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6/11/79



REPORT No. 671/2

MEMORANDUM

A STUDY OF DIE DESIGN CHANGES FOR THE IMPROVEMENT
OF THE SOUNDNESS AND UNIFORMITY OF TEST BARS

INDEXED

By

G. L. Herley

WATERTOWN ARSENAL
WATERTOWN, MASS.

REPRODUCED AT GOVERNMENT EXPENSE

THIS REPORT AVAILABLE IN MICROFICHE ONLY

AMERICAN SOCIETY FOR TESTING MATERIALS

200 SOUTH BROAD STREET, PHILADELPHIA, PA.



COMMITTEE B-6 ON DIE-CAST METALS AND ALLOYS

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W. H. GRAVES, VICE-CHAIRMAN, PACKARD MOTOR CAR CO., DETROIT, MICH.
P. V. PARAGHER, SECRETARY, ALUMINUM CO. OF AMERICA, PITTSBURGH, PA.

P.O.Box 263,
Palmerton, Pa.

January 20, 1937

Mr. P. R. Kosting,
War Dept., Watertown Arsenal,
Watertown, Mass.

At the June 1936 meeting of the A.S.T.M. held at Atlantic City, Committee B-6 approved the recommendation of Subcommittee V that atmospheric tests should be conducted on three zinc alloys, designated by the Society as No. XXI, No. XXIII and No. XXV, and two magnesium alloys, designated as No. 12 and No. 13.

Mr. Peirce reported to the Committee at that time that The New Jersey Zinc Company, using an insert or unit type of die, had shown a very marked improvement in the uniformity of physical properties of zinc die castings by accurate control of casting conditions and by changing the die design relative to gating, venting and the use of overflow wells. On the basis of this report, quoting from the minutes of the above-mentioned meeting "It was agreed that standard dies and casting conditions should be adhered to in producing the test specimens".

Since the time of the Atlantic City meeting, changes have been made to our die which was similar to that used by most producers in the first Committee B-6 exposure program and again these changes succeeded in greatly improving the uniformity and strength of zinc die castings.

The progress made in improving both the insert and so-called A.S.T.M. die is set forth in a Memorandum, a copy of which is attached to this letter.

It is hoped that each producer of specimens for the proposed A.S.T.M. atmospheric exposure tests will alter their dies to conform either with blueprints RF748B or RF761A, depending on the type of die to be used, so that the specimens for exposure will be as uniform in strength as it is possible to produce them.

Very truly yours,

George L. Werley
GEORGE L. WERLEY

GLW:MGW

Enclosure

M E M O R A N D U M

A STUDY OF DIE DESIGN CHANGES FOR THE IMPROVE-
MENT OF THE SOUNDNESS AND UNIFORMITY OF TEST PARS.

by

G. L. Werley

M E M O R A N D U M

A STUDY OF DIE DESIGN CHANGES FOR THE IMPROVE- MENT OF THE SOUNDNESS AND UNIFORMITY OF TEST BARS

Introduction

This memorandum is divided into two parts. Part I pertains to the development of an insert or unit die to produce sound test bars of uniform strength. Part II covers similar tests on a die which was built in 1927 primarily to cast test specimens for the first exposure tests conducted by Committee B-6 of the A.S.T.M. This die will be called the A.S.T.M. die in this memorandum.

The work under Part I was done in the interests of reducing the number of specimens that were required to be averaged to obtain significant results for routine tests. Part II was undertaken to effect similar improvements in the A.S.T.M. die so that those producers who have this type of die and are cooperating in the production of test bars for the proposed A.S.T.M. atmospheric exposure test can readily alter their die to attain an improvement in uniformity and soundness of their specimens.

Part I

In 1932, a unit or insert die provided with inserts for casting various types of test specimens was put into operation.

Specimens cast in the unit for the production of 1/4" test bars, under carefully controlled conditions, exhibited a wide degree of nonuniformity in physical properties. A statistical analysis showed that forty such impact bars were required to obtain, in 95 out of 100 cases, an average within plus or minus ten per cent of the average of a very large number of specimens. Radiographs also showed the test bars to have considerable porosity.

In an attempt to produce sound test bars of uniform strength, small changes were made repeatedly to the gates, vents, and overflow wells. Collectively, these changes produced the desired results and in addition each die change, which increased the uniformity, also increased the impact strength and, to a lesser extent, the Brinell hardness. The tension bars were improved in soundness but not in strength. In fact, a slight loss in tensile strength resulted.

Changes were made to the die with the following objectives in view:

1. The castings were to be virtually free of porosity in the test sections as shown by radiographs.

2. The impact bars were to have the same strength for the gate and vent halves of the specimen when tested at 21°C.
3. The average impact strength of any five bars taken at random was to be within plus or minus ten per cent of the average of a large number of specimens in 95 out of 100 cases.

The original plan of the unit die for the production of 1/4" test bars is shown in Figure 1. When this die was put into service the 1/4" impact specimens cast were too porous to be considered satisfactory test bars. In order to cast sounder specimens, the following changes were made to the die:

1. The overflow well at the vent end of the impact cavity was increased in size.
2. Four vents were added to the die at regularly spaced distances along the side of the impact cavity. (See Figure 8).
3. A waster in the shape of a 5/16" square impact bar, with an accompanying overflow well, was added to the die between the existing round tensile and 1/4" square impact cavities to facilitate getting the die up to the proper temperature and to assist in holding the temperature at a constant value. (See Figure 8).

The above changes were made to the die prior to the intensive study of the optimum design of this die.

The die with the above construction changes produced Zamak-3 bars (A.S.T.M. Alloy No. XXIII) with the following physical properties when cast in a modern die casting machine:

Table 1

Date Cast: 12/12/35

Alloy: Zamak-3

Pressure: 1500 Lbs. per Sq. In. (Calculated)

Metal Temperature: 425°C.

Die Temperature: 150, 200 and 250°C.

	Die Temperature - °C.		
	150	200	250
Tensile Strength-Lb./Sq.In.	44,000	43,400	43,000
Impact Strength-(Top or Gate End)- Ft.Lb.*	35	35	38
Standard Deviation-Ft.Lb.**	2.4	3.5	4.0
Coefficient of Variation***	6.9	9.9	10.5
Impact Strength-(Bottom or Vent End)- Ft.Lb.*	7.3****	9.6	18
Standard Deviation-Ft.Lb.	2.2	3.1	5.3
Coefficient of Variation	30.4	31.8	29.2
Impact Strength-Grand Average-Ft.Lb.	21	22	28
Standard Deviation-Ft.Lb.	13.8	13.2	10.7
Coefficient of Variation	65.8	59.6	38.4

*Tested at 21±0.5°C.

**Calculated using formula $\sqrt{\frac{\sum x^2}{n}}$, where x is the deviation of the individual bars from the arithmetic average and n is the number of specimens.

***The coefficient of variation is a measure of the variability which is independent of the scale units and which takes into account the size of deviations relative to the mean.

The coefficient of variation is determined by using the formula $V = \frac{100 \sigma}{M}$ where, σ = the standard deviation and M = the arithmetic mean

****The impact values were determined on a Charpy type machine fitted with three interchangeable hammers having the following capacities: 0-10.3; 0-38.5; 0-103.6 ft. lb. Contrary to our usual practice, impact values under 15 ft. lb. were reported to one decimal place. However, such results are believed to be significant when the proper hammer is used.

Note: Through common usage, the gate and vent ends are sometimes referred to as "top" and "bottom" respectively. Therefore, throughout this report wherever "top" is used, it refers to the gate end; and "bottom" refers to the vent end.

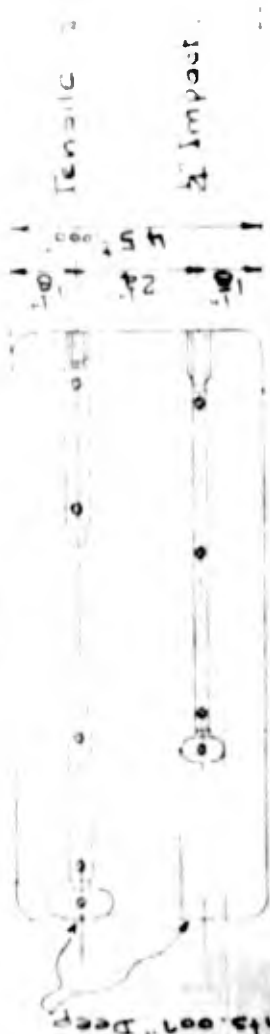
- 5 -

Figure 1

THE NEW JERSEY ZINC CO.
Research Division, Palmerton, Pa.
SERIAL No.
E3599
Date
Issued JAN 6-1937

10.250 ± .001"

3.050"



10.250 ± .001"

0.036"
10.250 ± .001"



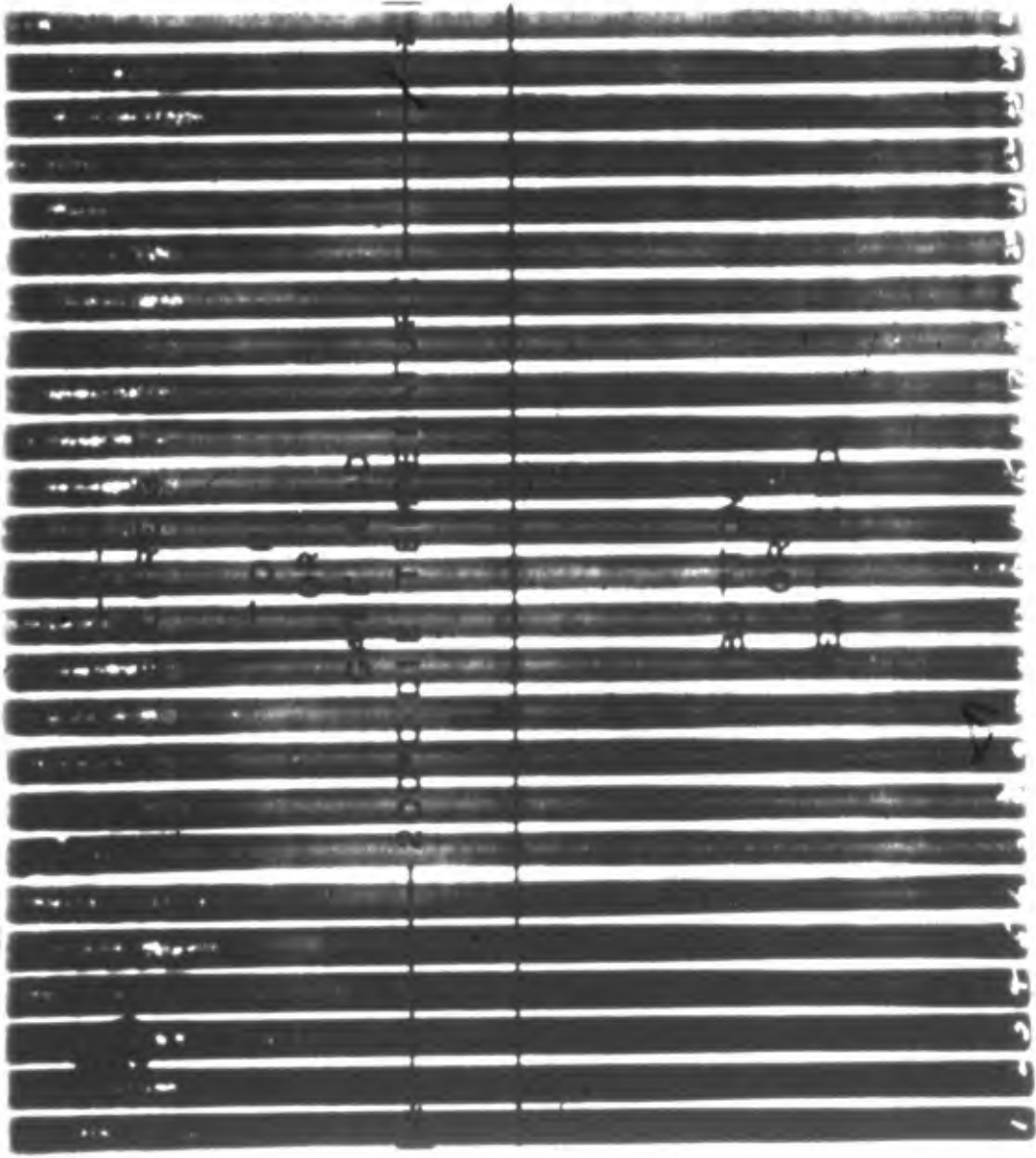
Detail of 1/4" Insert Die	RF7-63-D
REFERENCE DRAWINGS ABOVE	
THE NEW JERSEY ZINC CO. RESEARCH DIVISION - PALMERTON, PA.	
DATE: 7-36	SCALE: 1/4" = 1 Foot
Metal Section Die Casting 1/4" Impact Insert Die Original 5-19-32.	
DR BY: Lente	RF7-63-D
TR BY:	
CK BY: G.L.W.	
APP. BY:	CHARGE

REVISIONS:

The data in Table 1 show that, in impact strength, the vent halves of the bars are greatly inferior to the gate halves as well as being less uniform in strength.

Radiographs, Figures 2, 3, and 4, show considerable porosity at the gate, and some porosity at the vent, of the impact bars. Radiographs, Figures 5, 6, and 7, show considerable porosity in the vent end, and some objectionable porosity in the test section, of the round tension bars.

91091



10-
CORRECTION
DATE IN
DIE TEMPERATURE

2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

FIGURE 6

CUT TO END

20° CUT TO END FEATURE

6

In Figure 8 is shown the net result of the changes which were made to the die from its original construction, as shown in Figure 1. It now embodies what is believed to be about the optimum design for the die casting of Zamak alloys in this particular insert die.

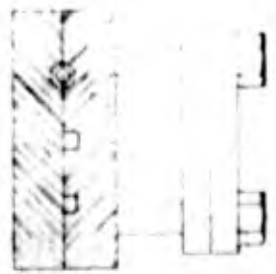
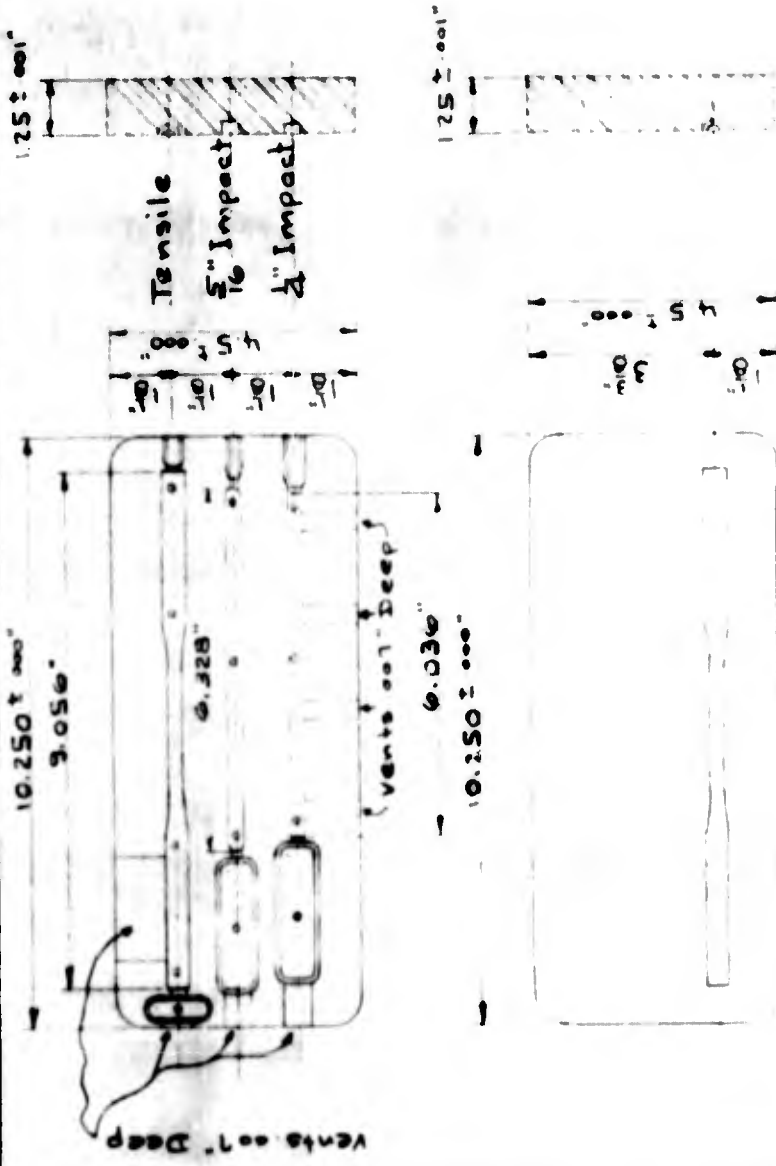
As previously stated in this report, the die changes were made in individual small steps. In this manner it was possible to study the effects which each die change produced and, therefore, recognize when the optimum condition for each type of change was reached. It is known that if the gate opening, for instance, is at its optimum size, a change in the size of the overflow well may disturb the optimum condition established for the gate. Thus, any change made in the die may cause some former alteration to be out of balance and create an almost endless series of minor changes. The die as shown in Figure 8 met the requirements listed earlier in this report concerning uniformity and strength and, therefore, was considered as being correctly designed.

The changes that were made in the die can be seen by comparing Figures 1 and 8. However, the major changes will be listed here for the convenience of the reader.

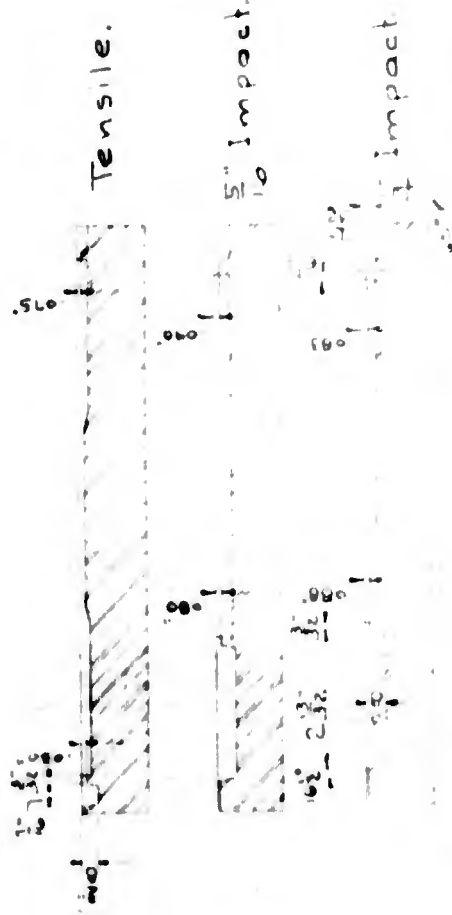
- 14 -

Figure 8

THE NEW JERSEY ZINC CO.
Research Division, Palmerton, Pa.
SERIAL P. O.
E3578
Date Issued **JAN 6-1937**



Detail of Insert Die RF7-48-B



THE NEW JERSEY ZINC CO
 4000 ...
 4 1/2 Feet

Metal Section Die Casting
 Impact Insert Die
 as Shown 3 4 30.

RF7-62-D

REVISIONS

1/4" Impact Bar Cavity

1. Gate depth increased from 0.030" to 0.083".
2. Overflow well runner depth increased from 0.030" to 0.088".
3. Overflow well increased from 0.07 to 0.6 cubic inch.
4. Four vents were placed in the die along the length of the cavity.

1/4" Round Tension Bar Cavity

1. Gate depth increased from 0.030" to 0.075".
2. Overflow well increased from 0.06 to 0.15 cubic inch*.

Further Alterations

1. The addition of a 5/16" square impact bar cavity** having:
 - a. Gate depth of 0.090".
 - b. Overflow well runner depth of 0.080".
 - c. 0.5 cubic inch overflow well.
 - d. Vent from the overflow well of 0.007" depth.

*The vent end grip of a tension bar is in effect an overflow well so far as the test section is concerned. On this basis, the overflow well capacity is 0.3 plus the above-mentioned 0.15 or a total of 0.45 cubic inch.

**This casting has no particular value as a test specimen and was added only to facilitate in getting the die up to the proper temperature and to assist in holding this temperature at a constant value.

Zamak-3 (A.S.T.M. Alloy No. XXIII) had the following physical properties when cast in the die shown in Figure 8 and using a modern die casting machine:

Table 2

Alloy: Zamak-3

Date Cast: 3/4/36

Pressure: 1500 Lbs. per Sq. In. (Calculated)

Metal Temperature: 415°C.

Die Temperatures: 150, 160, 170, 180, 190, 200, 210, 220, 230, 240 and 250°C.

	150	160	170	180	190	200	210	220	230	240	250
44000	42600	41900	40500	40700	40800	41300	41100	40500	40500	40100	
38	39	40	40	42	42	42	44	44	42	41	38
3.1	3.0	5.0	4.6	1.8	2.4	1.2	0.6	0.6	3.6	4.1	3.3
8.1	7.6	12.5	11.5	4.3	5.8	2.9	1.3	1.3	8.7	10.1	8.7
36	38	45	42	44	44	43	44	44	43	43	43
4.2	4.5	0.8	3.1	0.7	0.7	0.7	0.6	0.6	0.6	0.8	0.5
11.7	12.0	1.9	7.3	1.6	1.7	1.7	1.3	1.3	1.3	2.0	1.2
37	38	43	41	43	43	43	44	44	42	42	40
3.8	3.9	4.3	4.1	1.8	2.0	1.1	0.6	0.6	3.1	3.2	3.3
10.4	10.2	10.0	10.0	4.2	4.6	2.6	1.3	1.3	7.2	7.6	8.1

Tensile Strength-Lb./Sq. In.

Impact Strength-(Top or Gate

End)-Ft. Lb.*

Standard Deviation-Ft. Lb.

Coefficient of Variation

Impact Strength-(Bottom or

Vent End)-Ft. Lb.*

Standard Deviation-Ft. Lb.

Coefficient of Variation

Impact Strength-Grand Average-

Ft. Lb.

Standard Deviation-Ft. Lb.

Coefficient of Variation

*Tested at 21±0.5°C.

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Figure 9



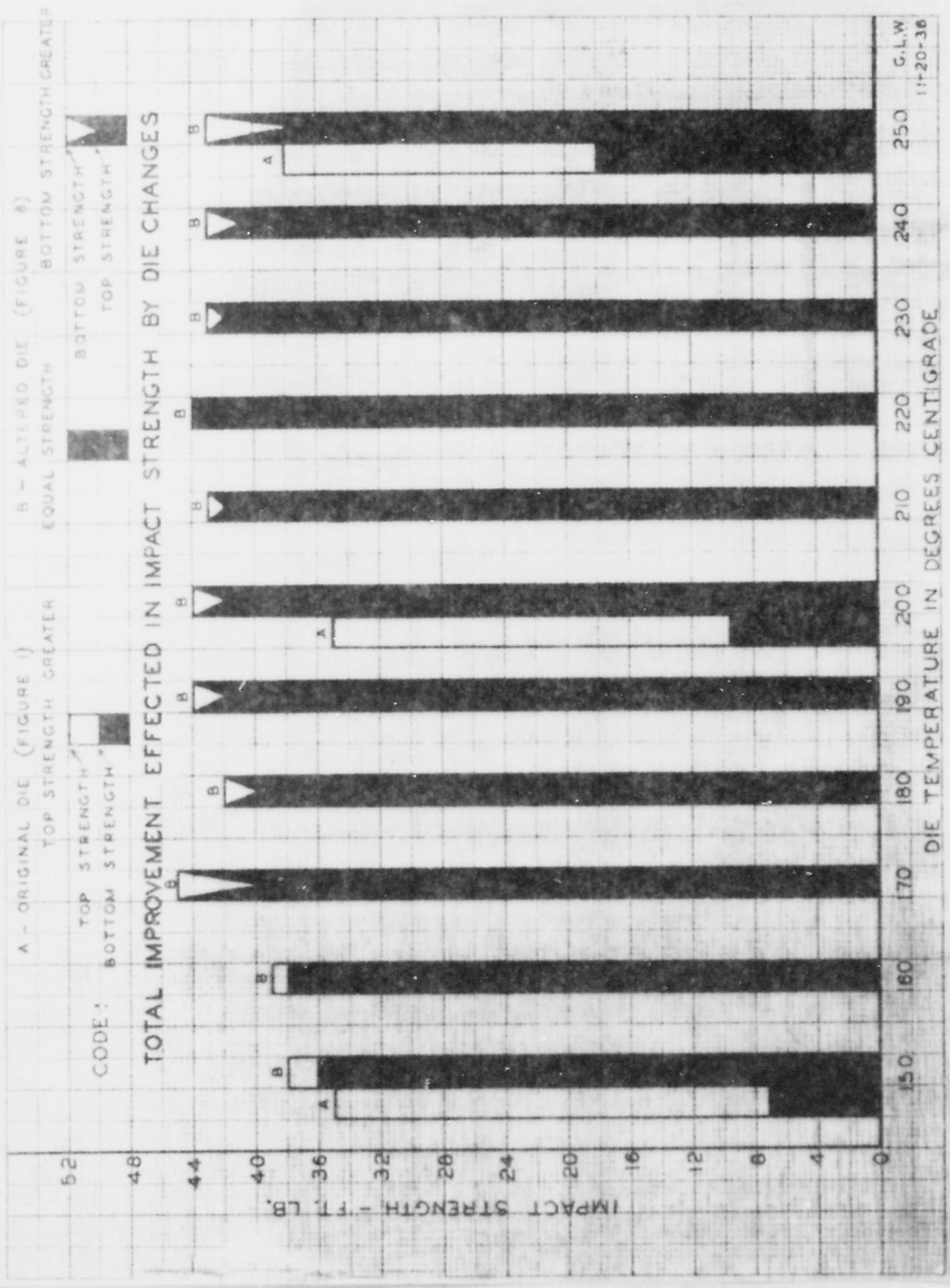


Figure 9 shows the impact data of Tables 1 and 2 in columnar diagrams. By means of this chart the improvement in impact strength resulting from the die changes, which were made during the period of December 12, 1935 to March 4, 1936, are readily apparent.

It will be noticed that the strength of the top half of the impact bars was not greatly affected by the die changes. The greatest improvement was in the impact strength of the bottom half of the bar. In many cases, in the final cast, the vent or bottom end of the bar exceeded in impact strength the gate or top end although the difference between the two was not considered significant.

The die was now in such shape that one of the objectives of this experiment had been attained, namely, that the impact bars should possess the same strength for the gate and vent halves of the specimen at 21°C.

The radiographs which follow as Figures 10 and 11 show the impact bars to be virtually free of porosity. Figures 12, 13 and 14 are radiographs of round tension bars. While these bars show the presence of porous areas in the grip ends, the test sections are in most cases free of porosity. It is believed that the porosity of these bars could have been reduced further if there had been room in the insert die to increase the overflow well. Test bars cast in this die, therefore, met the second objective of this experiment; namely, that they should be virtually free of porosity.

[REDACTED]

1/25/54

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23



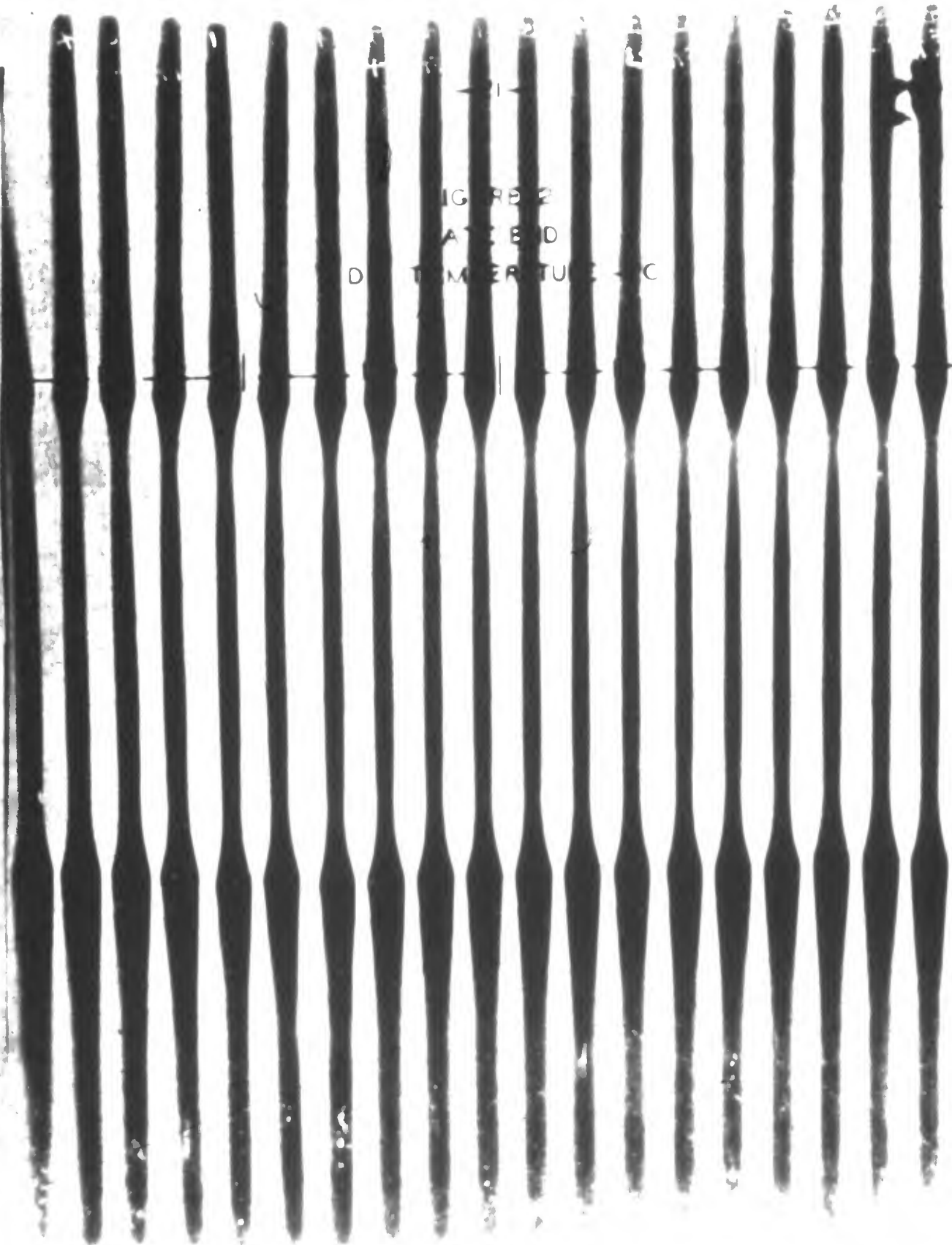
FIGURE 11

SECRET

FIGURE 2

DATE 8/10

D TEMPERATURE °C



22

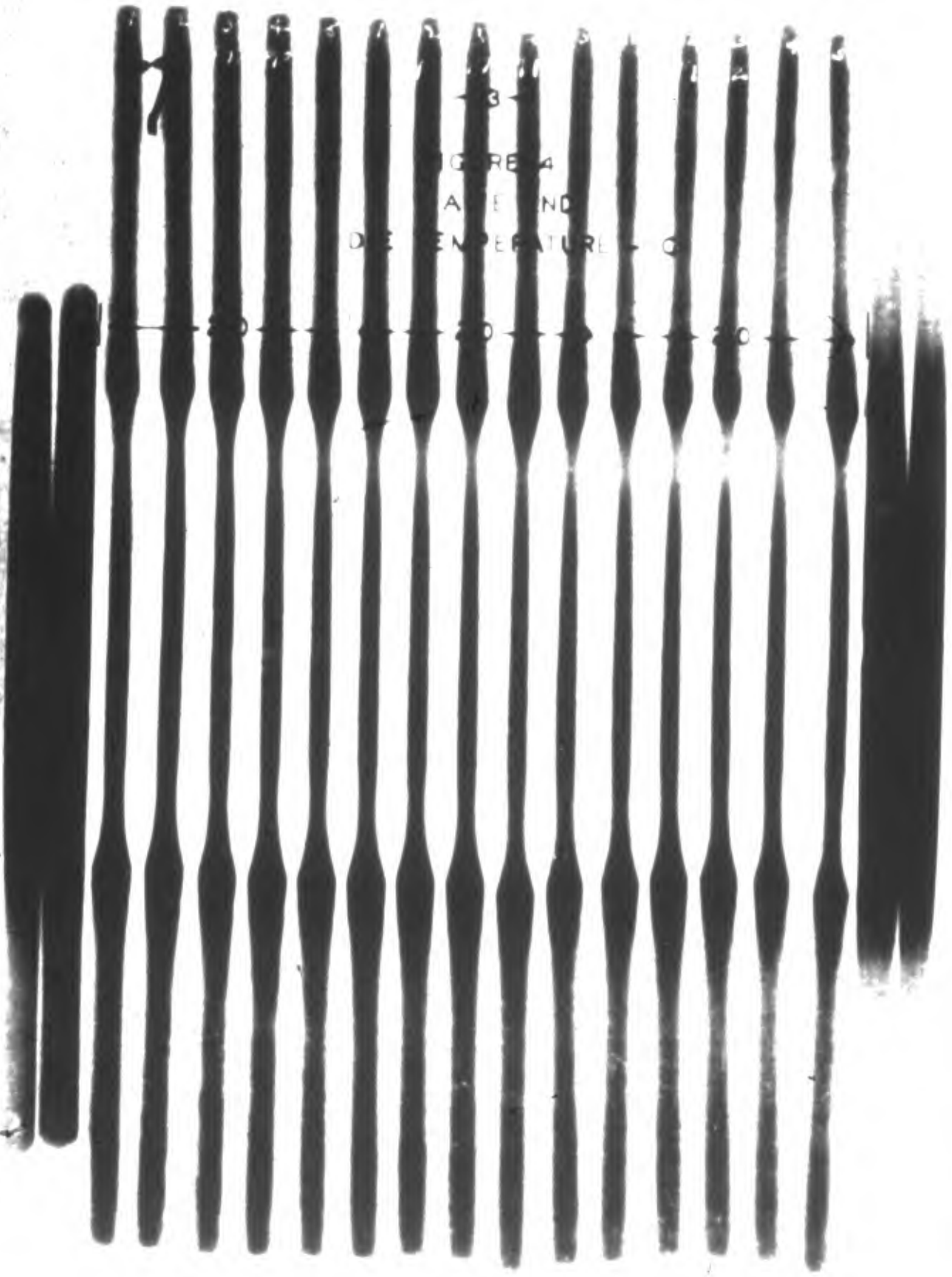
FIGURE 3

AGE D

DATE TIME RE

||

FIGURE 4
AGE AND
DIE TEMPERATURE



In order to study the uniformity of the specimens, one hundred impact bars of Zamak-3 cast under controlled conditions were tested for their impact strength at both the gate and vent ends making a total of two hundred tests. The following were the strengths reported for these bars:

<u>Impact Strength-Ft.Lb.</u>	<u>Number of Pieces</u>
33-35	2
37-39	4
39-41	7
41-43	11
43-45	20
45-47	153
47-49	2
49-51	<u>1</u>
Total	200

A statistical analysis of these data showed that a sample size of 3 to 5 bars was sufficient to yield an average impact value within plus or minus 10 per cent of the true average in 95 out of 100 cases.

The third condition, that the average impact strength of any five bars taken at random should be within plus or minus 10 per cent of the average of a large number of specimens in 95 out of 100 cases, was thus demonstrated to have been fulfilled.

It is known that Zamak-3 as normally cast does not show any appreciable drop in impact strength during a 95°C. steam test of ten days' duration. In order to determine whether this characteristic resistance to steam was retained in the specimens cast in the altered insert die, test bars were cast at a number of die temperatures and exposed in the 95°C. steam tank. The data follow in Table 3.

Table 3

Alloy: Zamak-3

Date Cast: 3/4/36

Pressure: 1500 Lbs. per Sq.In. (Calculated)

Metal Temperature: 415°C.

Die Temperatures: 150, 160, 170, 180, 190, 200, 210, 220, 230, 240 and 250°C.

		Die Temperature-°C.										
		150	160	170	180	190	200	210	220	230	240	250

As Cast

Impact Strength-(Top or Gate end)-Ft.Lb.-
Tested at 21+0.5°C.

Coefficient of Variation

Impact Strength-(Bottom or Vent end)-Ft.Lb.-
Tested at 21+0.5°C.

Coefficient of Variation

38	39	40	40	42	42	42	42	42	44	44	42	41	38
8.1	7.6	12.5	4.5	4.3	2.0	2.9	1.3	1.3	3.7	10.1	8.7		
36	38	45	42	44	44	43	44	43	44	43	43	43	43
11.7	12.0	1.9	7.3	1.6	1.7	1.7	1.3	1.3	1.3	2.0	1.2		

Exposed in 95°C. Steam Test for 10 Days

Impact Strength-(Top or Gate end)-Ft.Lb.-
Tested at 21+0.5°C.

Coefficient of Variation

Impact Strength-(Bottom or Vent end)-Ft.Lb.-
Tested at 21+0.5°C.

Coefficient of Variation

43	43	43	42	40	42	42	37	35	21	25			
6.2	7.7	2.3	5.7	10.0	9.2	3.8	17.7	29.1	57.5	59.2			
44	44	42	43	43	43	42	42	32	29	30			
6.0	1.6	8.0	2.1	0.9	2.8	1.2	3.3	30.4	51.4	38.3			

From the above data, it will be seen that while the impact strengths for as cast specimens are satisfactory for all of the die temperatures tried, namely, 150 to 250°C. in 10°C. intervals, nevertheless the steam test limits the permissible die temperature as measured on this die to a range of 150 to 220°C. Above 220°C. die temperature, there is an appreciable drop in impact strength during the 10-day 95°C. steam test and the impact values show wide variations as evidenced by the large coefficient of variations.

The die was considered to be in its optimum condition, so far as could be determined at this time, for Zamak-3, and, further tests along similar lines on three other Zamak alloys (including A.S.T.M. Alloy No. XXI and No. XXV) showed results as favorable as those obtained for Zamak-3. Only the data for Zamak-5 are reported here.

The results for Zamak-5 (A.S.T.M. Alloy No. XXV) are included in this report to link Part I with Part II since Zamak-5 was used in the development of the A.S.T.M. die (Part II of this report).

It would have been desirable to conduct the development of the insert die and the A.S.T.M. die with the same alloy. However, this was not practical, if the alloy composition changes in the die casting pot were to be held to a minimum to avoid contamination of one alloy with another, since the development work

*The permissible die temperature range may be different for each die since there is no standardized procedure for the determination of die temperatures.

extended from 12/12/35 to 11/4/36 and was conducted in connection with many other experimental programs. Unfortunately, for the sake of this report, it so happened that Zamak-3 was the alloy on which experimental work was in progress when the insert die was altered and Zamak-5 was being studied when the A.S.T.M. die was being improved.

The data on Zamak-5 show that the insert die was equally capable of casting this alloy to meet the standards established for Zamak-3, namely, (1) that the castings be virtually free of porosity in the test sections as revealed by radiographs, (2) that the impact bars show approximately the same strength for the gate and vent halves of the specimen when tested at 21°C.

The impact data obtained on Zamak-5 cast in the altered insert die follow in Table 4 and radiographs of these specimens are shown in Figures 15, 16, 17, 18, and 19.

Alloy: Zamak-5

Table 4

Date Cast: 3/12/36

Pressure: 1500 Lbs. per Sq.In. (Calculated)

Metal Temperature: 410°C.

Die Temperatures: 150, 160, 170, 180, 190, 200, 210, 220, 230, 240 and 250°C.

Specimens Cast After Final Alterations to Insert Die-

As Cast

	Die Temperature-°C.										
	150	160	170	180	190	200	210	220	230	240	250
Impact Strength-(Top or Gate end)-Ft.Lb.*	42	44	44	48	49	49	47	48	47	48	46
Coefficient of Variation	4.1	5.5	5.3	4.4	1.4	0.8	4.0	0.8	1.1	1.9	1.5
Impact Strength-(Bottom or Vent end)-Ft.Lb.*	33	43	44	45	48	48	48	48	47	48	46
Coefficient of Variation	13.6	9.0	12.0	11.2	1.3	2.7	0.8	0.8	1.7	2.7	1.9

*Tested at 21±0.5°C.

10.11



← 215 A → ← 5 P 5 B → ← 1 P 1 A → ← 8 P 1 A → ← 8 P 1 A → ← 8 P 1 A →

SPRIMEN DIE TEMPERATURE

← 250 P C → ← 240 C → ← 200 C →

TOP OR GATE END

BOTTOM OR VENT END

← 16 D →

← 8 P 1 A →

← 8 P 1 A →

← 8 P 1 A →

← 8 P 1 A →

← 8 P 1 A →

← 8 P 1 A →

← 8 P 1 A →

← 8 P 1 A →

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← 4 3 2 1 →

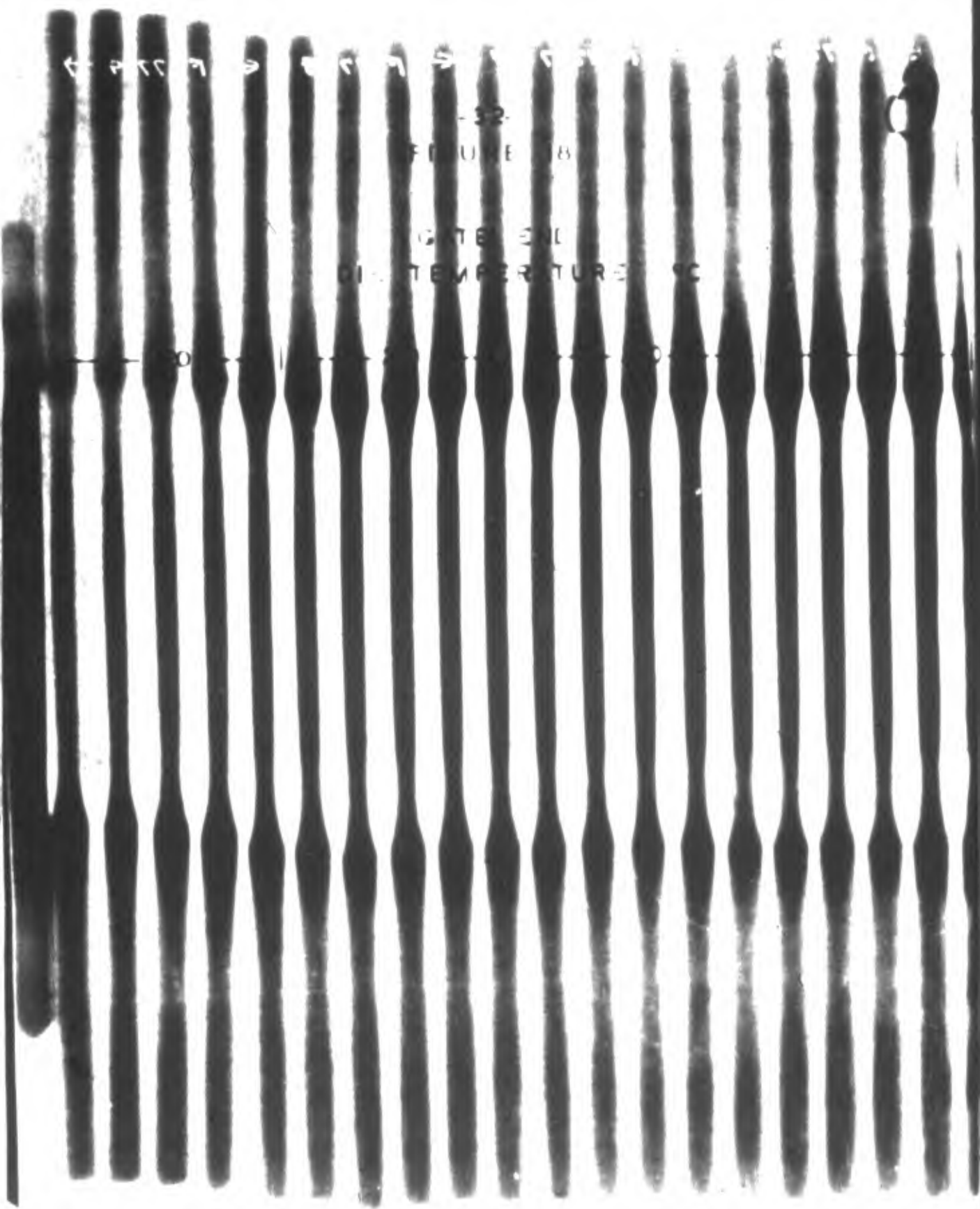
- 32 -

FIGURE 18

GATE IN
DI. TEMPERATURE °C

30

0



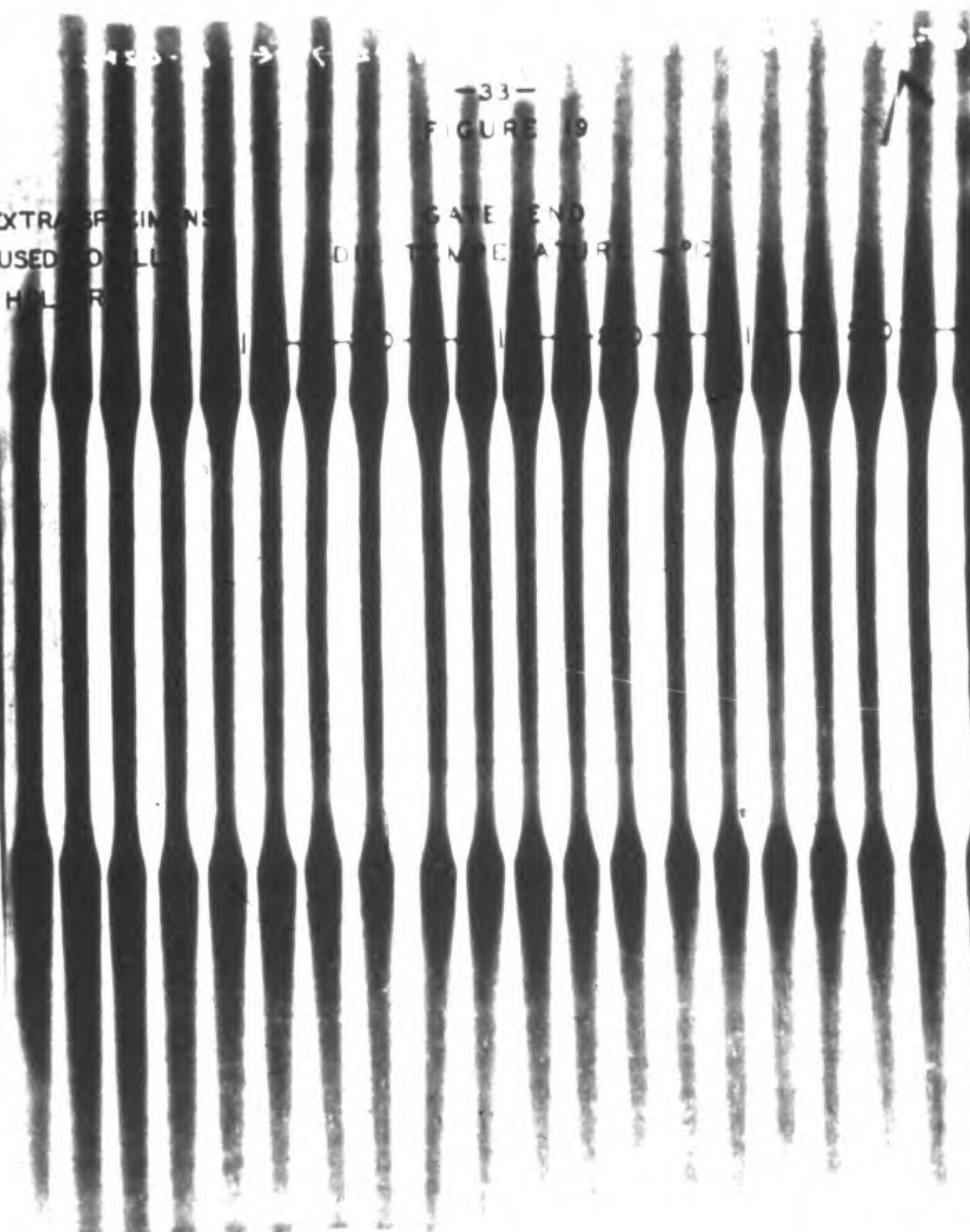
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-33-

FIGURE 19

EXTRA SPECIMENS
USED TO
HOLD

GATE END
DIE TEMPERATURE



As previously mentioned, Figure 8 shows the insert die in the form it is being used today. A detailed working drawing of this die, from which it may be constructed, is attached to this report.

Part II

The work done to improve the A.S.T.M. die was started following the A.S.T.M. Committee B-6 meeting held at Atlantic City on July 1, 1936. At that meeting, the possibility of producing sound test bars of uniform and higher strength than previously secured in an insert die was reported. On the basis of this report it was agreed that for the ensuing exposure tests the dies to be used by the producers should, if possible, be altered to produce sounder and more uniform specimens than were used in the first series of tests. Since some of the specimens will probably be produced on A.S.T.M. and not insert type dies, it became necessary to try to improve the A.S.T.M. die to the same standard attained in the unit die.

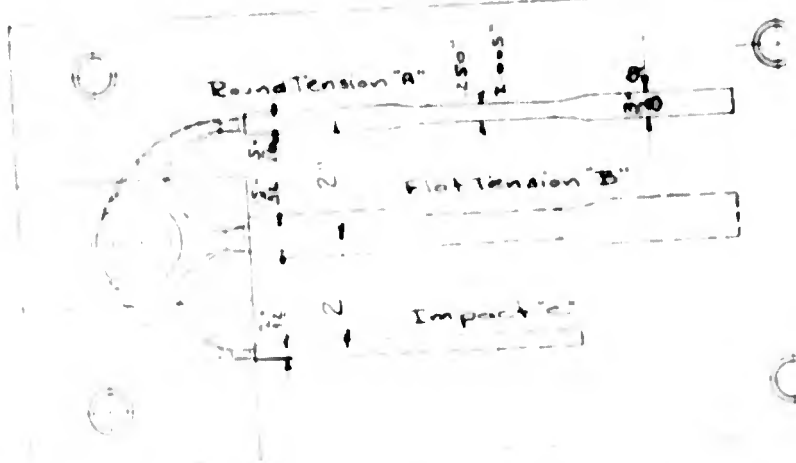
The A.S.T.M. die in its original form is shown in Figure 20. The flat tension bar cavity was altered during the development work but the results are not discussed in this report because Committee B-6 of the A.S.T.M. have standardized exclusively on the use of the round bar for tension and elongation tests. It is recommended, however, that the flat tension bar cavity be retained since the casting of some such form of waster bar in this part of the die is believed to be essential.

Specimens cast in this die, under carefully controlled conditions, exhibited a wide degree of nonuniformity in physical properties, and radiographs showed that the impact bars had considerable porosity.

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Figure 20

1-2 1/3"



Plan of Stationary Die



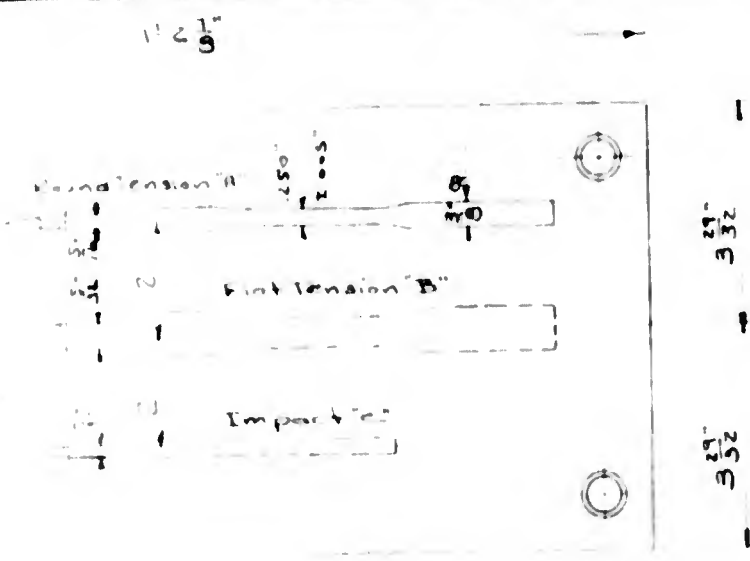
Round Tension "A"



Flat Tension "B"



Impact "C"



Plan of Stationary Die Block.

Round Tension "A"

Flat Tension "B"

Impact "C"

A.S.T.M. Specimen Die	
Detail RF7-65-C	
REFERENCE DRAWINGS ABOVE	
THE NEW JERSEY ZINC CO. RESEARCH DIVISION - PALMERTON, PA.	
DATE 11-23-36 SCALE 4" = 1 Foot	
Metal Section Die Casting A.S.T.M. Specimen Die Original 4-20-37	
DR. BY Lentz	RF7-65-C
TR. BY	
CR. BY C.L.W.	
APP BY	
GRADE	

The A.S.T.M. die in its original form as shown in Figure 20 produced Zamak-5 test bars with the following physical properties when operated in a modern die casting machine:

Table 5

Alloy: Zamak-5

Date Cast: 7/16/36

Pressure: 1500 Lbs. per Sq. In. (Calculated)

Metal Temperature: 410°C.

Die Temperatures: 150, 160, 170, 180, 190, 200, 210, 220, 230, 240 and 250°C.

		Die Temperature-°C.										
		150	160	170	180	190	200	210	220	230	240	250
Tensile Strength-Lb./Sq.In.	48800	48300	48800	47900	48000	47300	47200	47500	46500	47200	45000	
Impact Strength-(Top or Gate end)- Ft.Lb.*	19	20	22	21	22	21	27	29	28	30	27	
Standard Deviation-Ft.Lb.	2.9	2.1	1.5	2.9	2.4	2.2	6.0	6.0	3.7	5.1	5.5	
Coefficient of Variation	15.5	10.5	6.9	14.0	11.0	10.7	21.8	20.4	13.4	17.2	20.0	
Impact Strength-(Bottom or Vent end)- Ft.Lb.*	17	17	19	21	20	28	28	26	28	32	32	
Standard Deviation-Ft.Lb.	5.2	2.3	2.4	7.1	2.1	5.7	5.5	4.0	5.9	6.4	7.2	
Coefficient of Variation	31.6	14.1	13.0	33.7	10.8	20.3	19.9	15.4	20.9	20.1	22.6	
Impact Strength-Grand Average-Ft.Lb.	18	18	20	21	21	24	28	28	28	31	30	
Standard Deviation-Ft.Lb.	4.4	2.7	2.5	5.4	2.6	5.6	5.8	4.9	4.9	5.9	6.7	
Coefficient of Variation	24.9	15.0	12.3	26.0	12.4	23.0	20.9	17.5	17.4	19.1	22.7	

*Tested at 21±0.5°C.

The data in Table 5 show that the two halves of the impact bars were about equal in strength but the specimens were not uniform nor did they possess the high impact values which were obtainable in the improved or altered insert die.

Radiographs, Figures 21 and 22, show very objectionable porosity at the vent end and fine voids throughout the remainder of the bars. Radiographs, Figures 23, 24 and 25, show the round tension bars to be free of porosity in the test section and also throughout the remainder of the bars except for some minor voids in the vent end.

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JULY 23 20 11 6 5 4

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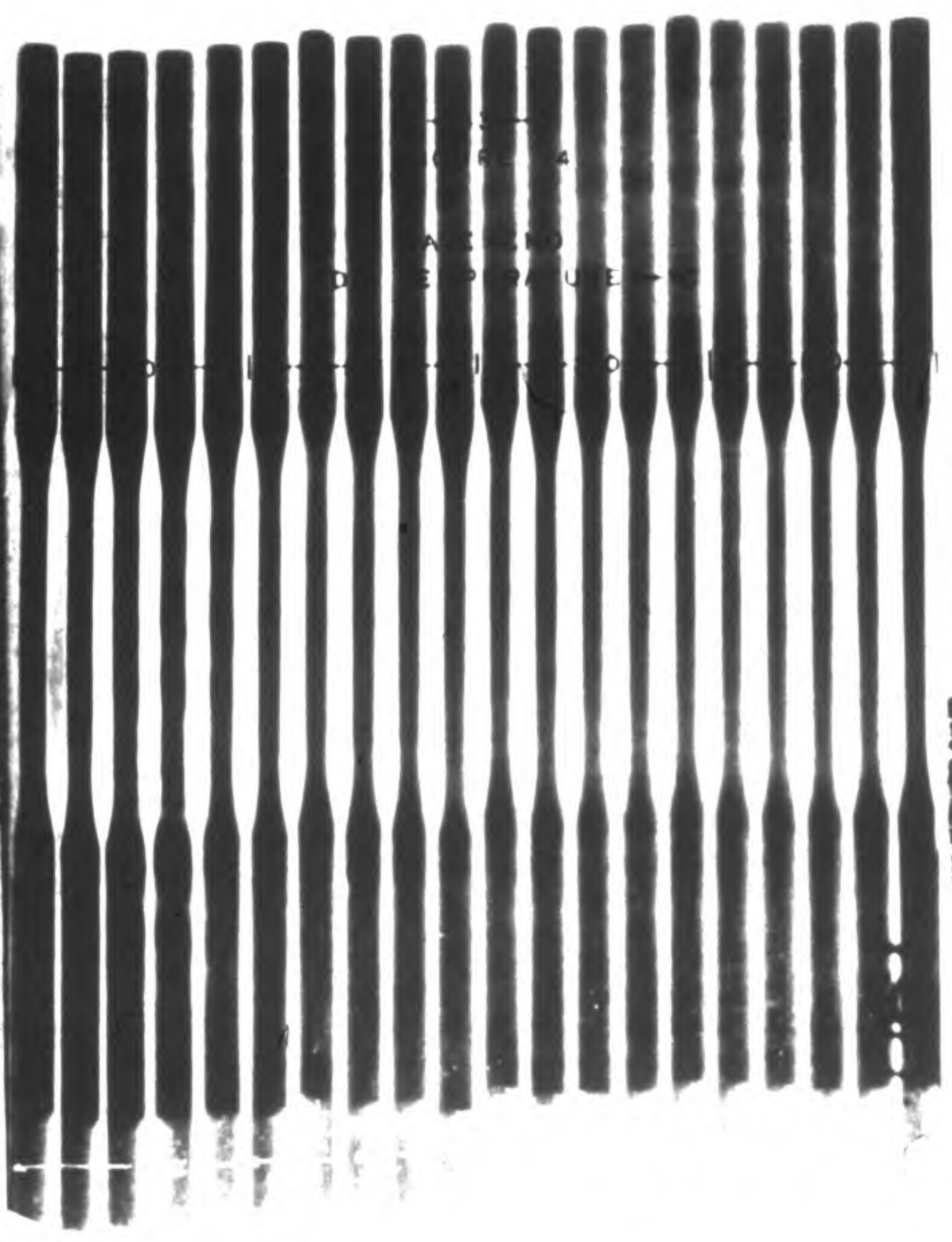
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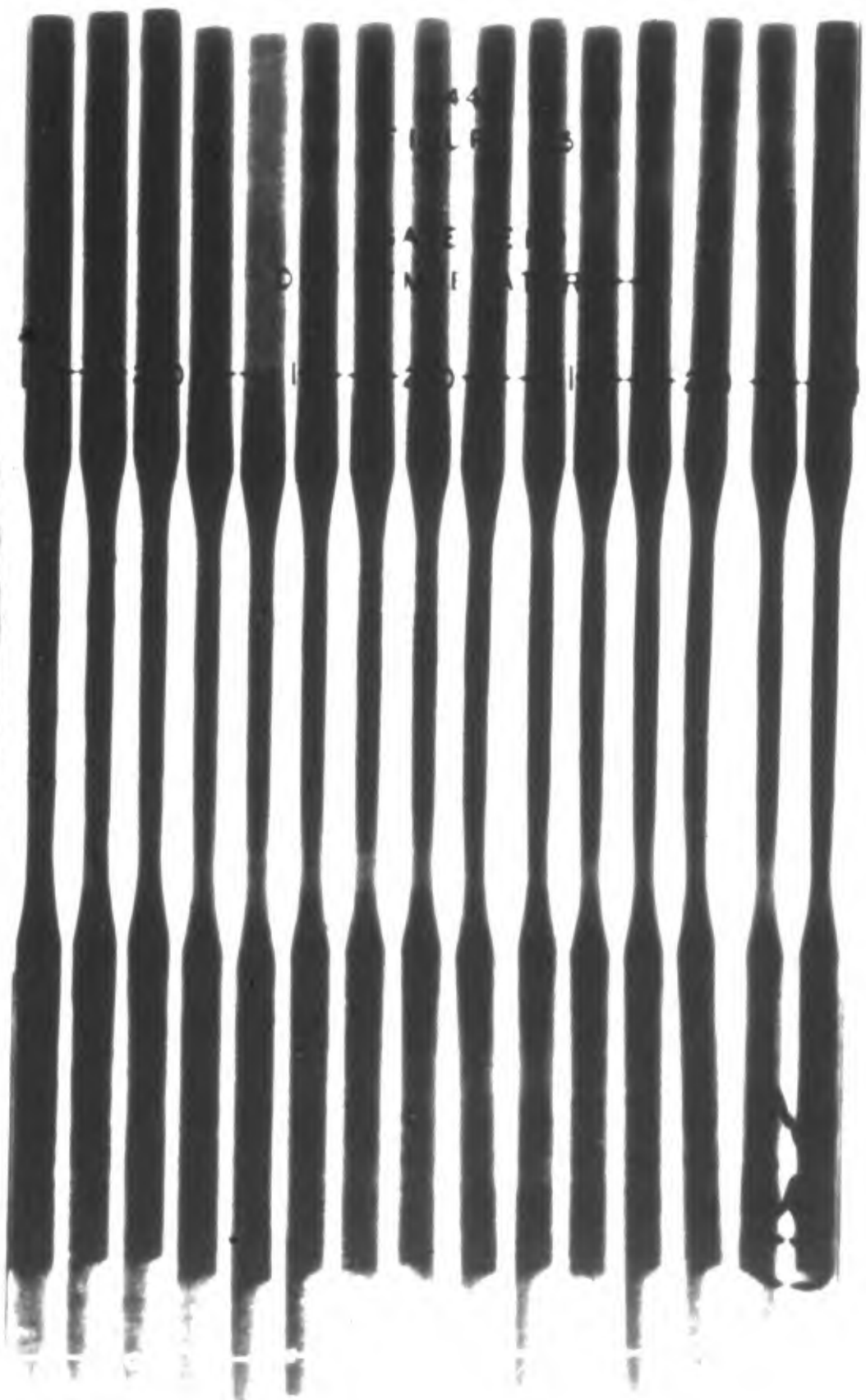
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The same line of attack used to produce sound, uniform strength test bars in the insert die was followed in the A.S.T.M. die, namely, making repeated changes to the gates, vents and overflow wells. As in the case of the insert die, the impact strength, and to a lesser extent, the Brinell hardness increased with the uniformity of the bars. Again, there was a slight loss in tensile strength as a result of these die changes.

In Figure 26 are shown the net result of the changes which were made to the die from its original construction, as shown in Figure 20. These changes produced material improvements in the impact strength, uniformity, and soundness of the bars but failed to produce the high degree of perfection attained in the insert die.

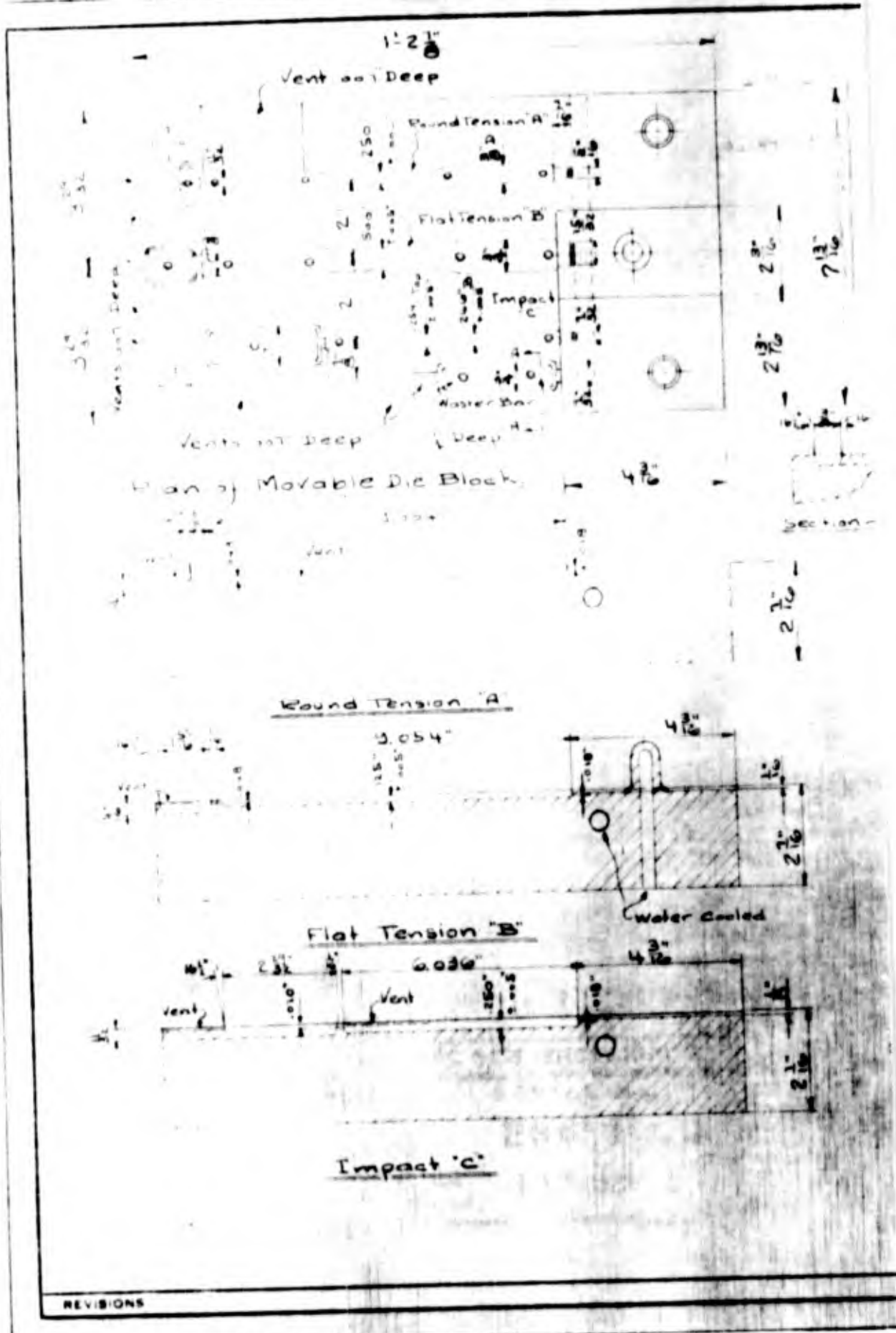
Lack of time has prevented completion of this investigation. The changes to the gate and vent openings, the addition to or enlarging of overflow wells, and the inclusion of waster bars were established, by trial, to be at about their optimum. It is believed that to achieve the same degree of perfection in this die as had been accomplished in the insert die it would be necessary to alter the major construction of this die. Such an operation would be time-consuming and since several die casters have already requested the information on the die changes so that they can alter dies or build new ones for the production of test bars for the proposed

A.S.T.M. atmospheric exposure tests, it was decided to forego any further alteration to the die at this time.

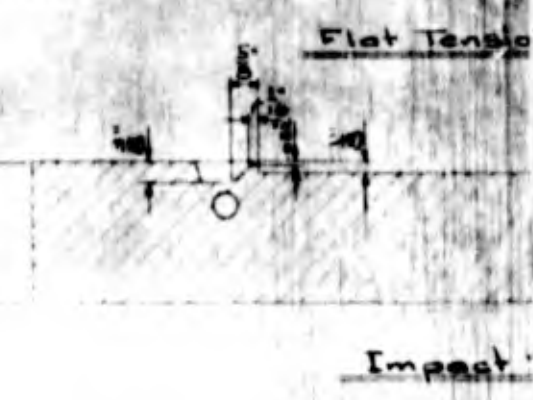
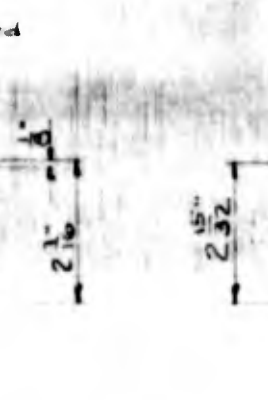
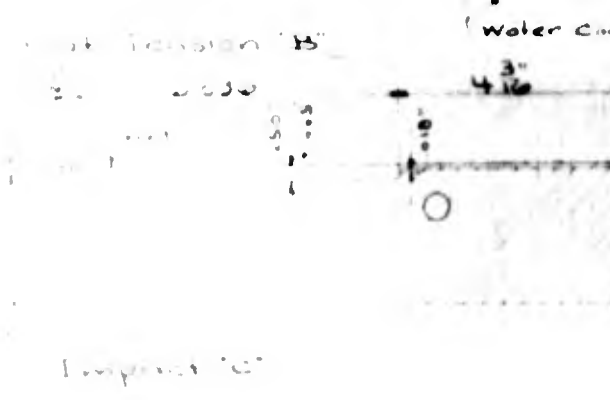
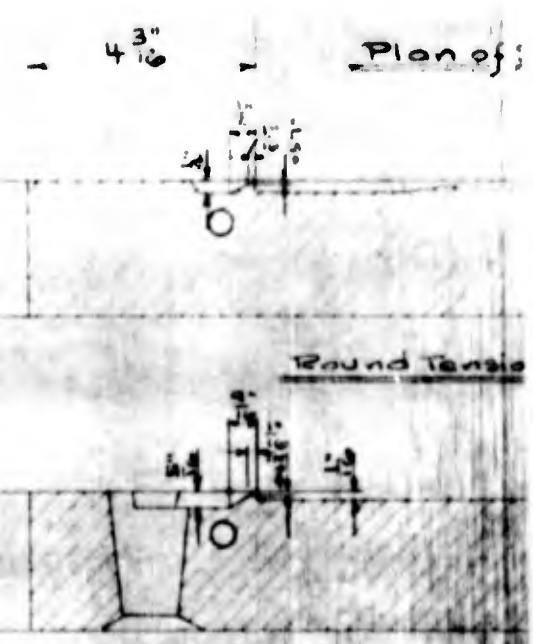
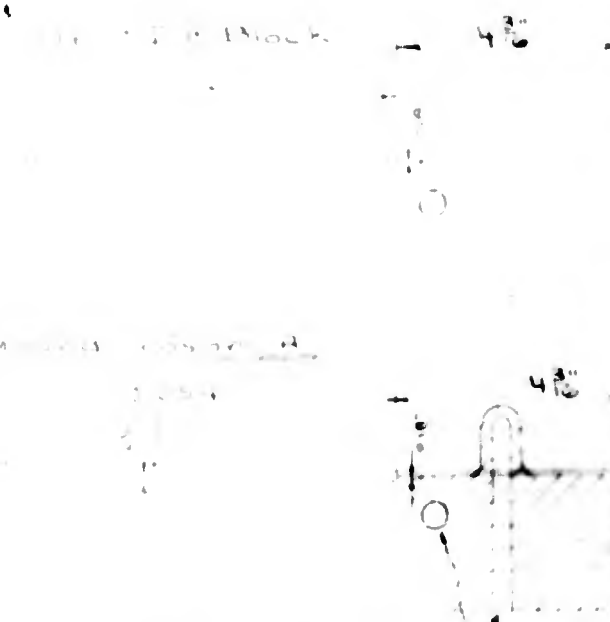
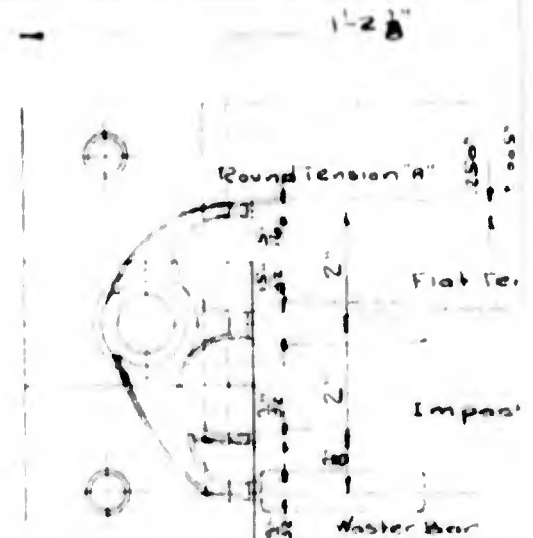
The changes that were made in the die can be seen by comparing Figures 20 and 26. However, the major changes will be listed here for the convenience of the reader:

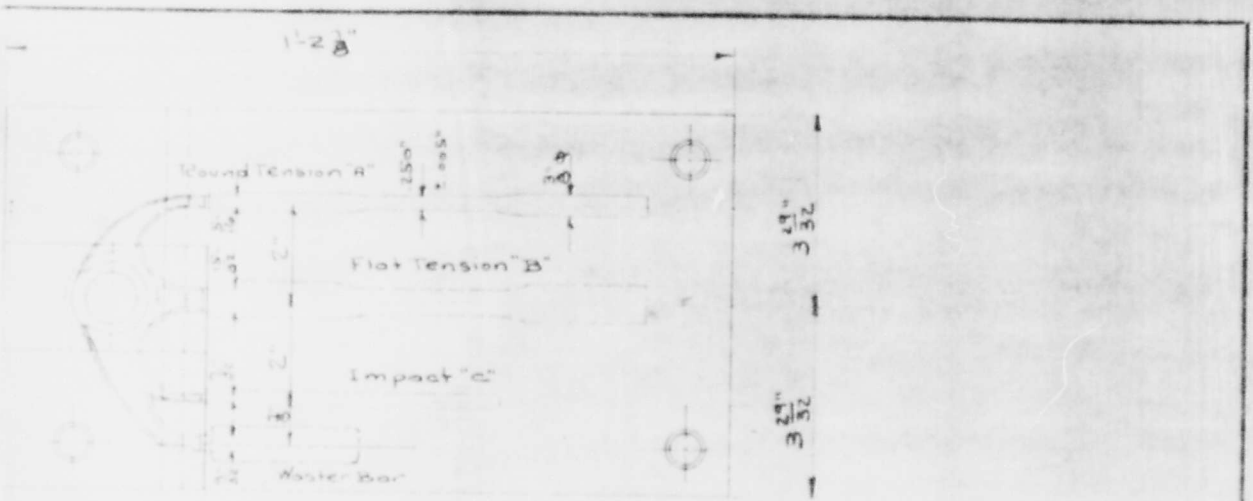
- 17 -

Figure 26

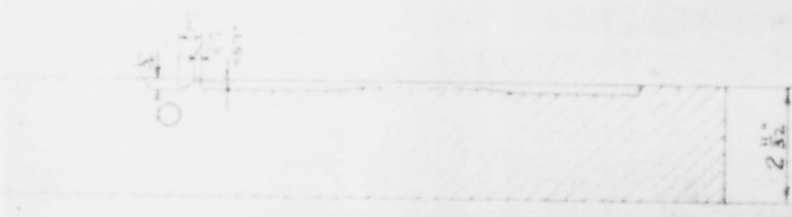


RF7-66-C 143

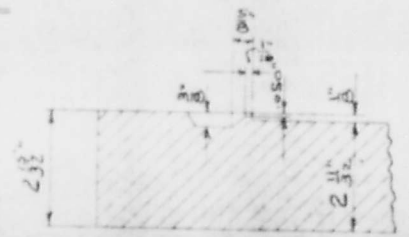




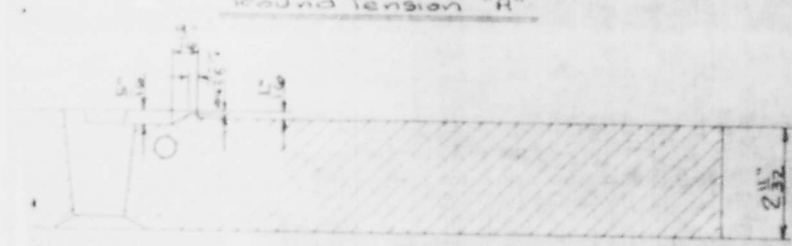
Plan of Stationary Die Block.



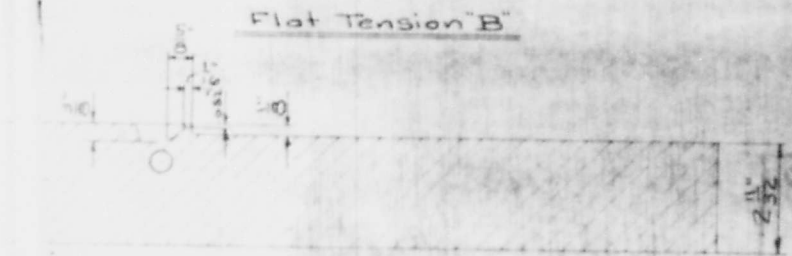
Round Tension "A"



Section of Washer Bar



Flat Tension "B"



Impact "c"

A. S. T. M. Specimen Die	
Details RF7-61-A	
REFERENCE DRAWINGS ABOVE	
THE NEW JERSEY ZINC CO.	
RESEARCH DIVISION - PALMERTON PA.	
DATE: 11-23-36	SCALE: 4" = 1 Foot
Metal Section Die Casting	
A. S. T. M. Specimen Die	
Altered 11-4-36	
DR. BY: Lentz	RF7-66-C
TR. BY:	
CR. BY: G.L.W.	
APP. BY:	CHARGE:

1/4" Impact Bar Cavity

1. Gate depth increased from 0.038" to 0.070". During the tests, gates up to 0.100" were tried.
2. Overflow well added and increased until it had a capacity of 0.9 cubic inch.
3. Runner depth to overflow well increased from 0.030" to 0.070".

1/4" Round Tension Bar Cavity

1. Gate depth increased from 0.046" to 0.075".
2. Overflow well of 0.07 cubic inch capacity added.
3. Runner depth to overflow well increased from 0.030" to 0.048".

Further Alterations

1. A 3" long x 3/4" wide x 1/4" deep cavity was cut along the outer edge of the die next to the impact cavity.*
2. The gate runners were increased in thickness by 1/8" from the sprue to the gates of the tension, impact, and waster bar cavities.

*This casting has no particular value as a test specimen. It was added to the die for the purpose of increasing the strength uniformity of the impact bar by facilitating the maintenance of a more uniform die temperature.

The die when altered as shown in Figure 26 produced Zamak-5 test bars with the following physical properties:

Alloy: Zamak-5

Table 6

Date Cast: 11/4/36

Pressure: 1500 Lbs. per Sq.In. (Calculated)

Metal Temperature: 410°C.

Die Temperatures: 150, 160, 170, 180, 190, 200, 210, 220, 230, 240, and 250°C.

	Die Temperature-°C.										
	150	160	170	180	190	200	210	220	230	240	250
Tensile Strength-Lb./Sq.In.	49100	48500	49200	46700	46700	45700	45600	44700	44400	44500	43800
Impact Strength-(Top or Gate end)-Ft.Lb.*	33	33	35	34	34	36	35	40	39	38	38
Standard Deviation-Ft.Lb.	2.6	2.8	3.0	2.4	1.7	2.6	2.2	2.0	3.2	3.1	1.7
Coefficient of Variation	7.9	8.4	8.7	7.1	5.1	7.2	6.3	5.1	8.2	8.0	4.5
Impact Strength-(Bottom or Vent end)-Ft.Lb.*	47	48	47	46	50	50	51	49	49	48	49
Standard Deviation-Ft.Lb.	3.2	2.7	1.2	1.4	0.7	0.6	0.7	0.9	0.7	0.7	0.8
Coefficient of Variation	6.8	5.7	2.5	2.9	1.3	1.3	1.4	1.8	1.5	1.5	1.8
Impact Strength-Grand Average-Ft.Lb.	40	40	41	40	42	43	43	44	44	43	43
Standard Deviation-Ft.Lb.	7.7	7.9	6.4	6.5	8.1	6.9	8.0	5.0	6.0	5.3	5.3
Coefficient of Variation	19.0	19.5	15.7	16.1	19.3	16.0	18.6	11.2	13.7	12.3	12.2

*Tested at 21±0.5°C.

Figure 27 shows the impact data of Tables 5 and 6 in columnar diagrams. By means of this chart the improvement in impact strength resulting from the die changes, which were made during the period of July 16, 1936 to November 4, 1936, are readily apparent.

It will be noticed that the impact strength was almost doubled as a result of the die changes. Unfortunately, however, the gate and vent ends of the impact bar differed materially in impact strength and all of the die changes which were tried increased, rather than decreased, the spread in strength between the two ends of the bars.

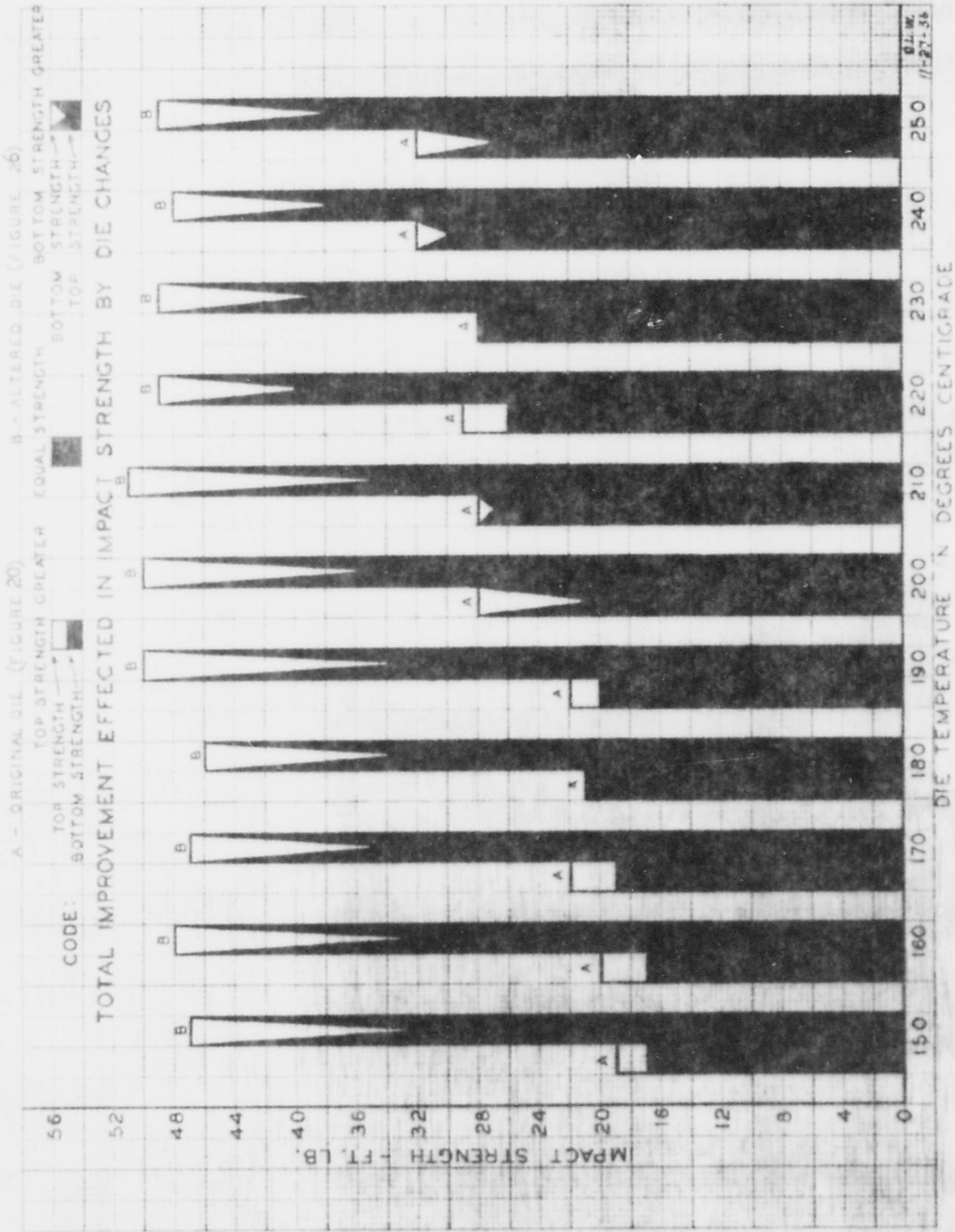
The radiographs which follow as Figures 28 and 29 show the impact bars to be virtually free of porosity and Figures 30* and 31* show only minor voids in the vent end of the round tension bars. Again, it is believed that the porosity in the round tension bars could have been reduced had there been room in the die to further increase the overflow well.

*As in all former cases, five round tension bars were cast at 10°C. intervals of die temperature from 150 to 250°C. but only three specimens of each group, and none of the 200°C. die temperature cast, were radiographed. This economy was practiced in order to get the tension bars on two plates.

- 51 -

Figure 27





A - ORIGINAL DIE (FIGURE 20) B - ALTERED DIE (FIGURE 26)

CODE: TOP STRENGTH GREATER EQUAL STRENGTH BOTTOM STRENGTH GREATER

TOP STRENGTH BOTTOM STRENGTH

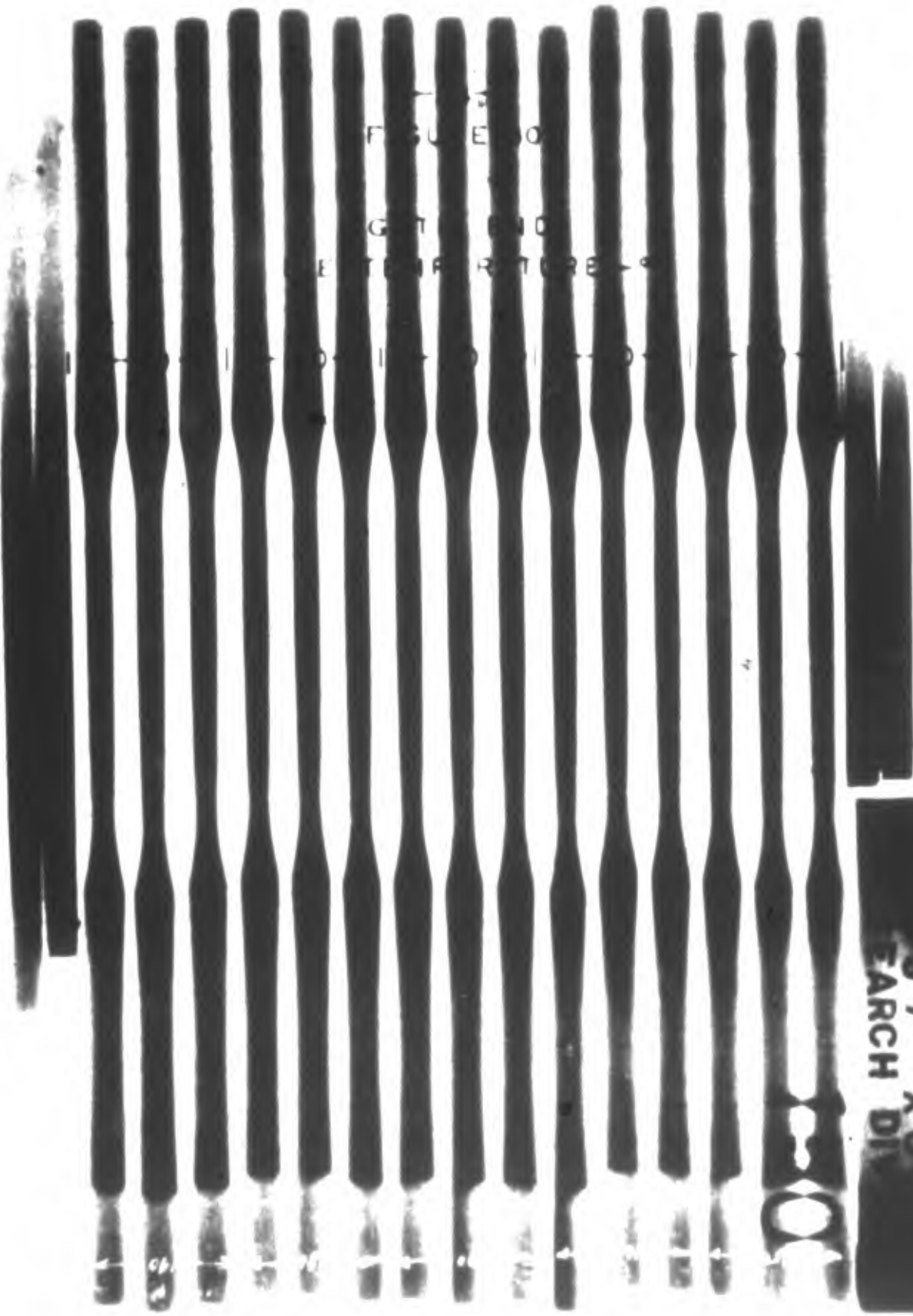


Table with multiple rows of data, heavily redacted with black bars. Some faint numbers are visible on the left side of the table, such as 100, 100, 100, and 100.

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It will be seen in Table 7 that the impact strengths for as cast specimens are satisfactory for all die temperatures tried, namely, 150 to 250°C. in 10°C. intervals.

For steam exposed specimens the coefficients of variation are all high values with no indication that any restricted range of die temperature is any better than the entire range of 150 to 250°C.

It is assumed from these data that the die temperature casting range for Zamak-5 is apparently not greatly restricted.

Alloy: Zamak-5

Table 7

Date Cast: 11/4/36

Pressure: 1500 Lbs. per Sq.In. (Calculated)

Metal Temperature: 410°C.

Die Temperatures: 150, 160, 170, 180, 190, 200, 210, 220, 230, 240 and 250°C.

Specimens Cast After Final Alterations to Die-As Cast

	Die Temperature--°C.										
	150	160	170	180	190	200	210	220	230	240	250
Impact Strength-(Top or Gate end)- Ft.Lb.*	33	33	35	34	34	36	35	40	39	38	38
Coefficient of Variation	7.9	3.4	8.7	7.1	5.1	7.2	6.3	5.1	8.2	8.6	4.5
Impact Strength-(Bottom or Vent end)- Ft.Lb.*	47	48	47	46	50	50	51	49	49	48	49
Coefficient of Variation	6.8	5.7	2.5	2.9	1.3	1.3	1.4	1.8	1.5	1.5	1.8

Similar Specimens Exposed in 95°C. Steam Test for 10 Days

Impact Strength-(Top or Gate end)- Ft.Lb.*	6.9	5.1	4.2	6.2	6.0	8.8	8.7	5.3	7.9	5.2	5.3
Coefficient of Variation	59.0	58.2	4.3	82.4	64.0	75.9	58.6	58.7	64.8	79.2	56.2
Impact Strength-(Bottom or Vent end)- Ft.Lb.*	13.7	17.0	10.1	11.9	5.0	10.3	14.8	6.5	8.6	11.3	8.2
Coefficient of Variation	25.0	46.2	41.1	59.1	41.8	70.1	43.1	90.5	89.7	63.1	73.3

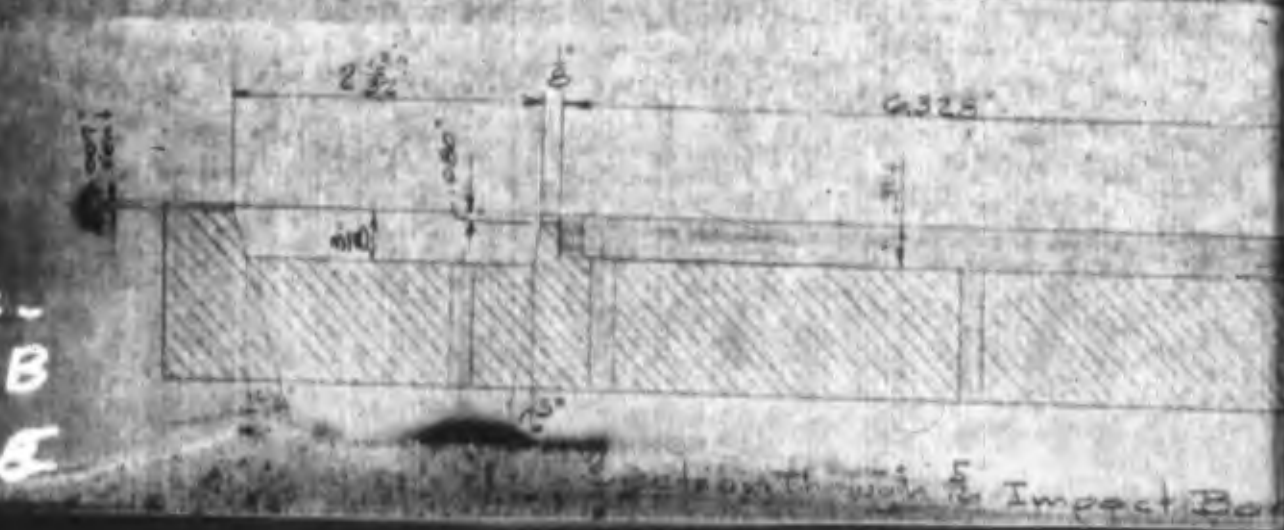
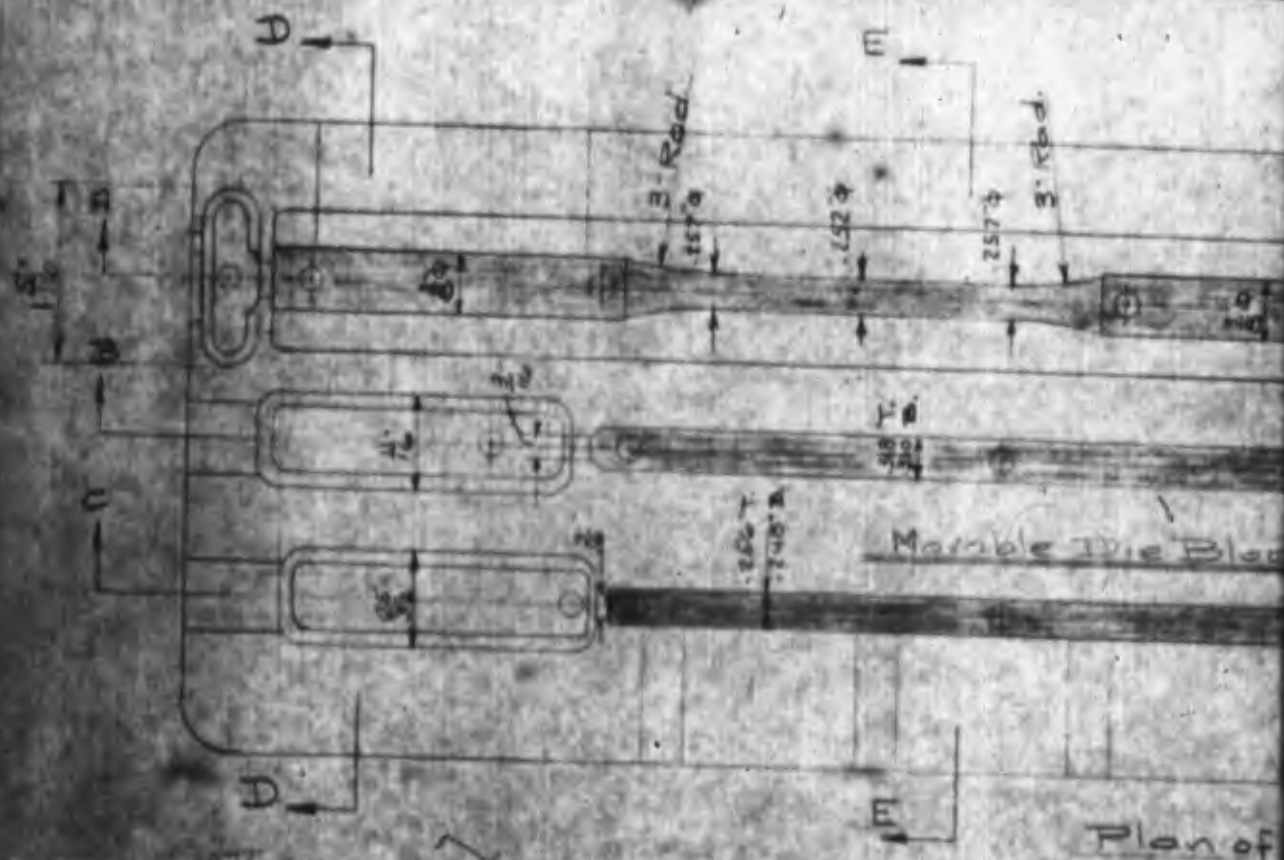
*Tested at 21±0.5°C.

As previously mentioned, Figure 26 shows the die in its improved form; however, this drawing is not complete enough for use in the actual construction of a die. For this reason, a detailed drawing of this die is attached to this report.

Conclusion

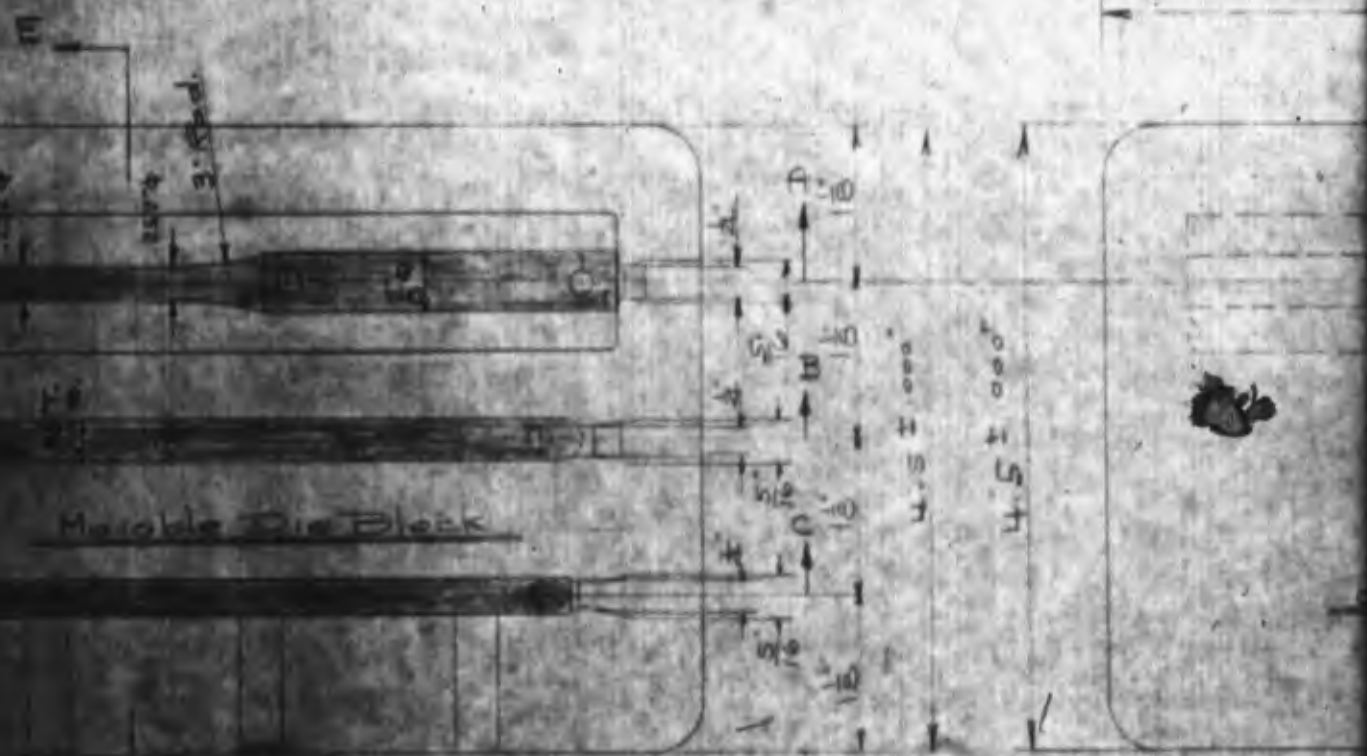
It is clearly evident that the insert die has been altered to a higher degree of perfection than the A.S.T.M. die. It would, therefore, appear desirable that any new dies constructed for use in producing specimens for the proposed A.S.T.M. atmospheric exposure tests be insert dies.

G. L. Werley,
Palmerton, Pa.-AMG



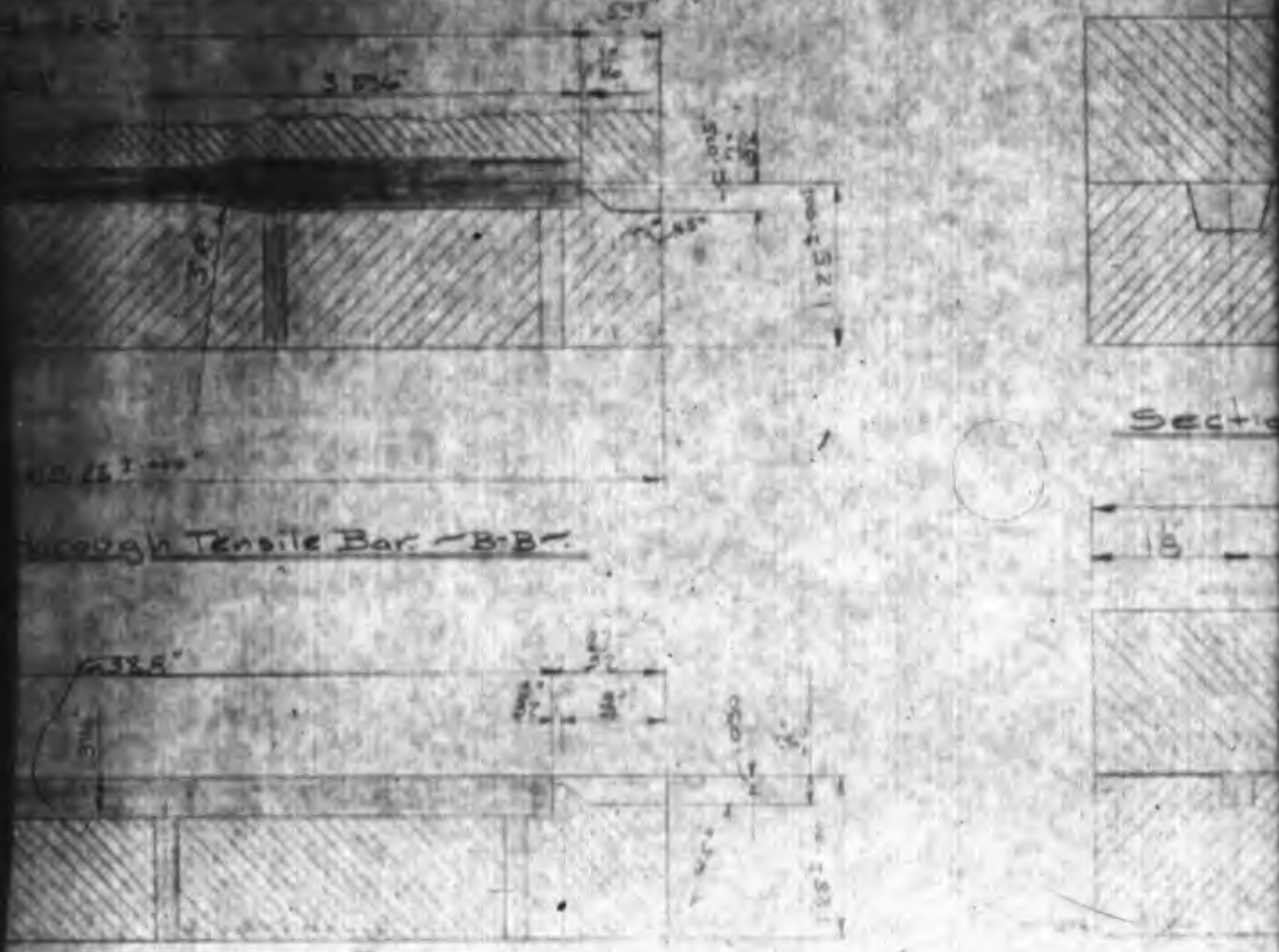
RF74-
48-B
14E

Section through Impact Bar



Die Block

Plan of Die Block

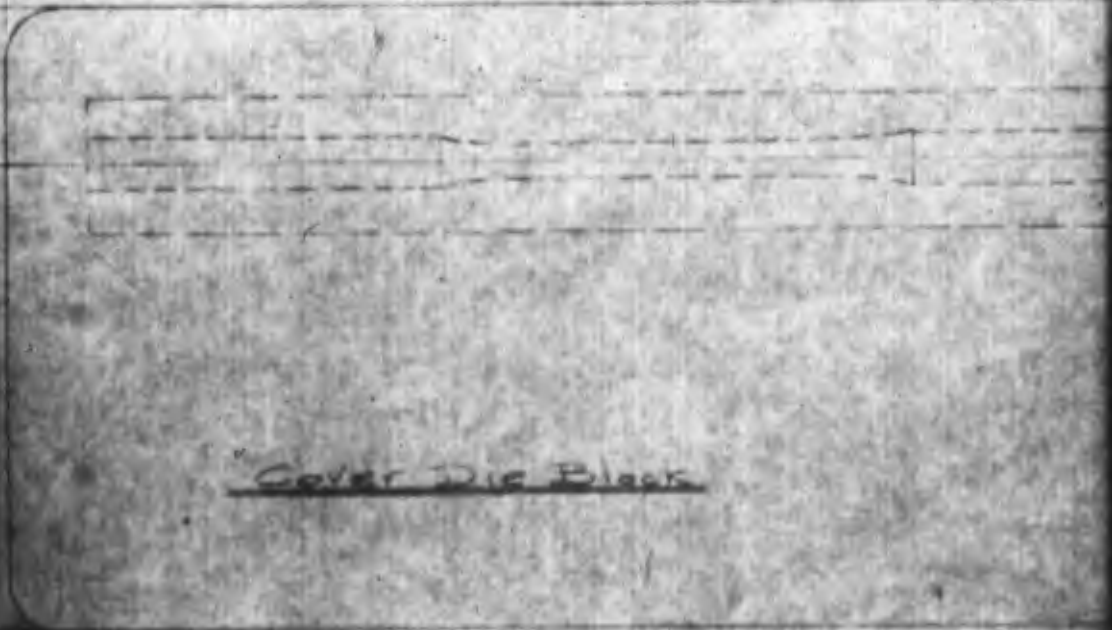


Tensile Bar - B-B

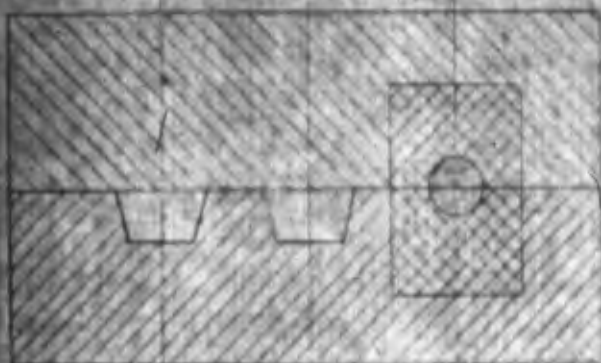
Section

10.25 ± .000"

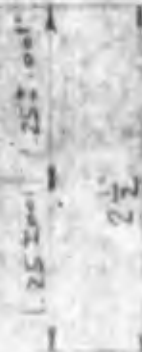
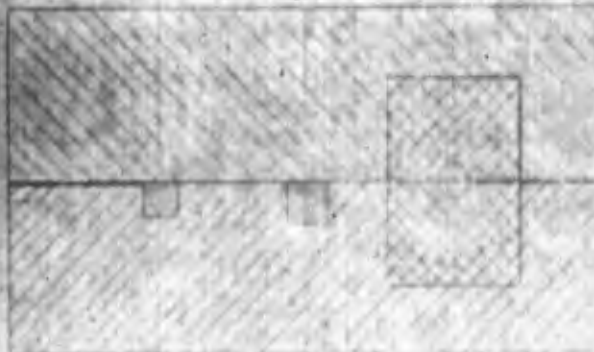
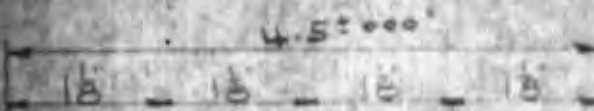
4.5 ± .000"



Cover Die Block

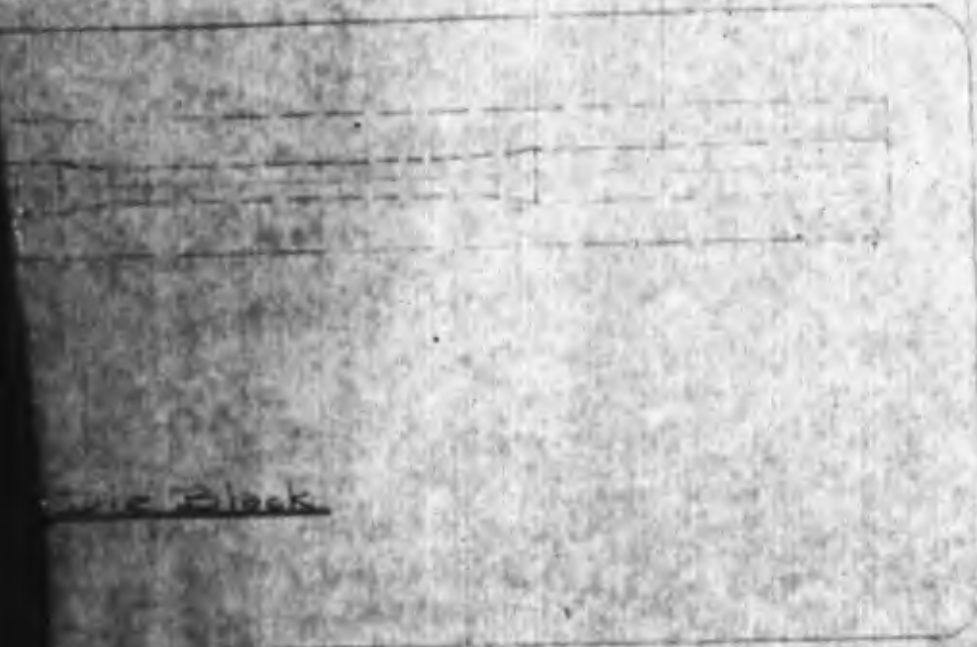


Section ~ D-D



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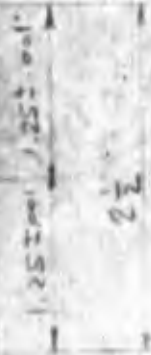
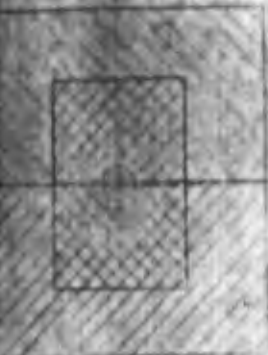
10.25 ± .000"



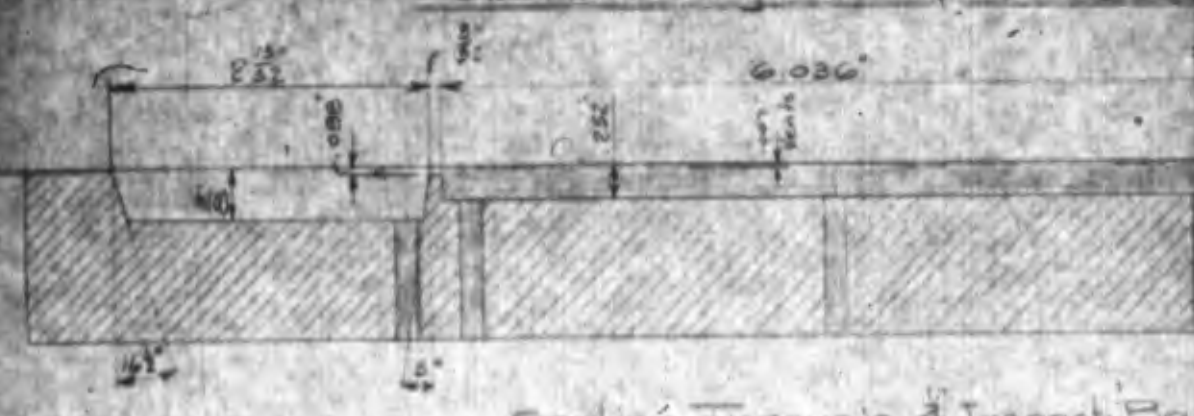
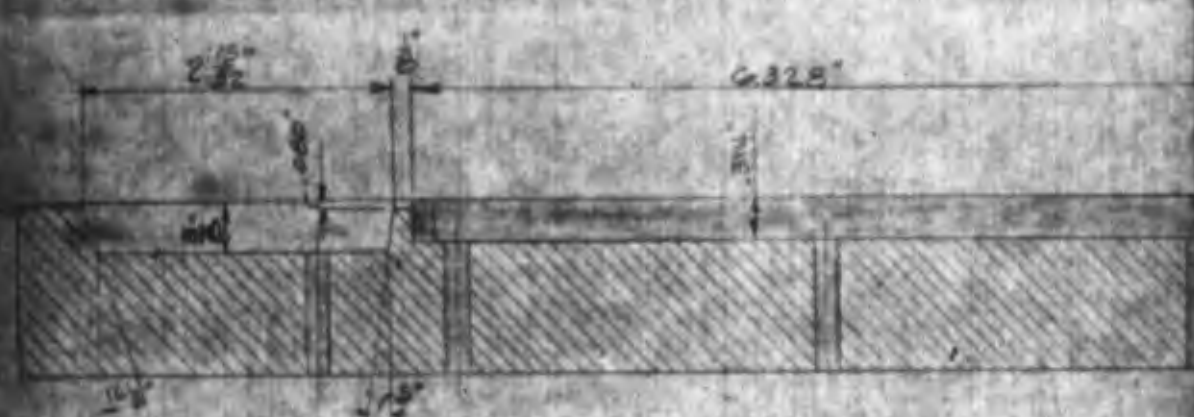
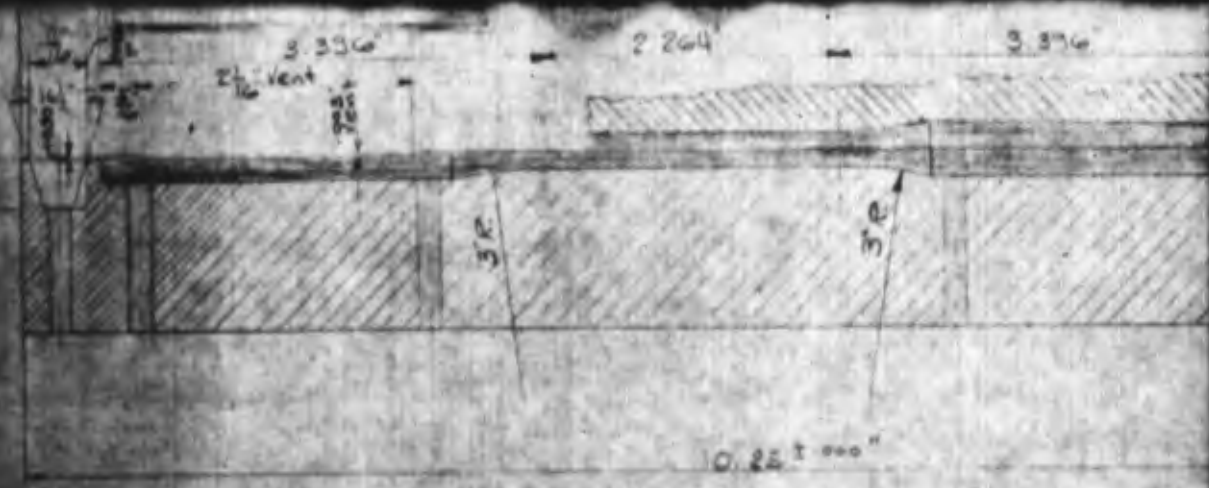
Black



D-D



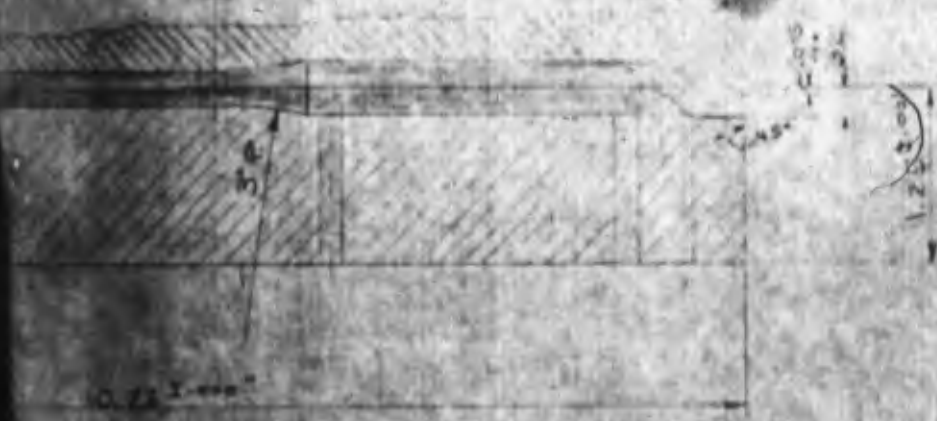
RF7-48-B
4 of 8



REVISION

5 of 7

2.104



Through Tensile Bar - B-B



Section

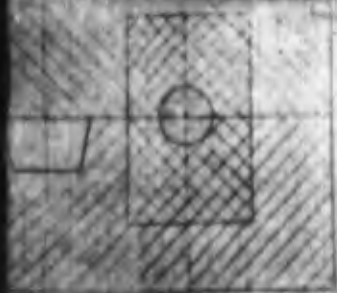


Through Impact Bar - B-B

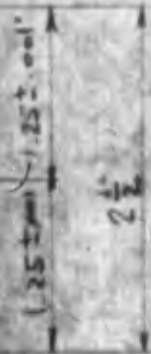
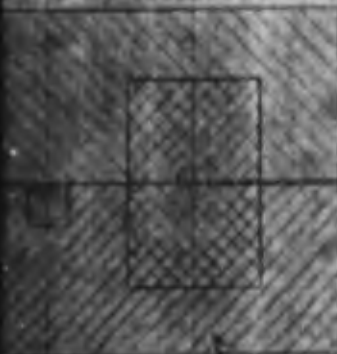
Section



Through Impact Bar - C-C



D-D



For E.P. 7

Wood to be



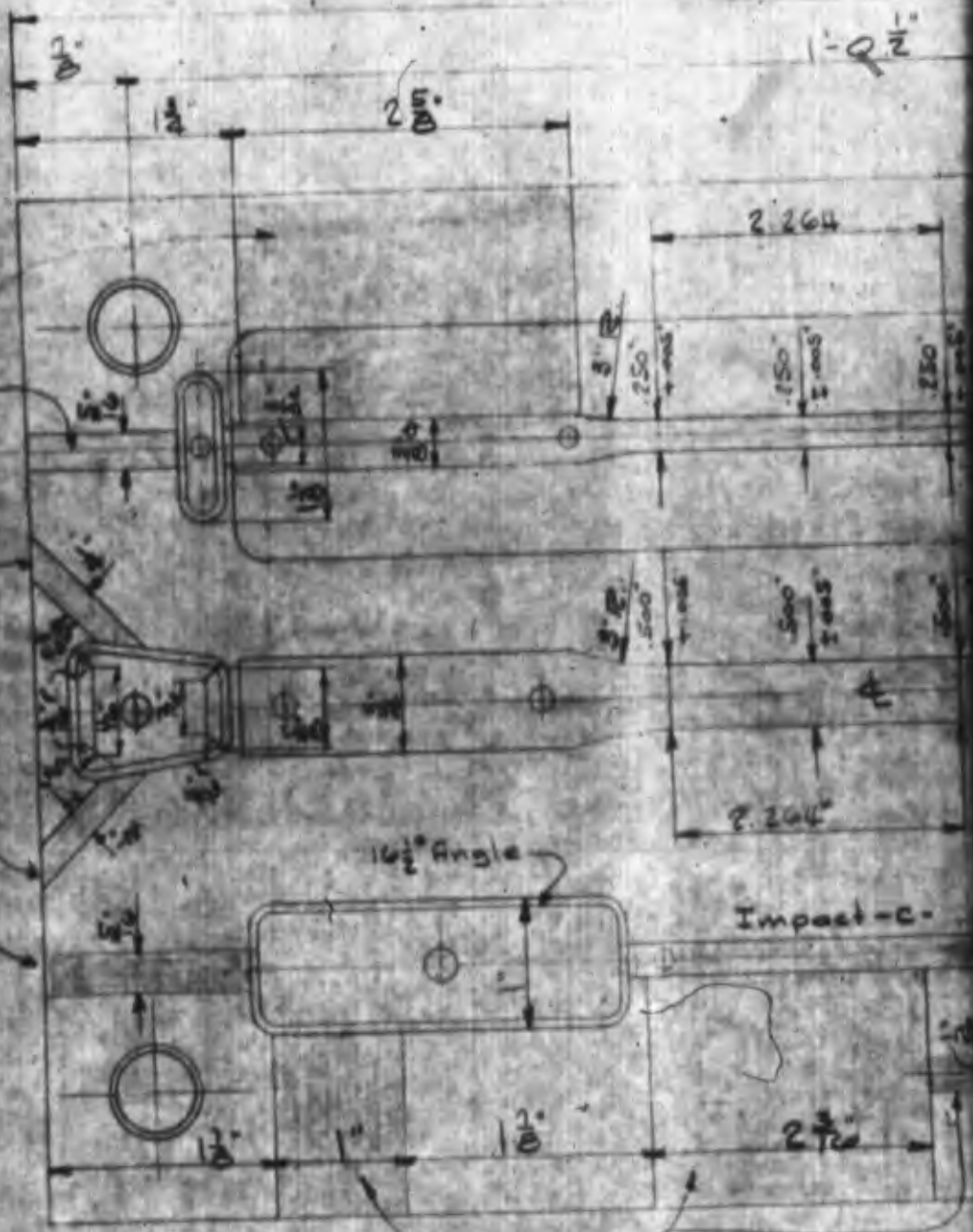
S E - E

REFERENCE DRAWINGS ABOVE	
THE NEW JERSEY ZINC CO. RESEARCH DIVISION <small>THE NEW JERSEY ZINC CO. 100 PA. BUCKINGTON, PA.</small>	
DATE <i>9-3-54</i>	SCALE <i>Full size</i>
<i>Metal Section Die Casting -</i> <i>4 Imp. - Indent Die</i> <i>Black Die</i>	
DRAWN BY <i>G. S. L...</i>	RF 7-48-B
TRACED BY	
CHECKED BY <i>ZRN</i>	
APPROVED BY	
CHARGE	

8 of 8

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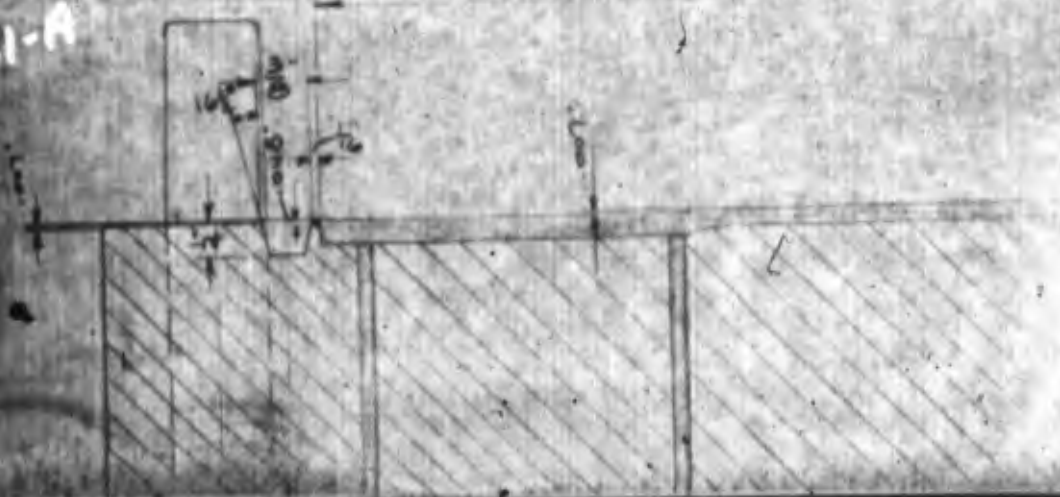


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Plan of Move

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RF7-61-A
1 of 16



1-78 $1-0\frac{1}{2}$ $1\frac{1}{2}$

Drill and Tap for $\frac{1}{2}$ " to 8" Pipe Bushing

Water Cooler



Round Tension - A-

Flat Tension - B-



1/8" Deep

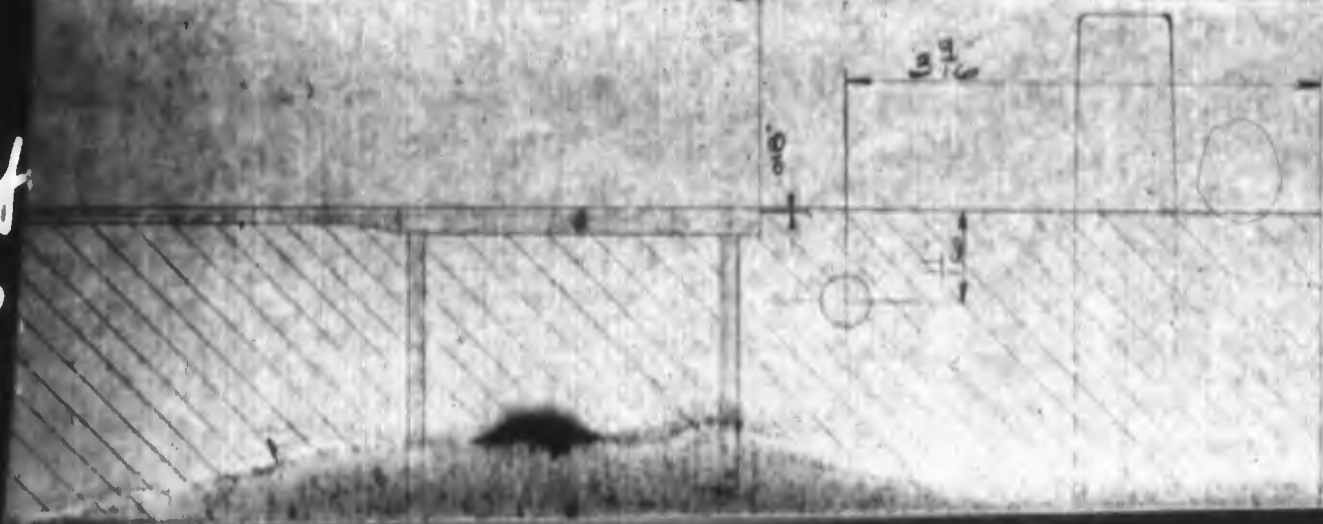
Drill and Tap for $\frac{1}{2}$ " to 8" Pipe Bushing

long of Moveable Die Block

3.054

3 3/16

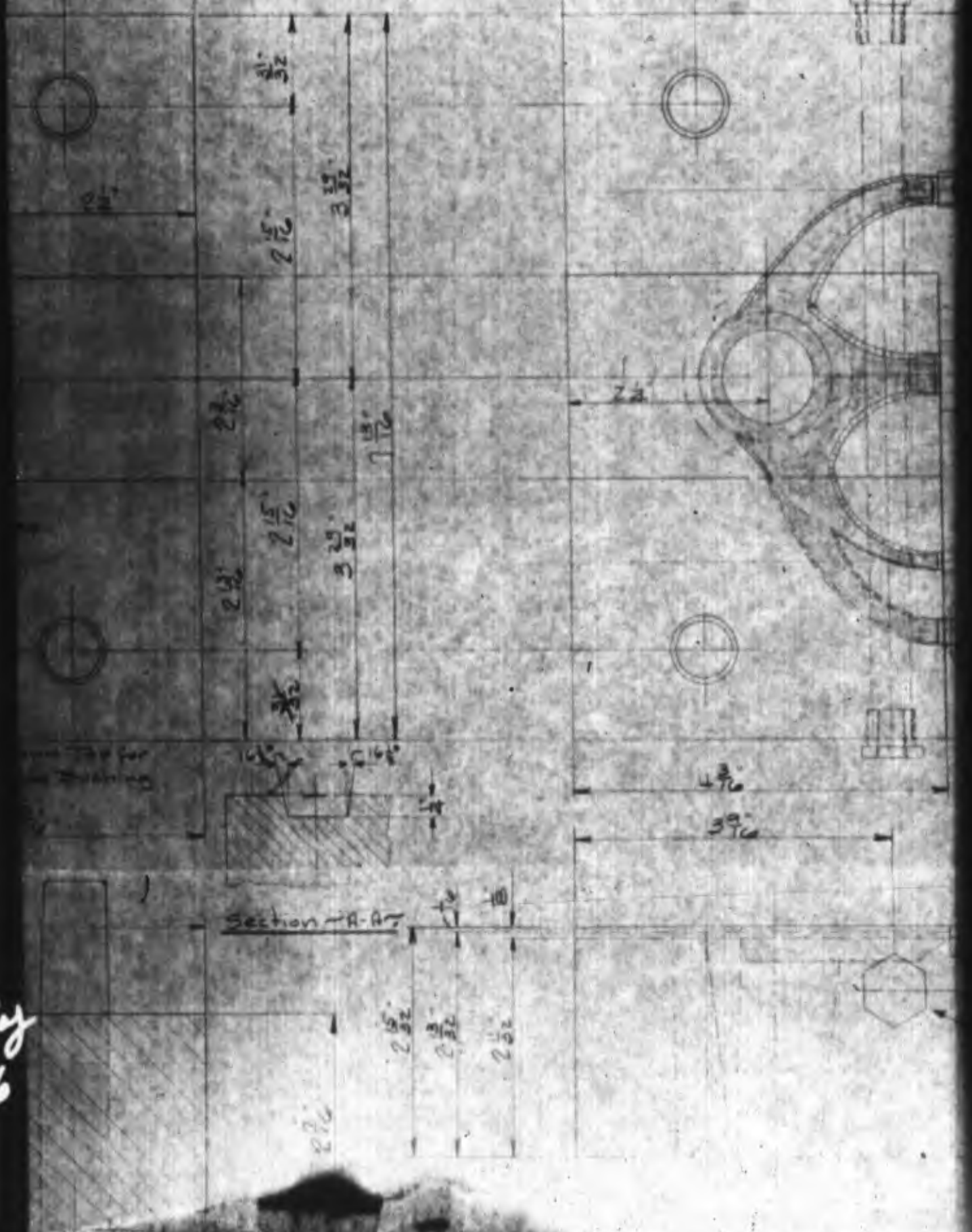
24
16



$1\frac{1}{2}$ "

$1\frac{1}{2}$ "

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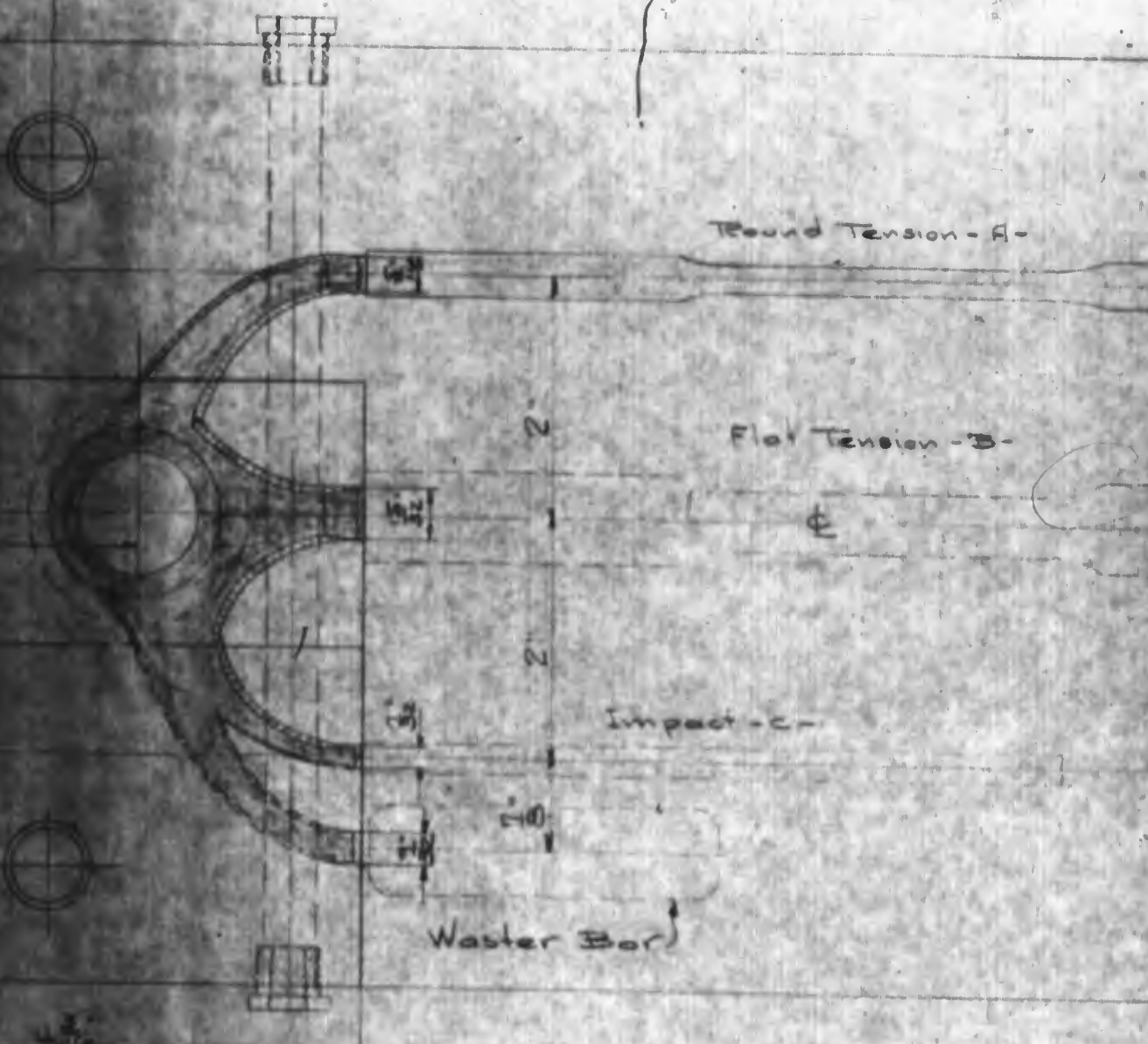


Section A-A

308
16

1-68

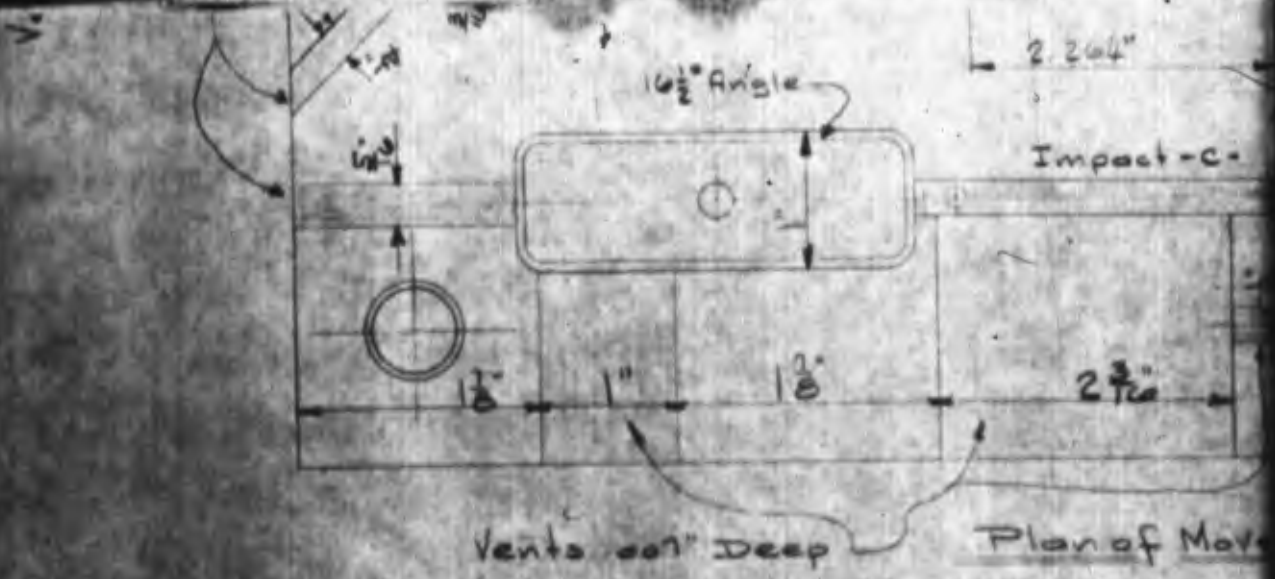
1-0 1/2



Plan of Stationary Die Blo

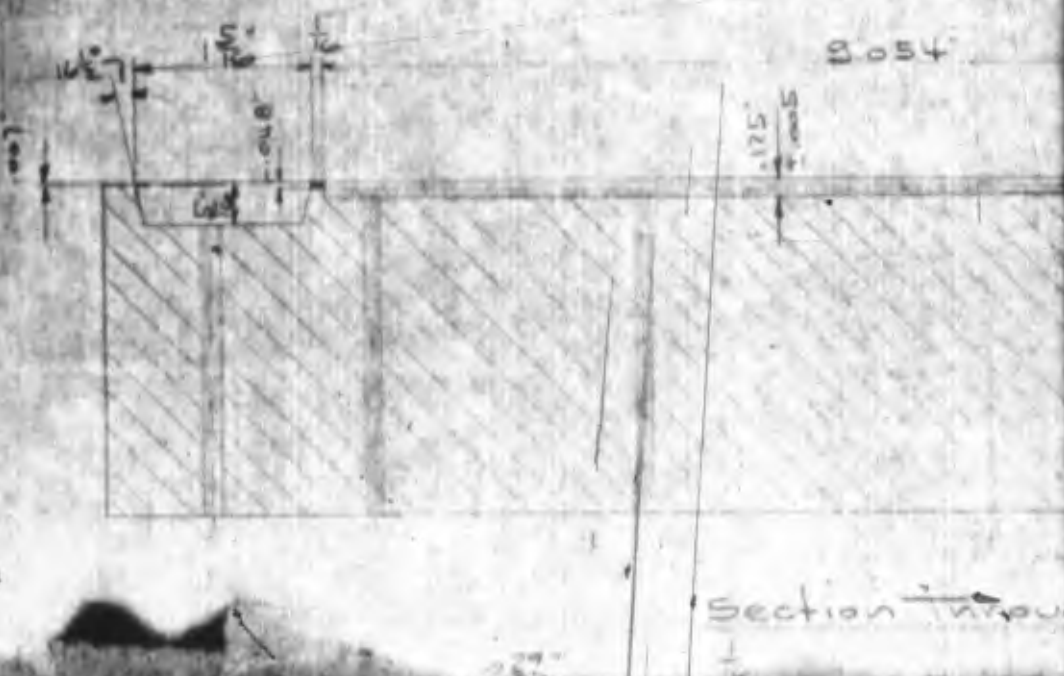
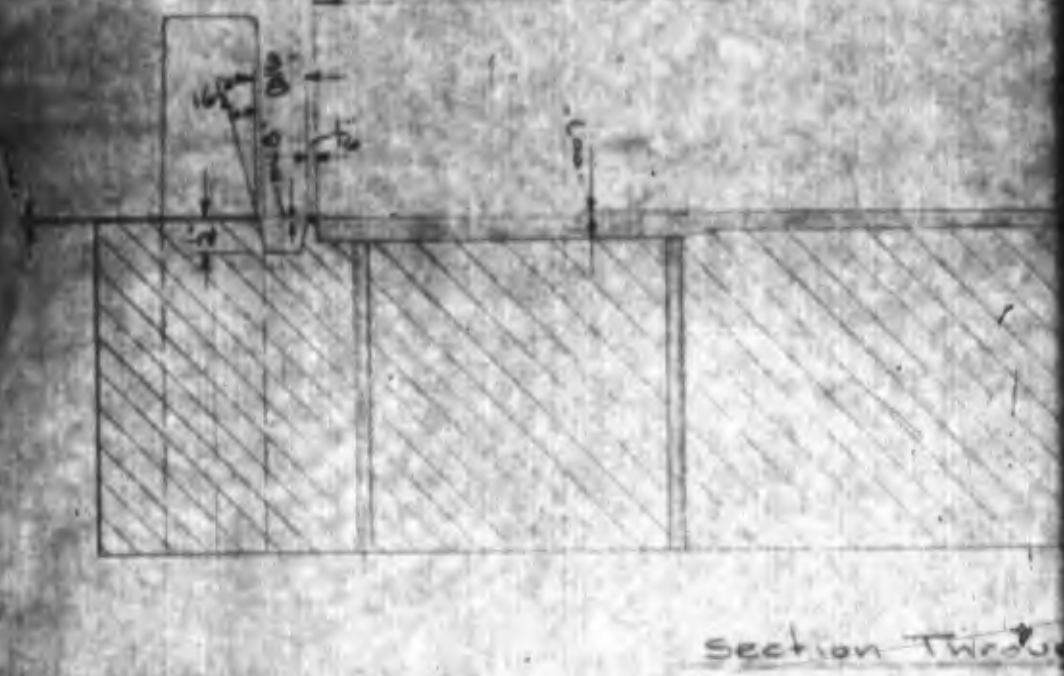
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16

Drill and Tap for
1/2 to 8 Bushing



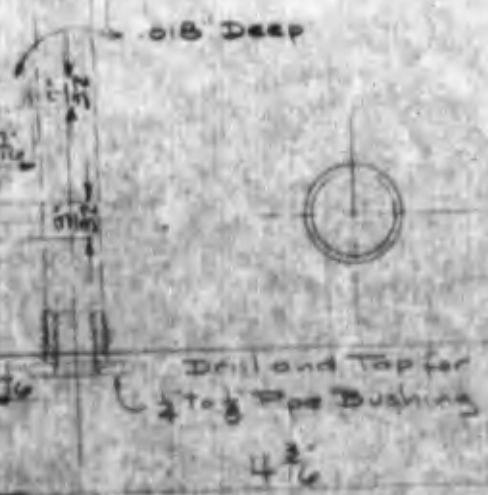
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5 of
16

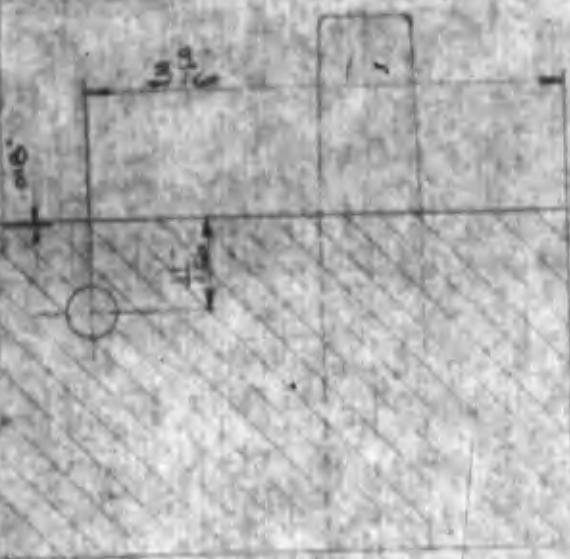




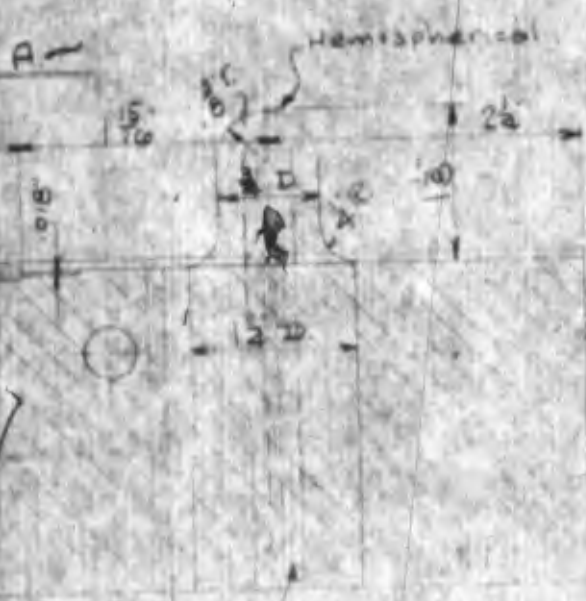
Cable Die Block



Section - A-A

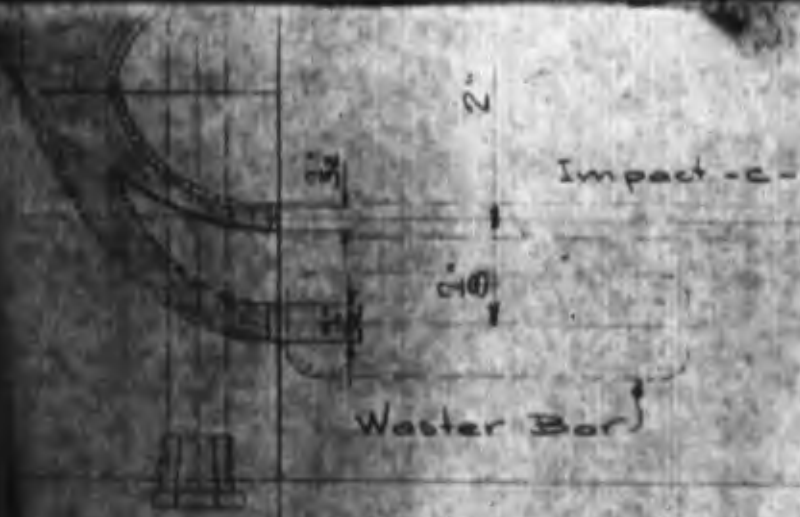


High Round Tension - A -



High Flat Tension - B -

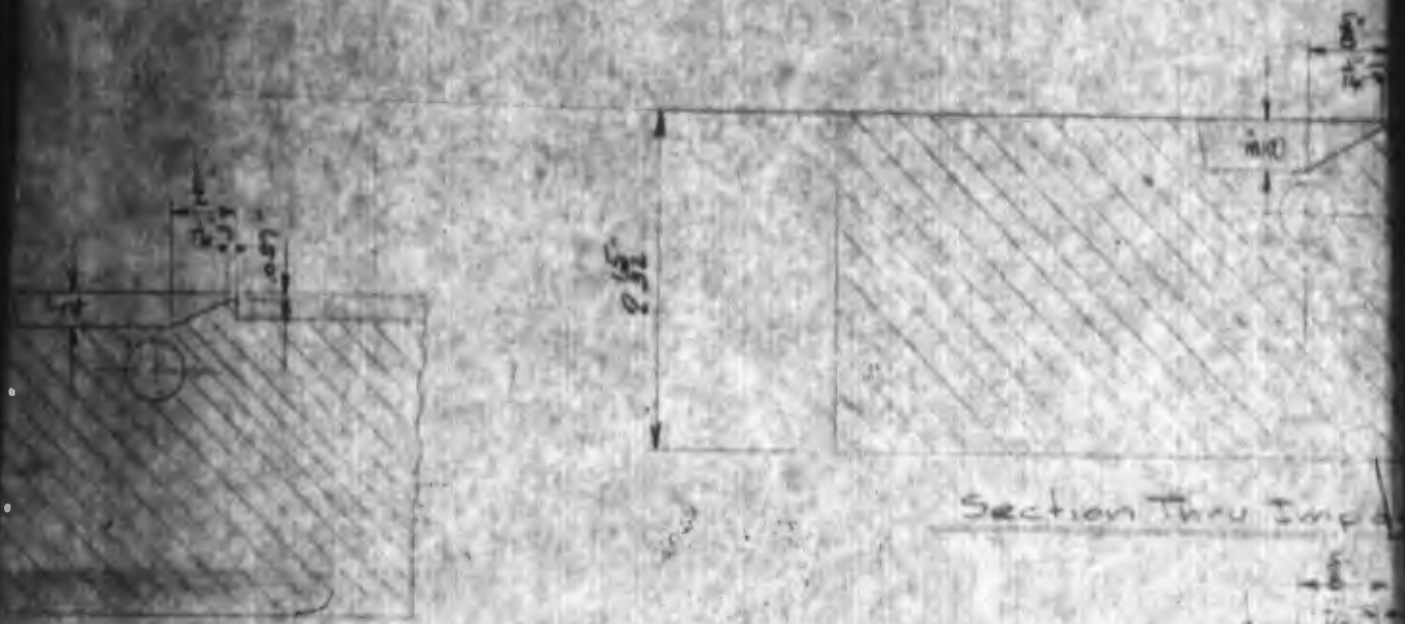
7 of 16



Plan of Stationary Die Block



9 of 16



Section Thru Impa

Bound Tension - A -

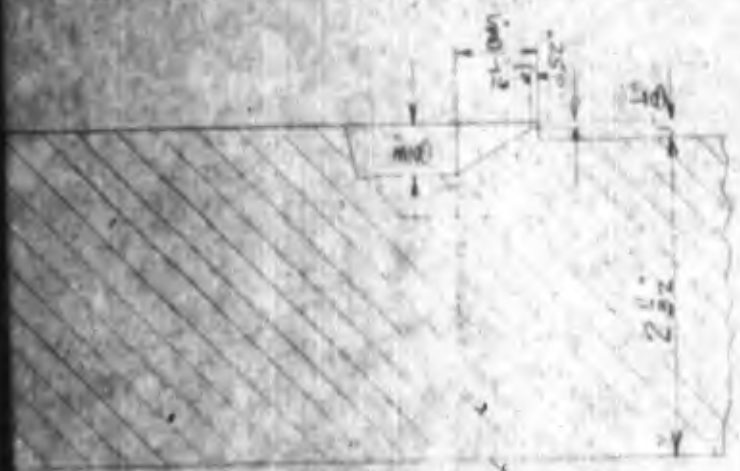




Die Block



10 of 16

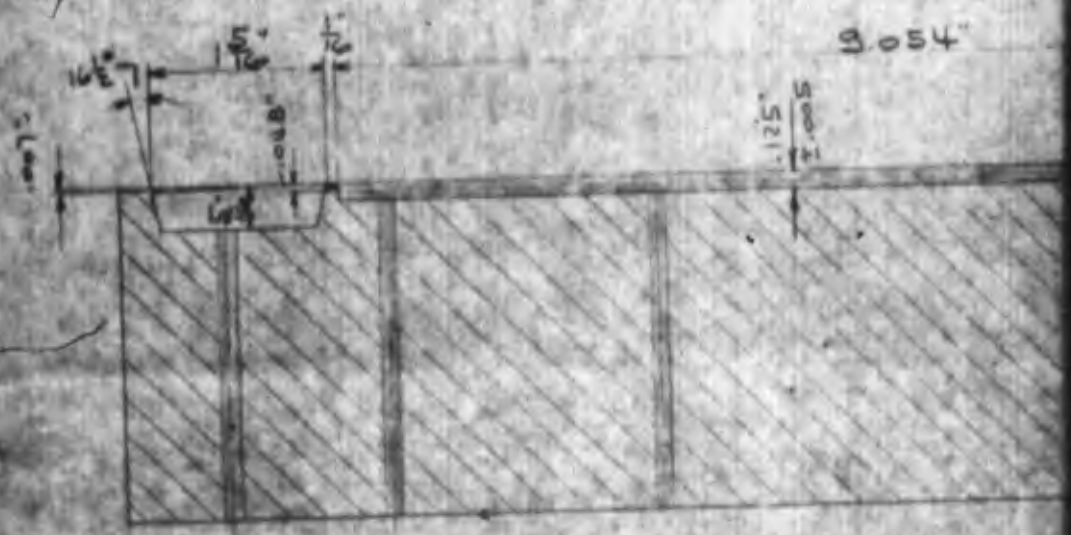


Section Thru Impact C

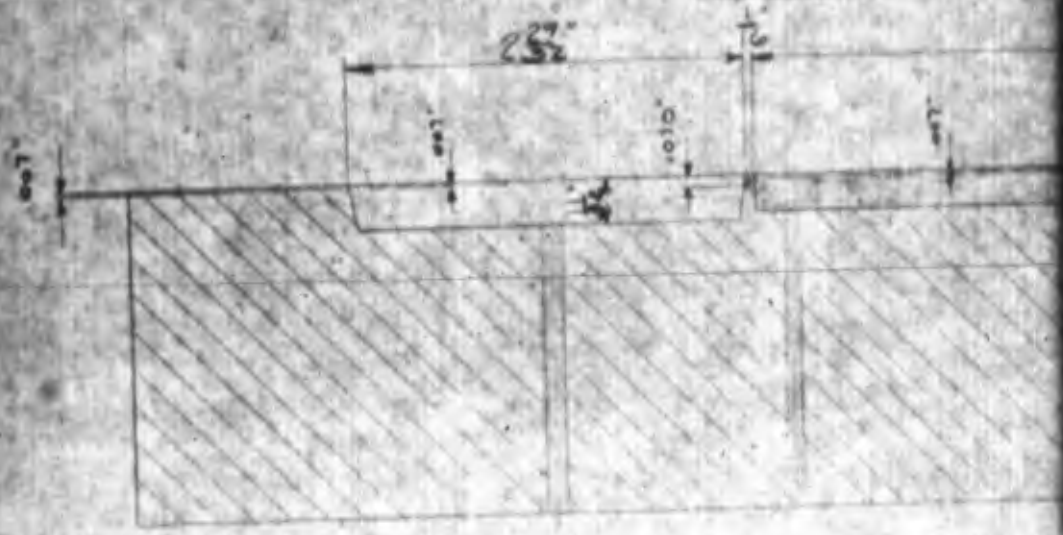




Section Throu



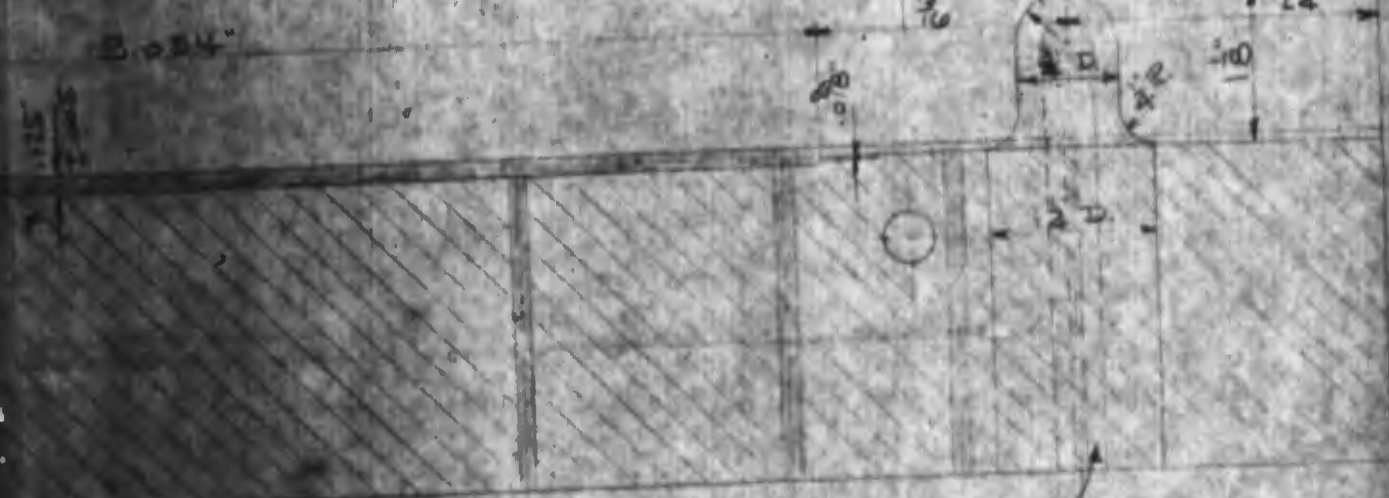
Section Throu



Section Through

11 of 16

Section Through Round Tension - A -



Section Through Flat Tension - B -



Section Through Impact - C -

2

Hemispherical

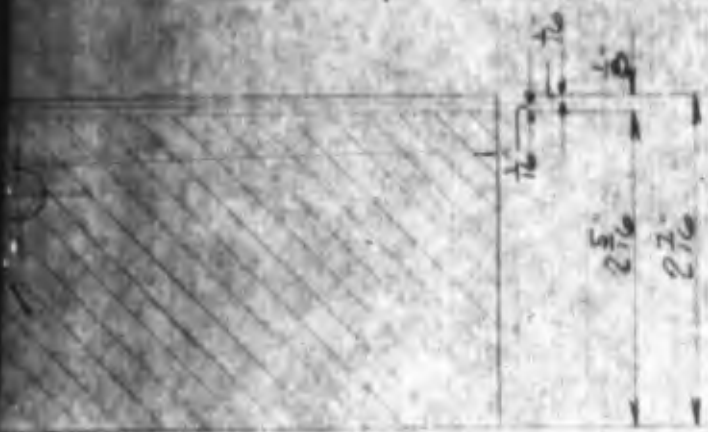


$2\frac{1}{2}$



Section

Water cooled



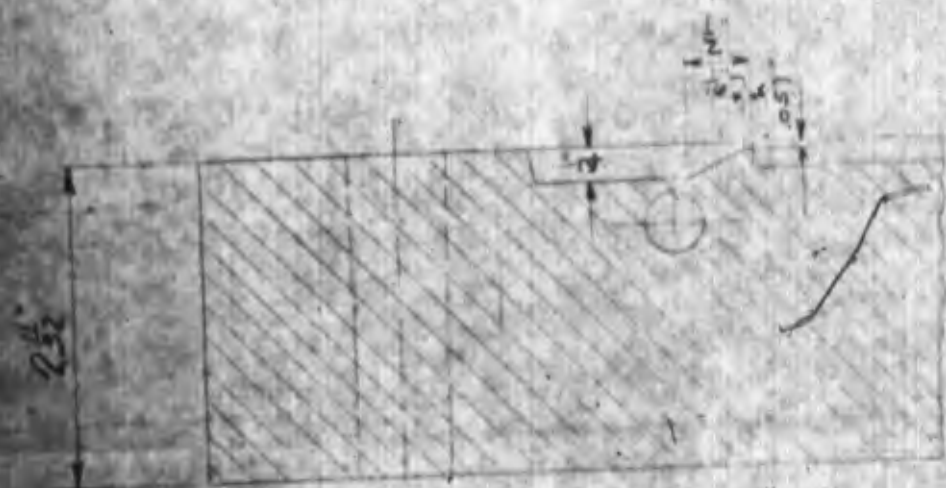
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$1\frac{1}{2}$

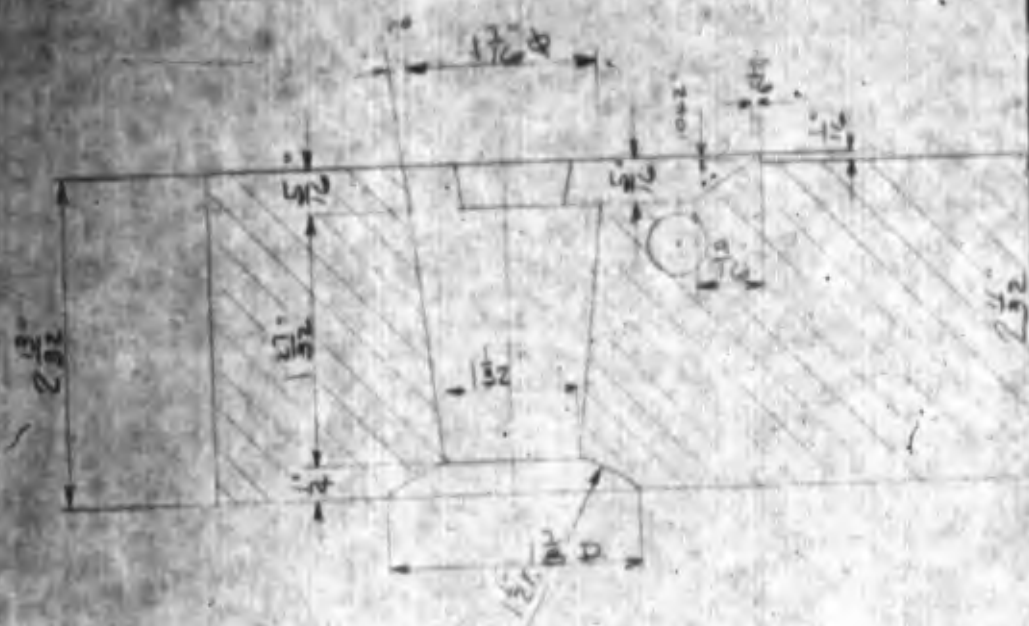
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Section

13 of 16



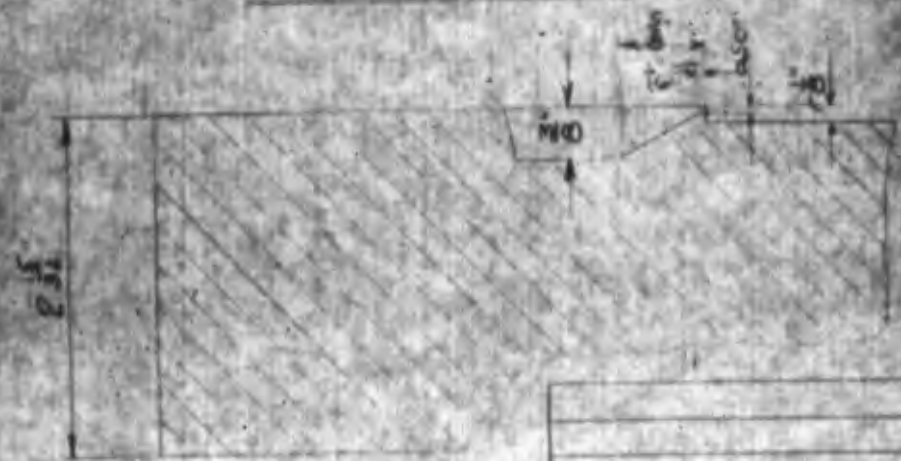
Section Thru Bound Tension - A-



Section Thru Flat Tension - B-



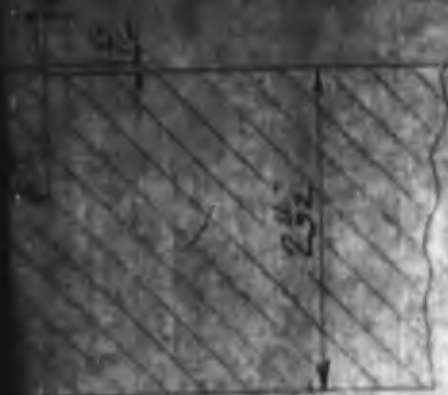
Section Thru Impact Cr.



Section Thru
Welder Bar

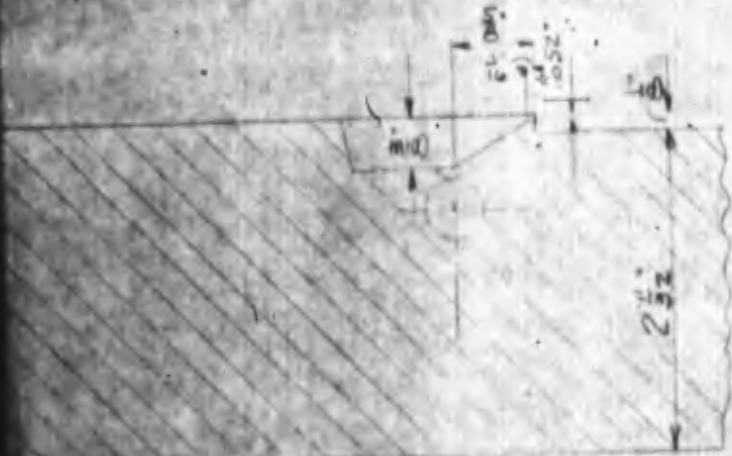


Section - A2

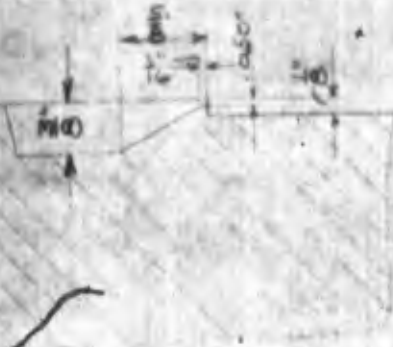


Section - B2

REFERENCE DRAW	
THE NEW JERS RESEARCH	
Detail-2-30	page 7
Metal Section D A.S.T.M. Specimen Saw 12 The Casting Detail	
DESIGNED BY	RF7
CHECKED BY	
APPROVED BY	CHART



Section Thru Impact Cr.



Section Thru Header Bar

REFERENCE DRAWINGS ABOVE

THE NEW JERSEY ZINC CO.
RESEARCH DIVISION

DATE 11-2-36 SCALE Full Size

Metal Section Die Casting
A. S. T. M. Specimen Die for
Schultz Die Casting Machine
Detail

DRAWN BY G. F. LENTZ

TRACED BY

CHECKED BY Lentz

APPROVED BY

RF7-61-A

CHANGE