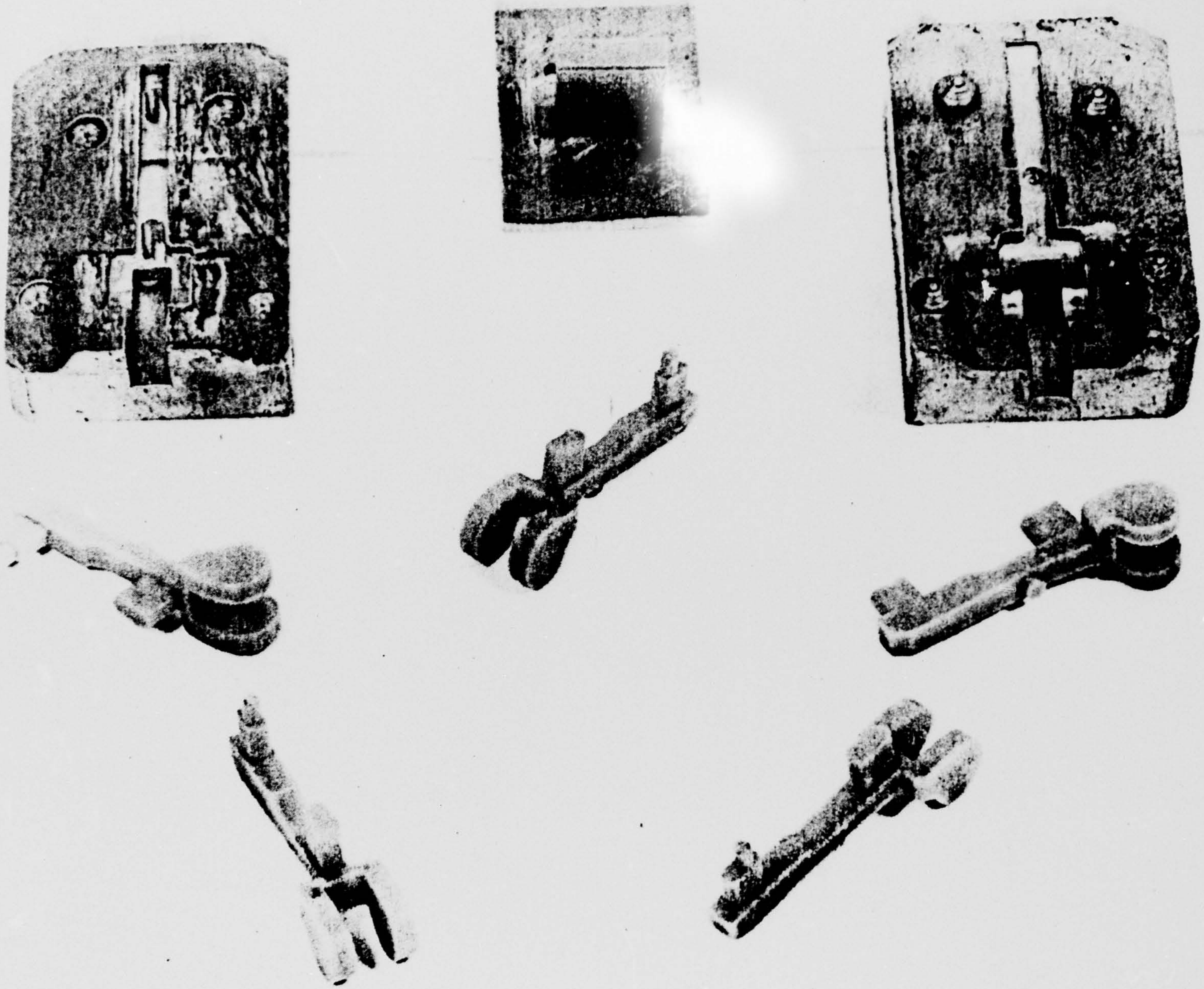


Figure 4 Sear

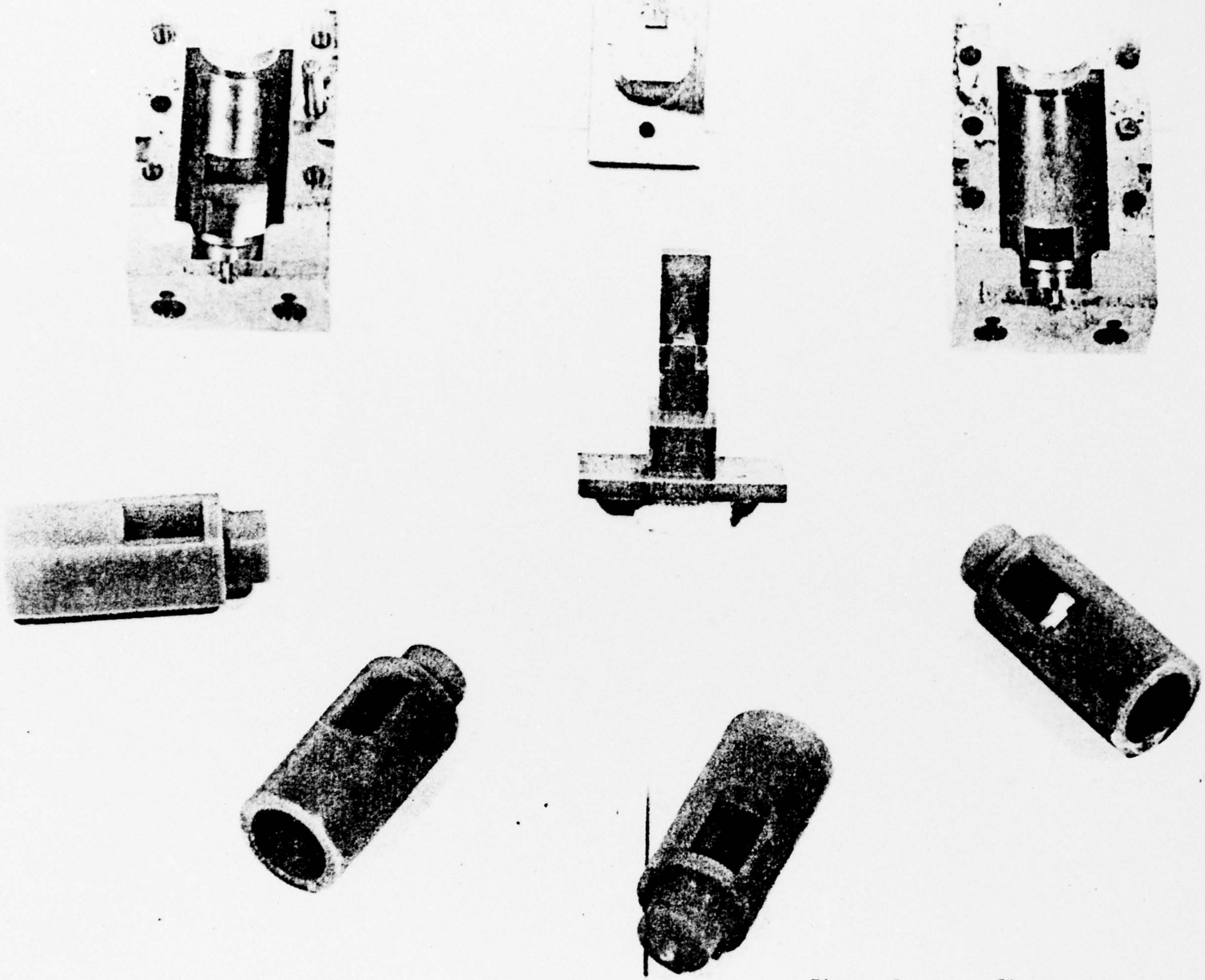


Figure 5 Sleeve

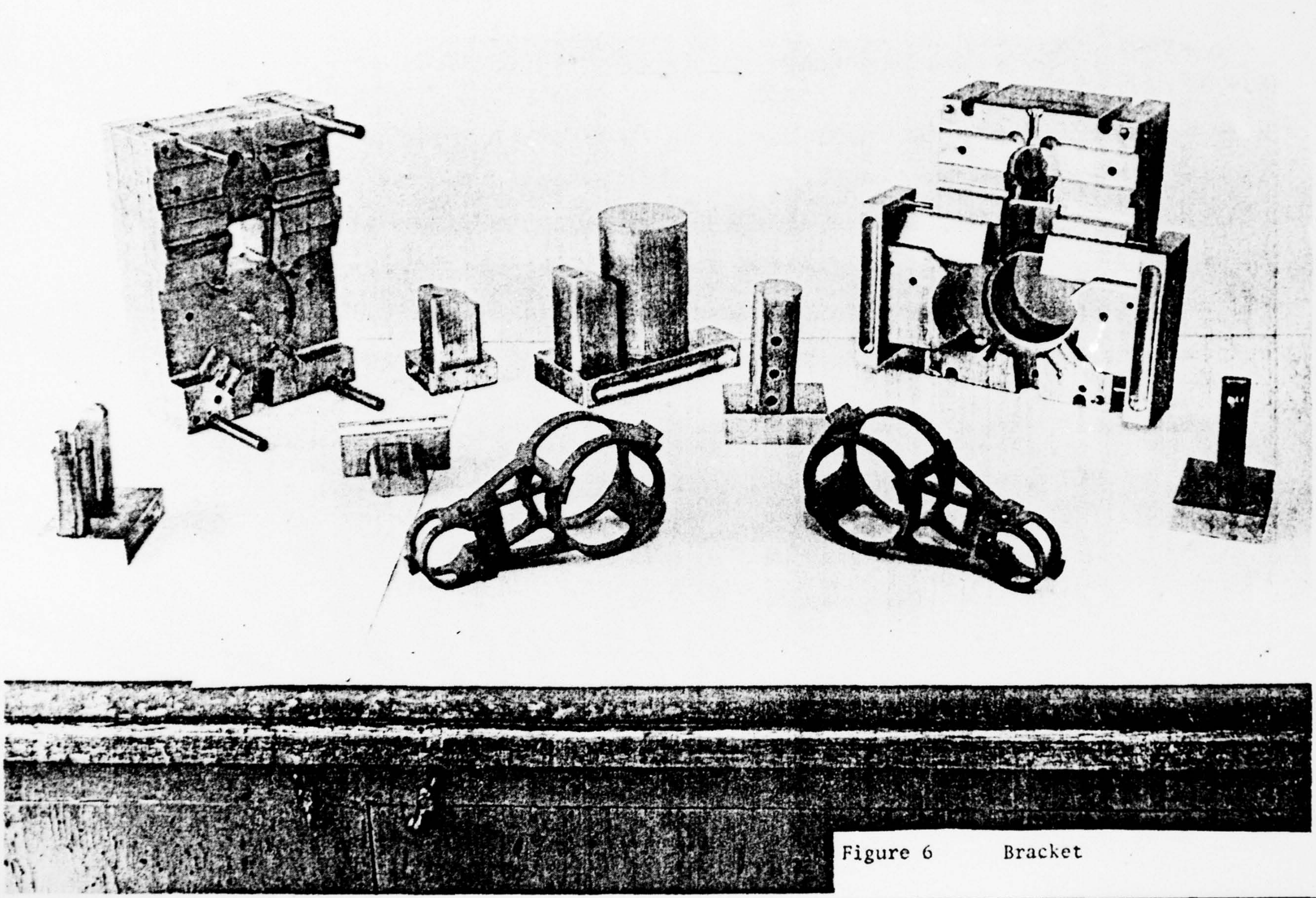


Figure 6 Bracket

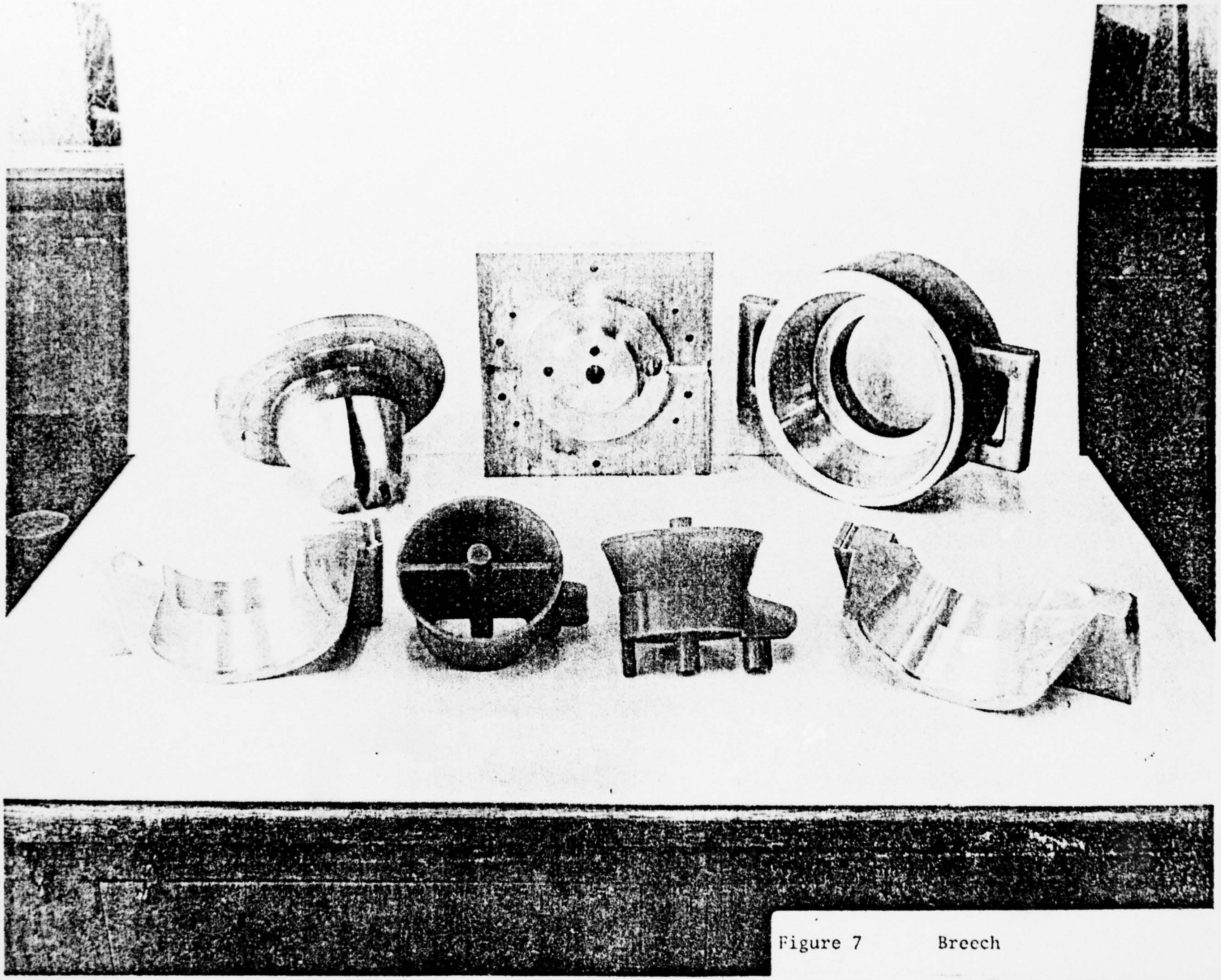
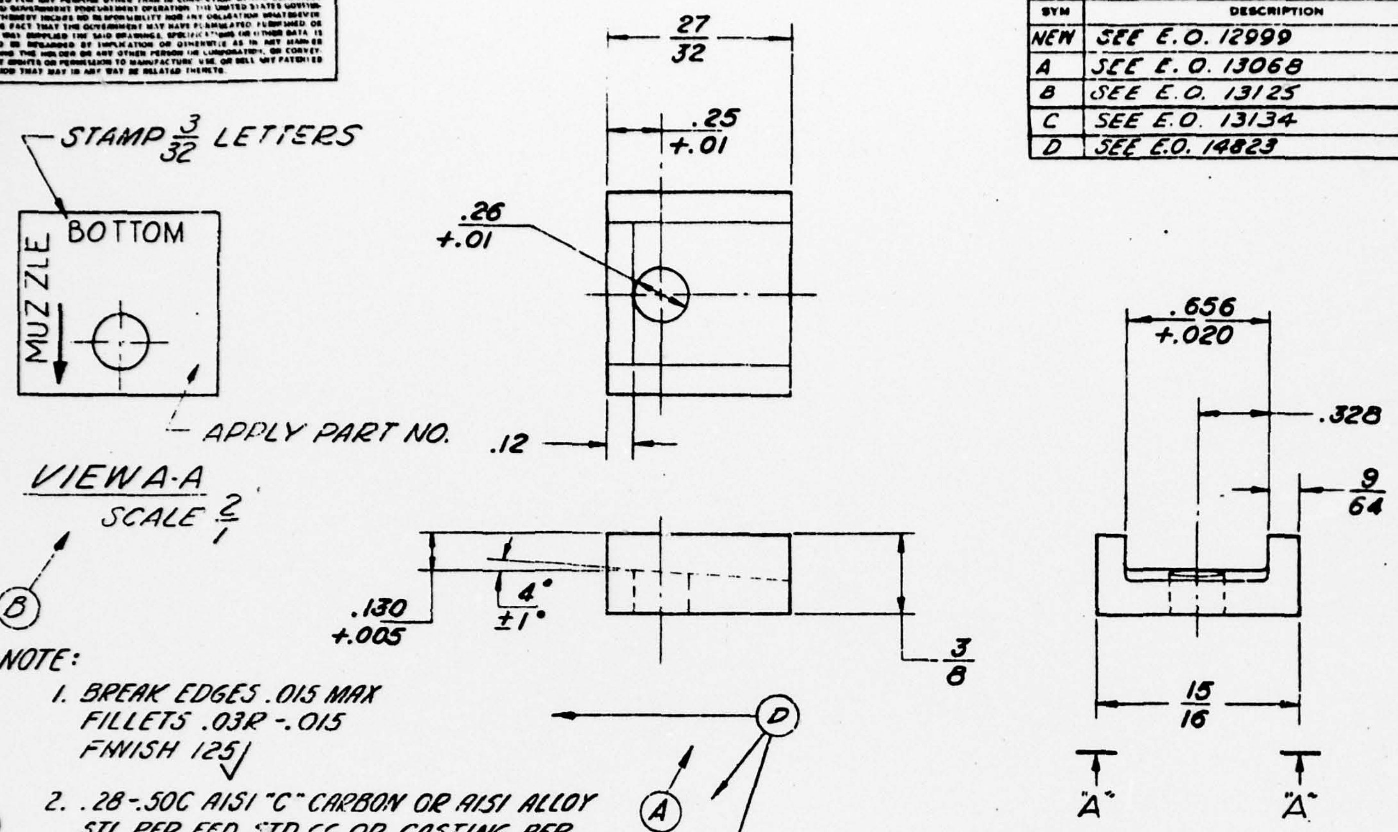


Figure 7 Breech

O.O. FORM 1 OCT 50 1176-1

B 8769489

REVISIONS				
SYM	DESCRIPTION	DATE	APP'D	MK NO. FILMED
NEW	SEE E.O. 12999			4 NOV
A	SEE E.O. 13068	12-3-63		DEC
B	SEE E.O. 13125	1-21-64		27 JAN 1964
C	SEE E.O. 13134	7-31-64		
D	SEE E.O. 14823	7-1-66		



NOTE:

1. BREAK EDGES .015 MAX
   FILLETS .03R -.015
   FINISH 125√
2. .28-.50C AISI "C" CARBON OR AISI ALLOY
   STL PER FED STD 66 OR CASTING PER
   DWG. B11577275 COMP 1,2,3,5 OR 9 CLASS NONE

(C)

PART NO. 8769489

F8765949 SH3	GUN: M68 CANNON, 105mm		
SEE ENGINEERING RECORDS			
NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
APPLICATION		QTY REQD	
DO	APPLY PART NO. AS SPECIFIED	MICROFILMED DATE	

PHYSICAL PROPERTIES	
Y.S. MIN	
Y.S. MAX	
TS	
EL 2	
RA	
BH	
RH	C30 C35

ORIGINAL DATE OF DRAWING: OCTOBER 30, 1963

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON FRACTIONS ± 1/64, DECIMALS ±.01, ANGLES ±5°

MATERIAL: SEE NOTE 2

FINAL PROTECTIVE FINISH: DWG A7308099 APPLIES

MAT'LS | PROCESS.

CLAMP

DEPT OF THE ARMY
WATERVLIET ARSENAL
WATERVLIET, N. Y.

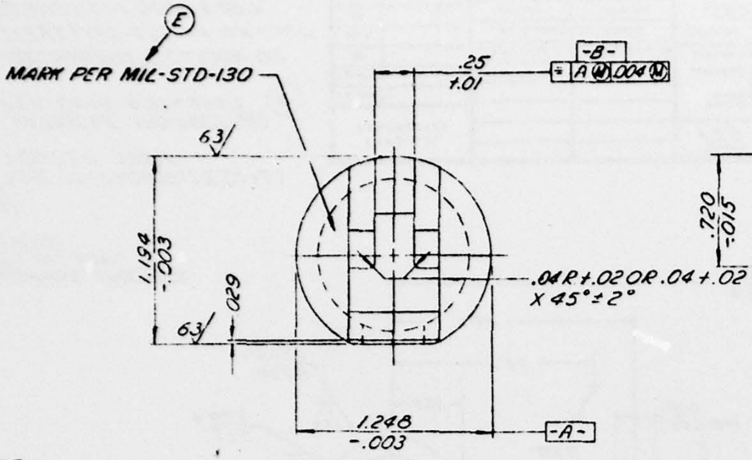
B 8769489

SCALE 2/1 | UNIT WT | CODE 19206 | SHEET OF

DIETZGEN New York 138-3 Approved Drafting Film 7-11 63 1500

C 7238349

SYM	DESCRIPTION	DATE	APP'D
C	———	11-2-65	
D	REDRAWN & REVISED		
	SEE E.O. 14610	4-1-66	
E	SEE WVR 26816	2-23-72	

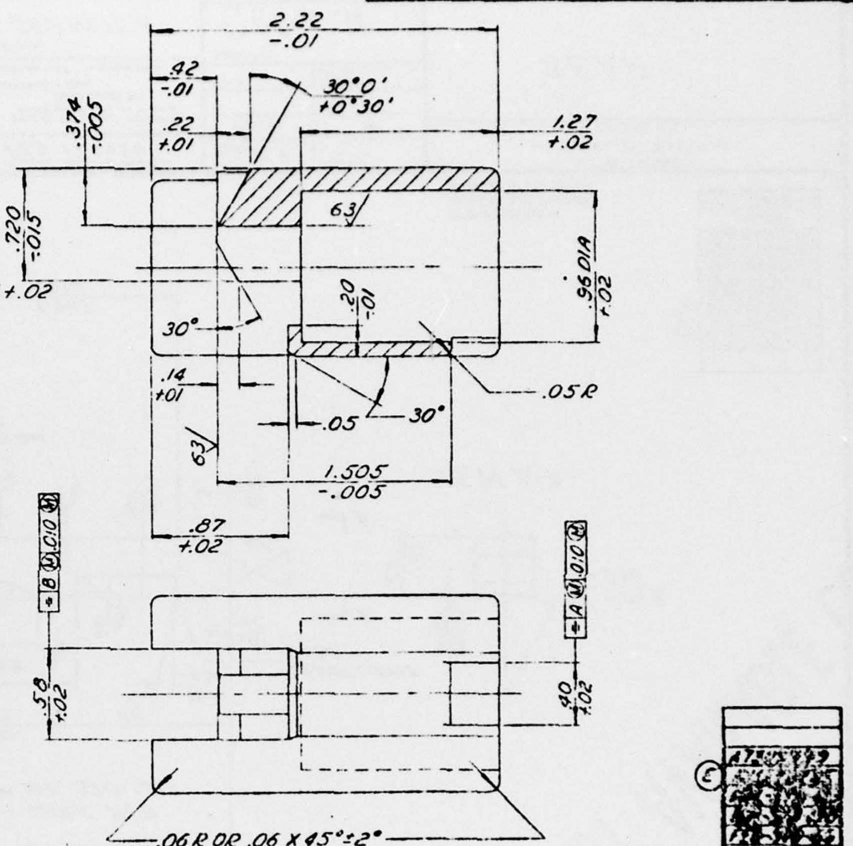


NOTES:

UNLESS OTHERWISE SPECIFIED:
BREAK EDGES .015 MAX
FILLETS .02 R -.01
FINISH 125

MATERIAL: .23 CARBON MAX AISI ALLOY STEEL
PER FED-STD-66 OR CASTING PER DWG
8115 77275 COMP 4 CL. B

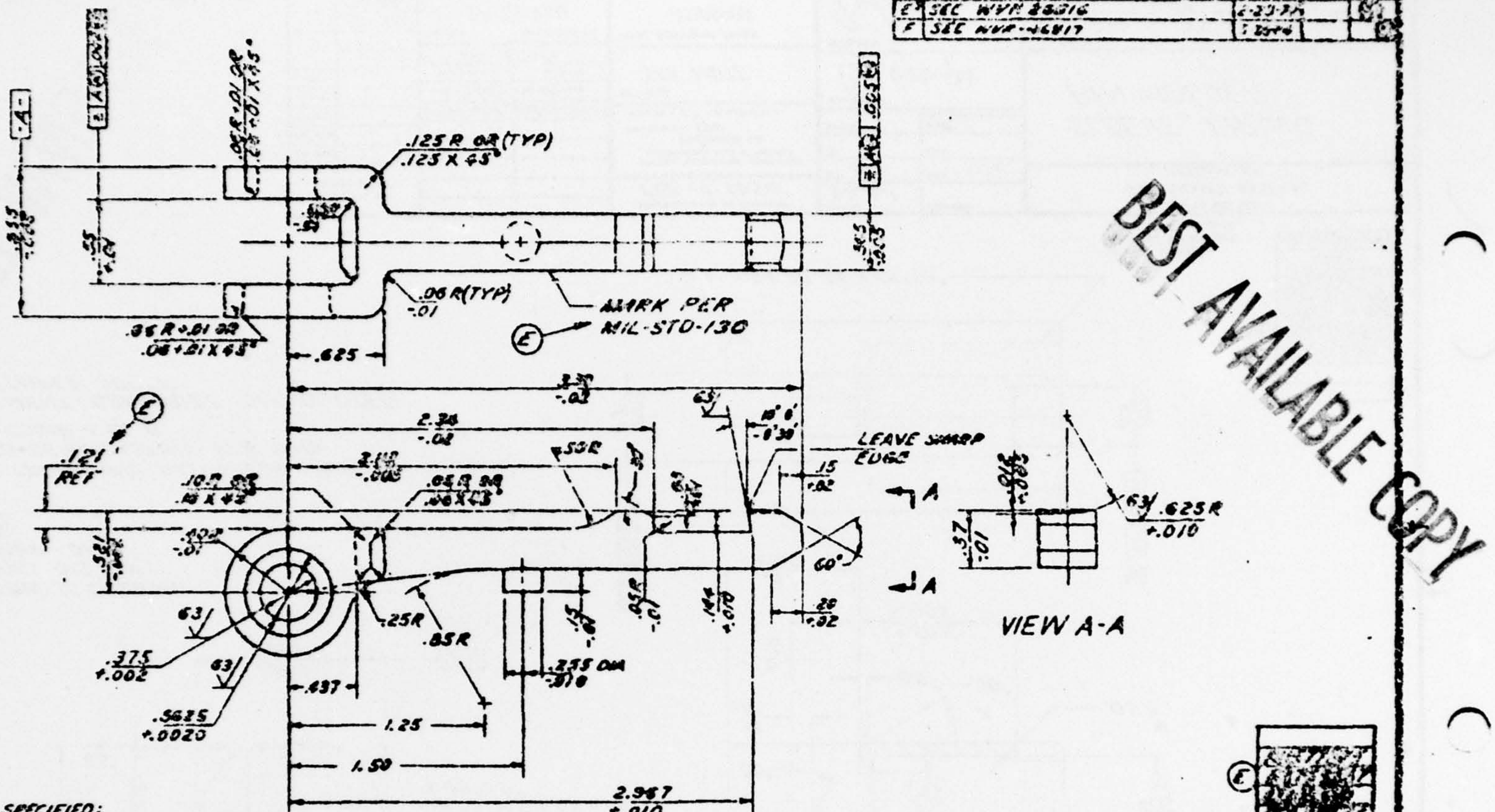
HEAT TREATMENT: CARBURIZE .01 + .01 DEEP,
MINIMUM TEMPER 300°F



PHYSICAL PROPERTIES		APPLICATION	ORIGINAL DATE OF DRAWING		
		C5508862 / FIRING LOCK	FEB 17, 1954	REN	E.C.Q.
			MATERIAL: SEE NOTE	C C Albright	WATERVLIET ARSENAL
BH	15 N 92 / 15 N 88	AS SPECIFIED	FINAL PROTECTIVE FINISH: A7309929		SLEEVE, FIRING PIN HOLDER
					C 19206 7238349
					SCALE 2/1

C 7238384

SYM	DESCRIPTION	DATE
D	REVISED WAS 7238	5-2-55
	SEE E.O. 1463	8-1-61
E	SEE WVR 28316	2-23-71
F	SEE WVR-46817	



NOTES:

1. UNLESS OTHERWISE SPECIFIED:
   BREAK EDGES .015 MAX.
   FILLETS .02 R -.01

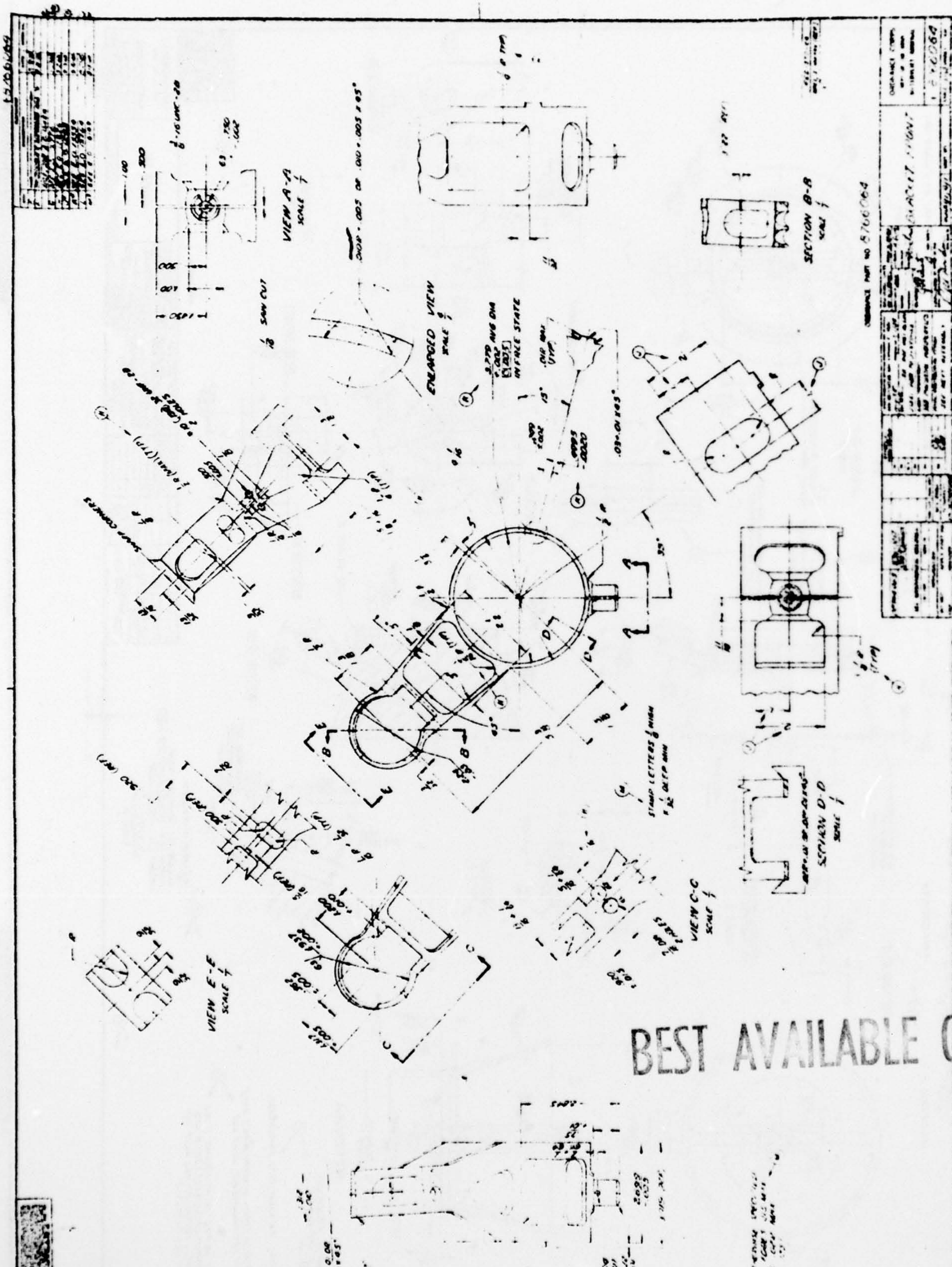
   FINISH 125/

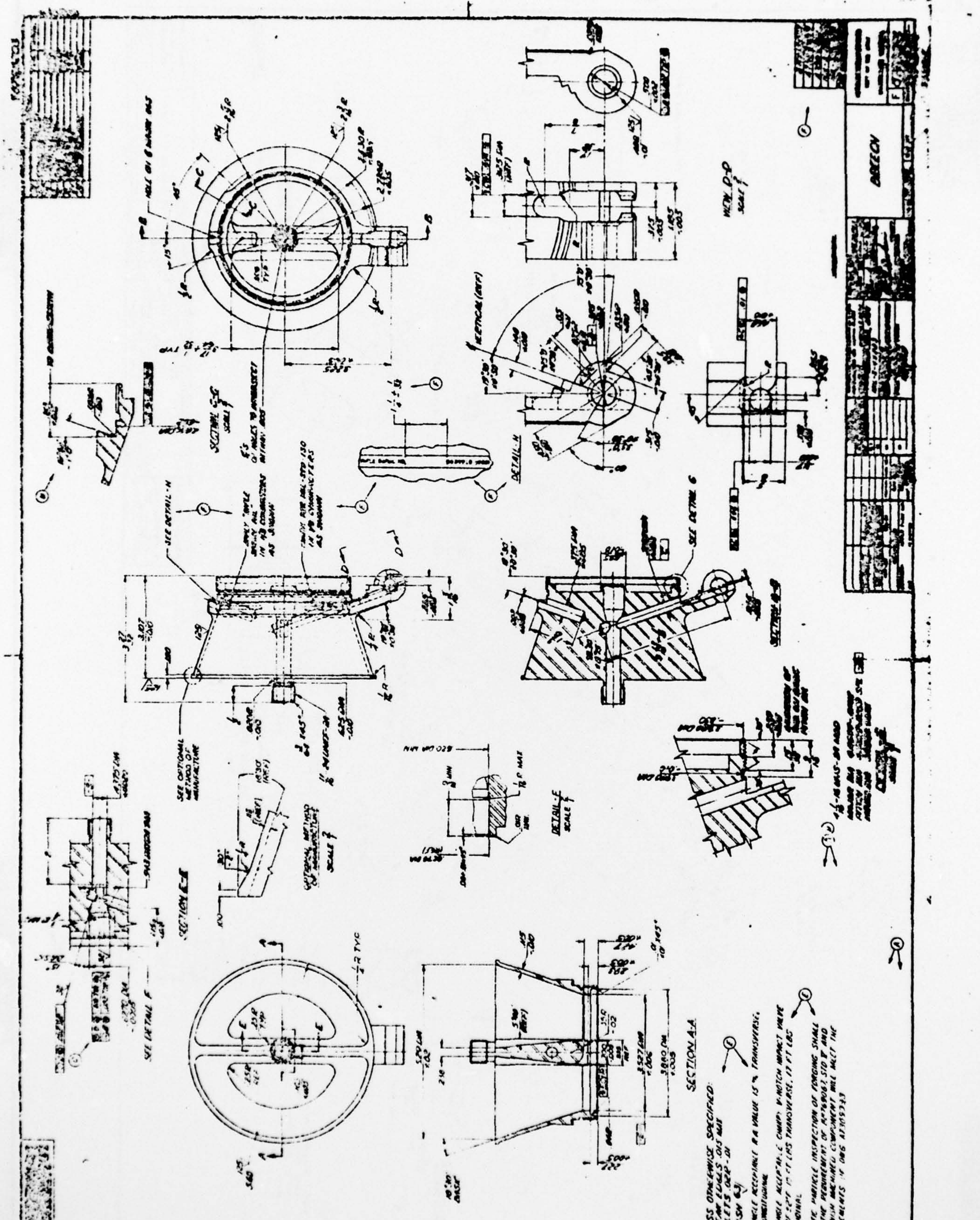
2. HEAT TREATMENT: CARBURIZE .01+.01 DEEP MIN TEMPER 300°F

3. MAGNETIC PARTICLE INSPECTION REQUIRED PER DWG B8763067 CLASS III (F)

4. MATERIAL: .23C MAX AISI "C" CARBON OR AISI ALLOY STEEL / FED-STD-66 OR CASTING PER DWG B11571275 COMP 4 OR 7, CLASS A & F

PHYSICAL PROPERTIES	APPLICATION	ORIGINAL DATE OF DRAWING		DEPT OF THE ARMY
	C5898845	FEB 17, 1954	E.C.R.	WATERVLIET ARSENAL
	AS SPECIFIED	MATERIAL: SEE NOTE 4		SEAR
15H-83 / 13H-82		FINAL PROTECTIVE FINISH: A7309333		C 19206 7238384
				SCALE 2/1


VIEW A-A
ENLARGED VIEW
SECTION B-B
SECTION D-D
VIEW C-C
VIEW E-E


SECTION A-A
DETAIL-H
SECTION B-B
BREECH
NOTES

APPENDIX 1

CLAMP
DWG. #B8769489

Clamp B8769489 is a small component used on the 105mm, M68 Gun. Previously this component had been cast using the Solid Mold Investment Casting Technique. It was felt that this component would be an ideal part to cast first in the Ceramic Shell Process as it was simple. A substantial saving could be shown and basic data on shrink could be obtained.

A trial run of castings were poured 2 June 1971. From this, some basic shrink information was obtained which was used to develop a new Master Pattern drawing and in turn, a modified Master Pattern.

A soft metal (Cerrotru) mold, (Figure A) was made from this pattern as were 120 wax (Cerita 245C) patterns (Figure B). These patterns were mounted on six trees (Figure C) of twenty each, and each set-up was given seven coats of ceramic (Figure D) which consisted of the following:

Zircon Slurry		Molochite Slurry	
75 lbs. Ludox (Colodial Silica)		120 lbs. Ludox (Collodial Silica)	
20 lbs. Water		150 lbs. Molochite - 200	
290 lbs. Zircon Flour			
6 Seconds	Viscosity	7.5 Seconds	Viscosity
2.80 cc	Density	1.80 cc	Density

Room Temperature	82°F
Humidity	40%
Atomospheric Pressure	30

2 Coats Zircon Slurry with Zircon stucco.
1 Coat Molochite Slurry with Molochite stucco (60-90 Mesh)
4 Coats Molochite Slurry with Molochite stucco (30-60 Mesh)

All molds were allowed to dry for one hour between each coat. After drying over night, each mold was placed in an oven at 1600°F for 20 minutes to remove the wax from the cavity of the mold. All six molds were then placed into a preheat oven at 1600°F for three hours before pouring.

The six molds were poured from a melt of 4140 steel. This material was melted down in a 30 lb. induction furnace,

Each mold was embedded in sand to hold them upright while pouring. Cylindrical stainless steel flasks were placed around each mold, before pouring, to prevent metal spillage in case of mold breakdown.

Two (2) molds were broken out, (Figure E) sand blasted, heat treated and dimensionally checked (Table 1). All castings (20) were x-rayed to ASTM E192-62T specification and pass Class A. Two dimensions were off and a correction to the master pattern was made to correct these dimensions; however, the castings were still acceptable for use. Chemical analysis of the metal passed all the requirements. Surface finish was in the range of 63-80. Definition of lettering was excellent. See drawing B8769489.

The following operations that will be eliminated and the time saved per piece is as follows:

Oper. #50	Grind opposite side	.03
Oper. #60	Dr[illegible] .260 + .01 hole. Time was .05	.04
Oper. #70	Benc[illegible] and apply Part No. Time was .08	.05
		.12 x $18.00 per hour

Estimated saving per piece $1.16. Actual saving per piece $2.16.

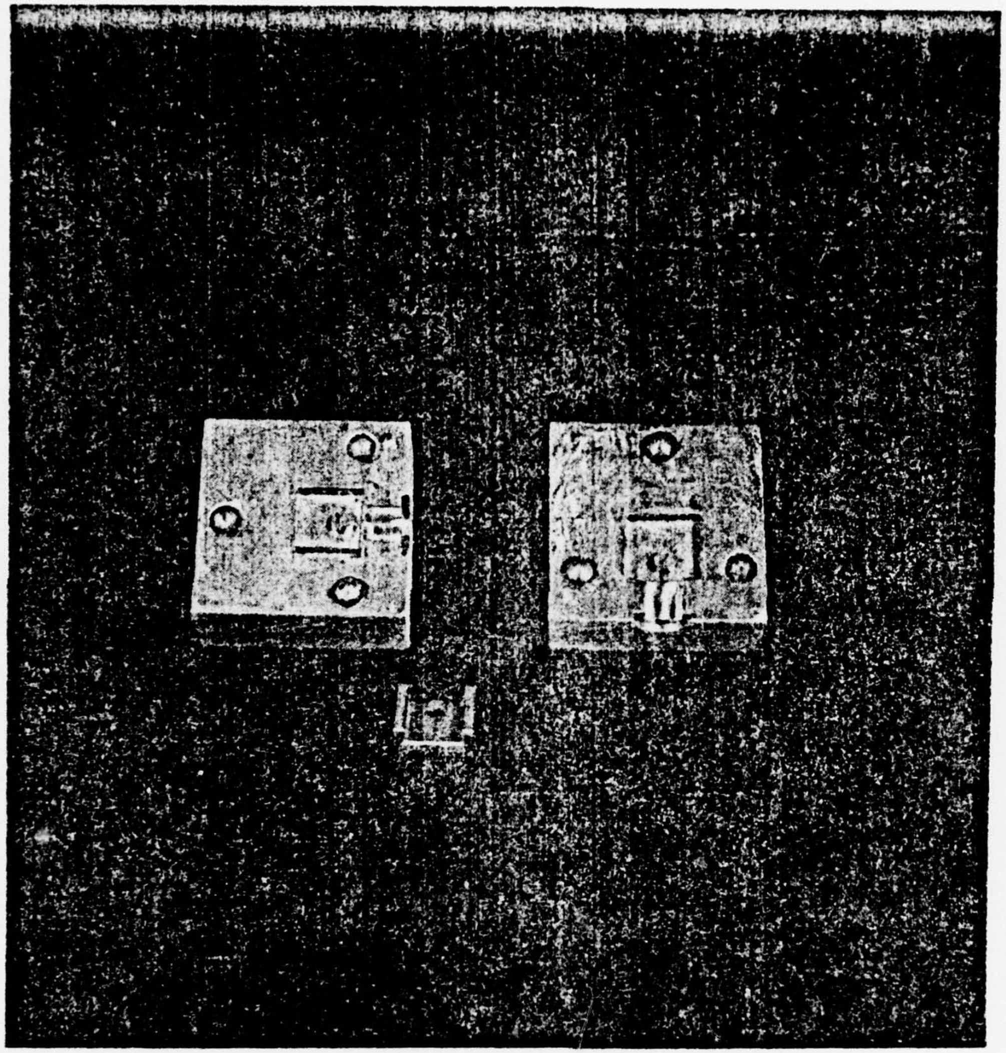


Figure A Cerrotru Mold

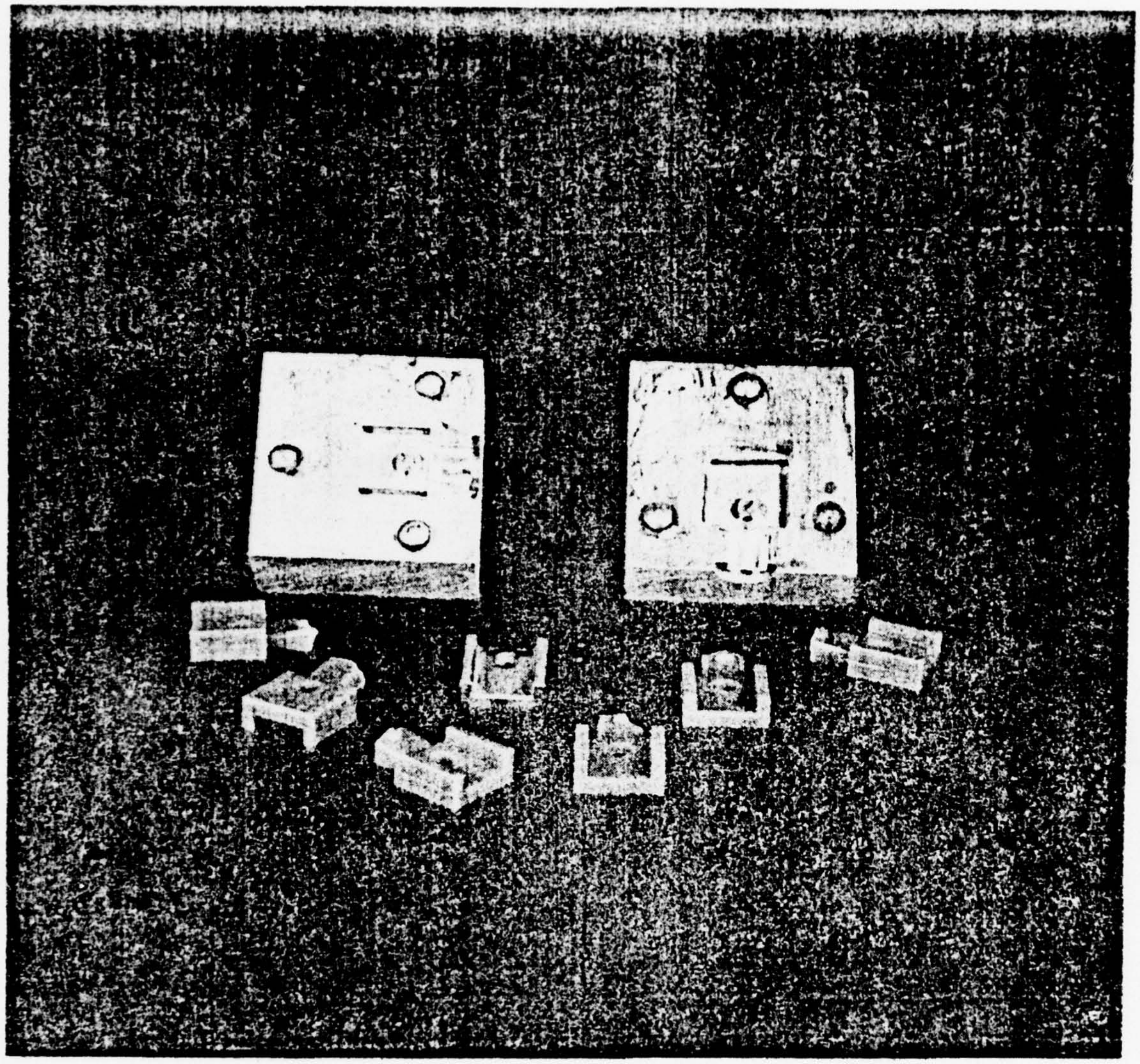


Figure B Wax Patterns

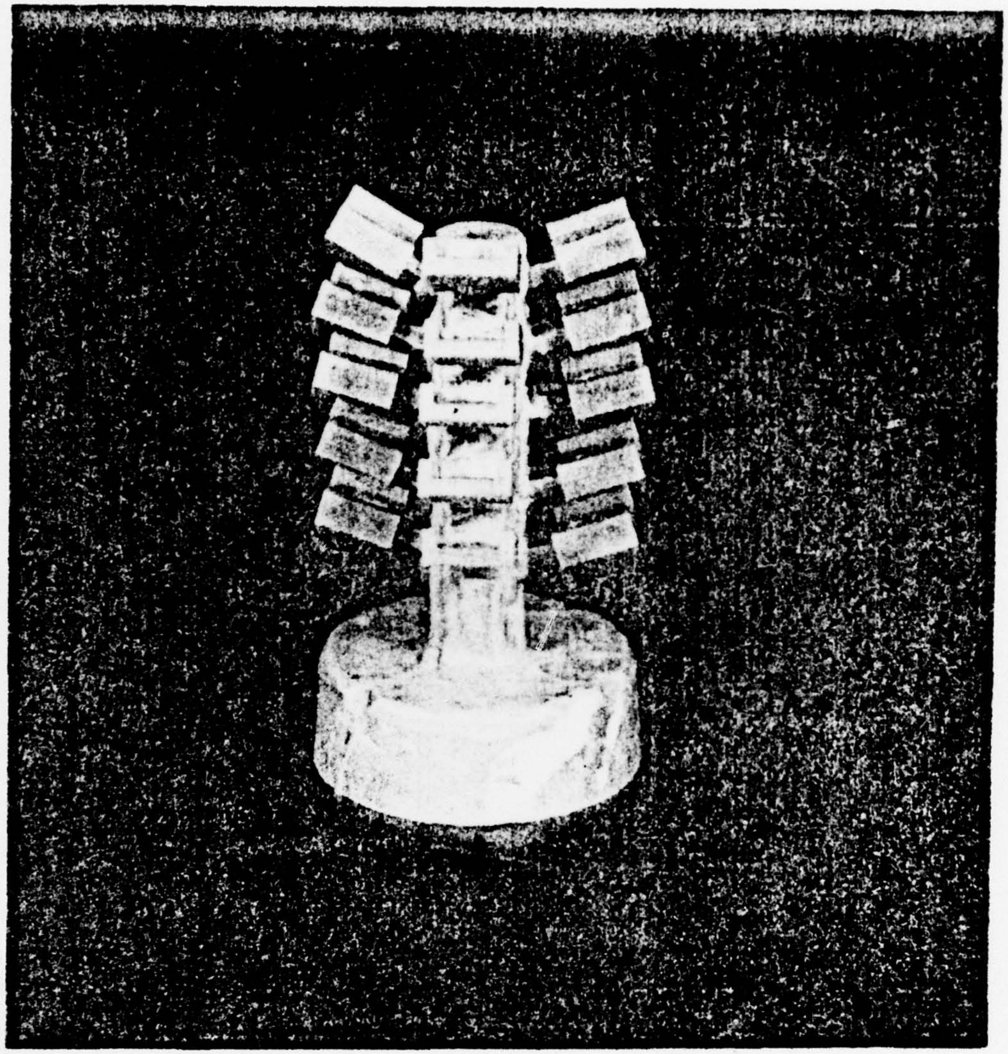


Figure C   Wax Set-Ups

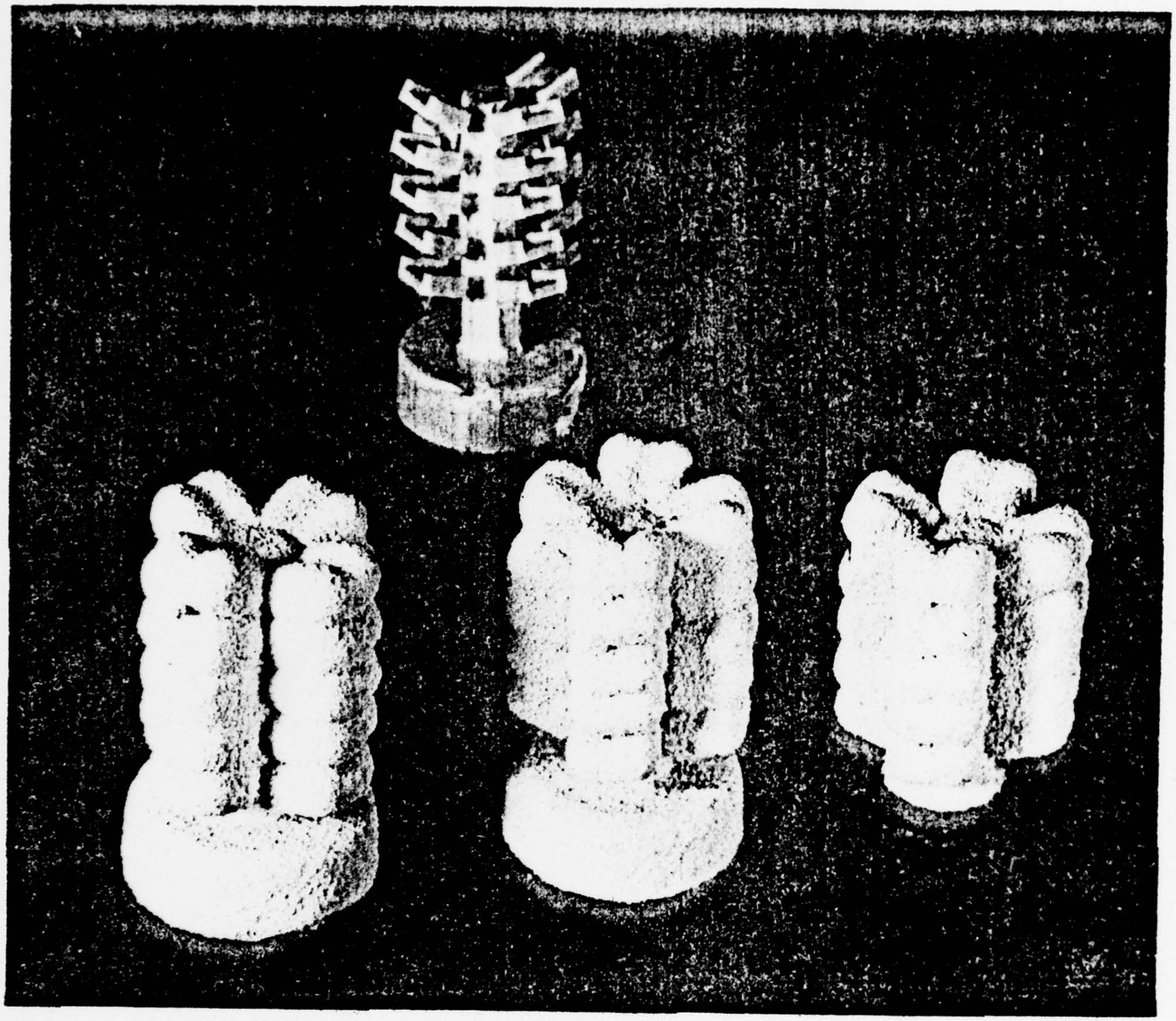


Figure D Ceramic Coated Patterns

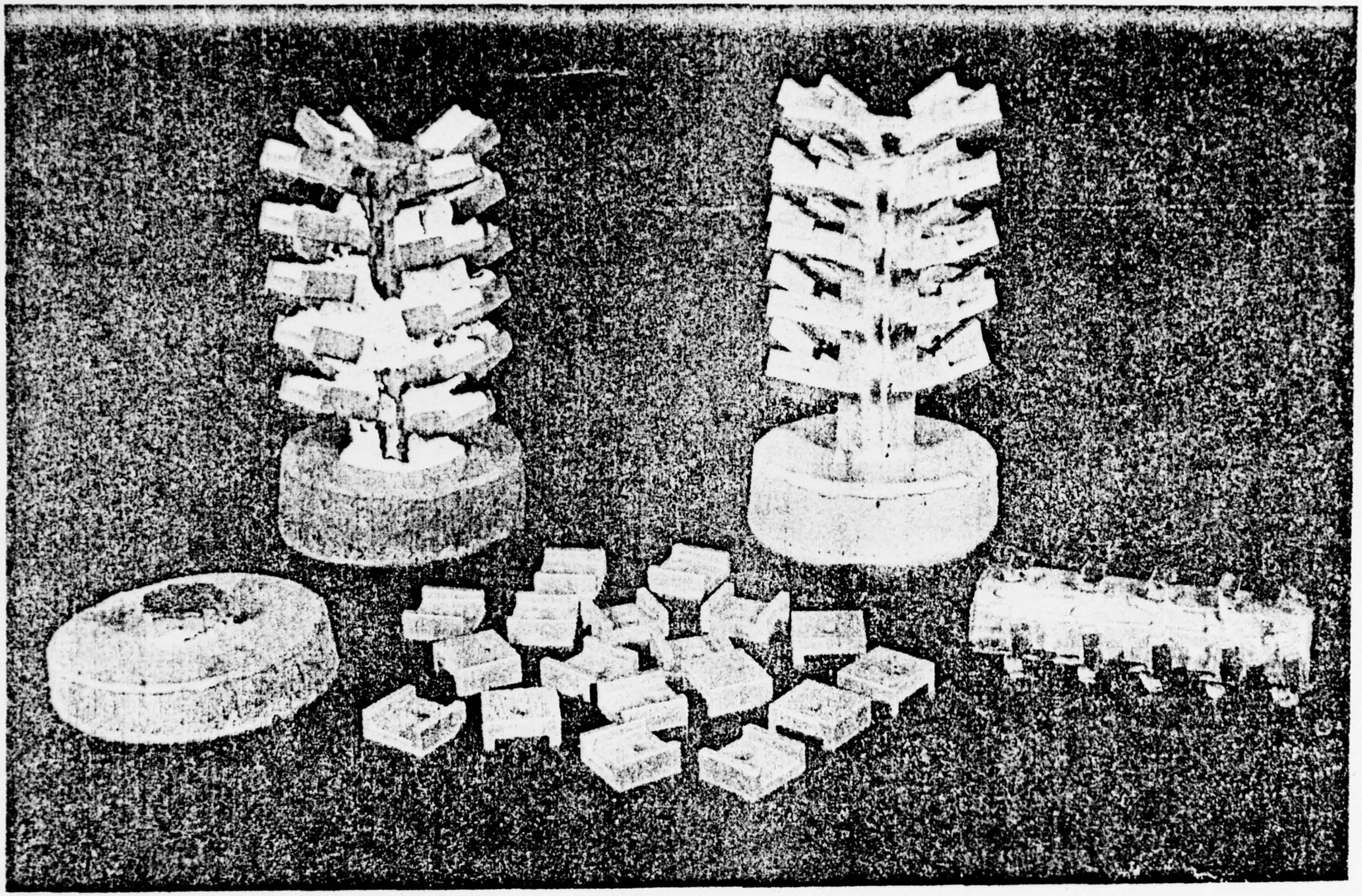


Figure E   Poured Castings

TABLE I

PIECES CHECKED	27/32 ± 1/64	.250 -.010	.260 DIA +.010	.120 ±.010	.130 +.005	4° ±1°	3/8 ± 1/64	.656 +.020	.328 ±.010	OPP SIDE	9/64 ± 1/64	15/16 ± 1/64
1	.851	.2595	.266	TO BE OBTAINED WHEN MACHINING INGATE	.138	OK	.373	.657	.324	.135	.138	.927-.929
2	.851	.259	"		.137	OK	.373	.658	.320	.135	.140	.931-.933
3	.848	TO BE OBTAINED WHEN MACHINING INGATE	"		.134	OK	.374	.654	AVERAGE LOCATION OF HOLES	.134	.138	.926-.929
4	.847		"		.141	OK	.373	.659		.133	.136	.927-.928
5	.847		"		.136	OK	.374	.656		.134	.138	.928-.929
6	.848		"		.138	OK	.372	.657		.133	.138	.928-.929
7	.848		"		.137	OK	.372	.655		.134	.139	.928-.928
8	.846		"		.136	OK	.373	.656		.134	.138	.928-.928
9	.848		"		.138	OK	.374	.656		.133	.138	.927-.929
10	.849		"		.138	OK	.373	.656		.135	.138	.929-.930
11	.847		"		.137	OK	.374	.657		.134	.140	.930-.931
12	.847		"		.137	OK	.374	.654		.135	.140	.929-.929
13	.846		"		.135	OK	.372	.654		.135	.140	.929-.929
14	.846		"		.138	OK	.372	.654		.136	.139	.929-.931
15	.846		"		.134	OK	.373	.656		.136	.139	.930-.931
16	.847		"		.139	OK	.373	.655		.135	.139	.929-.930
17	.846		"		.138	OK	.375	.655		.135	.139	.929-.929
18	.847		"		.137	OK	.373	.657		.134	.140	.930-.931
19	.847		"		.137	OK	.372	.656		.135	.138	.929-.930

NOTE:

PARTS NORMALIZED AND ANNEALED BEFORE STRAIGHTENING .656 + .02 DIMENSION.