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METHODS FOR PRODUCTION OF
CAST BREECH RINGS
AT
WATERTOWN ARSENAL

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METHODS FOR PRODUCTION
OF
CAST BREECH RINGS

AT

WATERTOWN ARSENAL

BY

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~~and~~
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Foreword

This report is issued in accordance with Watertown Arsenal Research Contract Number DA-19-066-ORD-207 for work to be done at M.I.T. during the period of one year between September 1, 1950 and November 30, 1951.

The report is written in condensed, or cook-book, fashion to be of optimum value to manufacturers of breech rings in the event an emergency develops and immediate sources of castings are required. The report is an accurate version of Watertown Arsenal practice for making breech rings of the 75, 76, 90, and 120 mm. types as of October 15, 1951.

The practices described are based upon or incorporate experimental and theoretical results obtained in the M.I.T. Foundry Laboratory. The work included studies of molding sand properties and behavior in service, mold and core washes, methods of risering and gating, thermal studies of steel castings, and other critical evaluations of applicable foundry procedures.

I. MOLDING SAND PRACTICE

The basic sand used for making both facing and core sands is a washed, essentially clay-free, number 80 sand. Its size-distribution curve is included as Figure 1. The shaded area in this figure represents the suggested latitude in grain size permissible for best results. In A.F.A. Grain Fineness Nos. The range is approximately from A.F.A. 70 to A.F.A. 90.

Green-sand facing for breech rings contains 0.82 percent by weight Mogul and 3.60 percent by weight western bentonite. In preparing the sand facing, bentonite, Mogul, and sand are first mixed dry for five minutes; then, water is added and the mixture mulled for an additional ten minutes.

For best results, the facing must meet the following requirements:

Moisture	3.50 - 4.00%
Green Permeability	160 - 210
Green Compressive Strength	5.5 - 6.5 psi.
Dry Compressive Strength	17 - 30 psi.

The backing sand consists of used sand from the shakeout and bentonite. One pound of western bentonite is added for each one hundred pounds of old sand. After mixing the sand and bentonite dry for five minutes, water is added and the mixture is mulled wet for ten minutes.

The mechanical properties desired are:

Moisture	3.00 - 3.50%
Green Permeability	150 - 200
Green Compressive Strength	8.0 - 10.0 psi.
Dry Compressive Strength	20 - 30 psi.

TAM Zirconite Paste Wash, obtained from the Titanium Alloy Manufacturing Company, National Lead Company, New York, New York, is used as a wash on green sand molds only; it is applied immediately after drawing the pattern. It is mixed with water to a smooth cream. Two mixes of zirconite wash are used: when used as a spray, the wash is mixed with water to a viscosity of 45 degrees Baume; when used as a wash, to a viscosity of 65 degrees Baume.

II. CORE SAND PRACTICE

The following mixture is used in making cores for 75 mm., 76 mm., 90 mm. (T-119), 90 mm. (M2A2), and 120 mm. (T-122) breech ring castings:

100 pounds washed A.F.A. No. 80 sand
1.0 pounds Mogul
0.33 pound wood flour
1.33 quarts core oil (Linoil #51)

In preparing core sand, Mogul, wood flour, and sand are mixed dry for five minutes. After adding water, the mixture is mulled three minutes longer. Core oil is then added and the mixture is mulled for seven additional minutes.

The mechanical properties required are:

Moisture	4.00 - 6.00%
Dry Permeability	170 - 190
Dry Tensile Strength	165 - 230 psi.

The following mixture is used as facing on cores for 120 mm. (M1E1) and 90 mm. (M1A3) breech ring castings:

97.0 pounds Zircon sand
0.70 pound core oil (Linoil #51)
3.0 pounds water

Three percent moisture is the upper limit for workability, i.e. ability to be molded and handled in cores.

The Zircon sand used as facing has the following size distribution:

<u>Retained on</u>	<u>Percent</u>
140 mesh	25.0
180 mesh	50.0
-180 mesh	25.0

Each core is coated with a fine zircon wash of the following composition:

100 pounds zircon flour (Zirkaton)
8.6 pounds western bentonite
8.6 pounds dextrine
34.5 gallons water
2.9 gallons core oil (Linoil #51)

This wash is prepared in the following manner:

1. Thoroughly mix the zircon flour and bentonite together.
2. Add sufficient water to make a heavy paste. Blend the zircon flour, bentonite, and water thoroughly.
3. Add core oil and stir until the oil is completely dispersed throughout the paste.
4. Add the remaining water; stir until the wash becomes smooth and free of lumps.

The amount of water added to this mixture is discretionary: enough should be added to make it just thin enough to be sprayed on the mold surface. Mold wash when used as a dip should be somewhat heavier.

Patching sand is used for repairing cores and core surfaces where deemed necessary. The mixture contains fifty pounds of silica flour and twenty pounds of western bentonite. In preparing it, the bentonite and silica flour are first thoroughly mixed together, then two quarts of water are added and the compound is mixed five minutes. To bring the moisture content of the patching sand into a workable range, seven additional quarts of water are added and the mixture is mulled for an additional ten minutes.

Core filler is used for filling and sealing seams in cores and molds. It has the following composition:

9.4 pounds silica flour

0.3 pound western bentonite

0.3 pound dextrine

Just enough water is added to render the filler material workable.

The core and molding sands used at the Watertown Arsenal are prepared in a 1000-pound Simpson Intensive Mixer of the pan-mill type. The mixing times mentioned above are based on experimental results attained with this equipment. In plants where other types of mixing equipment are used, preliminary experiments must be conducted to determine the optimum mixing schedules.

III. CORE MAKING PRACTICE

Cores for 75 mm., 76 mm., 90 mm. (T-119), and 90 mm. (M2A2) breech ring castings are made from the silica sand core mix; cores for 120 mm. (M1E1) and 90 mm. (M1A3) breech rings are faced with one-half inch zircon sand and then backed with the silica core sand mix. All cores are hand rammed. The rammed core is drawn from the core box and placed directly into a cold oven; eight hours are required to bake the cores thoroughly.

Most cores are given two coats of zircon core wash while still hot. The large cores, those for the M1E1 and T-122 breech rings, receive three coats of wash. Gate cores are also painted with wash, but only on those sections that come into direct contact with the metal.

IV. MOLDING PRACTICE

1. Riddle green sand facing into flash.
2. Pack facing carefully about the faces of the pattern.
3. Fill the remaining space in the flash with backing sand and then ram to maximum density.
4. On drawing pattern from mold, spray mold surfaces with mold wash and dry in air.
5. If necessary, apply a second coat and torch to dryness.
6. Fit cores into position and then close mold.

V. GATING AND RISERING

Figures 2 and 2a illustrate the correct method of "gating and risering" the T119, 90 mm. breech ring. Correct methods of "gating and risering" the M1E1 120 mm. and T83 75 mm. breech rings are shown in figures 2b and 2c. These sketches show how cores are set in the mold and include critical dimensions of gates and risers.

The T119 breech ring is typical and methods similar to those shown are used in making all the breech rings. The rigging and dimensions in each case must, of course, be accommodated to the size and configuration of the particular breech ring to be made.

VI. FURNACE PRACTICE

Steel is melted in an acid-lined induction furnace. The lining is made from Whitehead #108 sand, A.F.A. fineness ranging from 35 to 40. The furnace bottom is made from a mixture that contains 520 pounds #108 silica sand and 100 pounds silica flour. The sand is rammed in place dry to a depth of five inches. An asbestos sleeve is positioned in the center of the induction coil. The following mixture is used for building the side walls of the furnace crucible:

520 pounds Whitehead #108 sand

100 pounds silica flour

10 pounds western bentonite.

The maximum moisture content is two percent. The lining is rammed between the asbestos sleeve and an asbestos blanket covering the induction coil. It is rammed in two-inch layers until the lining is completely built up, sodium silicate being added to the mixture for the top six to eight inches. Sodium silicate is also added to the mixture above the asbestos liner and for shaping the collar and lip of the furnace.

VII. MELTING PRACTICE

The desired chemical compositions for the breech rings are shown in Table I.

The furnace charge is approximately 25 - 35 percent scrap (foundry returns), 1 1/2 - 2 percent pig iron, and the balance bar stock of the following approximate composition:

C - 0.12%
Mn - 0.29%
Si - 0.10%
Cr - 0.01%
Mo - 0.01%
Ni - 0.03%
Fe - balance
P - .012%
S - .020%

Adjustment of the final composition is made by additions of electrolytic nickel and various ferro-alloys.

The nickel is charged on the bottom of the furnace; then the bar stock and scrap is charged. The power is turned on and melt down attained in 1 1/2 to 1 3/4 hours. When the melt reaches a temperature of 2900°F, ferro-molybdenum is added.

After a two-minute interval, the pig iron is floated into the melt. This induces a violent boil which is effective in removing dissolved gases from the liquid steel. Three minutes later the ferro-chromium is added. When it has melted, the power is shut off and the slag removed.

The melt is then heated to the tapping temperature. The recommended tapping temperatures for the different size breech rings are:

75 and 76 mm.	3000°F
90 mm.	2950°F
120 mm.	2930°F

Melt temperatures in the furnace are measured with a platinum-platinum, 10 percent rhodium thermocouple in a fused silica protecting sheath. It is connected to a Brown Circular Chart Elektronik Potentiometer.

When the temperature has been checked, ferro-manganese is added to the bath and finally the ferro-silicon. After 15 seconds, the power is shut off and the heat tapped into the ladle. When the ladle is approximately one-third filled, aluminum in pellet form is added to deoxidize the heat. As a general rule, this addition is 0.7 percent.

Extreme care is taken during melting to effect a good boil for removing dissolved gases.

In plants where induction melting is available, it is simple to follow the melting practice employed at the Watertown Arsenal. In plants where other types of steel melting equipment are used, care must be taken to effect good boils and so remove dissolved gases.

TABLE I. CHEMICAL SPECIFICATIONS

In order to obtain the required physical properties, breech ring castings are made from two different compositions. The larger castings, namely the 90 and 120 mm. breech rings, contain more nickel and molybdenum.

<u>Type of Gun</u>	<u>C</u>	<u>Mn</u>	<u>Si</u>	<u>Cr</u>	<u>Mo</u>	<u>Ni</u>	<u>Al</u>	<u>P</u>	<u>S</u>
75 mm.	.23	.75	.20	.75	.30	1.90			
&	to	to	to	to	to	to	.03	.015 max.	.025 max.
76 mm.	.26	.90	.40	.85	.40	2.15			
90 mm.	.20	.70	.20	.75	.45	2.80			
&	to	to	to	to	to	to	.03	.015 max.	.025 max.
120 mm.	.23	.85	.40	.85	.55	3.05			

VIII. LADLE PRACTICE

Five thousand pound, lip-pouring ladles are used for pouring steel into the molds.

Monolithic ladle linings are used with excellent results. The ladle lining material is #104 Wet Patch Sillmanite, manufactured by Chas. Taylor Sons Company of Cincinnati, Ohio. This material is ready-mixed and does not require the addition of water or binder.

Patching sand, whose formula is given in the section on sand practice, is used for patching the side wall and lip of the ladle.

The steel is tapped into the ladle preheated to approximately 1600 to 1800°F.

Following are the recommended pouring temperatures, as measured by a platinum - platinum, 10% rhodium thermocouple, for the different breech ring castings:

<u>Type of Breech Ring</u>	<u>Recommended Pouring Temperature</u>
75 & 76 mm.	2750 - 2800°F
90 mm.	2750 - 2800°F
120 mm.	2750°F max.

Radiation losses from the tops of the risers are minimized by throwing rice hulls on the metal surface during pouring. About ten pounds of rice hulls are used for each casting, regardless of size. A quarter of this amount is added when the metal rises into the riser cavity; the rest when pouring is completed.

The last fifty pounds or so of metal from each ladle are pigged in order to prevent the high concentration of slag contained in it from entering the mold. An additional precaution against entrapment of slag in the mold cavity is the use of ball-type slag traps at the junctions of runners and ingates.

With the 90 mm. (M1A3) and 120 mm. (M1E1) breech rings only, top pouring is employed after the metal has risen about three inches into the riser cavity. This further expedient for eliminating sand cannot, because of sand erosion, be used where a vertical core extends through the riser.

IX. SHAKE-OUT AND CLEANING

Castings are cooled in the molds. The smaller castings are "shaken-out" twenty-four hours after pouring and the larger castings forty-eight hours after pouring.

After burning off gates and sprues, the smaller castings are first normalized and then sent to the cleaning room for sawing off risers; the larger castings, because of their size, are sent to the cleaning room for riser removal before normalizing.

Risers are removed by sawing. The saws are of the positive feed, power type. Risers are removed from the 75, 76, and 90 mm. breech rings with a Marvel No. 18 Hydraulic Universal Roll Stroke Saw. Milford Reziator blades of the following specifications are used: length, 24 inches; width, 2 inches; thickness, 0.100 inch; and pitch, 4 teeth per inch. The saw is set at 75 - 100 strokes per minute, a 0.003-inch positive feed, and a 300-pound pressure for the 75 and 76 mm. breech rings. The risers on 90 mm. breech rings are removed with the saw set at 75 - 85 strokes per minute, a 0.003-inch positive feed, and a 300-pound pressure.

The risers of 120 mm. breech ring castings are cut in a Marvel No. 24 Hydraulic Universal Roll Stroke Saw. A 3625E Marvel blade of the following specifications is used: length, 36 inches; width, 4 1/2 inches; thickness, 0.125 inch; and pitch, 2 1/2 teeth per inch. The saw is set at 25 - 30 strokes per minute, a 0.002-inch positive feed, and a 400-pound pressure.

The collant used for sawing off risers is the Houghton Antiseep All-Purpose Coolant of the emulsion type. It is manufactured by Houghton of Philadelphia, Pa.

The following schedule is specified for cleaning room operations:

1. After normalizing, remove sand and scale from casting by shot-blasting.
2. Grind gate junction flush with surface of casting using swing-frame grinder.
3. Inspect casting surface visually and with magnetic powder testing method. Surface defects - such as cracks, porosity, and sand holes - are completely removed by chipping and grinding. Hand tools used for probing surface defects at Watertown Arsenal are pencil, conical, and disc grinders. Since the alloy steel used for breech rings is extremely sensitive to thermal cracking, care must be taken not to overheat the surfaces being ground. High-speed grinding wheels and low-surface temperatures will prevent thermal cracking during grinding.
4. If defects extend below specified machine finish, pre-heat and weld castings on approval of government inspector according to specifications included in Section XII.
5. Heat treat castings according to specifications presented in Section X.
6. After shot-blasting heat-treated casting, inspect casting by the magnetic-powder testing method for surface cracks developed during heat treatment.

7. If necessary, remove and repair defects in accordance with the specifications outlined in paragraphs IX-3 and IX-4.

8. Heat treat repaired casting in the manner specified in paragraph IX-5.

9. After shot-blasting repaired casting free of scale, inspect surfaces for surface cracks by magnetic-powder testing method.

10. On approval of government inspector, machine casting to drawing specifications and ship to designator.

X. HEAT TREATMENT

Three heat-treating cycles have been developed to obtain the required mechanical properties. This has been necessary to account for the marked differences in chemical composition and size of the castings. The heat-treating cycles are included below according to breech ring size.

A. Heat Treatment for 75 and 76 mm. Breech Rings.

1. Heat to 1800°F and hold at temperature for 8 hours; cool in air to room temperature.
2. Heat to 1625°F and hold at temperature for 5 hours; furnace cool to 1500°F and hold at temperature for 2 hours.
3. Quench in water and hold for 3.5 minutes. Remove from water quenching tank and quench in oil; hold casting in oil bath for 5 minutes.
4. Place breech ring in furnace at 600°F and hold at temperature for 1 hour; raise the furnace temperature slowly to 1130°F; hold at temperature for 4 hours and then quench in water to quenching bath temperature.
5. Place tempered casting into hot furnace; heat to 1130°F and hold at temperature for 4 hours; then quench in water to quenching bath temperature.

B. Heat Treatment for 90 mm. Breech Rings.

1. Heat to 1800°F and hold at temperature for 8 hours; cool in air to room temperature.
2. Heat to 1650°F and hold at temperature for 6 hours; furnace cool to 1500°F and hold at temperature for 2 hours.

3. Quench in water and hold casting therein for 6 minutes. Remove from water and cool in air for 4 minutes; then quench in oil for 15 minutes.

4. Remove breech ring from oil bath and place in draw furnace at 600°F. Hold at 600°F for 1 hour and then raise furnace slowly to 1110°F; hold at temperature for 5 hours; quench in water to quenching bath temperature.

5. Heat breech ring to 1110°F and hold at temperature for 5 hours; quench in water to quenching bath temperature.

C. Heat Treatment for 120 mm. Breech Rings.

1. Heat to 1800°F and hold at temperature for 8 hours; cool in air to room temperature.

2. Heat to 1650°F and hold at temperature for 6 hours; furnace cool to 1500°F; then hold at temperature for 2 hours.

3. Quench in water and hold for 6 minutes in quenching bath; remove breech ring from water and cool in air for 4 minutes; then quench in oil bath for 20 minutes.

4. Remove breech ring from oil bath and place in draw furnace held at 600°F. Hold at temperature for 2 hours; then raise furnace temperature slowly to 1100°F and hold at temperature for 5 hours; quench in water to water quenching temperature.

5. Heat breech ring to 1100°F and hold at temperature for 5 hours; quench in water to quenching bath temperature.

The heat-treating furnaces used are gas-fired vertical pit and oil-fired car-bottom types. The vertical pit furnaces used are 8

feet in diameter by 16 feet, 24 feet, and 35 feet deep. Both types are Watertown Arsenal designed and built.

The quenching oil used in Houghton #2 or its equivalent. The limiting temperatures maintained are 70°F to 150°F.

Quenching water is constantly flowing and its temperature is not controlled. The length of time work is in this bath is adjusted to compensate for bath temperature.

XI. INSPECTION

Visual, magnetic powder and radiographic testing methods are used for the detection and investigation of casting defects. The procedures are presented in the following U.S. Army Specifications:

- 57-0-7 Radiographic Inspection of Metals
- 57-0-8 Radiographic Standards for the Inspection of
Arc and Gas Welds in Steel
- 57-0-9 Radiographic Standards for the Inspection of
Steel Castings
- 57-0-10 Radiographic Procedure and Qualification Tests
- 57-0-5 Magnetic Particle Inspection; Process for
Ferromagnetic Materials

A. Foundry Procedure Qualification.

Qualification of a casting procedure is accomplished through the following tests of the first (pilot) casting submitted for inspection.

1. The pilot casting is examined on all surfaces by means of a magnetic particle test for the presence of cracks.
2. Radiographic inspection of the pilot casting is accomplished by sectioning the casting transversely as shown in Figure 3 and radiographing each section normal to the cut surface.
3. Two tensile tests and four Charpy impact specimens are taken as shown in Figure 4 and are tested according to the specifica-

tions given in Section XI, Specification for Mechanical Properties.

4. Failure of the pilot casting to meet all requirements is cause for rejection of foundry procedure.

B. Check Castings.

1. The government inspector may, at the expense of the government, select production castings at random from an accepted lot for check tests.

2. Castings so selected may be subjected to any or all of the tests specified in Section A for the pilot casting.

3. Failure of a check casting shall require the testing of two additional production castings from the same heat. If either of these castings fail, the casting procedure is rejected and requalification of the foundry procedure is required.

4. Requalification necessitated by the failure of check castings is accomplished by testing a casting produced either by the same or a different procedure provided it was not cast in the same heat as those which caused the procedure to be disqualified.

C. Specifications.

1. Any defect - surface crack, hot tear, sand hole, porosity or shrinkage - is thoroughly investigated.

2. Casting defects which are found to extend below the machine surface must be welded.

3. Sections requiring repairs must be free of defects as revealed by the magnetic particle test prior to welding.

4. The government inspector shall determine the areas requiring repairs. No defects can be repaired in breech recess fillet areas of the casting. Any defects in this area of the casting shall be cause for rejection.

XII. WELDING

The welding procedure outlined below is used for repairing breech ring castings:

1. The casting is preheated to 700°F in a furnace. The temperature of the casting is continually checked with Tempil Sticks or a contact pyrometer to make certain that the preheating temperature is maintained. An oxy-acetylene torch may be used to maintain the desired temperature.

2. The casting is welded with the generator set at 40 - 45 volts and 165 - 175 amperes. The initial pass is made with the welder set at 175 amperes. In order to prevent excessively high localized temperatures, the welding current is gradually lowered from 175 to 165 amperes on subsequent passes.

3. A straight-line welding technique is used in repairing defective areas. The maximum thickness of each bead can be no greater than twice the thickness of the welding wire. Should the bead thickness exceed this value, the bead is deposited by weaving and cracking may result.

4. Remove slag completely after each pass.

The following types of electrodes are permissible for repairing breech ring castings; any other must be qualified:

- a. Murex AWL
- b. Tensilend 100
- c. Manganend 2M

XIII. SPECIFICATION FOR MECHANICAL PROPERTIES

At least one cylindrical test coupon, the dimensions of which are given in the following table, is cast and heat treated with each melt of castings.

<u>Size of Test Coupons</u>		
<u>Breech Rings</u>	<u>Diameter (inches)</u>	<u>Height (inches)</u>
75 mm.	3	8 1/2
76 mm.	3	8 1/2
90 mm.	5	12
120 mm		
MLE1	5 1/2	12
T122	6	15

One tension test and two Charpy impact specimens are taken from the locations shown in Figure 5.

The tension test specimens are machined to the form and dimensions of type 1 of Federal Specification QQ-M-151.

The yield strength is determined by the offset method as described in Federal Specification QQ-M-151. The limit set is 0.10 percent.

The Charpy impact test specimens shall be machined to the form and dimensions shown in Figure 6.

Impact tests are made with the specimens at a temperature of $-20^{\circ}\text{F} \pm 3^{\circ}\text{F}$.

The following are the minimum mechanical properties required of the types and sizes of heat-treated breech ring castings discussed in this report. These data are taken from Specification Number MLL-S-10029 (ORD), Amendment 2, dated 2 February 1950.

1. The yield strength values shall range from 100,000 to 130,000 psi.

2. The minimum values of the reduction in area and Charpy impact at -20°F are tabulated below. These minimum values are based on the yield strength values obtained at 0.10 percent offset.

<u>Yield Strength</u>	<u>Minimum Red. in Area</u>	<u>Minimum Charpy in Ft.-lbs. at -20°F</u>
100,000 - 104,999	23.0	37.0
105,000 - 109,999	22.0	33.0
110,000 - 114,999	21.0	29.0
115,000 - 119,999	20.0	26.0
120,000 - 124,999	19.0	23.0
125,000 - 129,999	18.0	21.0

3. Each casting is subjected to Brinell hardness tests in two or more places. The hardness is determined on a standard or portable Brinell hardness testing machine in accordance with Federal Specification QQ-M-151.

The diameter of Brinell hardness impressions of all castings not tested for yield strength shall be within a range of ± 0.25 mm. of the average of not less than four tests taken on the pilot casting or test coupon for the particular heat involved.

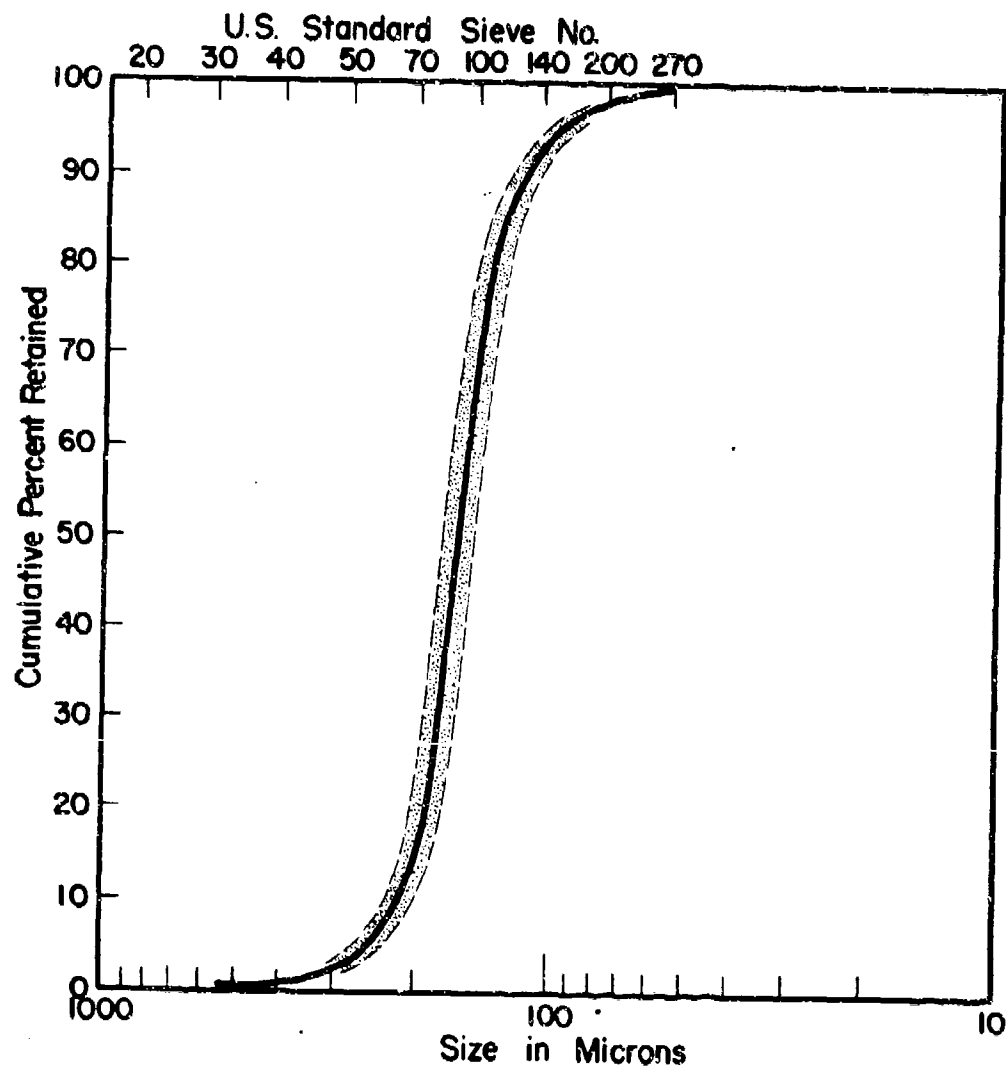


Figure 1. Size Distribution Curve for Molding Sand

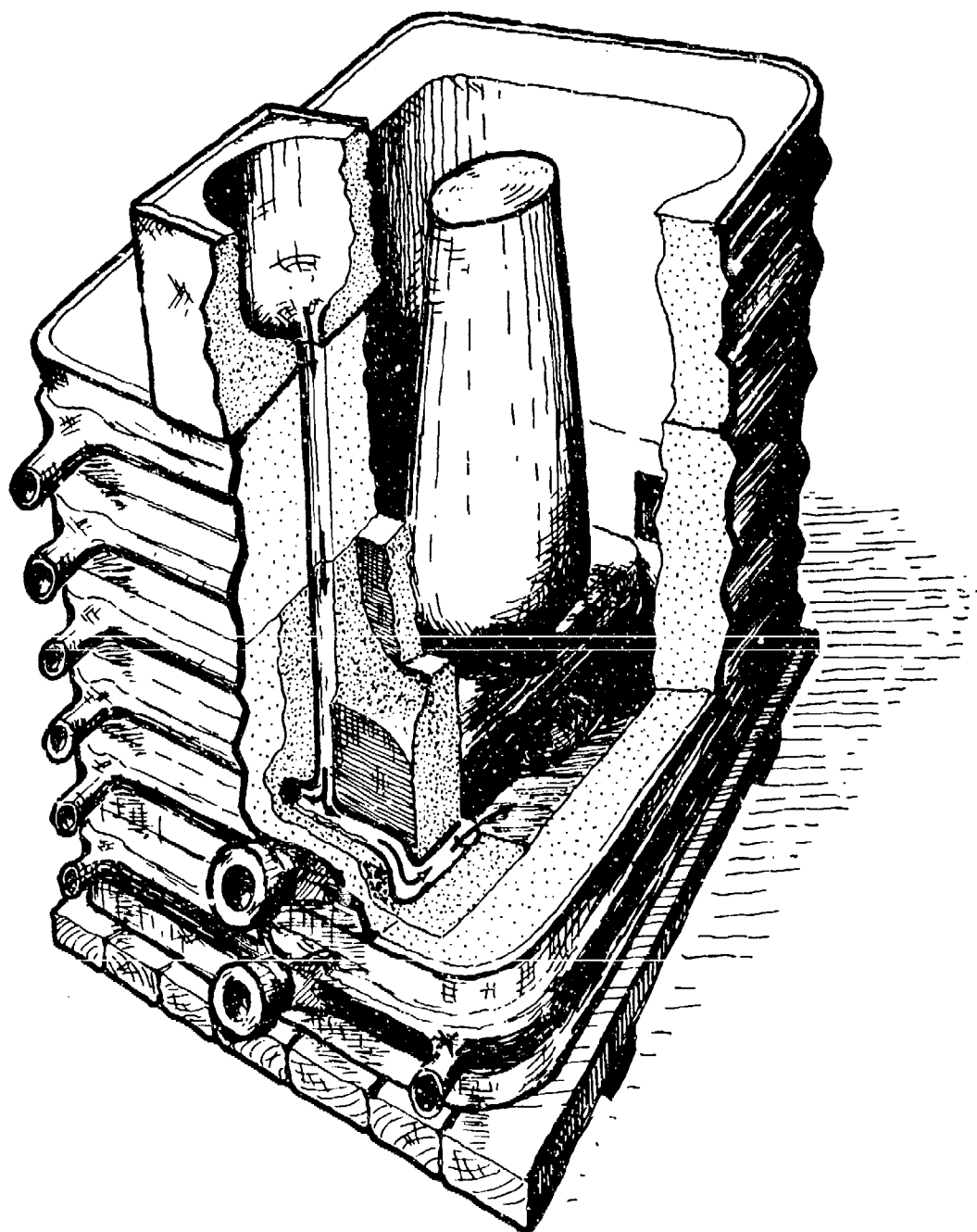


Figure 2. Cut-Away Perspective View of Breech Ring Mold
(T-119, 90 mm.)

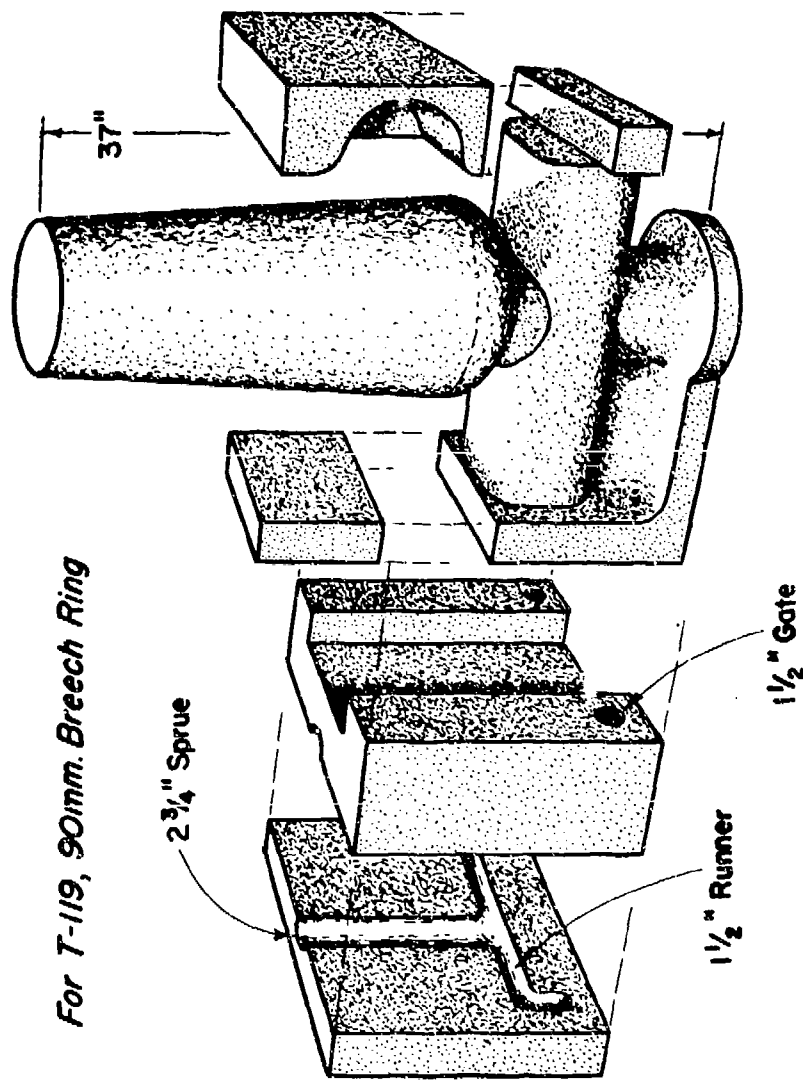


Figure 2a. Exploded View of Cores Used in Breech Ring Mold

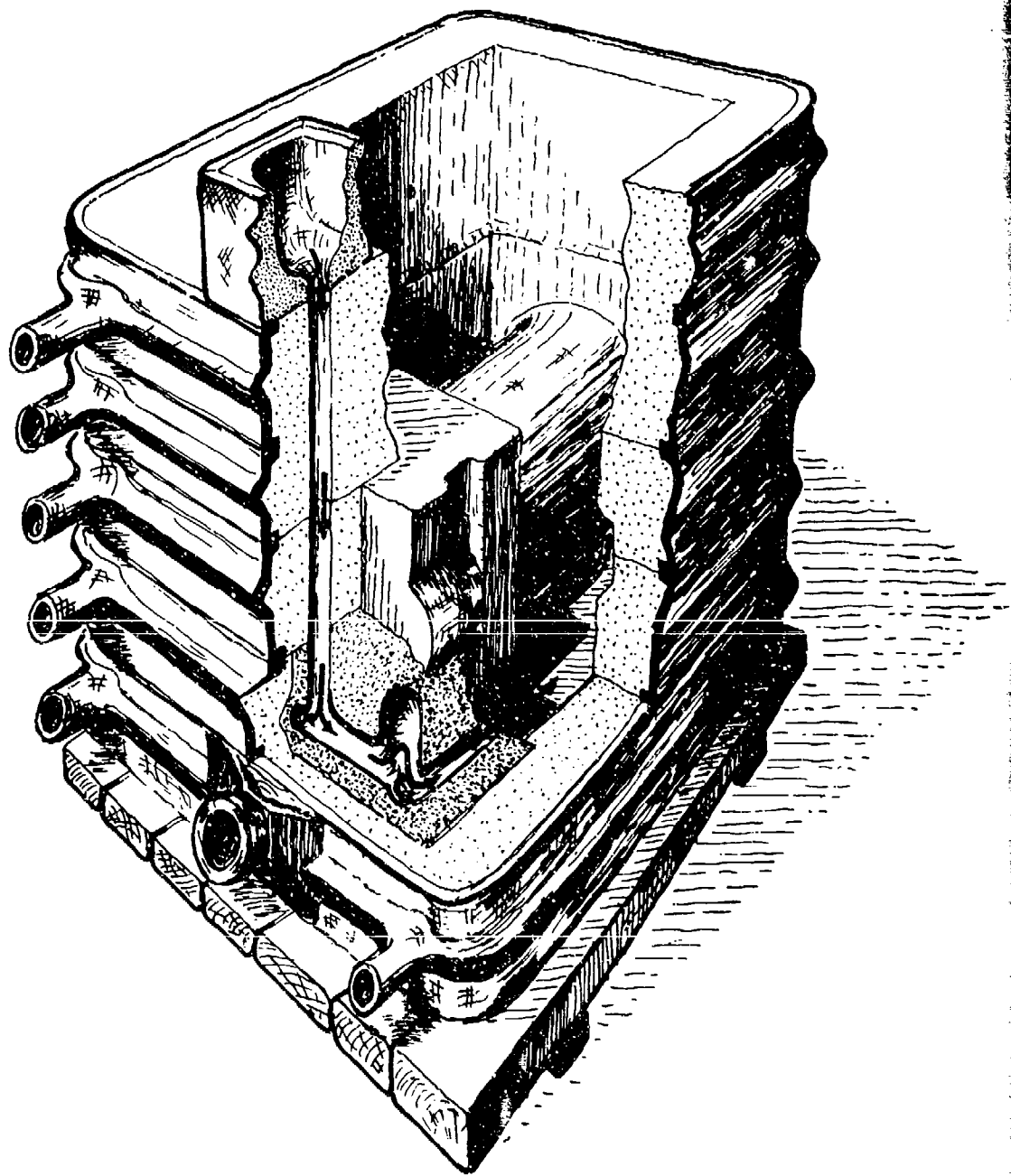


Figure 2b. Cut-Away Perspective View of Breech Ring Mold
(M1E1, 120 mm.)

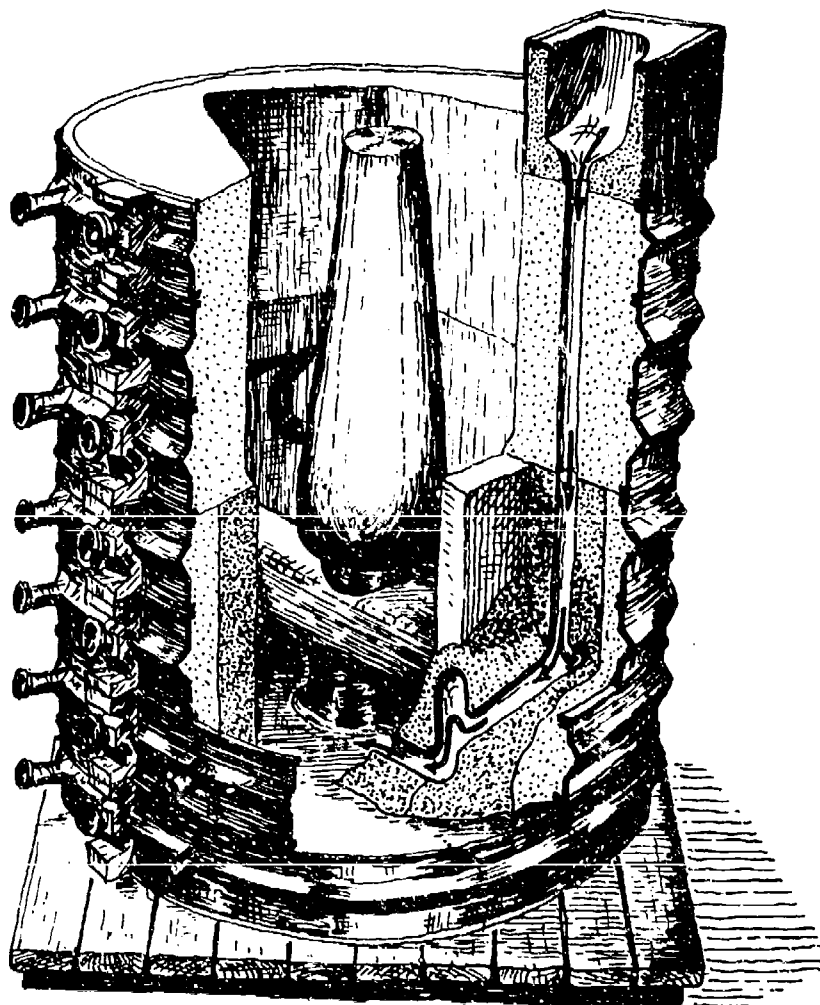


Figure 2c. Cut-Away Perspective View of Breech Ring Mold
(T-83, 75 mm.)

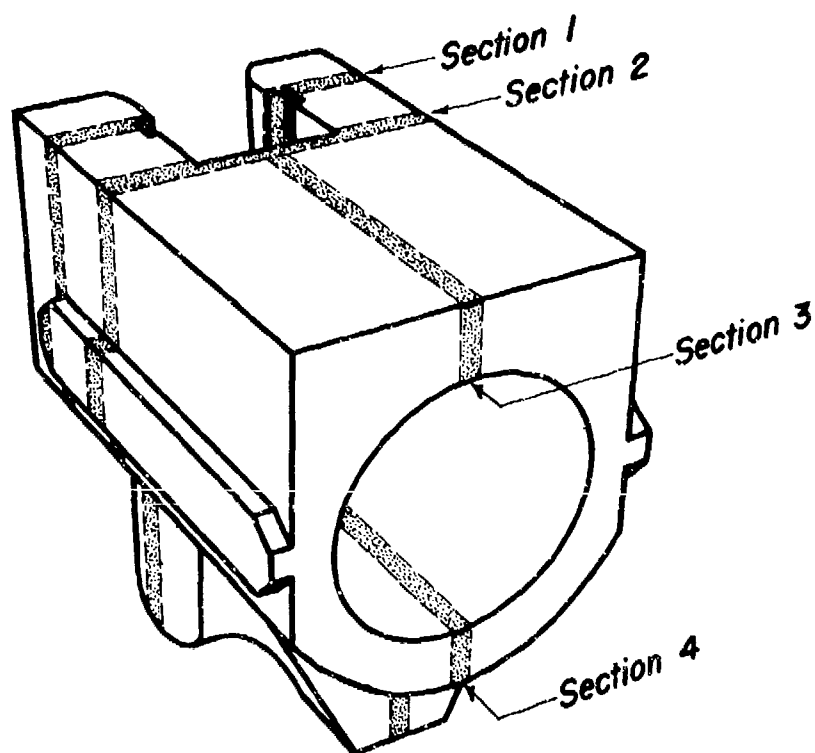


Figure 3. Transverse Radiographic Sections for
Qualifying Breech Rings

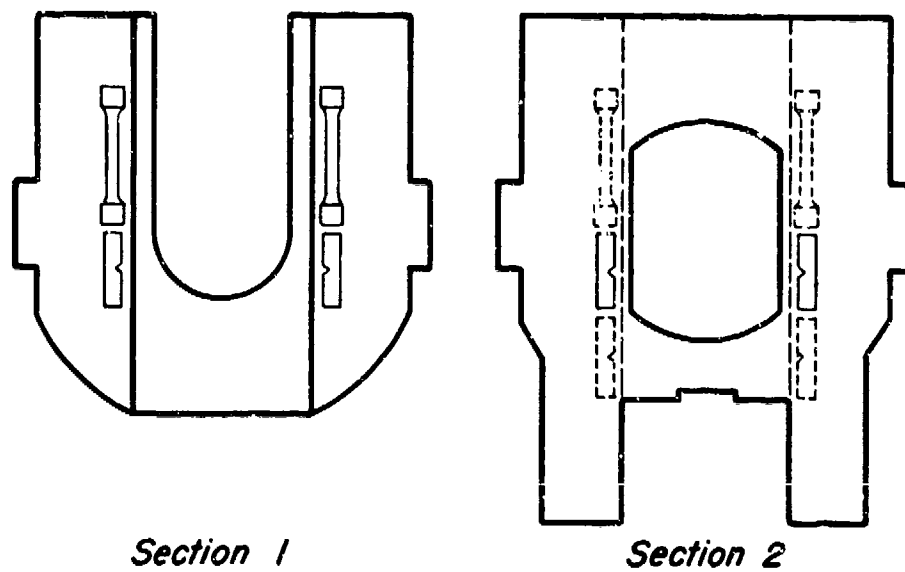
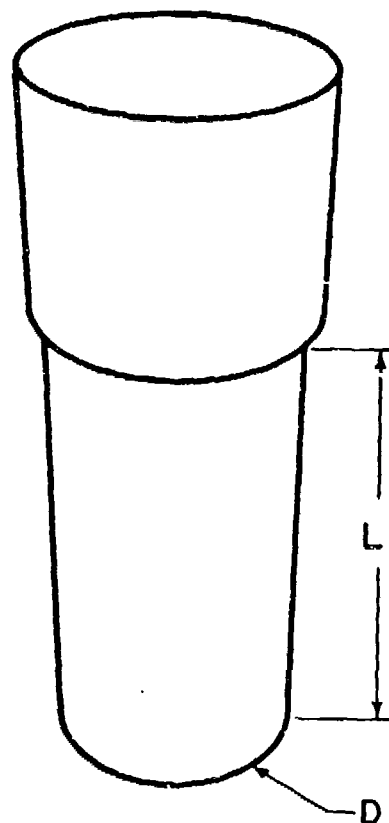


Figure 4. Location in Pilot Casting of Qualifying Tension and Impact Specimens



<i>Diameter (D)</i> inches	<i>Length (L)</i> inches
3	8.5
5	12
5.5	12
6	15

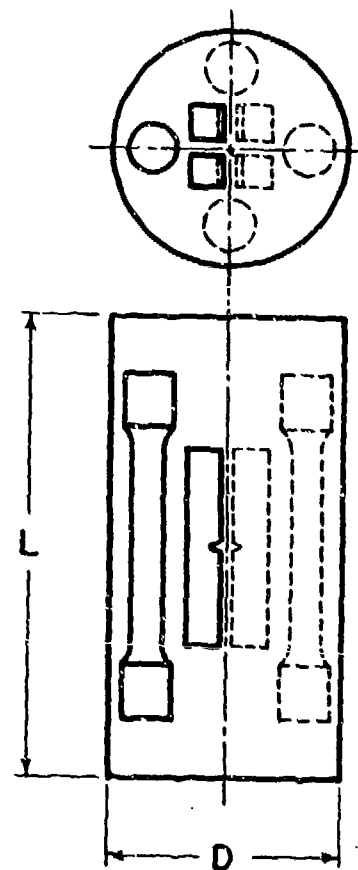
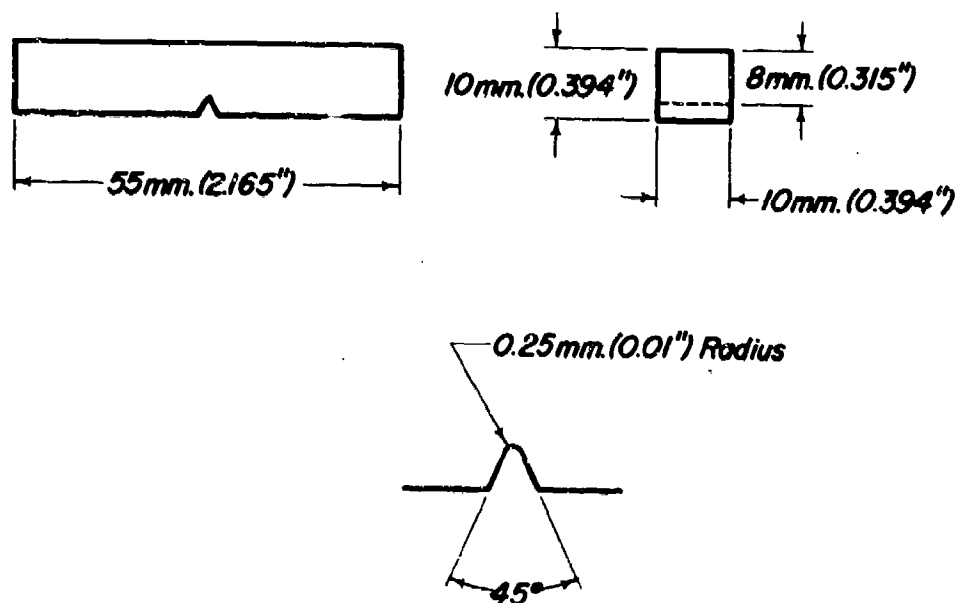


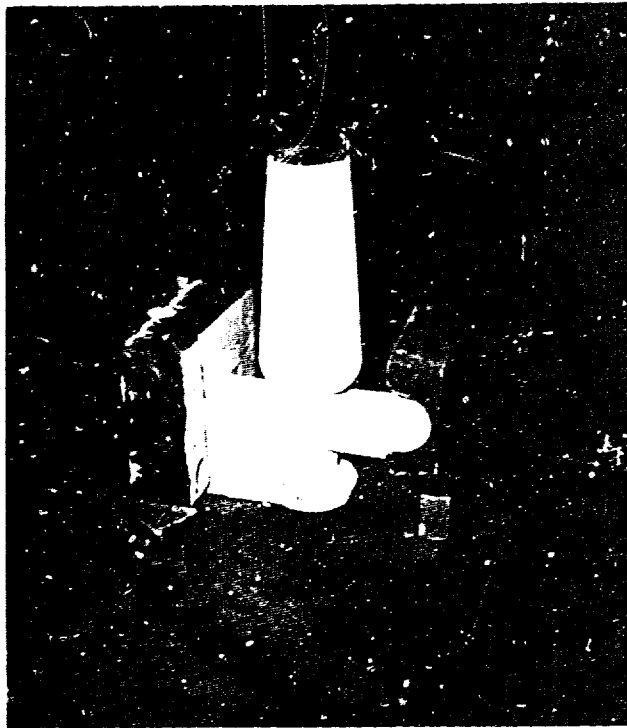
Figure 5. Location in Test Coupon of Inspection Tension and Impact Specimens



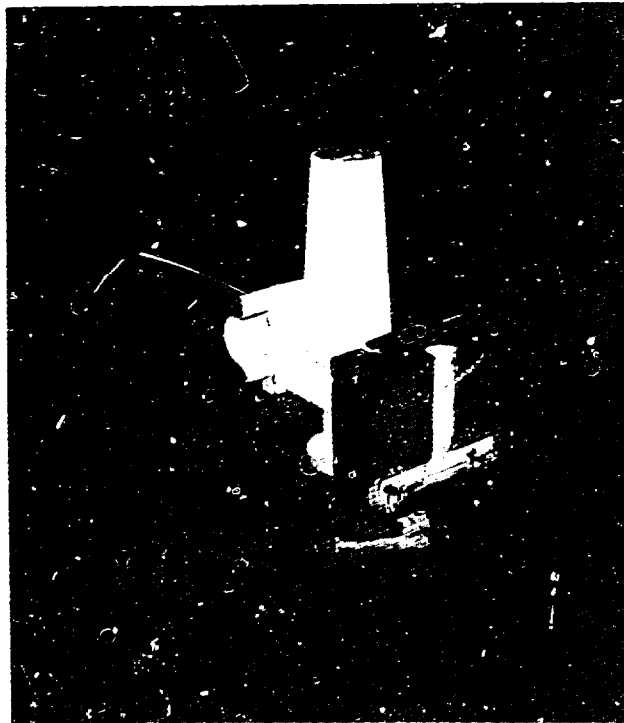
PERMISSIBLE VARIATIONS

Cross Section Dimensions	$\pm 0.025\text{mm. (0.001")}$
Length of Specimen	$\pm 0.25\text{mm. (0.010")}$
Angle of Notch	$\pm 1^\circ$
Radius	$\pm 0.025\text{mm. (0.001")}$

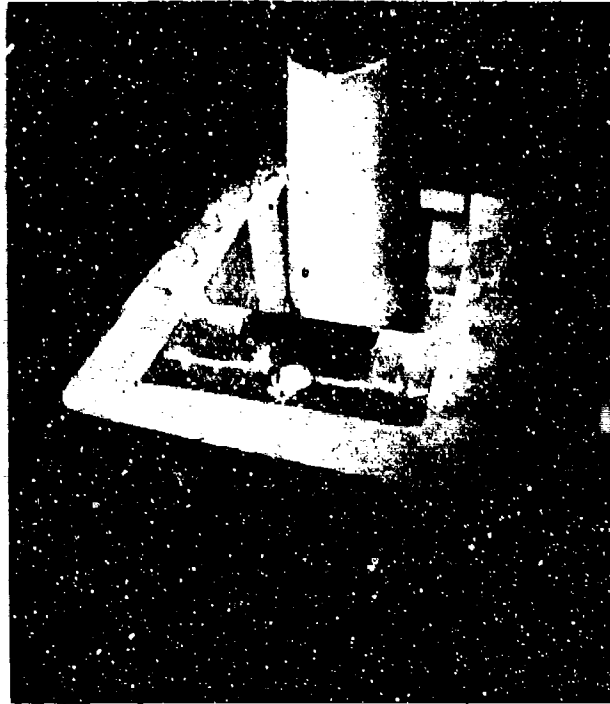
Figure 6. Dimensions of Charpy Impact Specimen



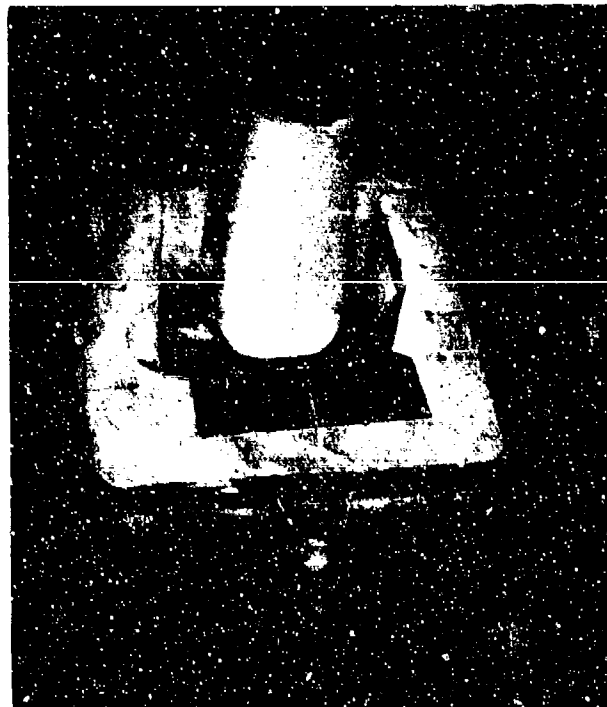
Print 1. Cores for 90 mm. T-119 breech ring, showing their relative placement in the mold.



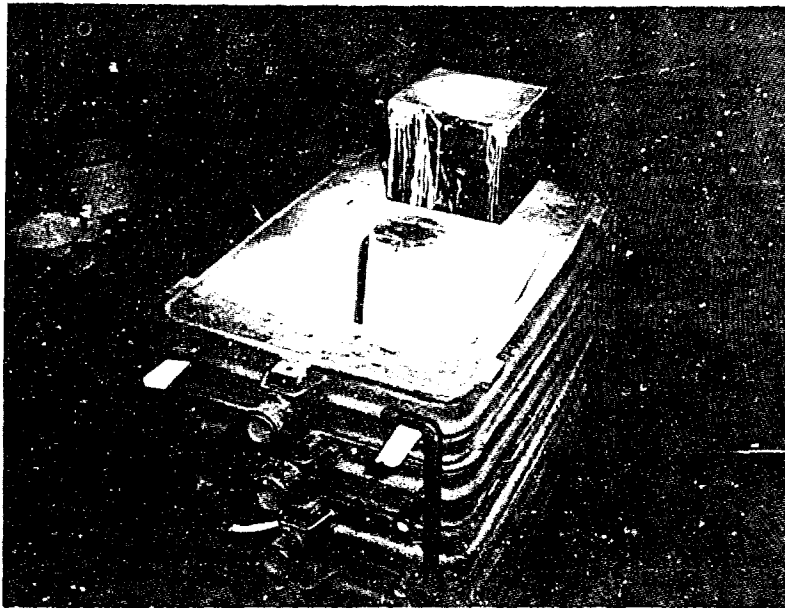
Print 2. Cores shown in Print 1 with half of gate core removed to show sprue, runner, and ingates.



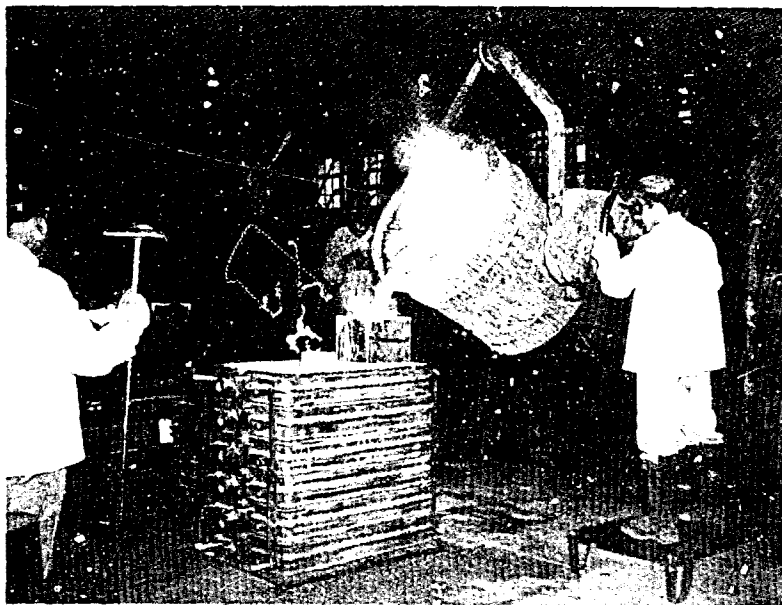
Print 3. Drag half of mold for T-119 breech ring
from the gate end.



Print 4. Drag half of mold shown in Print 3 from
end opposite gates, showing gate entrance
into mold cavity.



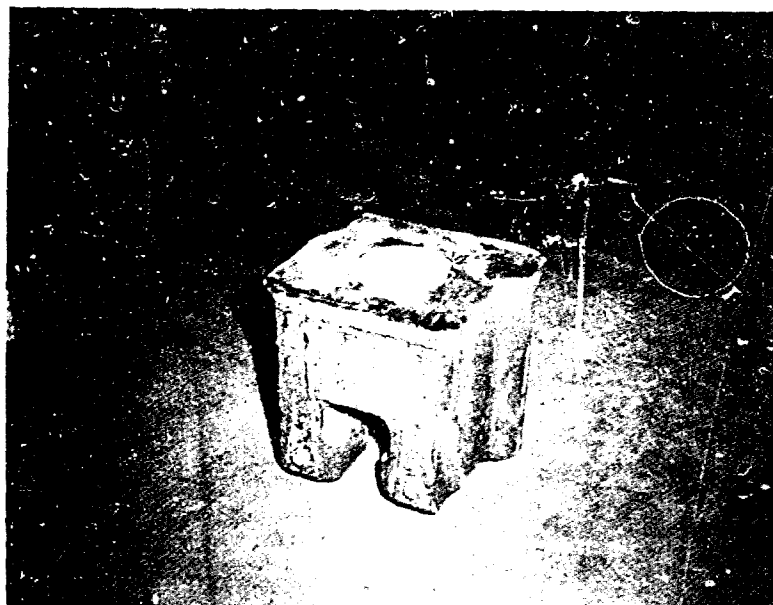
Print 5. Completed mold for T-119 breech ring with pouring basin in position.



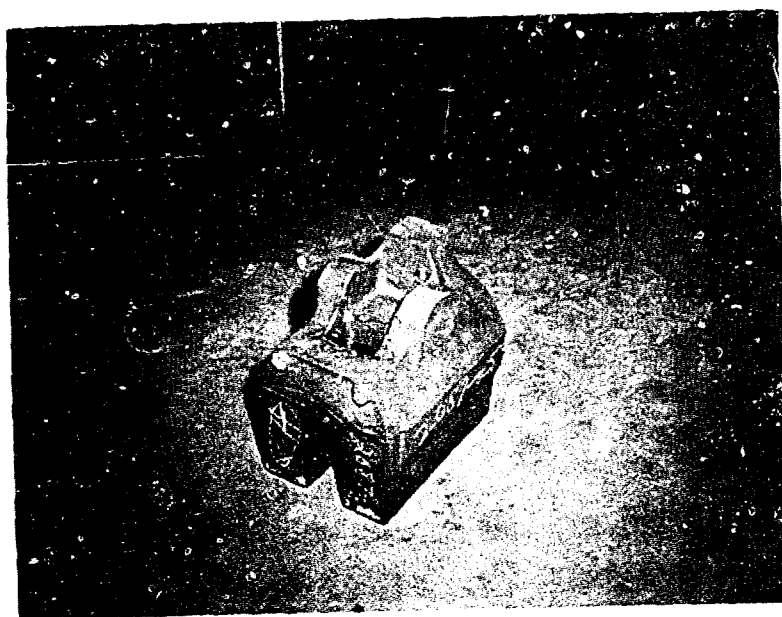
Print 6. Pouring T-119 breech ring.



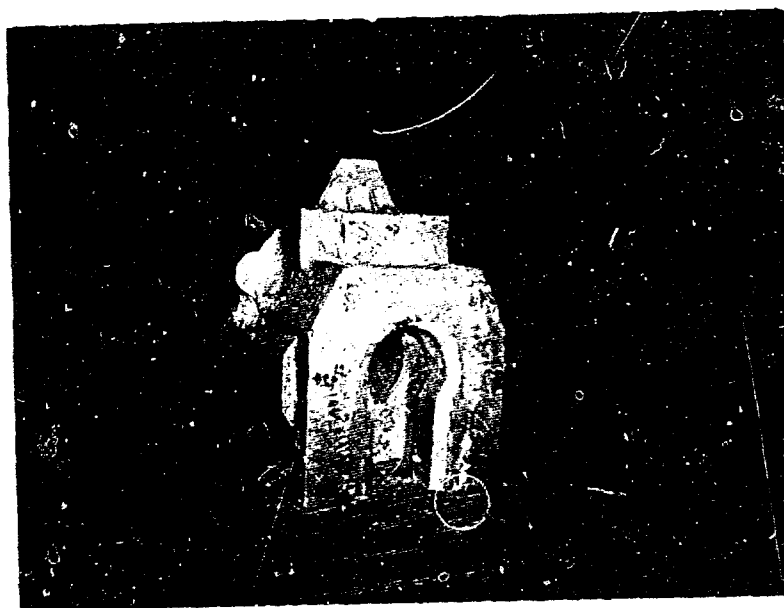
Print 7. T-119 breech ring as shaken out;
gates and riser intact. Note
test coupon.



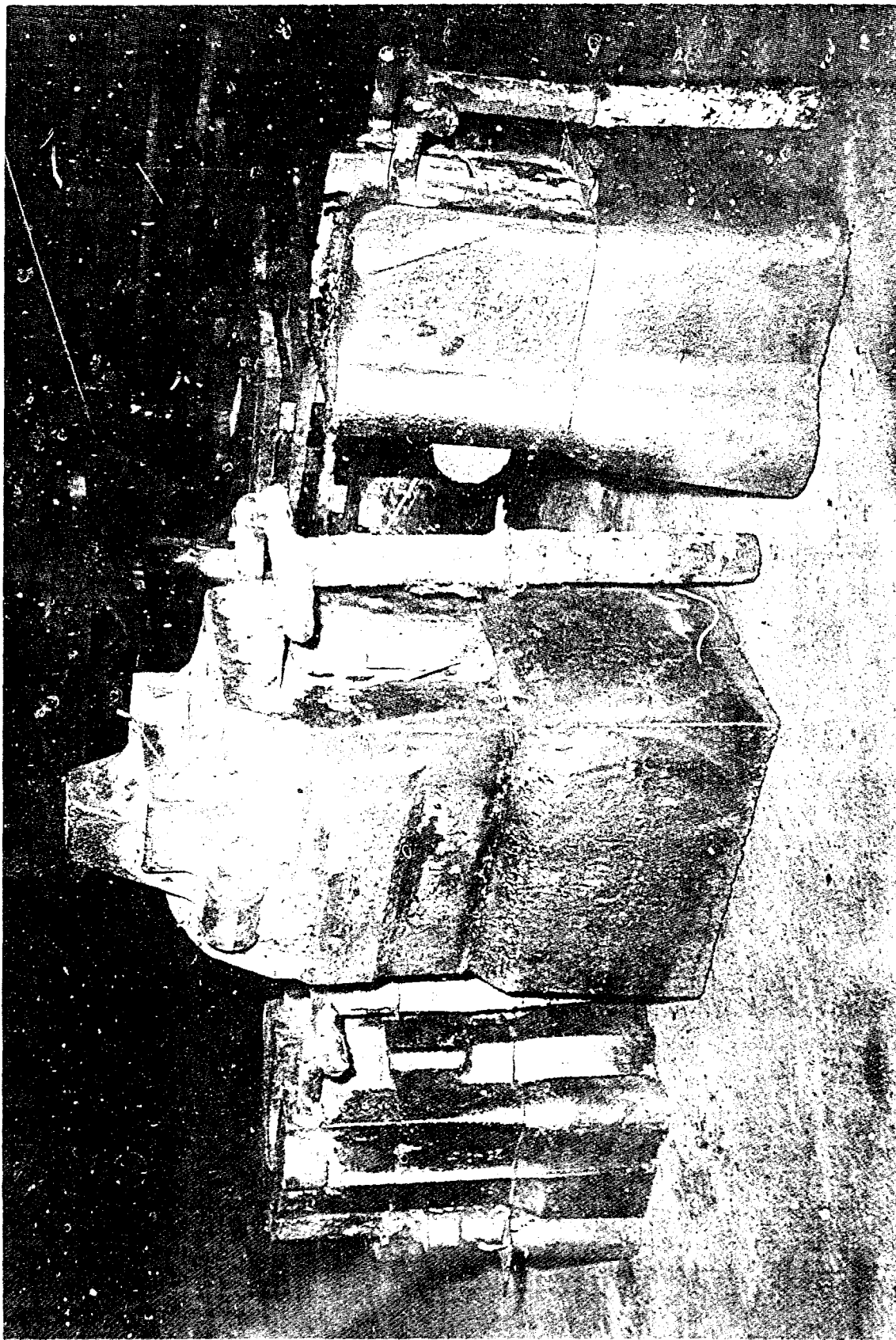
Print 8. T-119 breech ring with gates
and riser removed.



Print 9. T-83 breech ring.



Print 10. M1E1 breech ring.



Print 11. As-cast breech rings with gates and risers attached: left to right - 90 mm. M2A2, 120 mm. M1E1, and 90 mm. T-119.