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26 April 1943

NRL SHOCK-FRACTURE TEST FOR WELDED
JOINTS IN ARMOR

By
Clarence E. Jackson

Report No. M-2050

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WASHINGTON 20, D. C.

26 April 1943

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NAVY DEPARTMENT

NRL Report No. M-2050

First Partial Report

on

NRL Shock-Fracture Test for Welded Joints in Armor.

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D.C.

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Experimental Work Leading to Development of Shock Fracture
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ABSTRACT

This report presents the development of a laboratory scale shock-fracture test for armor and welded joints in armor. The shock-fracture test is especially suited as a rapid quantitative development test which should increase the speed of testing and provide a number of short cuts in development studies of the welding of armor. The shock-fracture test possesses the following qualifications:

- (a) A greater number of test specimens per unit cost of welding and materials can be provided.
- (b) High velocities similar to those encountered in service are used for testing.
- (c) The specimen is such that it is stressed during test in a relatively simple fashion without the complication of internal stresses.
- (d) The method of test is such that successive specimens can be stressed in an identical manner.

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AUTHORIZATION

1. This problem was authorized by Bureau of Engineering letter Ll-1/1940 (4-14Fs) of 11 July 1939.

2. The studies reported here are preliminary to Welding Test No. 302 - Low Alloy Ballistic Steel Welded with 19-9 Mn and 25-20 Electrodes - Weldability of. BuShips file #ZP/W&C-(4)-(5) (3692) of 31 January 1943.

3. In a memorandum dated 12 August 1942, Armor Plate Section, Tank & Motor Branch, Office Chief of Ordnance, addressed to Welding and Casting Section, Bureau of Ships, Navy Department, Mr. E. Brooker stated the need for a shock-fracture test of welded joints in armor and suggested the initial test methods. The memorandum was forwarded by the Bureau of Ships to the Naval Research Laboratory for action.

STATEMENT OF PROBLEM

4. In the past years many hundred shock tests have been made ballistically by both the Navy and Army. These tests have been a major factor in demonstrating the utility and efficiency of welding processes in the manufacture of ships, tanks and other armored vehicles. These large scale tests have been used effectively in overcoming the prejudice encountered in the extensive conversion from riveted to welded structures in fighting equipment. In many cases the larger scale shock tests do not yield quantitative information in regard to the shock resistance because of the number of intangible factors and variables that always accompany large scale tests; frequently a critical analysis is impossible, although the full scale test may be satisfactory as a summary test.

5. From the above, it is evident that a need exists for a test supplementing the large scale tests which can be made under laboratory conditions. Such a quantitative laboratory shock test must meet the following requirements:

- (a) The test should be such that stresses can be applied to successive specimens in an identical manner.
- (b) High testing velocities similar to those encountered in service should be used.
- (c) It would be highly desirable if a greater number of test specimens could be provided per unit cost of welding and materials; the saving of time is also a factor.
- (d) The specimen should be such that it is stressed during test in a relatively simple fashion without the complication of internal stresses.

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NARRATIVE OF ORIGINAL WORK AT THE NAVAL RESEARCH LABORATORY

6. Ways and means of achieving the above have been under consideration for some time. Several hundred tests have been made and a testing procedure with a small-scale test specimen has been developed which appears to meet all of the above requirements.

7. The dimensions of the standard specimen for one-inch armor are shown in Plate 1. The specimen consists of a rigid base 2-1/2 by 5 inches with three fingers extending from one side. These fingers are 2-1/2 inches long and have a cross section of one square inch with a clearance of 1/2 inch between the fingers. A square shoulder 1/2 inch wide is made on each end of the specimen in order to provide a similar stress pattern for all three fingers. The specimens are prepared using a power hack-saw with a positive feed and water coolant. The center cuts at the base of the fingers are made on a Deall band saw.

8. A considerable amount of experimental work (see Appendix A) was necessary in order to develop a satisfactory type of test specimen. It was essential that the type of test piece adopted should, first, be sufficiently sensitive that it could be used in the evaluation of the quality of an armor or the efficiency of a weld joint and, second, be of such dimensions that no particular difficulty would be encountered in the testing of the specimen within the limits of energy available. Further restrictions such as reproducibility of results, ease of manipulation and low unit cost were kept in mind.

9. After consultation with Dr. G.R. Irwin and Dr. G.D. Kinzer of the Mechanics and Electricity Division of the Naval Research Laboratory, it was decided to use a caliber .50 ballistic pendulum in a preliminary study of the shock resistance behavior of armor and welded test pieces. A ballistic pendulum under the cognizance of the Mechanics Division using caliber .50 ball M-1 ammunition served as an excellent means for accurately locating the impacts and for measuring the velocity of impact. The location of the impacts may be controlled within $\pm 1/64$ inch. The velocity is controlled by varying the powder charge. The general construction of the caliber .50 ballistic pendulum and gun mount is shown in Plates 2 to 7. The weight of the pendulum assembly is approximately 365 lbs. The velocity of the dart in feet per second is measured by the maximum swing of the pendulum which is recorded by the slider on the indicating bar (Plates 2 and 5). An accuracy of velocity measurement of better than 1% is attained. For a more complete discussion of the theory and performance of the ballistic pendulum, reference may be made to NRL Report No. O-1778 dated 4 September 1941. The equipment may be operated by one man, although a crew of four trained men can obtain data on over 50 impacts per 8-hour day.

10. A special jig which was mounted in the pendulum to hold the specimens securely during testing was found necessary (Plates 7, 8 and 9). The weight of the jig (approximately 80 lbs.) was distributed so that the impact of the dart at 1 inch from the end of a finger would not be far from the center of gravity of the jig as positioned in the pendulum assembly.

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11. In order to reduce the deformation of the specimen at the point of impact, the caliber .50 ball projectile was inserted into the powder case in the reversed position. Thus the base of the projectile instead of the point strikes the finger, and a smaller proportion of the energy is expended in penetration or in crater formation. The first impact is made at a medium velocity and the velocity of subsequent impacts is made higher or lower, depending upon the effect of the first impact. A limit velocity is estimated from the resulting damage to the fingers and may be defined as the exact velocity required to just break the finger from the specimen. In all cases an attempt was made to bracket as closely as possible the limit velocity with two impacts. The accuracy of an estimated limit velocity may be improved only by increasing the number of impacts.

METHODS AND DESCRIPTION OF EXPERIMENTS WITH #206 ARMOR

12. In order to determine the behavior of the standard test piece (Plate 1), a number of test specimens were prepared using a supply of one inch thick #206 armor. No weld joints were used as it was desired to have test specimens which were uniform throughout in order to determine the behavior of the test piece. Specimens were prepared with the principal direction of rolling along the finger and also transverse to the length of the fingers. The test specimens were cut with a power hack-saw with a water coolant, and then heat-treated to hardnesses ranging from approximately 260 to 350 Brinell. An attempt was made to determine the limit velocity for each three-fingered test specimen. Preliminary tests on two other types of armor were also made.

DATA OBTAINED ON #206 ARMOR

13. The performance of the test specimens of #206 plate material indicated greater ability to absorb energy in the shock-fracture test when the finger is cut in the principal direction of rolling than in the transverse direction. There is a decrease in the limit velocity and hence a decrease in the energy absorption in the shock-fracture test as the hardness is increased from 260 to 350 Brinell. This relation is contrary to the increase in limit velocity with an increase in hardness obtained for full penetration by A.P. projectiles. A similar shock behavior has been observed for other grades of armor. These data are presented graphically in Plates 24 and 25.

METHODS AND DESCRIPTION OF EXPERIMENTS WITH WELDED SAMPLES

14. The performance of the test piece used in the study of unwelded armor indicated that it would be entirely satisfactory for use in testing the quality of a number of welded sections taken from H-plates (in the one-inch thickness) which had previously been tested at the Aberdeen Proving Grounds. Test specimens were prepared from each of these sections in accordance with details given in Plate 26 and tested in the NRL shock fracture test.

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DATA OBTAINED FOR WELD JOINT SAMPLES

15. The performance of the test samples from H-plates which were tested with 75 mm. proof projectiles is given in Table II. Photographs of the H-plate and NRL shock fracture test specimens are given in Plates 27 to 44. The criterion which many experts regard as the most indicative of H-plate performance is the amount of cracking on the back of the plate when subjected to the impact of the 75 mm. slug. These data are presented in Table III and Plate 45.

16. The performance of the NRL shock-fracture tests on samples from H-plates varies for this series of tests over a considerable range with limit velocities of 1700 ft./sec. to over 2378 ft./sec. Some of the reasons why a better correlation was not found between the tests in all cases are:

- (a) The direction of rolling of the armor in the test piece was not the same for all welds.
- (b) The front and back of the H-plate samples were not designated.
- (c) If additional material were available, the shock-fracture properties of the virgin armor could be determined. This would be useful in interpretation of the joint behavior.
- (d) Difficulty is often encountered in obtaining an accurate limit velocity with three impacts in the NRL small-scale shock-fracture test.
- (e) It is often difficult to establish definitely the average length of cracking in the H-plate when subjected to impact by a 75 mm. proof projectile. Such factors as the location of impact, the effect of previous impacts, and misleading cracking in the cross bar are often present and make it difficult to analyze the exact effect of each round.

17. In spite of these variables and unknowns, a surprising correlation is shown between the limit velocity obtained by the NRL shock-fracture test and the amount of cracking on the back of the Aberdeen H-plates when subjected to 75 mm. T-21 proof projectiles. The correlation for all tests in which shock-fracture limit velocities good to ± 50 ft./sec. or better were obtained and where a definite average cracking on the back of the H-plate could be established is shown in Plate 46. It is to be noted that with a NRL shock-fracture limit velocity of less than 1950 ft./sec., the H-plate showed cracking in all cases of more than 18 inches.

18. For the limited number of plates tested in which the 57 mm. T-1 slug was used for H-plate testing at Aberdeen, poor

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These data are shown graphically in Plate 47. Five of the ten H-plates were welded using two types of armor which made the interpretation of results difficult. Three of the remaining samples were cast steels and only two samples were rolled homogeneous armor from the same manufacturer.

19. A number of typical sections of fingers which have been subjected to the shock-fracture test are shown photographically (3x) in Plates 48 to 52 inclusive. Many of the fractures start at the toe of the weld, follow the outer edge of the heat affected zone and progress through the plate. This may be noted in the fracture of #183 (Plate 49). A second type of fracture is that shown in specimen #169 (Plate 50) in which failure is restricted entirely to the fusion line. Two other types of failures have been noted, a complete weld failure as shown in specimen #184 (Plate 50) and a practically complete plate failure as shown in specimen #185 (Plate 49). The improvement in properties in specimens with the principal direction of rolling along the finger is to be noted by the appearance and behavior of specimen #181 (Plate 48).

SUMMARY AND CONCLUSIONS

20. With the test in its present state of development, quantitative data may be obtained to show the effect of changes in heat treatment of armor plate on energy absorption in shock. A definite directional effect was found in the performance of three grades of armor plate in the NRL shock-fracture test. The limit velocity at any hardness for the fingers cut longitudinal to the principal direction of rolling was higher than for the specimens with the fingers transverse to the direction of rolling. A study of the performance of the armor plate is essential in order to evaluate properly the efficiency of a welded joint.

21. A definite correlation is found between results of the NRL shock-fracture test and the performance of H-plates tested under the 75 mm. T-21 shock test. Further tests are being arranged, and an attempt is being made to control a larger number of the recognized variables such as the quality of the plate and direction of rolling. Specimens from virgin armor will be included in future test work in order to determine weld joint efficiency.

SUGGESTIONS FOR FUTURE TESTS

22. Tests have been initiated by the Bureau of Ships, Welding and Casting Section, under Welding #302 in order to observe the behavior of a low alloy ballistic steel welded with modified 19-9 and 25-20 Cr-Mn electrodes. These tests will provide an excellent opportunity for a study of the NRL shock fracture behavior because of a rather extensive concurrent survey of the metallurgical and ballistic performance of this class of material.

23. A study of the behavior of other types of test specimens is under way. A single-fingered specimen has been used in some

tests. Specimens are being machined with radii at the base of the finger in order to observe the effect of the contour at the point of stress concentration in the test specimen.

24. A number of other ballistic steels are being studied to determine their behavior in the NRL shock-fracture test. Samples of NAX and Republic armor which are now available will be tested at various hardness levels.

25. The effect of changes in the diameter of electrodes and changes in welding technique for a number of types and makes of austenitic and ferritic electrodes should be determined.

26. A further study of the effects of changes in joint design will be worth while. This should include such factors as root opening, groove angle, root face, root radius, as well as various T and angle joints.

27. The location of the base of the fingers should be further investigated in weld specimens.

28. The development of a test procedure for armor of 1/4 and 1/2 inch thickness is needed to determine the welding properties of the range of thickness used in aircraft and armored vehicles.

29. The determination of low temperature behavior of armor plate and weld joint specimens may readily be studied with the type of equipment here described. It would be simple to determine shock fracture over a wide range of testing temperatures and with a wide range of thermal treatment.

30. While it is realized that this report presents only a limited amount of test data, it is strongly felt that it does present a test method for obtaining quantitative data of considerable value in development work preliminary to the larger scale Navy or Army H-plate shock test. With an increase of data from the caliber .50 shock fracture tests and with a better understanding of the performance of this test, we may be justified in going to heavier caliber and larger specimens. The use of a 20 mm. with 1-1/2 inch thick armor samples is an entirely logical development. At present, the small-scale shock fracture test gives us a quantitative test which should increase the speed of testing and provide a number of short cuts in development studies of the welding or armor.

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TABLE I

SHOCK-FRACTURE PERFORMANCE OF ARMOR #206 (1" THICK)

<u>Finger on ft./sec.</u>	<u>Finger off ft./sec.</u>	<u>Limit Velocity ft./sec.</u>	<u>BHN</u>	<u>Principal Direction of Rolling</u>
2462	2505	2480 +25	257	Transverse
2408	2406	2400 +25	286	"
2371	2456	2415 +25	298	"
2340	2488	2425 +50	307	"
2251	2398	2320 +25	309	"
2386	2484	2425 +25	323	"
2090	2146	2125 +25	341	"
2670	2728	2700 +25	264	Longitudinal
2600	----	2625 +25	295	"
2486	2568	2525 +50	311	"
2586	2629	2600 +25	311	"
2376	2554	2500 +50	323	"
2418	2497	2460 +25	341	"
2451	2731	2475 +25	355	"

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TABLE II

RELATION OF SHOCK-FRACTURE AND H-PLATE (75 mm.) TEST RESULTS

NRL #	H-Plate #	Shock-Fracture			Average Length**	
		Limit Velocity			of Cracking on	
		ft./sec.			Back of H-Plate	
					inches	
169	Ternstedt 38	2200	+200 (3)*	L	10 1/2 - 13 1/2	(2)*
207	Ternstedt 58	1830	+50 (3)	T	26 1/2 - 26 3/4	(2)
168	Ternstedt 61	1950	+50 (3)	T	15 3/4 - 17 3/4	(2)
198	Ternstedt 63	1770	+100 (3)	T	18 3/4 - 30 1/2	(1)
199	Ternstedt 65	1790	+40 (3)	T	29 1/2	(1)
202	Ternstedt 76	1820	+90 (3)	T	18 - 25 1/2	(1)
203	Ternstedt 78	1790	+50 (3)	T	36 - 38	(1)
204	Ternstedt 80	1990	+150 (3)	T	22 - 30 1/2	(1)
208	Ternstedt 82	1920	+50 (3)	T	12 - 20 1/4	(1)
200	Maremont H-1000 Automotive	1875	+25 (3)	T	24 1/4	(1)
180	So. Cal. Div. 33	2040	+40 (3)	T	11 1/2	(2)
181	Caterpillar H5	2450	+50 (4)	L	1 1/2	(3)
186	Cadillac 80	2200	+150 (3)	T	13 1/4	(1)
187	Cadillac 81	1990	+50 (3)	T	17 - 19 1/4	(1)
182	Heil 12	2250	+50 (4)	L	5 1/2	(2)
183	Heil 13	2300	+50 (4)	L	10 1/4	(2)
205	Heil 14	1900	+50 (3)	T	10	(3)
170	Gordon 1	1920	+40 (3)	T	20	(1)

* Number of fair shots.

L Direction of rolling longitudinal.

T Direction of rolling transverse.

** First value cracking in leg welds.

Second value total cracking in H-plate.

TABLE III

RELATION OF SHOCK-FRACTURE AND H-PLATE (57 mm.) TEST RESULTS

<u>NRL #</u>	<u>Aberdeen H-Plate #</u>	<u>Shock-Fracture Limit Velocity ft./sec.</u>	<u>Average Length** of Cracking on Back of H-Plate inches</u>
197	TH 59	< 2110 (3) C*	5 1/4 (3)*
184	TH 62	2280 ±140 (3) C	4 (2)
201	Cad 76	2360 ±75 (3) T	4 1/2 - 4 3/4 (2)
190	GMTC 39	1850 ±140 (3) T	6 1/2 (1)
193	GMTC 40	2350 ±50 (3) L	0 (1)
185	GMTC 41	2240 ±90 (3) C	13 (1)
192	GMTC 42	1700 ±20 (3) T	19 1/4 - 20 1/2 (1)
189	GMTC 43	< 1978 (3) T	----- (0)
188	GMTC 44	> 2303 (3) L	7 1/2 (2)
191	GMTC 45	> 2286 (3) L	----- (0)

* Number of fair shots.

** First value cracking in leg welds and plate.
Second value total cracking in H-plate.

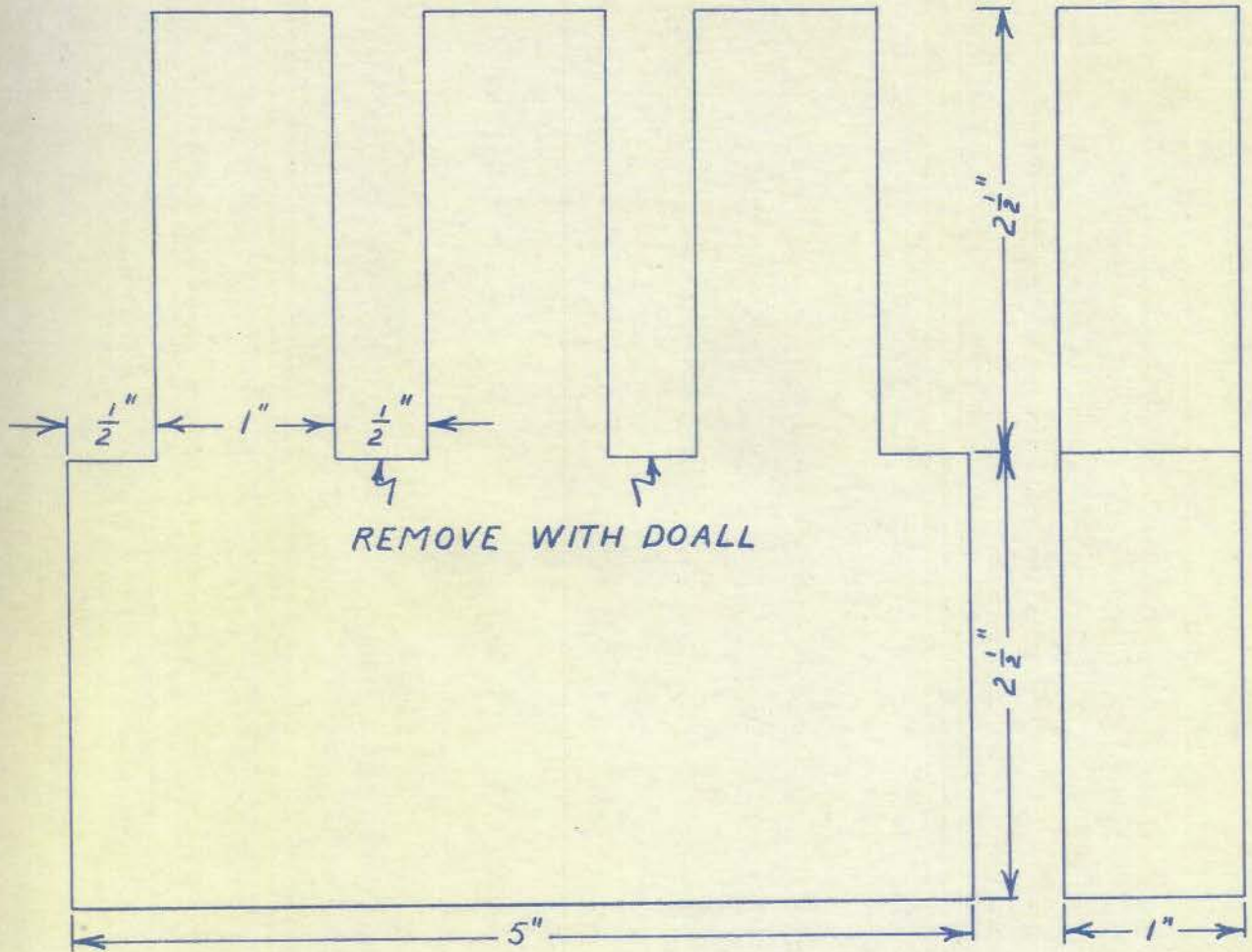
T Direction of rolling transverse.

L Direction of rolling longitudinal.

C Cast armor.

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SPECIMEN PREPARED BY POWER HACK SAW

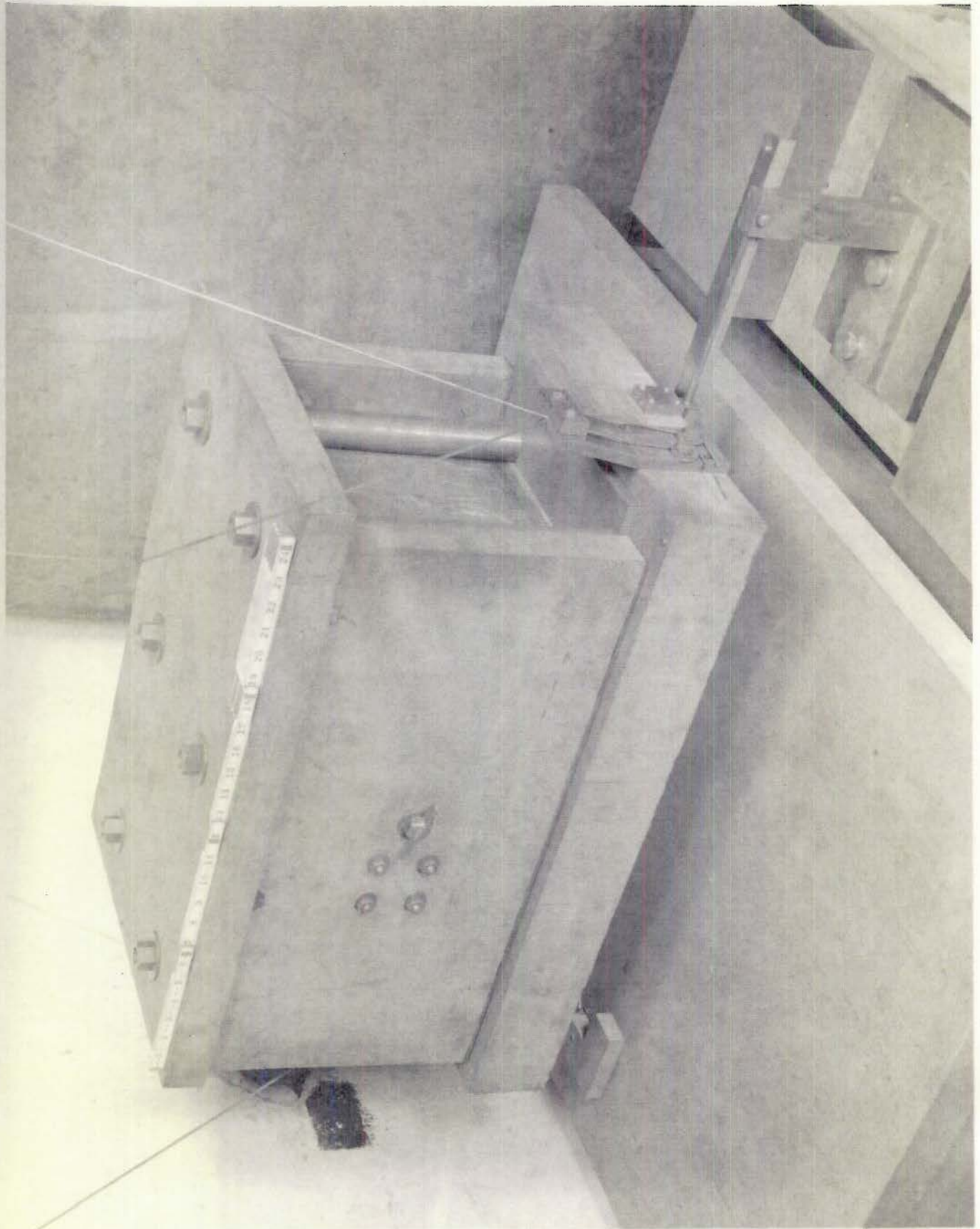


NRL SHOCK FRACTURE TEST SPECIMEN

PLATE I

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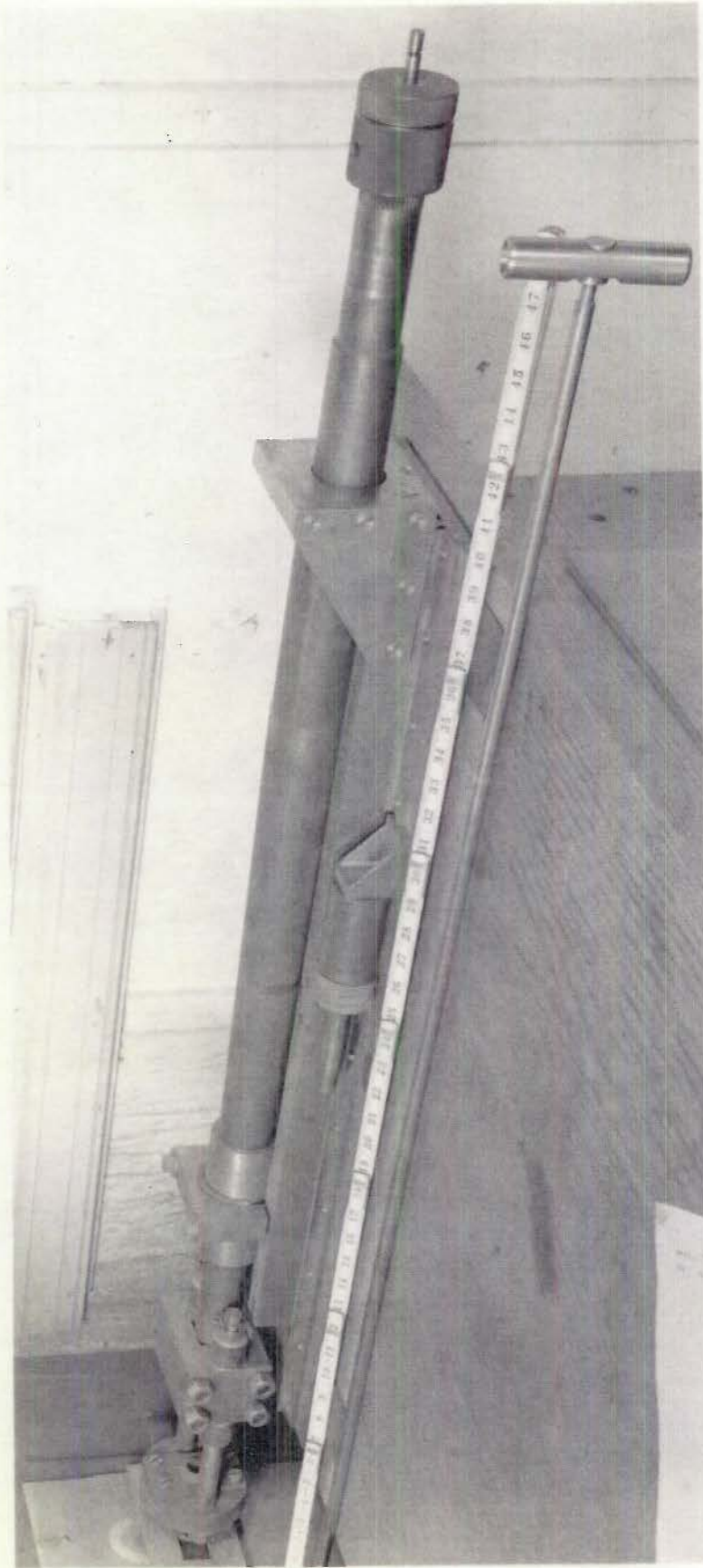


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PLATE 2

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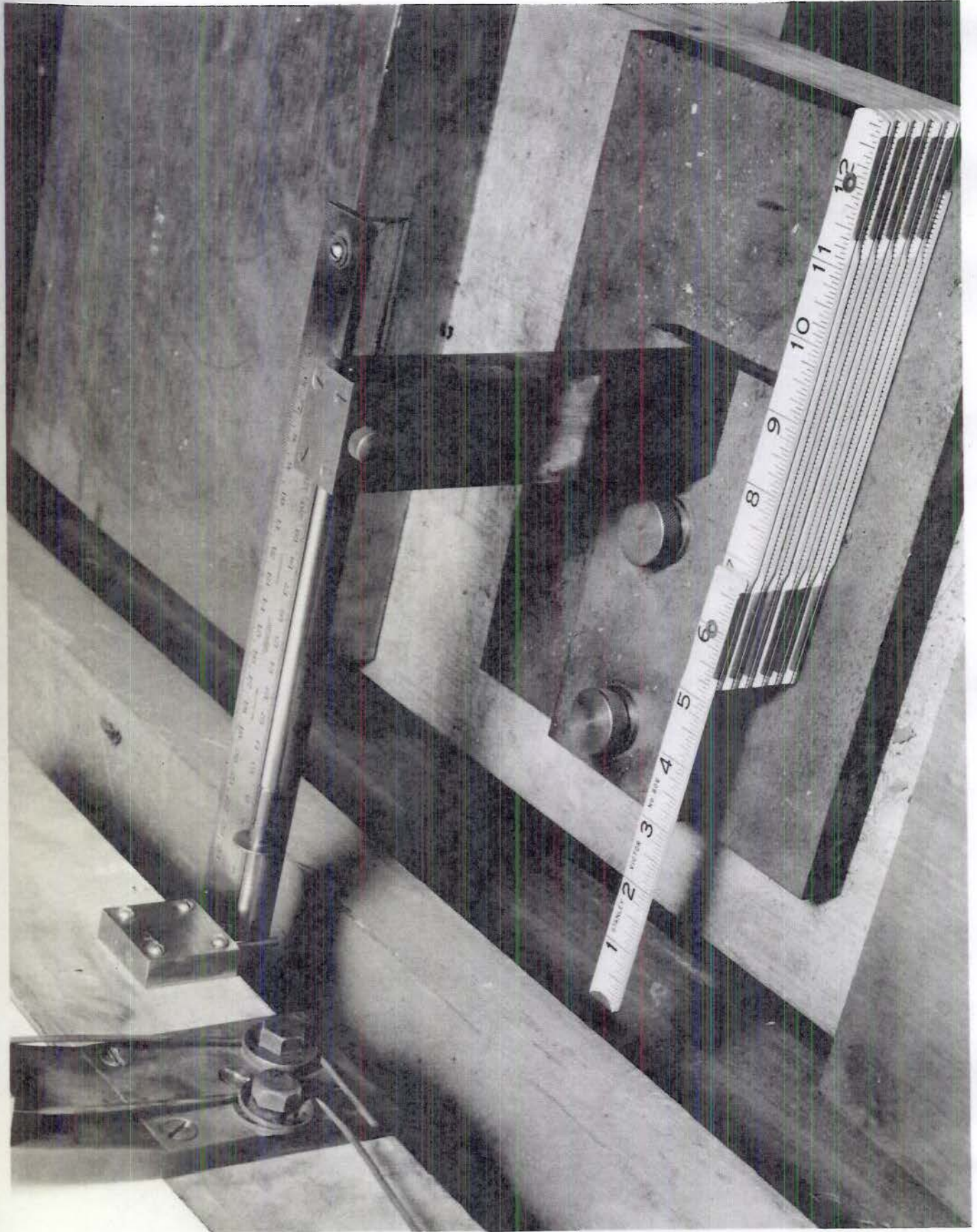
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PLATE 4

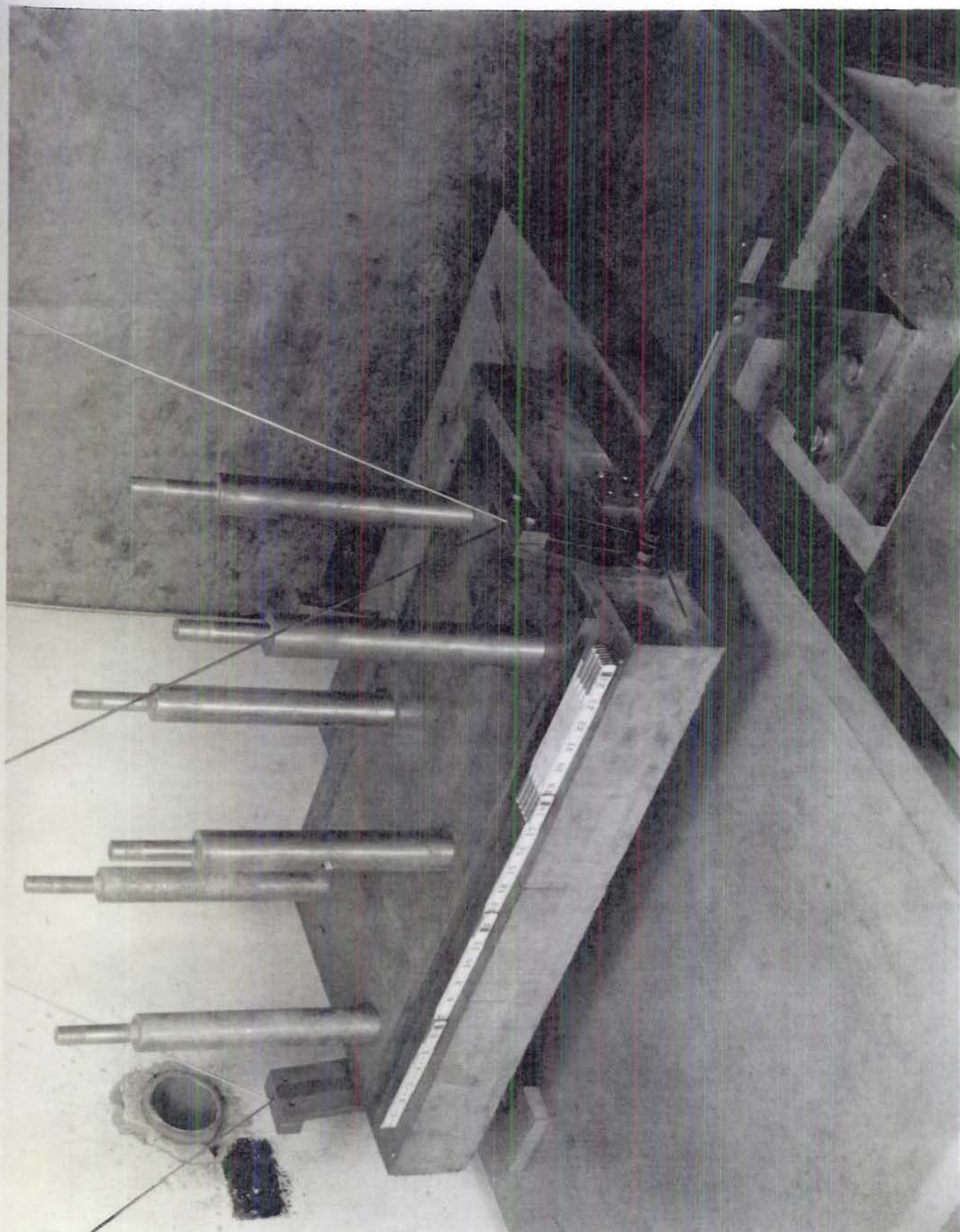
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PLATE 5

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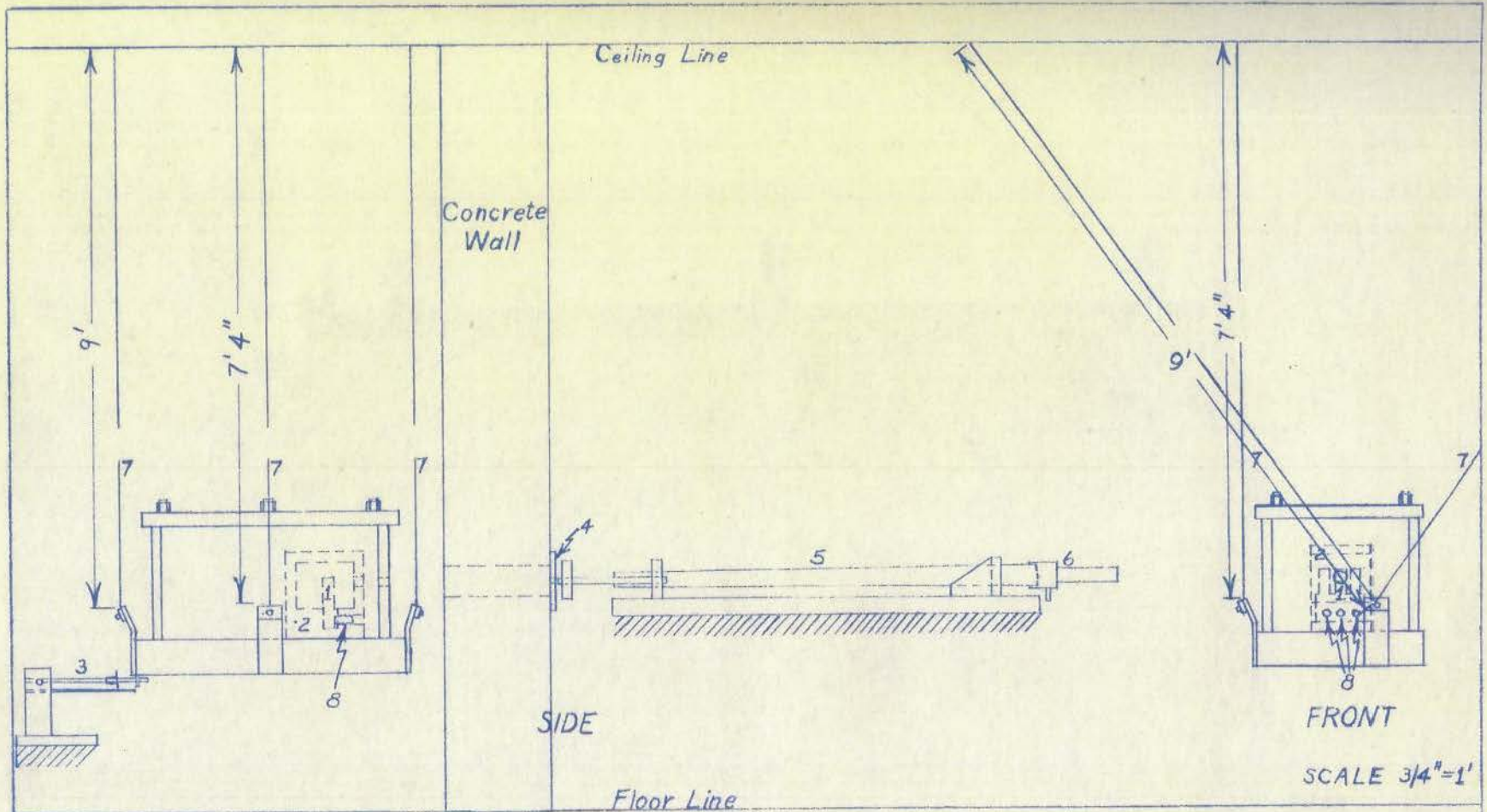
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PLATE 6

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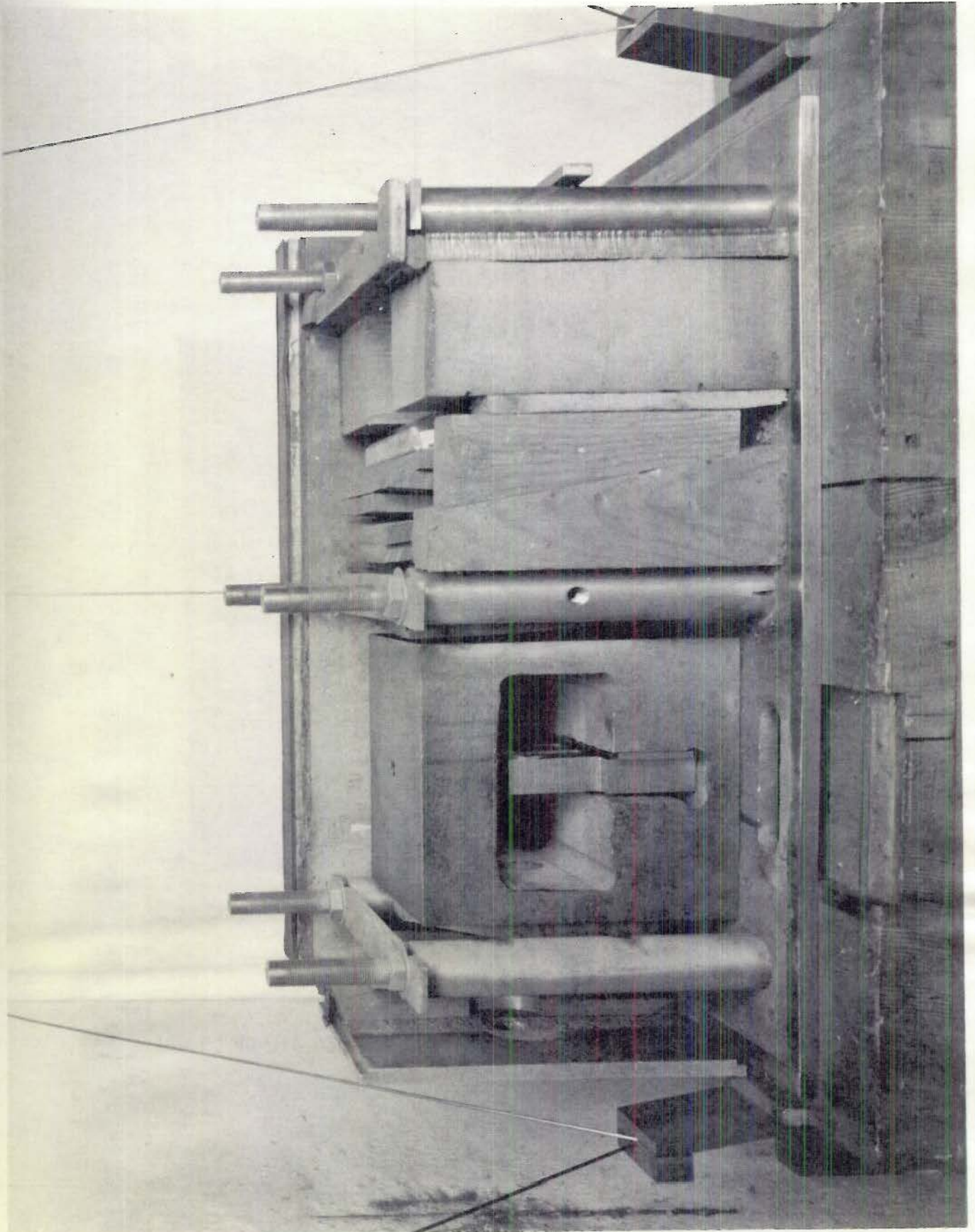
1. Specimen
2. Jig
3. Sliding Indicator and Scale
4. Blast Shield
5. Caliber .50 Browning Machine Gun

6. Air-Operated Firing Mechanism
7. Five Wire Supports
8. 3/4" Allen Screws to Hold Specimen

SCALE 3/4"=1'

PLATE 7

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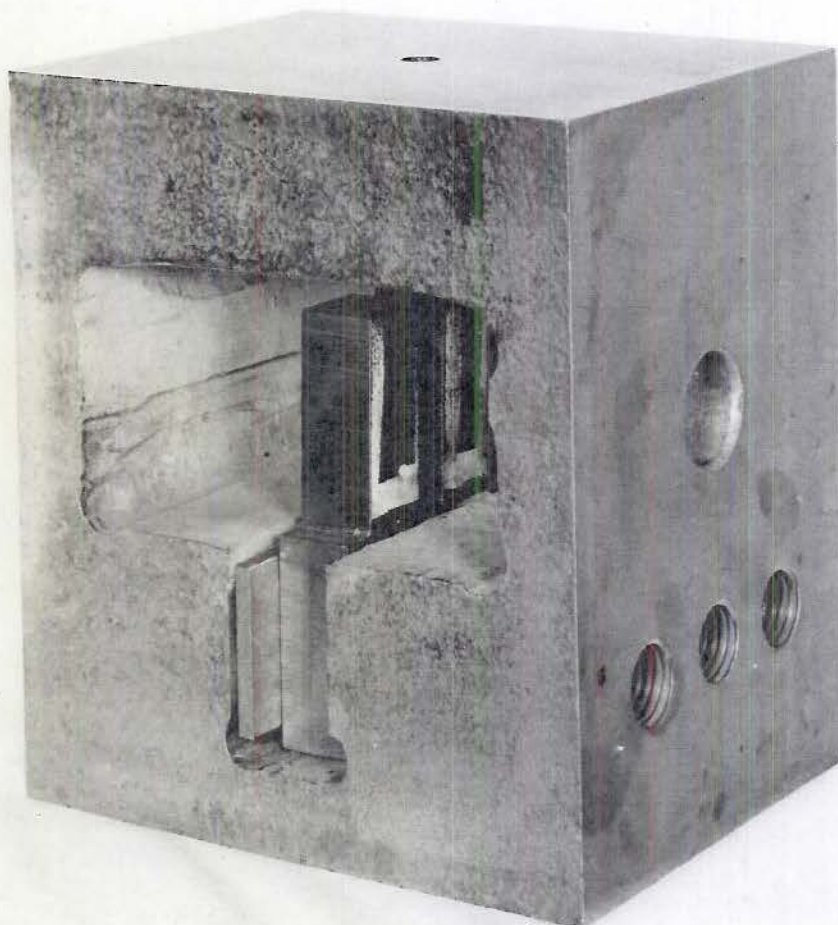


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PLATE 8

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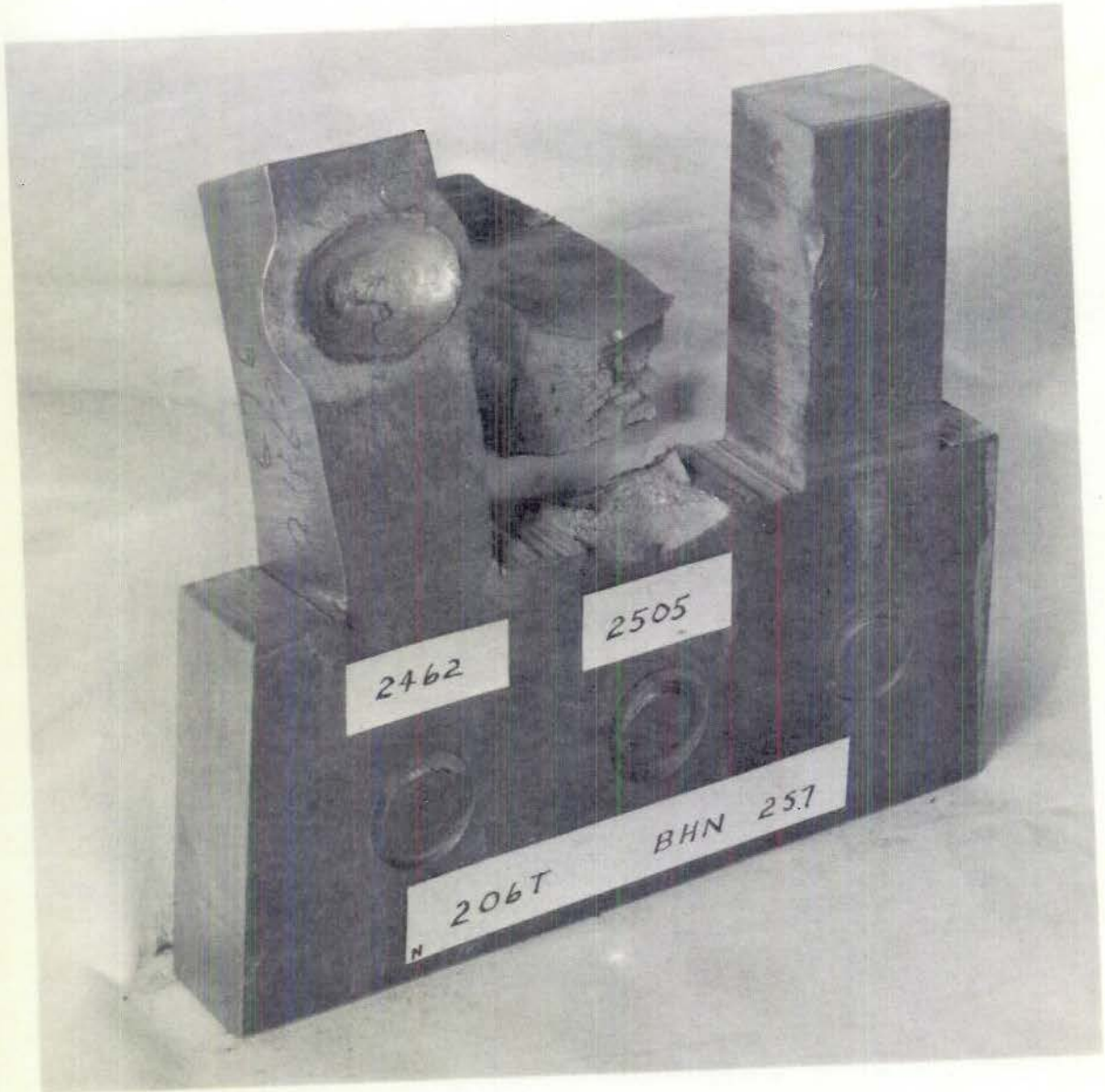


100 POUND JIG USED FOR HOLDING NRL SHOCK FRACTURE SPECIMENS

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PLATE 9

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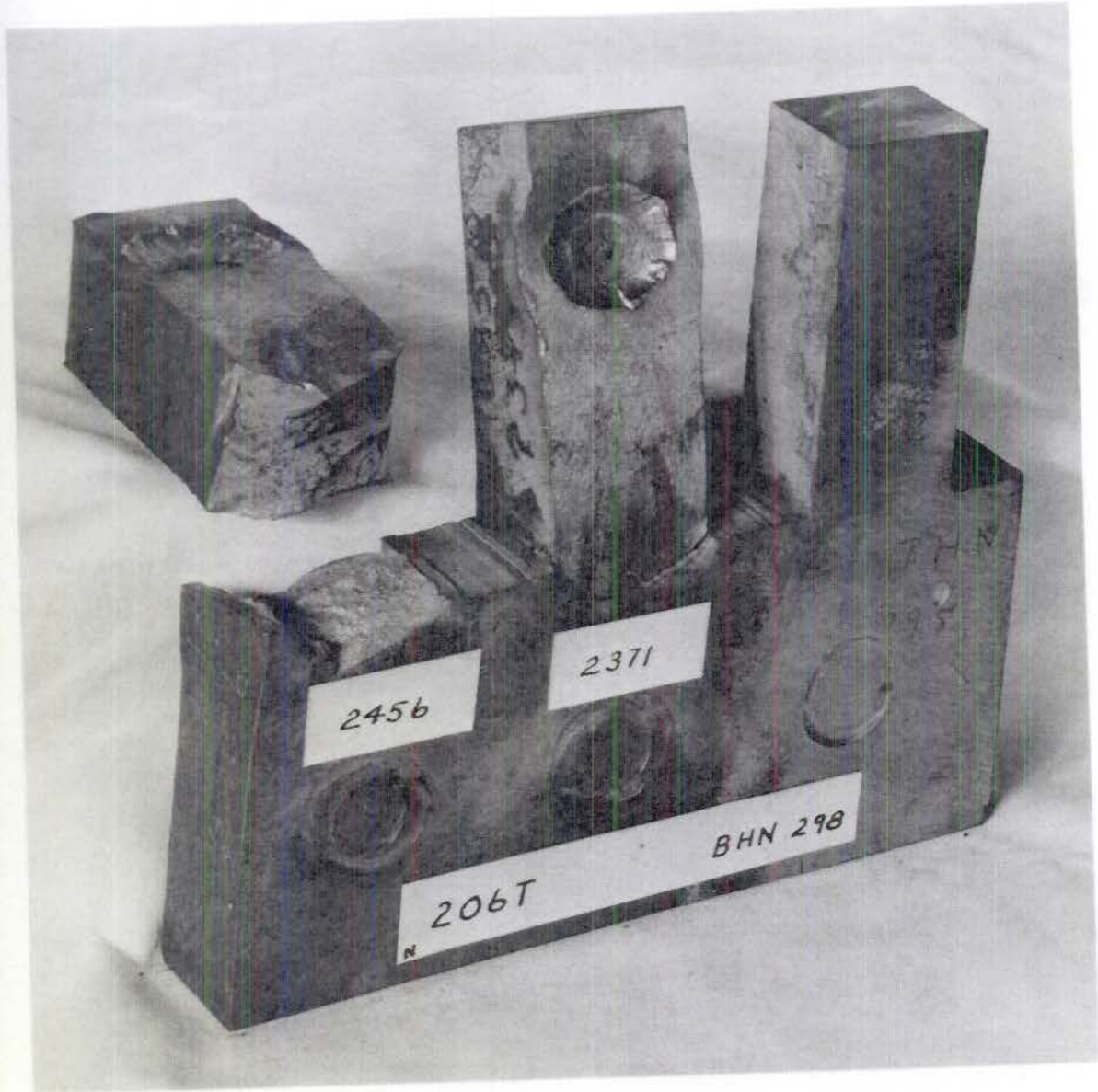
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PLATE 10

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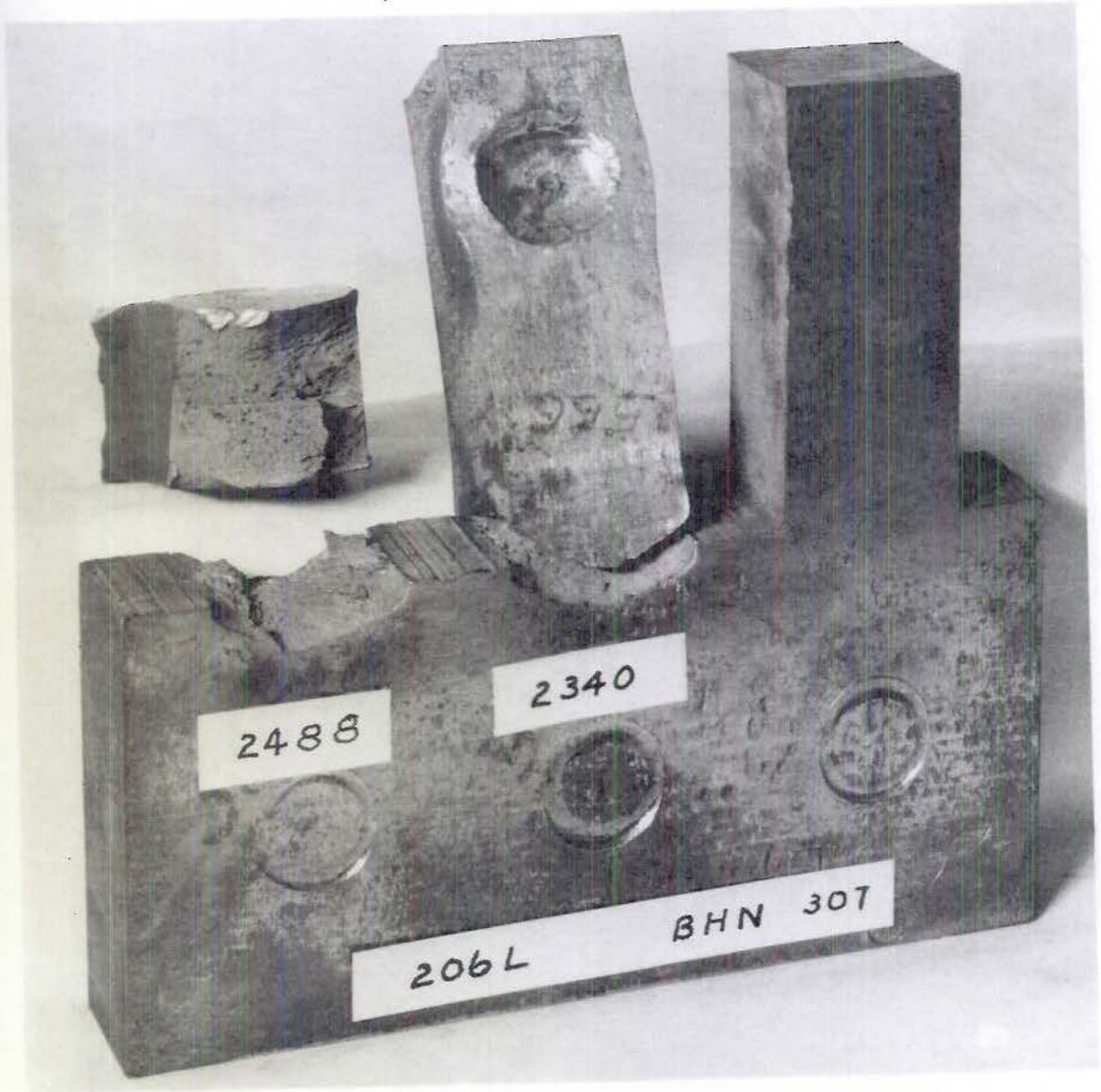


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PLATE 12

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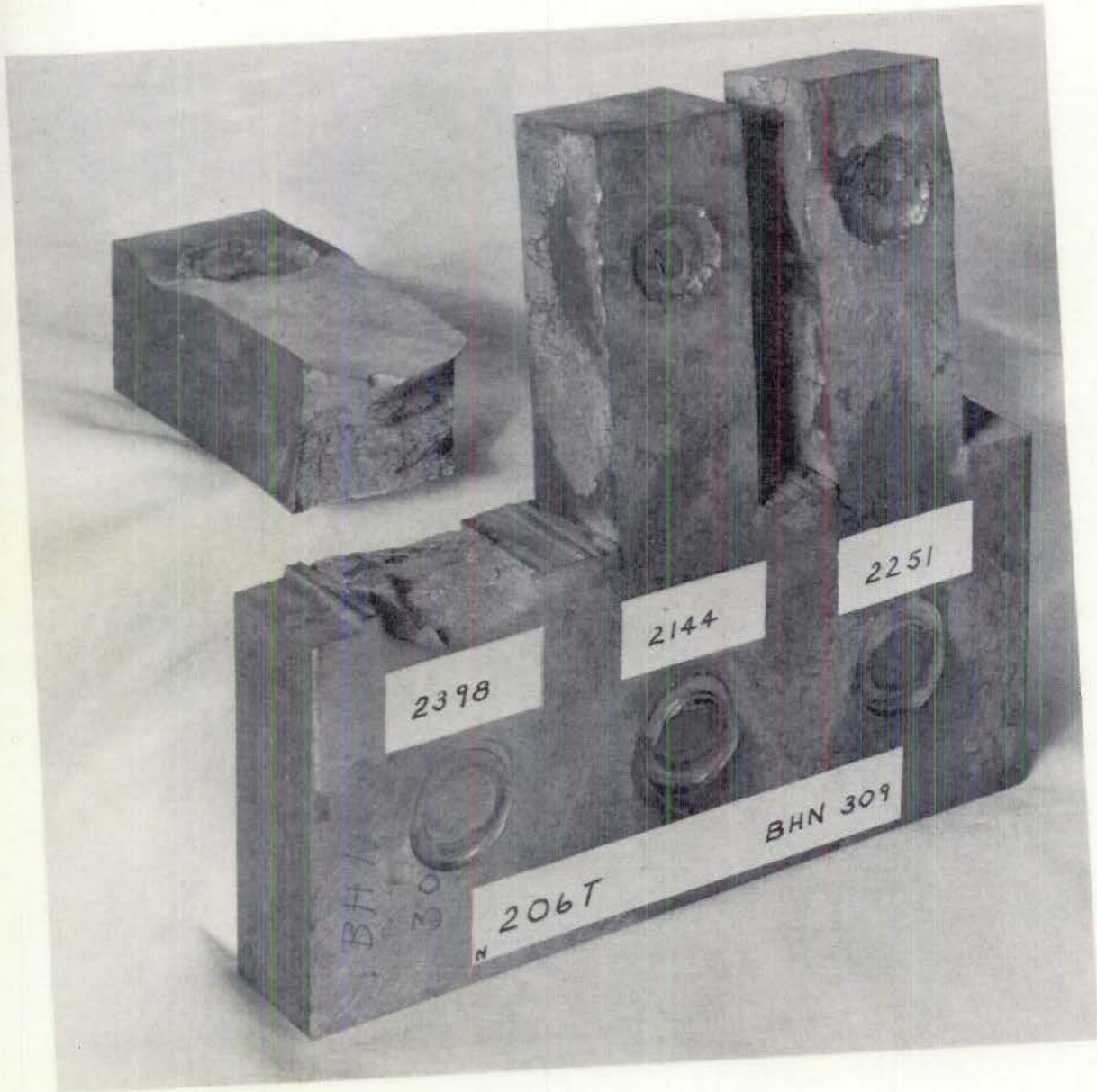


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PLATE 13



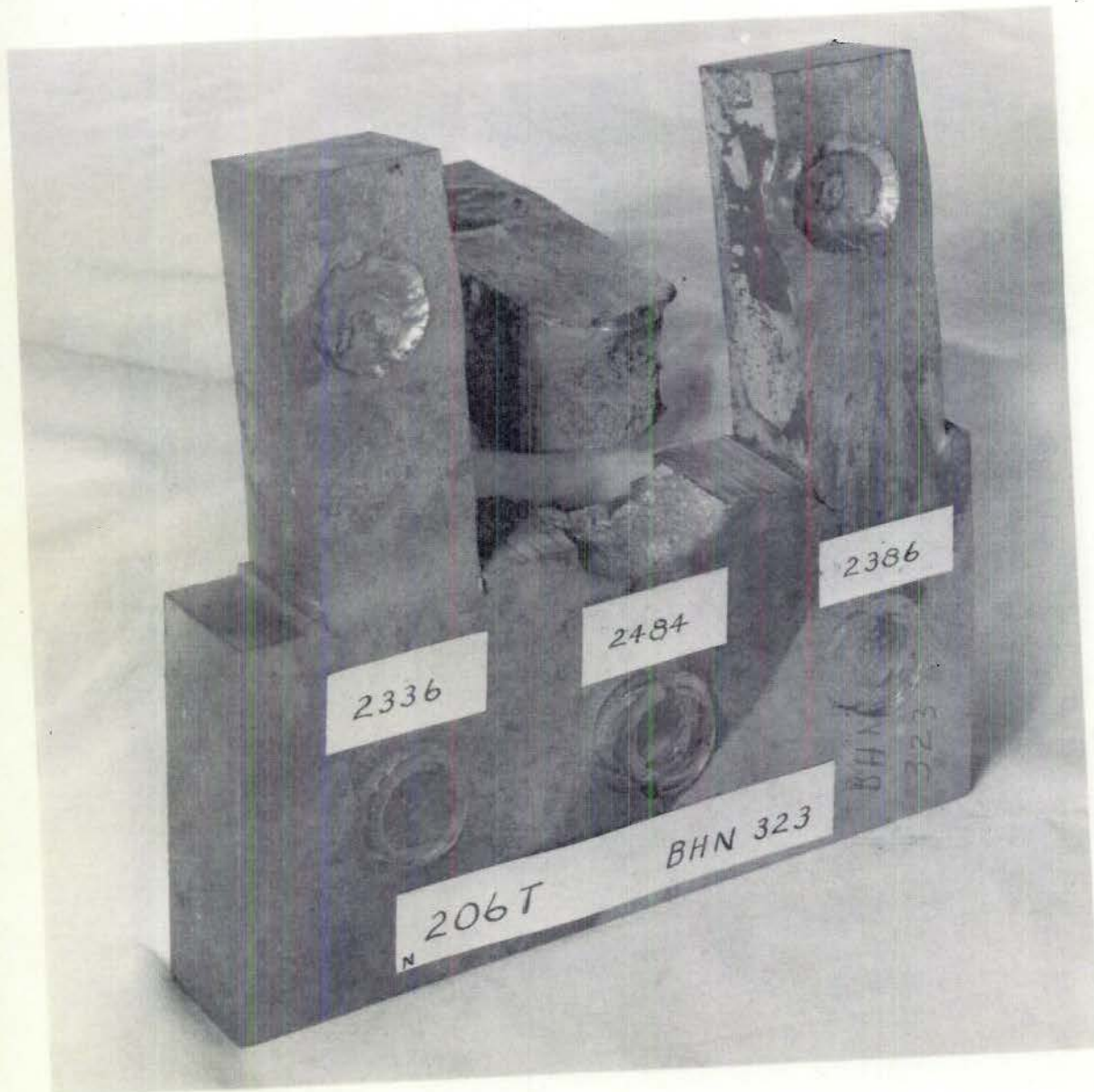
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PLATE 14

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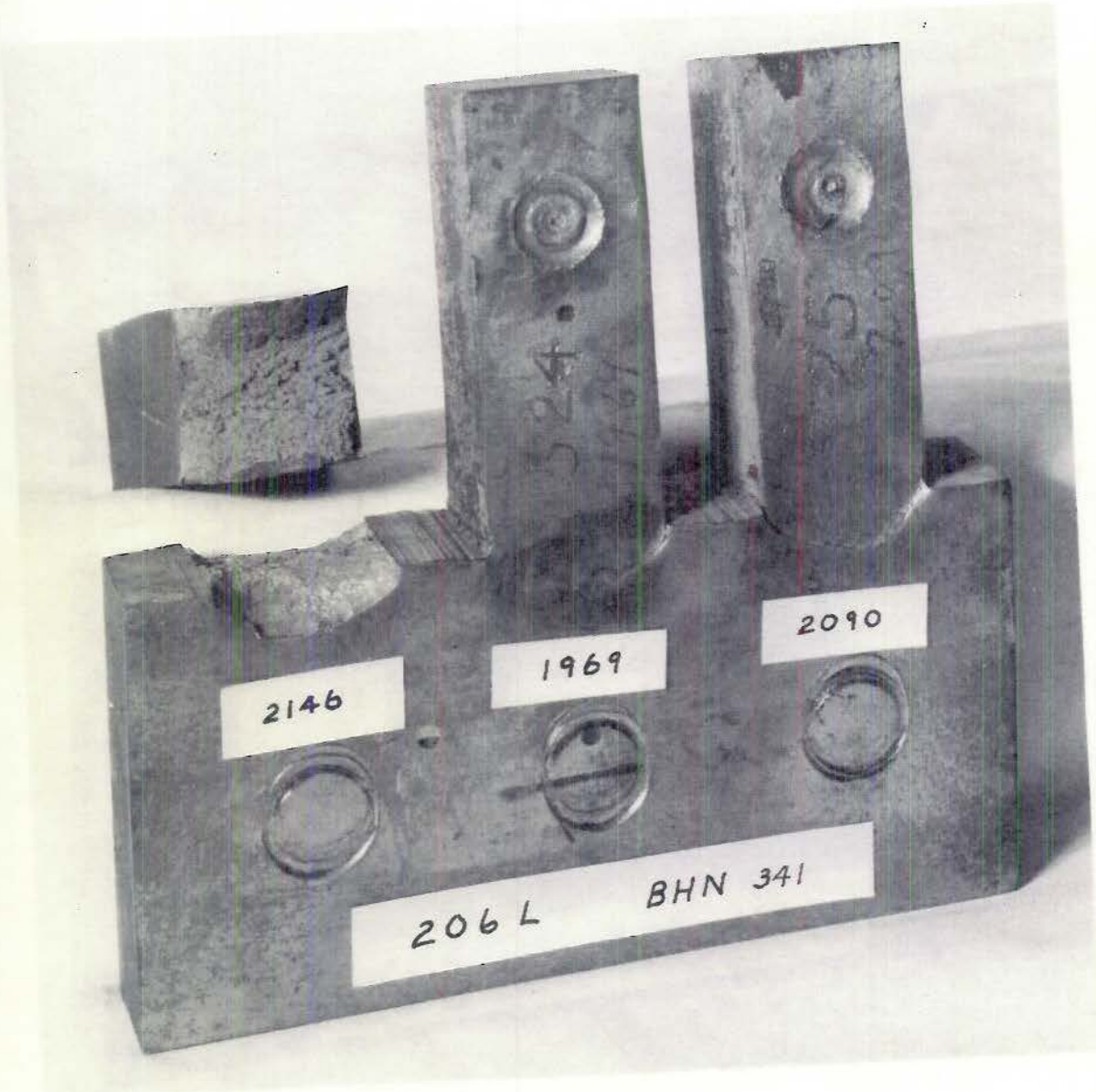
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PLATE 15

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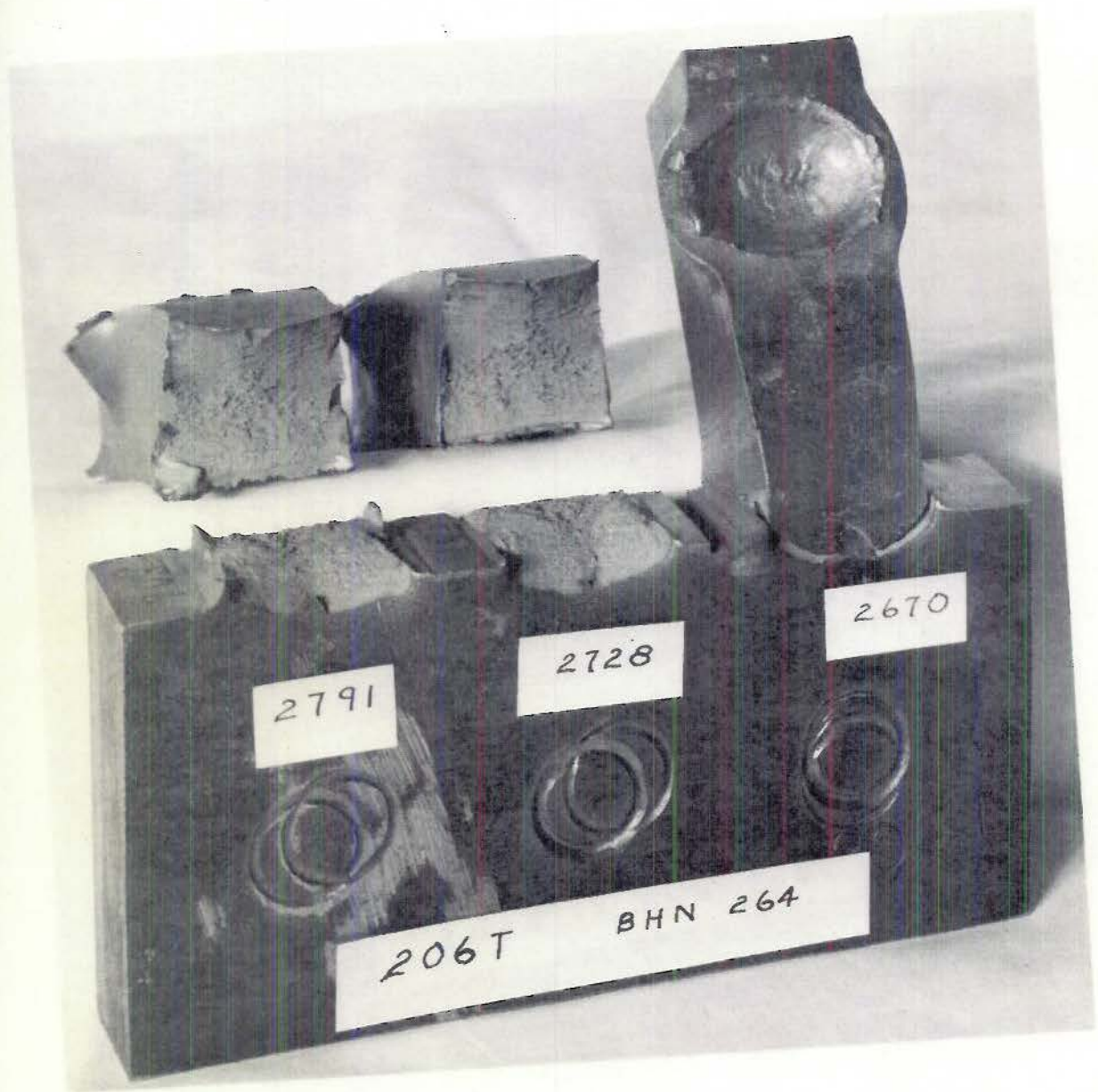


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PLATE 16

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LONGITUDINAL

PLATE 17

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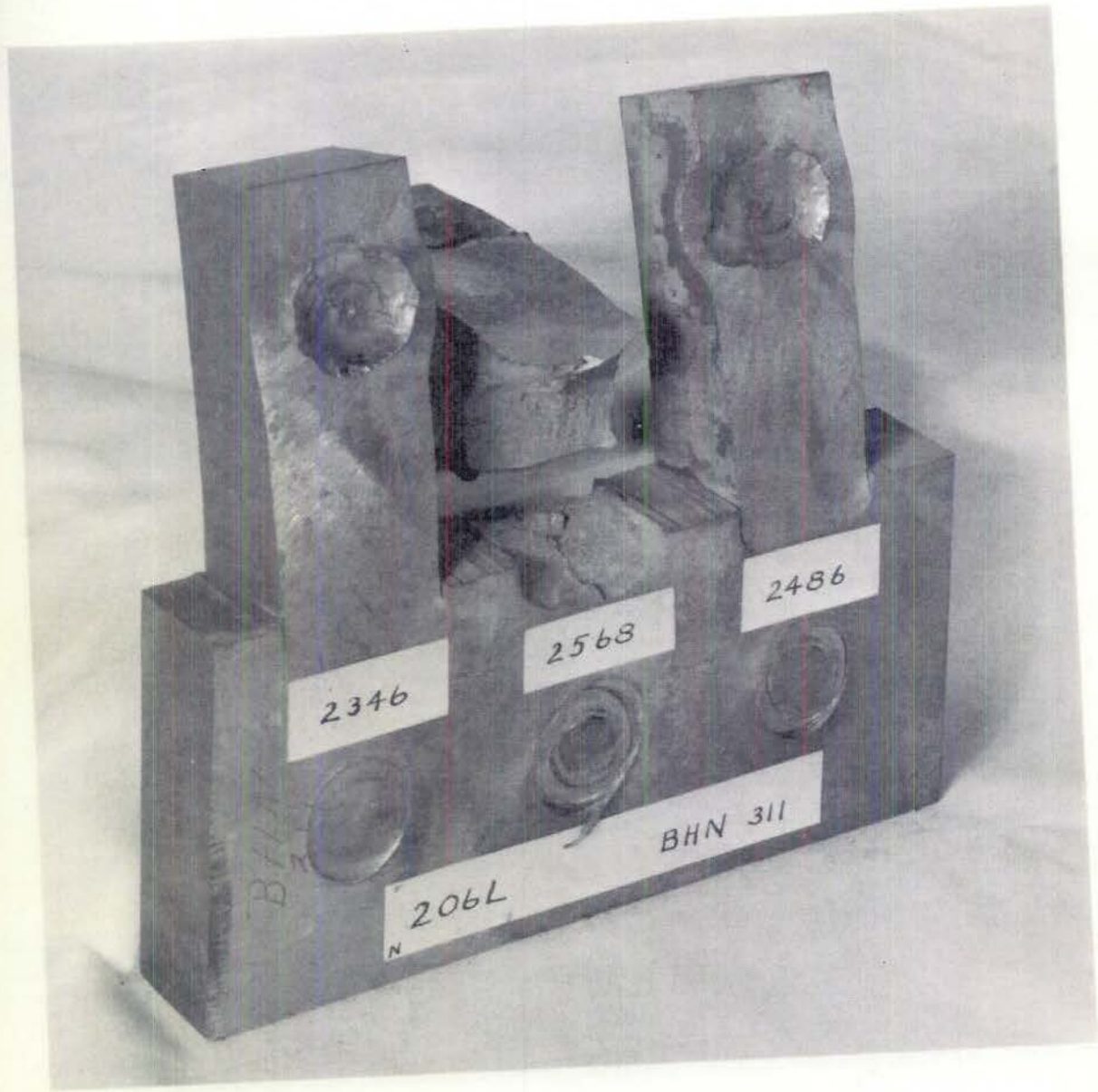


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LONGITUDINAL

PLATE 18



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LONGITUDINAL

PLATE 19

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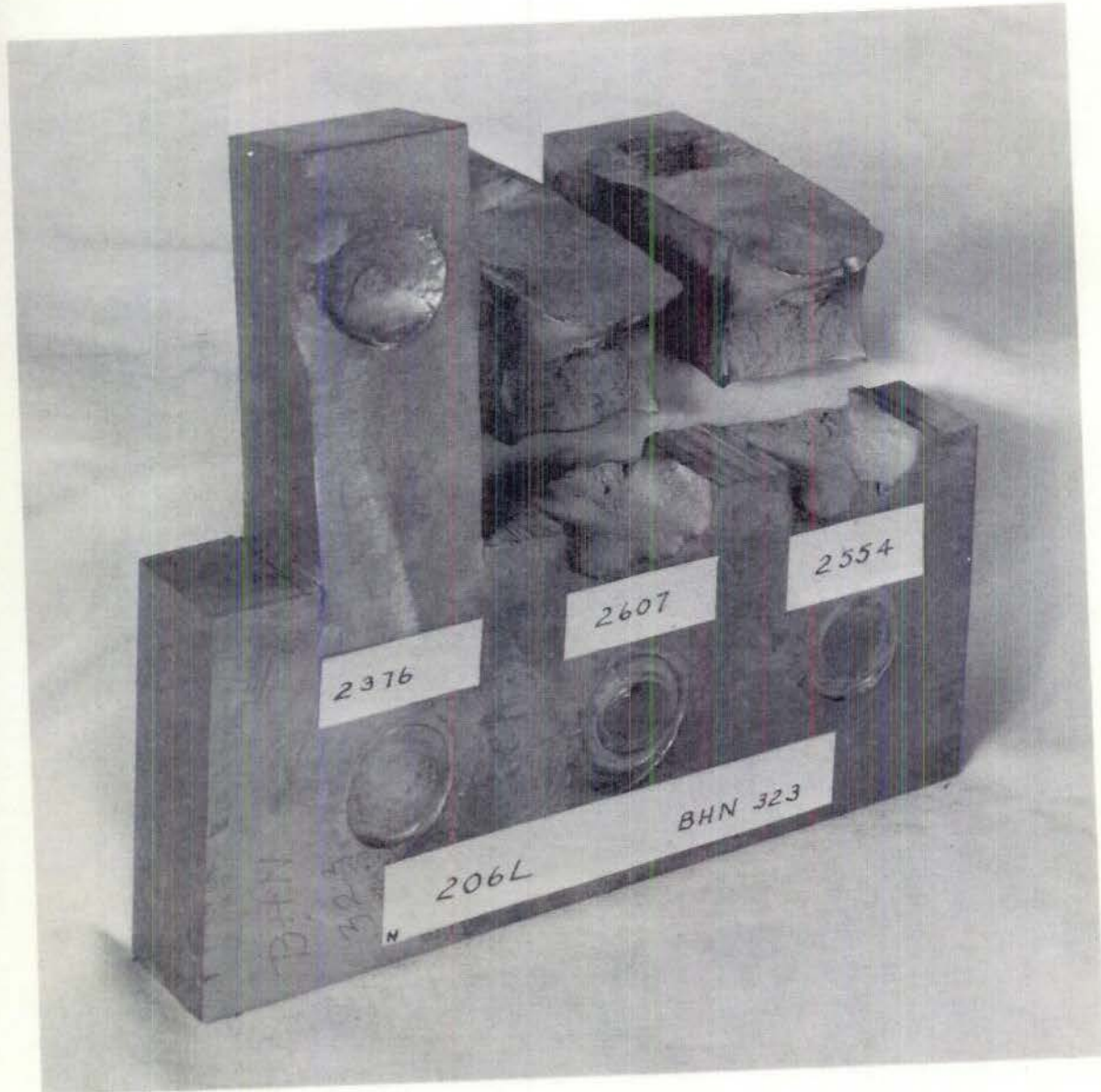
DECLASSIFIED

RESTRICTED

LONGITUDINAL

PLATE 20

DECLASSIFIED



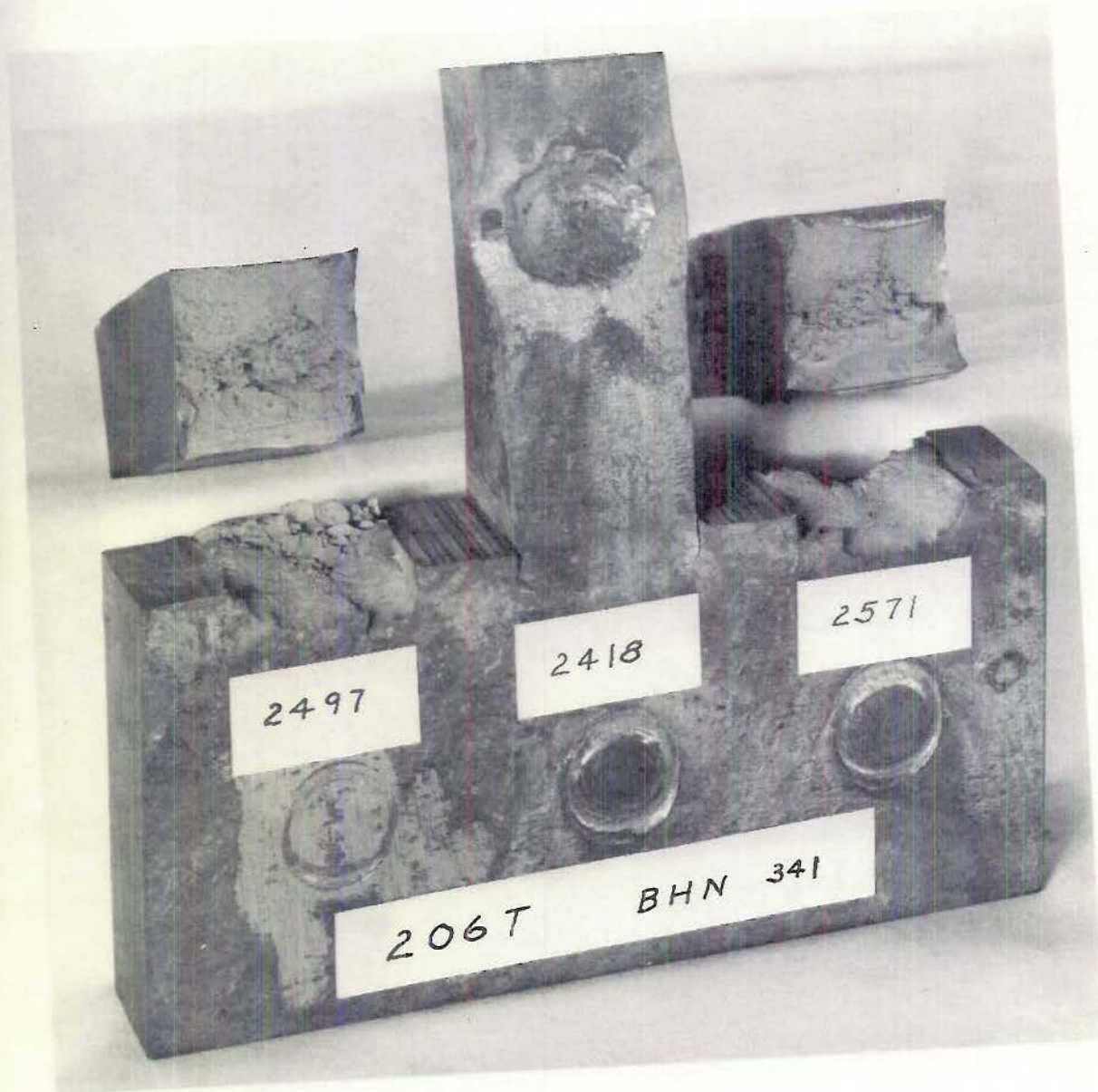
DECLASSIFIED

RESTRICTED

LONGITUDINAL

PLATE 21

DECLASSIFIED



DECLASSIFIED

LONGITUDINAL

PLATE 22

~~RESTRICTED~~

DECLASSIFIED



DECLASSIFIED

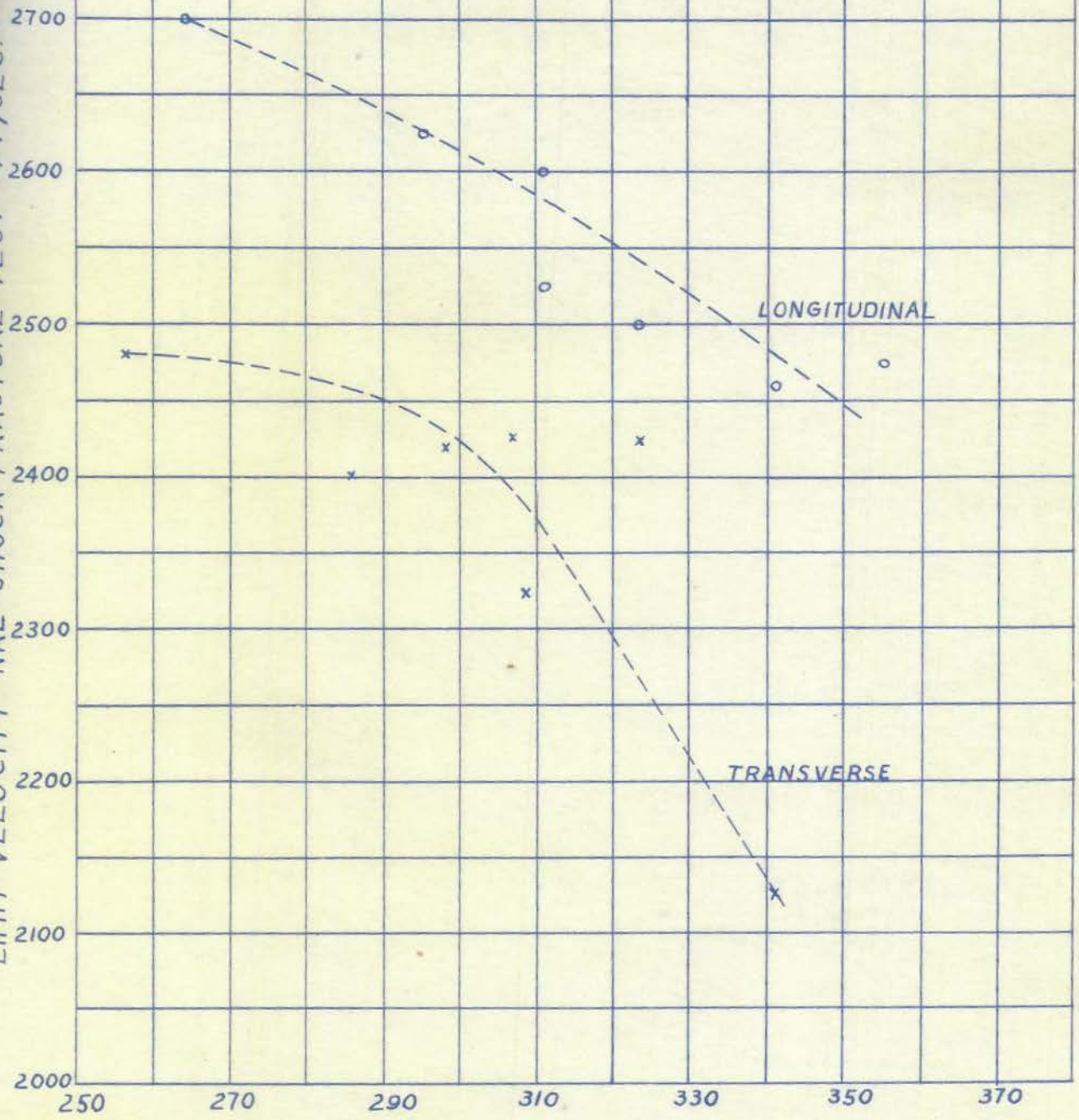
LONGITUDINAL

PLATE 23

RESTRICTED

COMPARISON OF LIMIT VELOCITIES FOR
#206 ARMOR IN LONGITUDINAL AND
TRANSVERSE TO DIRECTION OF
ROLLING

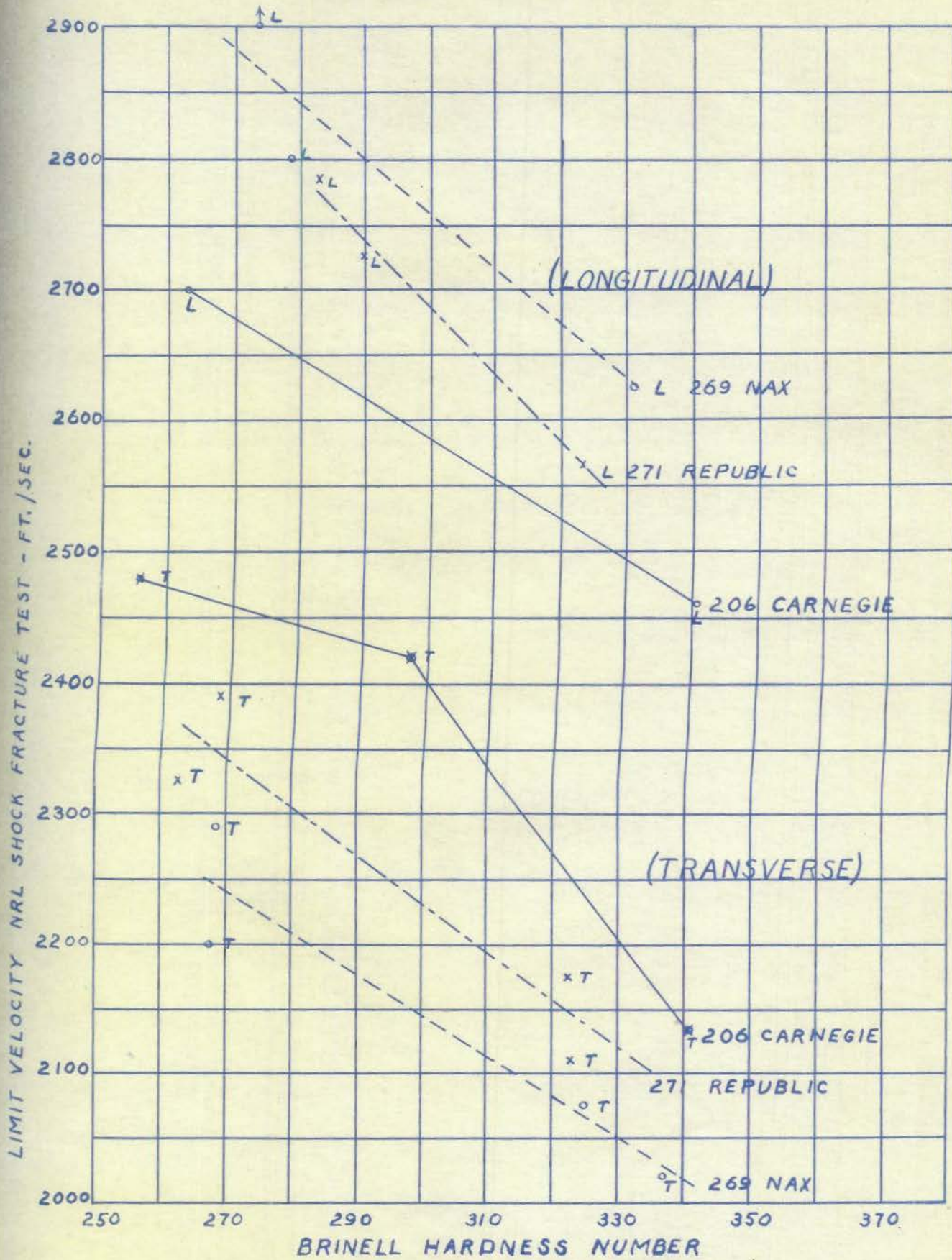
LIMIT VELOCITY NRL SHOCK FRACTURE TEST - FT/SEC.



BRINELL HARDNESS NUMBER

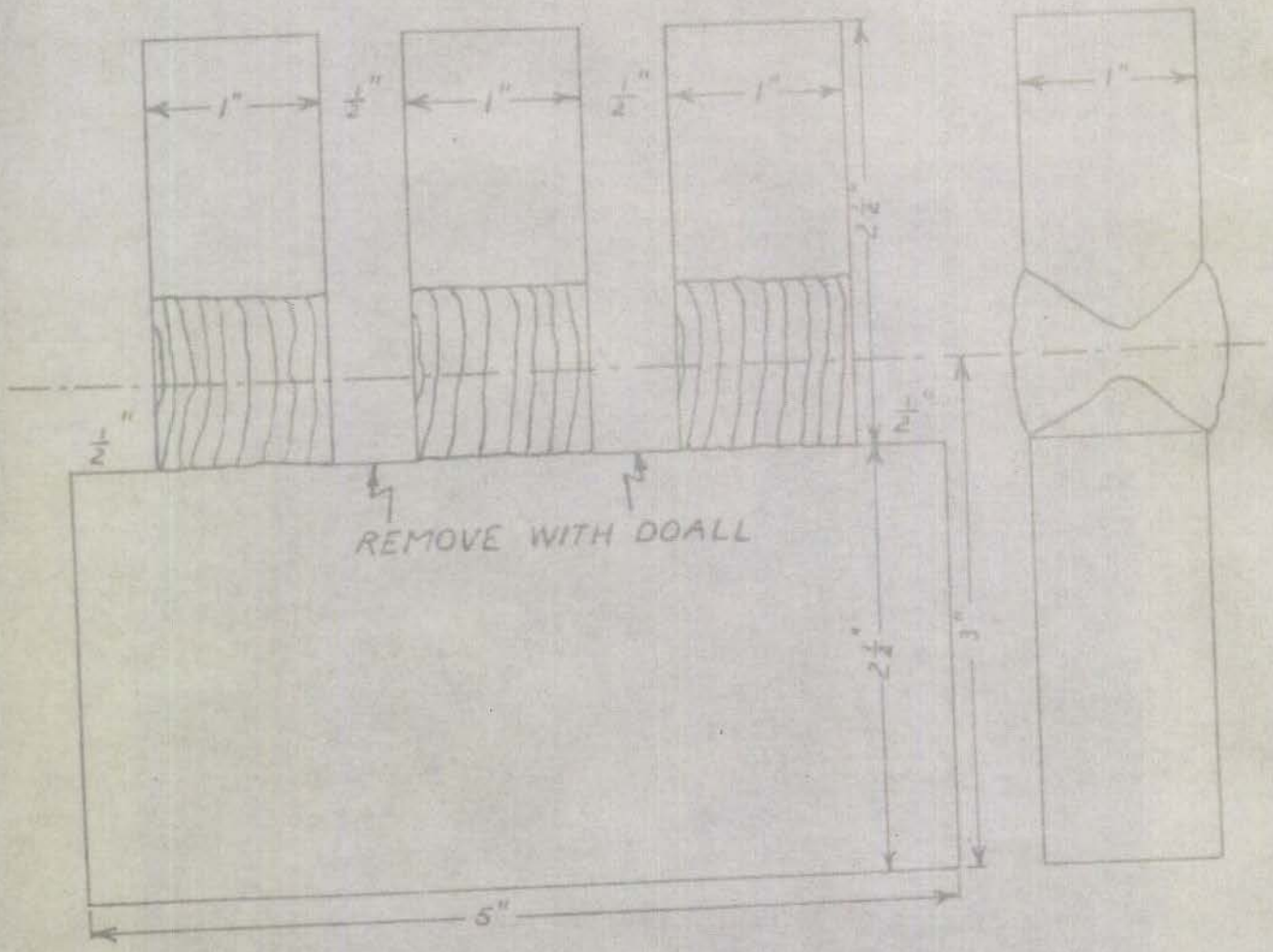
DECLASSIFIED

PLATE 24



DECLASSIFIED

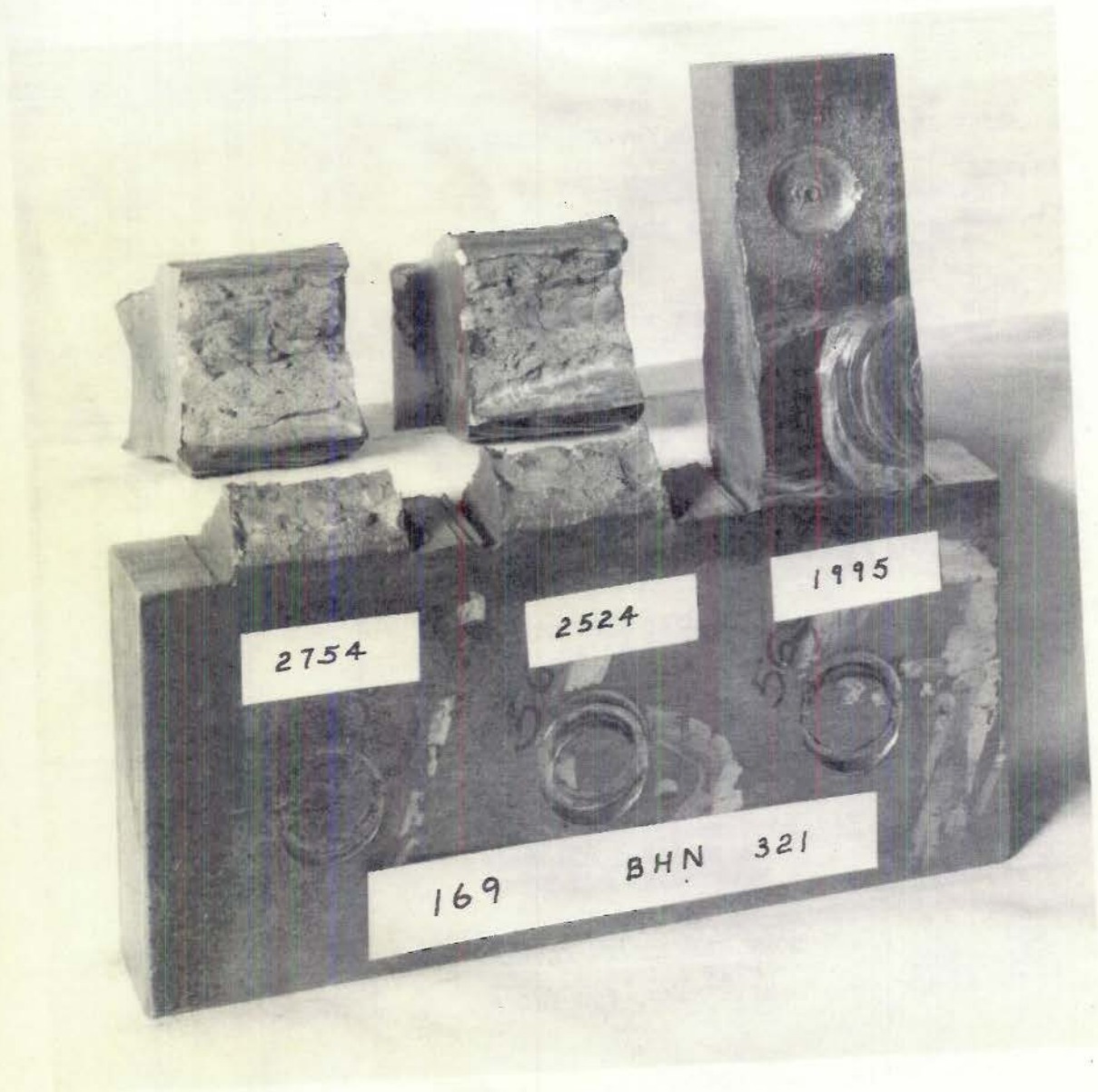
SPECIMEN PREPARED BY POWER HACK SAW



NRL SHOCK FRACTURE TEST SPECIMEN FOR WELD JOINT

DECLASSIFIED

DECLASSIFIED



DECLASSIFIED

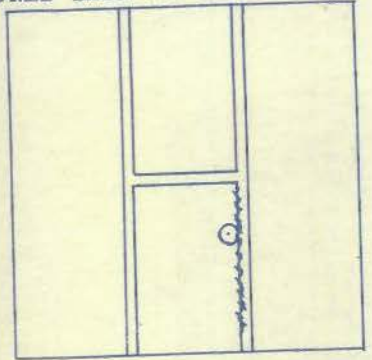
PLATE 27 A

RESTRICTED

DATA ON SHOCK TESTS OF WELDMENTS

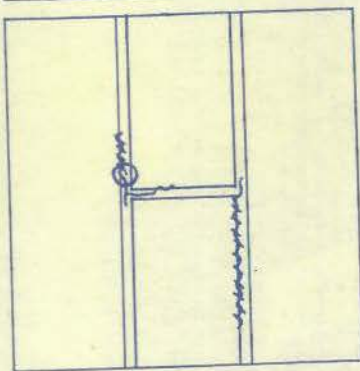
SUBMITTED BY TERNSTEDT MANUFACTURING DIVISION PLATE NO. TH 38
ARMOR MFR GREAT LAKES STEEL & JONES AND LAURENCE TYPE 1" ROLLED HOMO
ELECTRODE ALLOY RODS - REID AVERY MN. MOD 18-8 AUS PURPOSE QUALIFICATION
PROJECTILE 25MM T31 PROOF PROJECTILE DATE 10-20-42
TEMPERATURE OF PLATE AT TIME OF TESTING _____

ONLY BACK CRACKING SHOWN



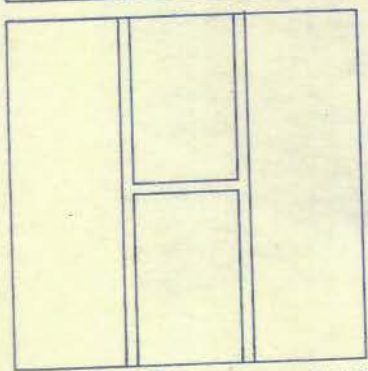
RD. 1 VEL. 776 FT/SEC.
HIT $1\frac{3}{4}$ " LEFT OF RIGHT LEG AND $6\frac{1}{4}$ " BELOW CROSS WELD
CROSS WELD CRACK FROM LEG,
LEFT LEG CRACK WITH CROSS WELD,
 $10\frac{1}{4}$ " RIGHT LEG CRACK WITH ALL BELOW CROSS WELD, $4\frac{3}{4}$ " F.Z.

BACK
CROSS WELD CRACK FROM LEG,
LEFT LEG CRACK WITH CROSS WELD,
 $13\frac{1}{4}$ " RIGHT LEG CRACK WITH ALL BELOW CROSS WELD, ALL F.Z.



RD. 2 VEL. 763 FT/SEC.
HIT ON OF LEFT LEG AND $2\frac{1}{2}$ " ABOVE CROSS WELD
 4 " CROSS WELD CRACK FROM LEFT LEG, ALL F.Z.
 $5\frac{1}{4}$ " LEFT LEG CRACK WITH ALL ABOVE CROSS WELD, $1\frac{3}{4}$ " F.Z.
 $11\frac{3}{4}$ " RIGHT LEG CRACK WITH ALL BELOW CROSS WELD, $4\frac{3}{4}$ " F.Z.

BACK
 5 " CROSS WELD CRACK FROM LEFT LEG, 2 " H.A.Z.
 9 " LEFT LEG CRACK WITH 8 " ABOVE CROSS WELD, $5\frac{1}{2}$ " F.Z.
 15 " RIGHT LEG CRACK WITH 1 " ABOVE CROSS WELD, $13\frac{1}{2}$ " F.Z.
 $1\frac{1}{4}$ " HORIZONTAL BULGE $1\frac{1}{8}$ " VERTICAL BULGE



RD. HIT VEL. OF LEG AND FT/SEC. CROSS WELD
CROSS WELD CRACK FROM LEG,
LEFT LEG CRACK WITH CROSS WELD,
RIGHT LEG CRACK WITH CROSS WELD,

BACK
CROSS WELD CRACK FROM LEG,
LEFT LEG CRACK WITH CROSS WELD,
RIGHT LEG CRACK WITH CROSS WELD,

IMPACT \odot WELD CRACKING ~~~~~
FUSION ZONE CRACKING (F.Z.) ~~~~~
HEAT AFFECTED ZONE (H.A.Z.) ~~~~~

- (✓) WELDS SATISFACTORY
- () WELDS UNSATISFACTORY
- () SUGGESTS REWELD

REMARKS LOCATION OF NRL SAMPLE UNKNOWN

DECLASSIFIED



DECLASSIFIED

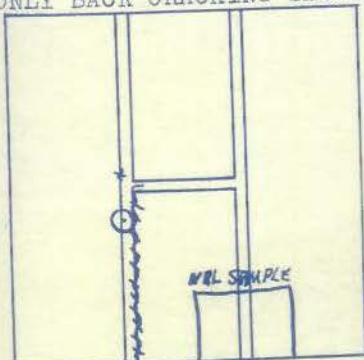
PLATE 28 A

RESTRICTED

DATA ON SHOCK TESTS OF WELDMENTS

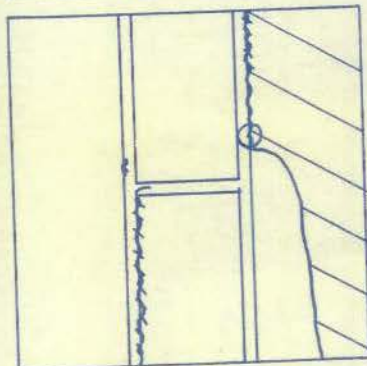
SUBMITTED BY TEARSTEDT MANUFACTURING DIV. PLATE NO. TH 58
 ARMOR MFR GREAT LAKES STEEL COMPANY TYPE 1" ROLLED HOMO
 ELECTRODE REID AVERY PURPOSE QUALIFICATION
 PROJECTILE 75MM PROOF PROJECTILE T-21 DATE 11-25-42
 TEMPERATURE OF PLATE AT TIME OF TESTING 65°F

ONLY BACK CRACKING SHOWN



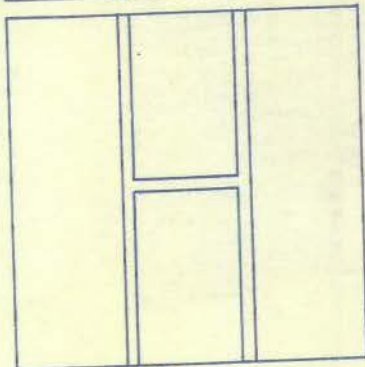
RD. VEL. 735 FT/SEC.
 HIT $\frac{3}{4}$ " LEFT OF LEFT LEG AND $5\frac{1}{2}$ " BELOW CROSS WELD
 CROSS WELD CRACK FROM LEG,
 19" LEFT LEG CRACK WITH ALL BELOW CROSS WELD, ALL F.Z.
 RIGHT LEG CRACK WITH CROSS WELD,

BACK
 1" CROSS WELD CRACK FROM LEFT LEG,
 19" LEFT LEG CRACK WITH 1" ABOVE CROSS WELD, ALL F.Z.
 RIGHT LEG CRACK WITH CROSS WELD,



RD. 2 VEL. 777 FT/SEC.
 HIT $\frac{1}{4}$ " RIGHT OF RIGHT LEG AND 7" ABOVE CROSS WELD
 CROSS WELD CRACK FROM LEG,
 18" LEFT LEG CRACK WITH ALL ABOVE CROSS WELD, ALL F.Z.
 12 $\frac{1}{4}$ " RIGHT LEG CRACK WITH ALL ABOVE CROSS WELD, 8 $\frac{1}{2}$ " F.Z.; 3 $\frac{1}{2}$ " H.A.Z.
 2 $\frac{1}{2}$ " PLATE CRACK

BACK
 1" CROSS WELD CRACK FROM LEFT LEG,
 19" LEFT LEG CRACK WITH 1" ABOVE CROSS WELD, ALL F.Z.
 12 $\frac{1}{4}$ " RIGHT LEG CRACK WITH ALL ABOVE CROSS WELD, 6 $\frac{1}{4}$ " F.Z.;
 2 $\frac{1}{2}$ " PLATE CRACK 6" H.A.Z.



RD. VEL. FT/SEC.
 HIT OF LEG AND CROSS WELD
 CROSS WELD CRACK FROM LEG,
 LEFT LEG CRACK WITH CROSS WELD,
 RIGHT LEG CRACK WITH CROSS WELD,

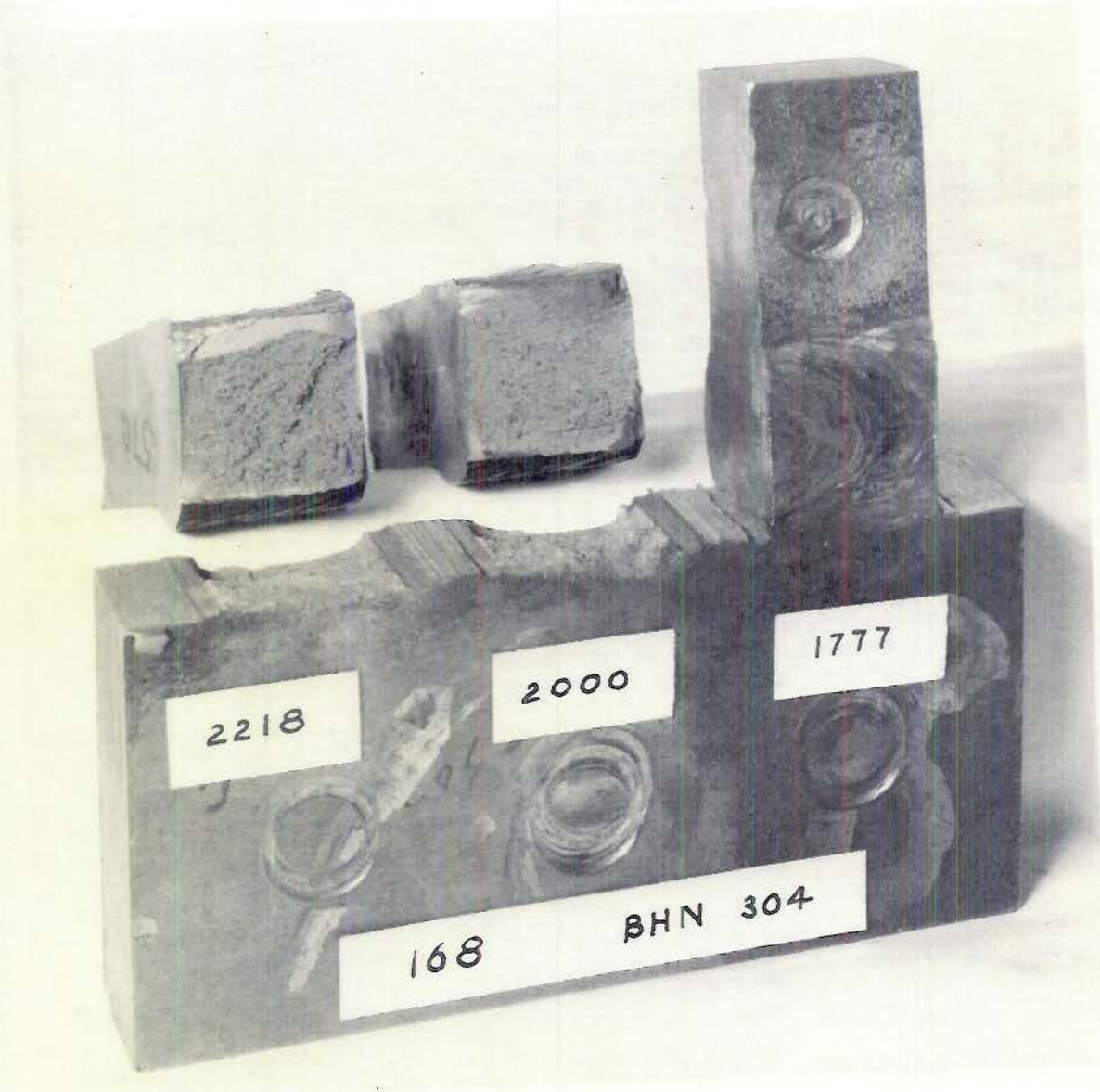
BACK
 CROSS WELD CRACK FROM LEG,
 LEFT LEG CRACK WITH CROSS WELD,
 RIGHT LEG CRACK WITH CROSS WELD,

IMPACT WELD CRACKING
 FUSION ZONE CRACKING (F.Z.)
 HEAT AFFECTED ZONE (H.A.Z.)

() WELDS SATISFACTORY
 (✓) WELDS UNSATISFACTORY
 () SUGGEST REWELD

REMARKS _____

DECLASSIFIED



DECLASSIFIED

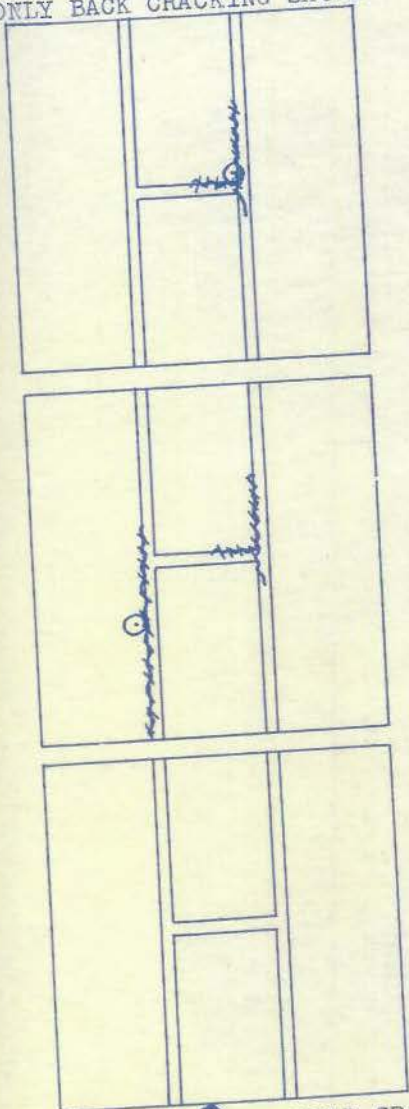
PLATE 29 A

RESTRICTED

DATA ON SHOCK TESTS OF WELDMENTS

SUBMITTED BY TERNSTEDT MANUFACTURING DIV PLATE NO. TH-61
 ARMOR MFR GREAT LAKES STEEL COMPANY TYPE 1" ROLLED HOMO
 ELECTRODE ARMORWELD MN MOD A-8 AUS PURPOSE QUALIFICATION
 PROJECTILE 25MM T-21 PROOF PROJECTILE DATE 10-30-42
 TEMPERATURE OF PLATE AT TIME OF TESTING 65°

ONLY BACK CRACKING SHOWN



RD. 1 VEL. 760 FT/SEC.
 HIT $\frac{1}{8}$ " LEFT OF RIGHT LEG AND $1\frac{1}{2}$ " ABOVE CROSS WELD
 4" CROSS WELD CRACK FROM RIGHT LEG, ALL F.Z.
 LEFT LEG CRACK WITH CROSS WELD,
 9 $\frac{1}{2}$ " RIGHT LEG CRACK WITH $6\frac{1}{2}$ " ABOVE CROSS WELD, 2" F.Z.
 BACK
 5" CROSS WELD CRACK FROM RIGHT LEG, ALL F.Z.
 LEFT LEG CRACK WITH CROSS WELD,
 11 $\frac{1}{2}$ " RIGHT LEG CRACK WITH 8" ABOVE CROSS WELD, 10 $\frac{1}{4}$ " F.Z.
 1 $\frac{1}{4}$ " HORIZONTAL BULGE 1" VERTICAL BULGE

RD. 2 VEL. 685 FT/SEC.
 HIT $1\frac{1}{8}$ " LEFT OF LEFT LEG AND 6" BELOW CROSS WELD
 4" CROSS WELD CRACK FROM RIGHT LEG, ALL F.Z.
 19 $\frac{3}{4}$ " LEFT LEG CRACK WITH 9" ABOVE CROSS WELD, 17 $\frac{1}{4}$ " F.Z.
 9 $\frac{9}{8}$ " RIGHT LEG CRACK WITH 7" ABOVE CROSS WELD, 2" F.Z.
 BACK
 5 $\frac{1}{2}$ " CROSS WELD CRACK FROM RIGHT LEG, 5" F.Z.
 32" LEFT LEG CRACK WITH 18" BELOW CROSS WELD, 21" F.Z.
 11 $\frac{1}{2}$ " RIGHT LEG CRACK WITH 8" ABOVE CROSS WELD, 10 $\frac{1}{4}$ " F.Z.
 1" HORIZONTAL BULGE $\frac{3}{4}$ " VERTICAL BULGE

RD.	VEL.	FT/SEC.	CROSS WELD,
HIT	OF	LEG AND	
			LEG,
			CROSS WELD,
			CROSS WELD,
BACK			LEG,
			CROSS WELD,
			CROSS WELD,

IMPACT WELD CRACKING
 FUSION ZONE CRACKING (F.Z.)
 HEAT AFFECTED ZONE (H.A.Z.)

(✓) WELDS SATISFACTORY
 () WELDS UNSATISFACTORY
 () SUGGESTS REWELD

REMARKS LOCATION OF NRL SAMPLE UNKNOWN

FORM NO WAS-2

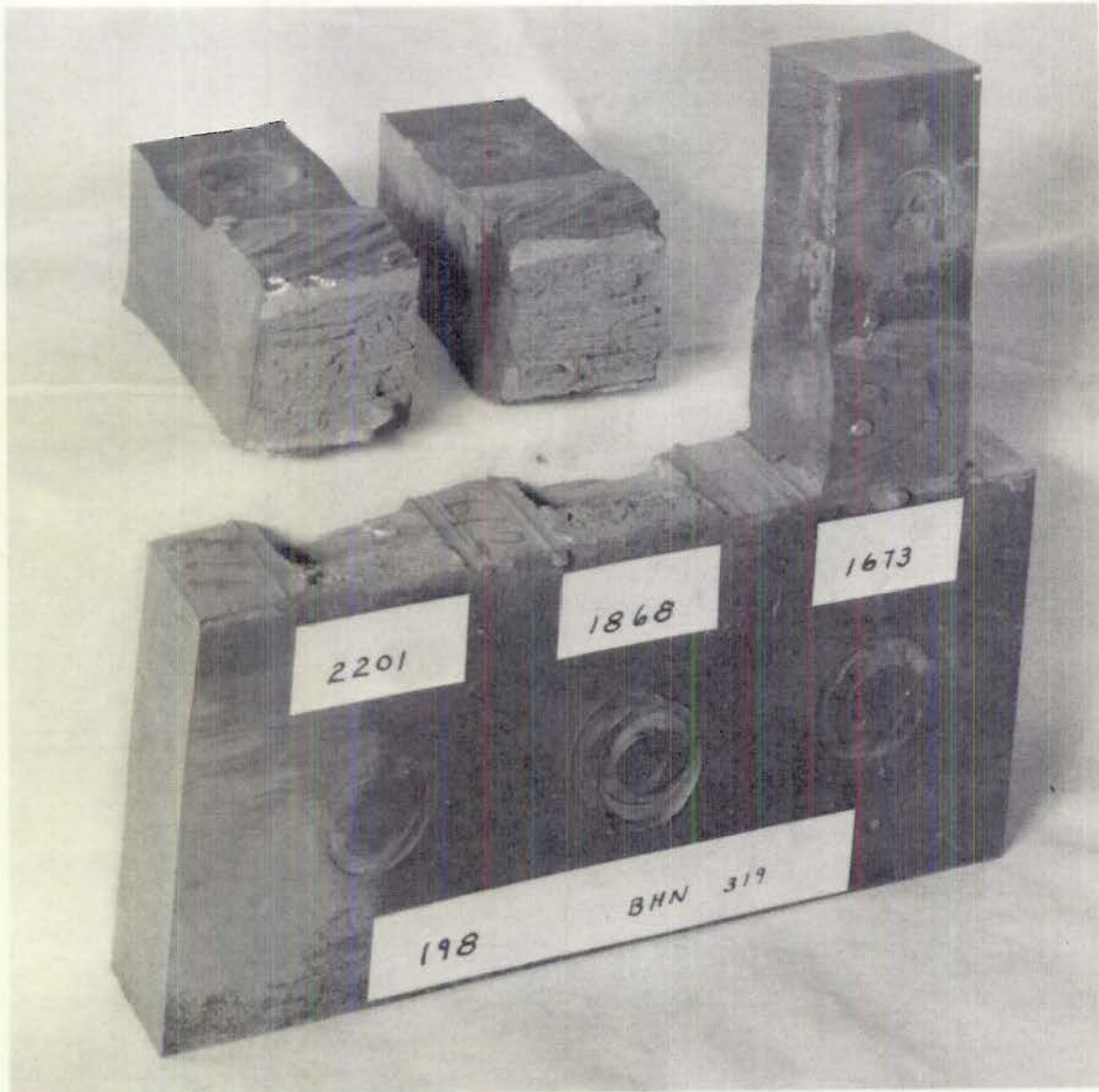
SHEET 3

SCALE 1/16

PLATE 29B

DECLASSIFIED

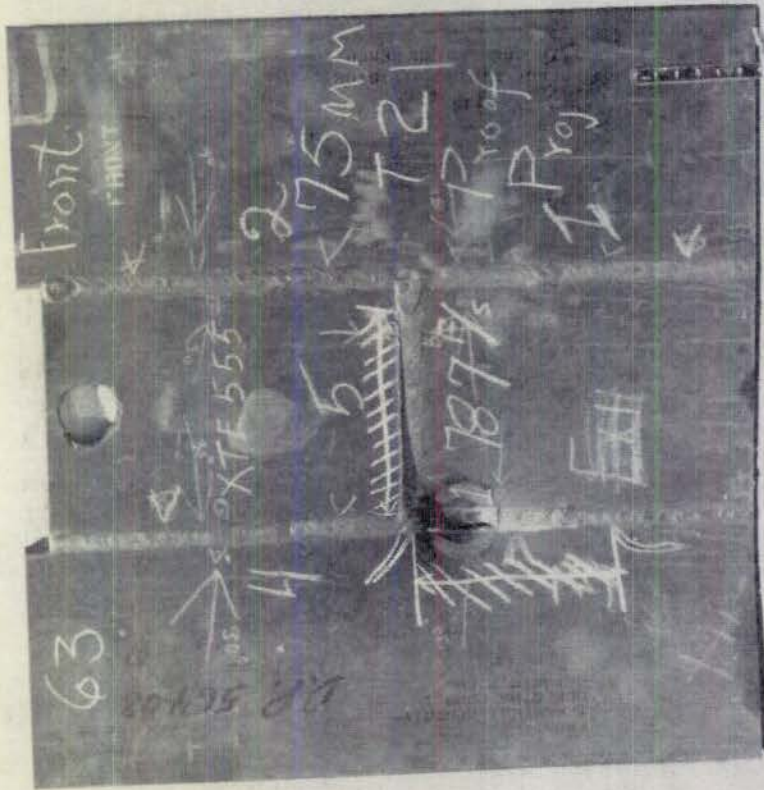
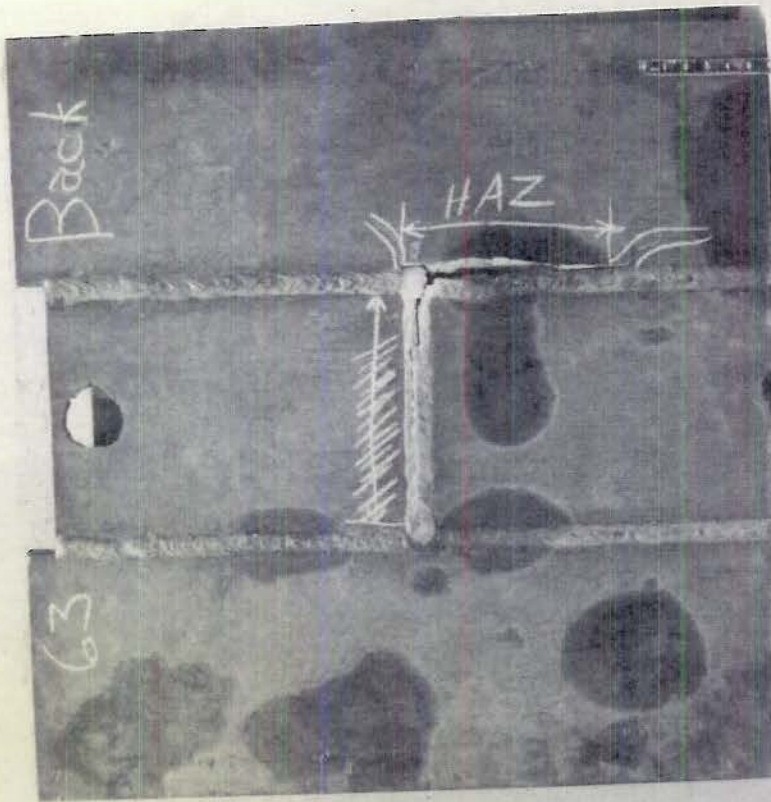
DECLASSIFIED



DECLASSIFIED

PLATE 30 A

RESTRICTED



74552 12-2-42
 Ordnance Dept.
 ABERDEEN PROVING GROUND
 Ternstedt Mfg. Co. Plate #TH-63. 1# rolled homogeneous Great Lakes Steel Armor "H" welded with Armorsarc B electrode.

RESTRICTED

DECLASSIFIED



NRL SHOCK FRACTURE SPECIMEN. DOUBLE V WELDS AT BASE OF FINGERS.

DECLASSIFIED

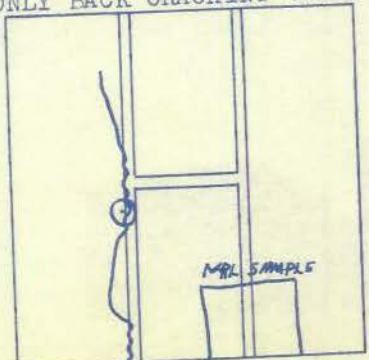
PLATE 31A

RESTRICTED

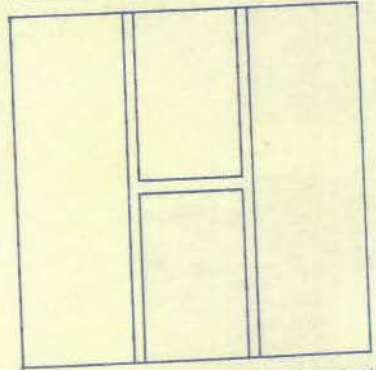
DATA ON SHOCK TESTS OF WELDMENTS

SUBMITTED BY TERNSTEDT MANUFACTURING DIV PLATE NO. TH-65
 ARMOR MFR GREAT LAKES STEEL TYPE 1" ROLLED HOMO
 ELECTRODE REID FEVER 8 ARMORAD PURPOSE QUALIFICATION
 PROJECTILE 25MM PROOF PROJECTILE T21 DATE 12-1-42
 TEMPERATURE OF PLATE AT TIME OF TESTING 65°F

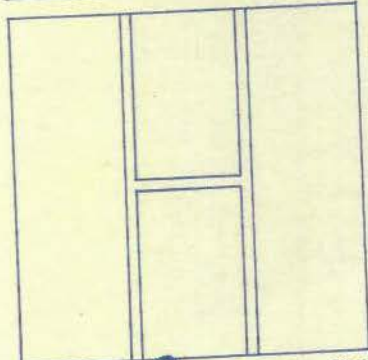
ONLY BACK CRACKING SHOWN



RD. 1 VEL. 779 FT/SEC.
 HIT $\frac{1}{4}$ " LEFT OF LEFT LEG AND $\frac{5}{8}$ " BELOW CROSS WELD
 CROSS WELD CRACK FROM LEG
 $10\frac{1}{2}$ " LEFT LEG CRACK WITH ALL BELOW CROSS WELD, ALL H.A.Z.
 RIGHT LEG CRACK WITH CROSS WELD,
 $6\frac{3}{4}$, $10\frac{1}{4}$ " PLATE CRACKS
 BACK CROSS WELD CRACK FROM LEG
 $11\frac{1}{2}$ " LEFT LEG CRACK WITH ALL BELOW CROSS WELD, ALL H.A.Z.
 RIGHT LEG CRACK WITH CROSS WELD,
 $9\frac{1}{2}$, $8\frac{1}{2}$ " PLATE CRACKS



RD. VEL. FT/SEC.
 HIT OF LEG AND CROSS WELD
 CROSS WELD CRACK FROM LEG
 LEFT LEG CRACK WITH CROSS WELD,
 RIGHT LEG CRACK WITH CROSS WELD,
 BACK CROSS WELD CRACK FROM LEG
 LEFT LEG CRACK WITH CROSS WELD,
 RIGHT LEG CRACK WITH CROSS WELD,



RD. VEL. FT/SEC.
 HIT OF LEG AND CROSS WELD
 CROSS WELD CRACK FROM LEG,
 LEFT LEG CRACK WITH CROSS WELD,
 RIGHT LEG CRACK WITH CROSS WELD,
 BACK CROSS WELD CRACK FROM LEG,
 LEFT LEG CRACK WITH CROSS WELD,
 RIGHT LEG CRACK WITH CROSS WELD,

IMPACT WELD CRACKING ~~~~~
 FUSION ZONE CRACKING (F.Z.) ~~~~~
 HEAT AFFECTED ZONE (H.A.Z.) ~~~~~

() WELDS SATISFACTORY
 () WELDS UNSATISFACTORY
 (+) SUGGESTS REWELD SEE LAST PAGE

REMARKS _____

DECLASSIFIED

DECLASSIFIED



DECLASSIFIED

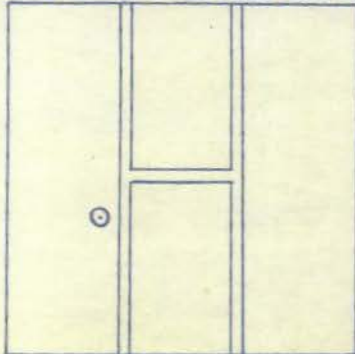
PLATE 32 A

RESTRICTED

DATA ON SHOCK TESTS OF WELDMENTS

SUBMITTED BY TERNSDETT MANUFACTURING DIVISION PLATE NO. TH-76
 ARMOR MFR GREAT LAKES STEEL TYPE 1" ROLLED HOMO
 ELECTRODE ARMORLOY AND ARMORARC PURPOSE QUALIFICATION
 PROJECTILE 22 MM PROOF PROJECTILE T21 DATE 12-12-42
 TEMPERATURE OF PLATE AT TIME OF TESTING 65°

ONLY BACK CRACKING SHOWN

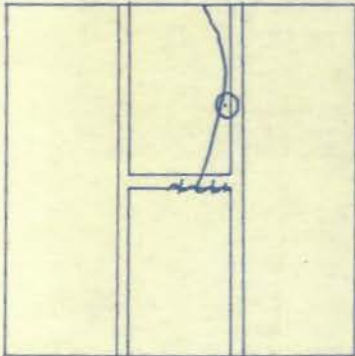


RD. 1 VEL. 768 FT/SEC.
HIT 2 1/4" LEFT OF LEFT LEG AND 5/8" FROM CROSS WELD

CROSS WELD CRACK FROM LEG,
LEFT LEG CRACK WITH CROSS WELD,
RIGHT LEG CRACK WITH CROSS WELD,

BACK

CROSS WELD CRACK FROM LEG,
LEFT LEG CRACK WITH CROSS WELD,
RIGHT LEG CRACK WITH CROSS WELD,
7/8" HORIZONTAL BULGE 13/16" VERTICAL BULGE

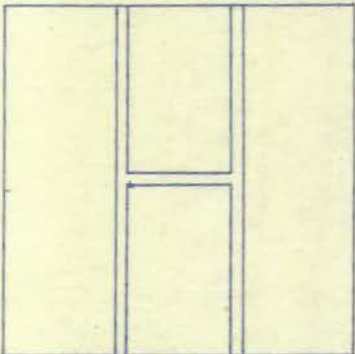


RD. 2 VEL. 785 FT/SEC.
HIT 1 1/4" LEFT OF RIGHT LEG AND 7/8" ABOVE CROSS WELD

7" CROSS WELD CRACK FROM RIGHT LEG, ALL F.Z.
LEFT LEG CRACK WITH CROSS WELD,
RIGHT LEG CRACK WITH CROSS WELD,
13" PLATE CRACK

BACK

7 1/2" CROSS WELD CRACK FROM RIGHT LEG, ALL F.Z.
LEFT LEG CRACK WITH CROSS WELD,
RIGHT LEG CRACK WITH CROSS WELD,
18" PLATE CRACK



RD. HIT VEL. OF FT/SEC. LEG AND CROSS WELD

CROSS WELD CRACK FROM LEG,
LEFT LEG CRACK WITH CROSS WELD,
RIGHT LEG CRACK WITH CROSS WELD,

BACK

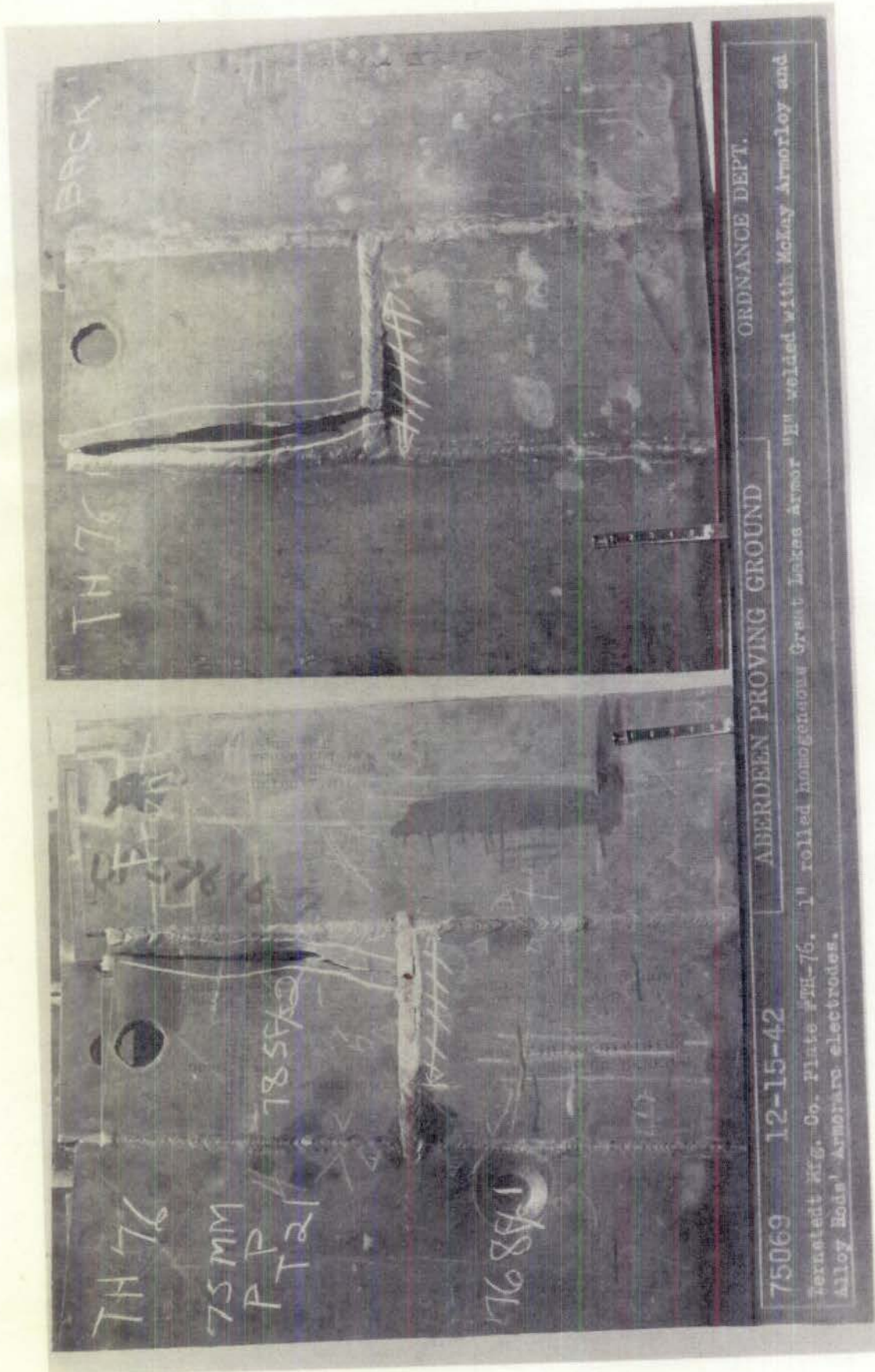
CROSS WELD CRACK FROM LEG,
LEFT LEG CRACK WITH CROSS WELD,
RIGHT LEG CRACK WITH CROSS WELD,

IMPACT WELD CRACKING ---
 FUSION ZONE CRACKING (F.Z.) ---
 HEAT AFFECTED ZONE (H.A.Z.) ---

() WELDS SATISFACTORY
 () WELDS UNSATISFACTORY
 (✓) SUGGESTS REWELD

REMARKS LOCATION OF NRL SAMPLE UNKNOWN

DECLASSIFIED



ORDNANCE DEPT.

ABERDEEN PROVING GROUND

75069 12-15-42

ternstedt Mfg. Co. Plate #TH-76. 1" rolled homogeneous Great Lakes armor "H" welded with McKay Armorloy and Alloy Bods' Armorarc electrodes.

DECLASSIFIED

PLATE 32 - C

RESTRICTED

DECLASSIFIED



DECLASSIFIED

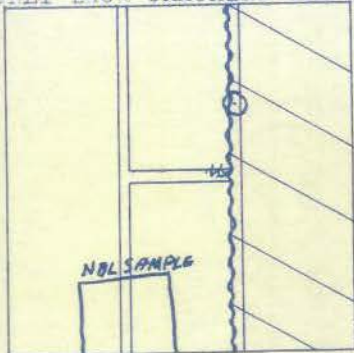
PLATE 33 A

~~RESTRICTED~~

DATA ON SHOCK TESTS OF WELDMENTS

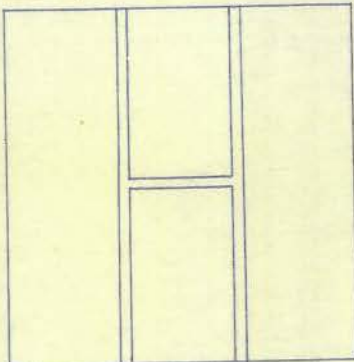
SUBMITTED BY TERNSTEDT MANUFACTURING DIV PLATE NO. TH-78
ARMOR MFR GREAT LAKES STEEL TYPE 1" ROLLED HOMO
ELECTRODE ARMORLY A-5 AND ARMORARC "B" PURPOSE QUALIFICATION
PROJECTILE 75MM PROOF PROJECTILE T-21 DATE 12-11-42
TEMPERATURE OF PLATE AT TIME OF TESTING _____

ONLY BACK CRACKING SHOWN



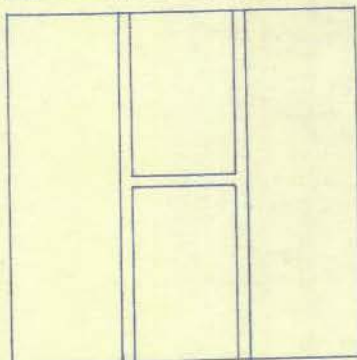
RD. 1 VEL. 746 FT/SEC.
HIT $\frac{1}{4}$ " LEFT OF RIGHT LEG AND $\frac{7}{8}$ " ABOVE CROSS WELD
CROSS WELD CRACK FROM LEG,
LEFT LEG CRACK WITH CROSS WELD,
36" RIGHT LEG CRACK WITH 18" ABOVE CROSS WELD, ALL H.A.Z.

BACK
3" CROSS WELD CRACK FROM RIGHT LEG, ALL F.Z.
LEFT LEG CRACK WITH CROSS WELD,
36" RIGHT LEG CRACK WITH 18" ABOVE CROSS WELD, ALL H.A.Z.
2" SECONDARY CRACK



RD. HIT VEL. OF FT/SEC. LEG AND CROSS WELD
CROSS WELD CRACK FROM LEG,
LEFT LEG CRACK WITH CROSS WELD,
RIGHT LEG CRACK WITH CROSS WELD,

BACK
CROSS WELD CRACK FROM LEG,
LEFT LEG CRACK WITH CROSS WELD,
RIGHT LEG CRACK WITH CROSS WELD,



RD. HIT VEL. OF FT/SEC. LEG AND CROSS WELD
CROSS WELD CRACK FROM LEG,
LEFT LEG CRACK WITH CROSS WELD,
RIGHT LEG CRACK WITH CROSS WELD,

BACK
CROSS WELD CRACK FROM LEG,
LEFT LEG CRACK WITH CROSS WELD,
RIGHT LEG CRACK WITH CROSS WELD,

IMPACT WELD CRACKING
FUSION ZONE CRACKING (F.Z.)
HEAT AFFECTED ZONE (H.A.Z.)
() WELDS SATISFACTORY
() WELDS UNSATISFACTORY
() SUGGESTS REWELD

REMARKS PLATE DOES NOT MEET BALLISTIC REQUIREMENTS A65 497-3



DECLASSIFIED

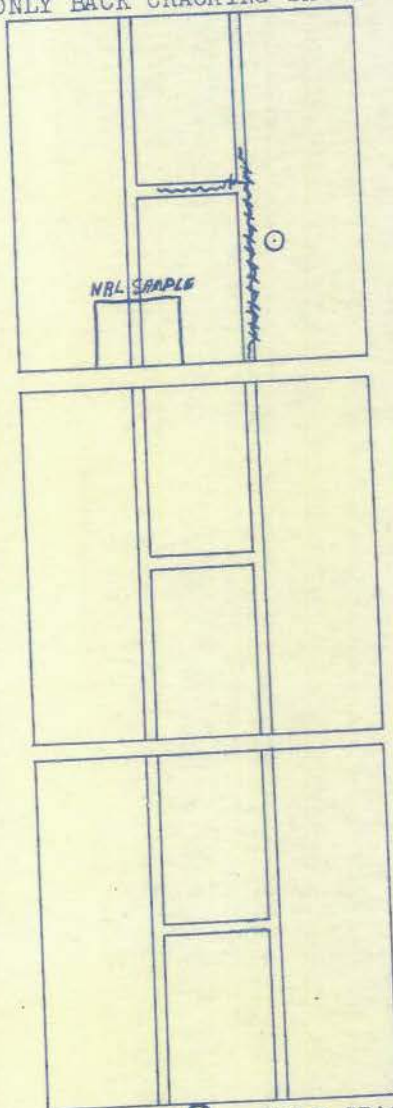
PLATE 34 A

RESTRICTED

DATA ON SHOCK TESTS OF WELDMENTS

SUBMITTED BY TERNSTEDT MANUFACTURING DIV PLATE NO. TH-80
 ARMOR MFR GREAT LAKES STEEL TYPE 1" ROLLED HOMO
 ELECTRODE KEID AVERY PURPOSE QUALIFICATION
 PROJECTILE 75MM PROOF PROJECTILE T21 DATE 12-12-42
 TEMPERATURE OF PLATE AT TIME OF TESTING 65°F

ONLY BACK CRACKING SHOWN



RD. 1 VEL. 755 FT/SEC.
 HIT 2 1/2" RIGHT OF RIGHT LEG AND 5 1/2" BELOW CROSS WELD
 5 1/4" CROSS WELD CRACK FROM LEG, —
 LEFT LEG CRACK WITH CROSS WELD,
 20" RIGHT LEG CRACK WITH 2" ABOVE CROSS WELD, ALL F.Z.

BACK 8 1/2" CROSS WELD CRACK FROM RIGHT LEG, 1 1/4" F.Z.
 LEFT LEG CRACK WITH CROSS WELD,
 22" RIGHT LEG CRACK WITH 4" ABOVE CROSS WELD, 9 1/2" H.A.Z.
 1 1/2" HORIZONTAL BOLGE 3/4" VERTICAL BOLGE 6" F.Z.

RD. VEL. FT/SEC. CROSS WELD
 HIT OF LEG AND
 CROSS WELD CRACK FROM LEG,
 LEFT LEG CRACK WITH CROSS WELD,
 RIGHT LEG CRACK WITH CROSS WELD,

BACK CROSS WELD CRACK FROM LEG,
 LEFT LEG CRACK WITH CROSS WELD,
 RIGHT LEG CRACK WITH CROSS WELD,

RD. VEL. FT/SEC. CROSS WELD
 HIT OF LEG AND
 CROSS WELD CRACK FROM LEG,
 LEFT LEG CRACK WITH CROSS WELD,
 RIGHT LEG CRACK WITH CROSS WELD,

BACK CROSS WELD CRACK FROM LEG,
 LEFT LEG CRACK WITH CROSS WELD,
 RIGHT LEG CRACK WITH CROSS WELD,

IMPACT () WELD CRACKING
 FUSION ZONE CRACKING (F.Z.)
 HEAT AFFECTED ZONE (H.A.Z.)

() WELDS SATISFACTORY
 (✓) WELDS UNSATISFACTORY
 () SUGGESTS REWELD

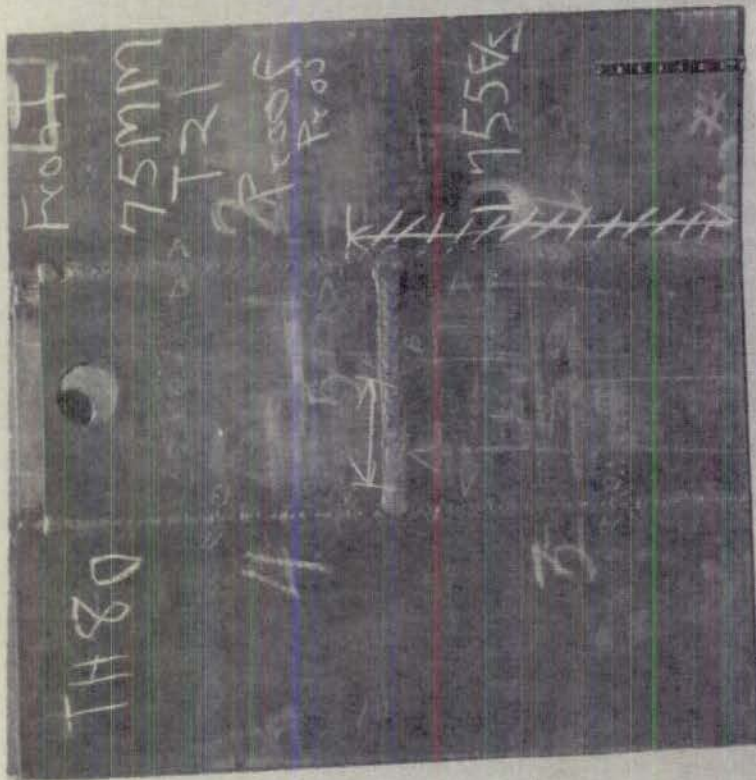
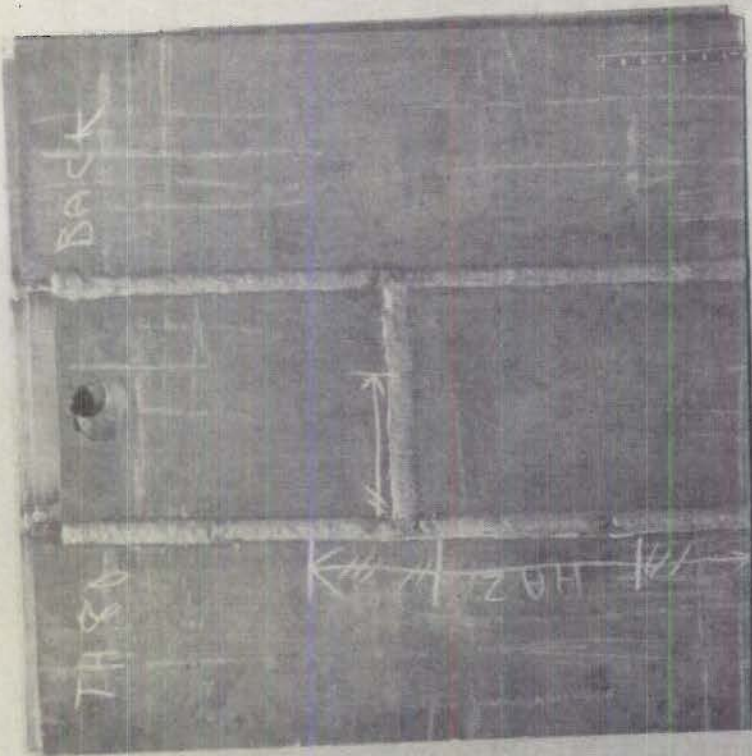
REMARKS

FORM NO WAS-2

SHEET 3

SCALE 1/16

PLATE 34B

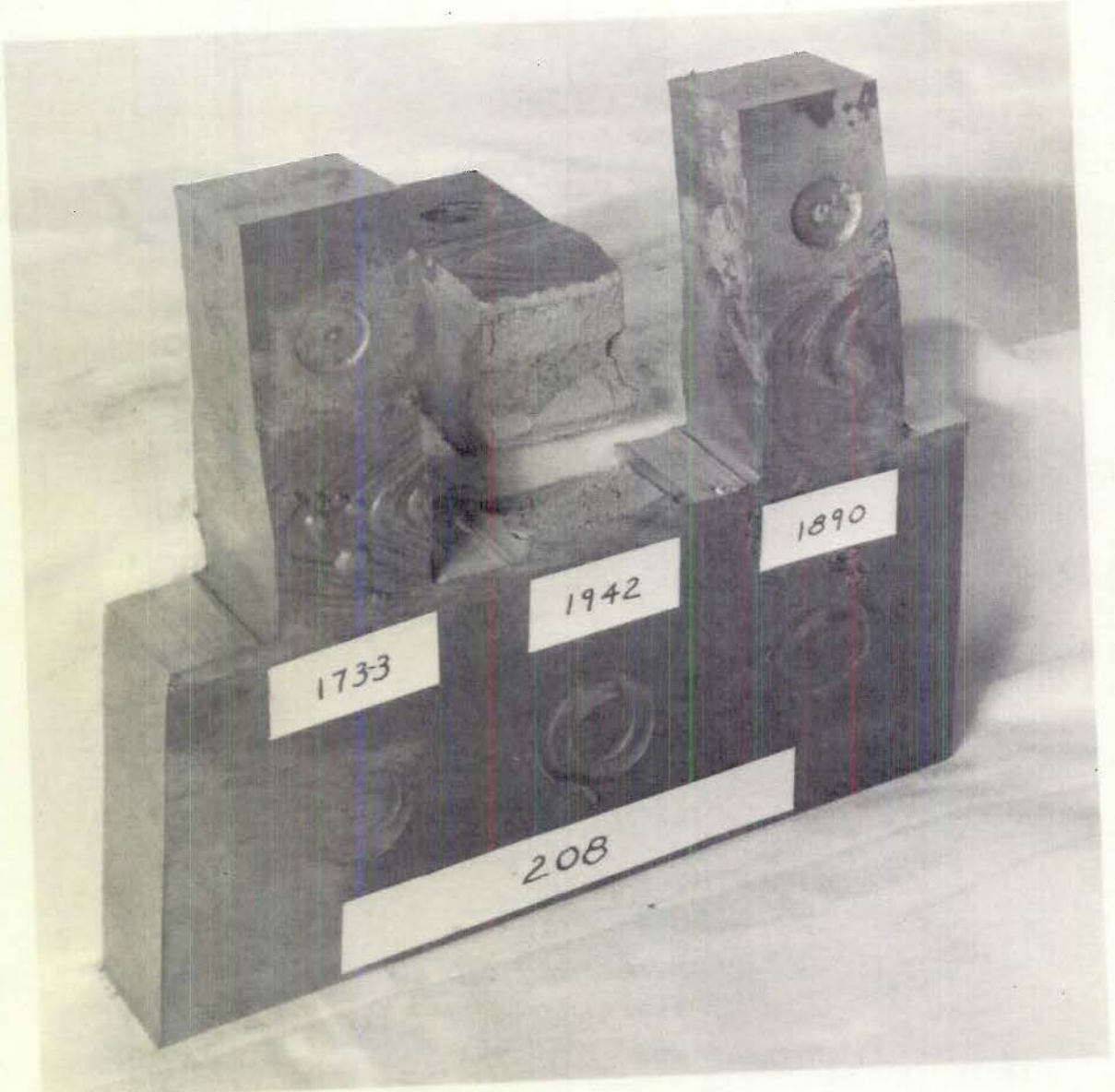


ORDNANCE DEPT.

ABERDEEN PROVING GROUND

75086 12-15-42

Terminated Mfg. Co. Plate #TH80. 1" rolled homogeneous Great Lakes Armor #Hd welded with Reid Avery elec-
trodes.



~~RESTRICTED~~

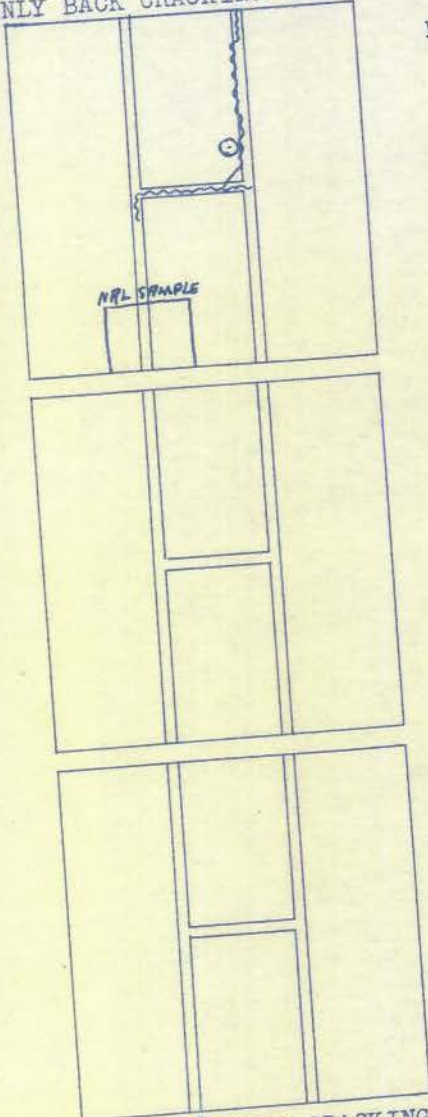
DECLASSIFIED

PLATE 35 A

DATA ON SHOCK TESTS OF WELDMENTS

SUBMITTED BY TERNSTEDT MANUFACTURING CO PLATE NO. TH 82
 ARMOR MFR GREAT LAKES TYPE 1" ROLLED HOMO
 ELECTRODE ARMORPP "B" AND ARMORLOY A-5 PURPOSE DEVELOPMENT
 PROJECTILE 25MM T31 BRACE PROJECTILE DATE 12-23-42
 TEMPERATURE OF PLATE AT TIME OF TESTING _____

ONLY BACK CRACKING SHOWN



RD. 1 VEL. 762 FT/SEC.
 HIT 1/2" LEFT OF RIGHT LEG AND 5" ABOVE CROSS WELD,
 1 1/4" CROSS WELD CRACK FROM RIGHT LEG,
 1 3/4" LEFT LEG CRACK WITH ALL BELOW CROSS WELD, ALL F.Z.
 1 5/8" RIGHT LEG CRACK WITH ALL ABOVE CROSS WELD, ALL F.Z.
 3/8" PLATE CRACK
 BACK
 12" CROSS WELD CRACK FROM _____ LEG, _____
 3" LEFT LEG CRACK WITH ALL BELOW CROSS WELD, _____
 15" RIGHT LEG CRACK WITH ALL ABOVE CROSS WELD, 11" F.Z.
 3/4" PLATE CRACK

RD. VEL. FT/SEC. CROSS WELD,
 HIT OF LEG AND
 CROSS WELD CRACK FROM LEG,
 LEFT LEG CRACK WITH CROSS WELD,
 RIGHT LEG CRACK WITH CROSS WELD,

BACK LEG,
 CROSS WELD CRACK FROM CROSS WELD,
 LEFT LEG CRACK WITH CROSS WELD,
 RIGHT LEG CRACK WITH CROSS WELD,

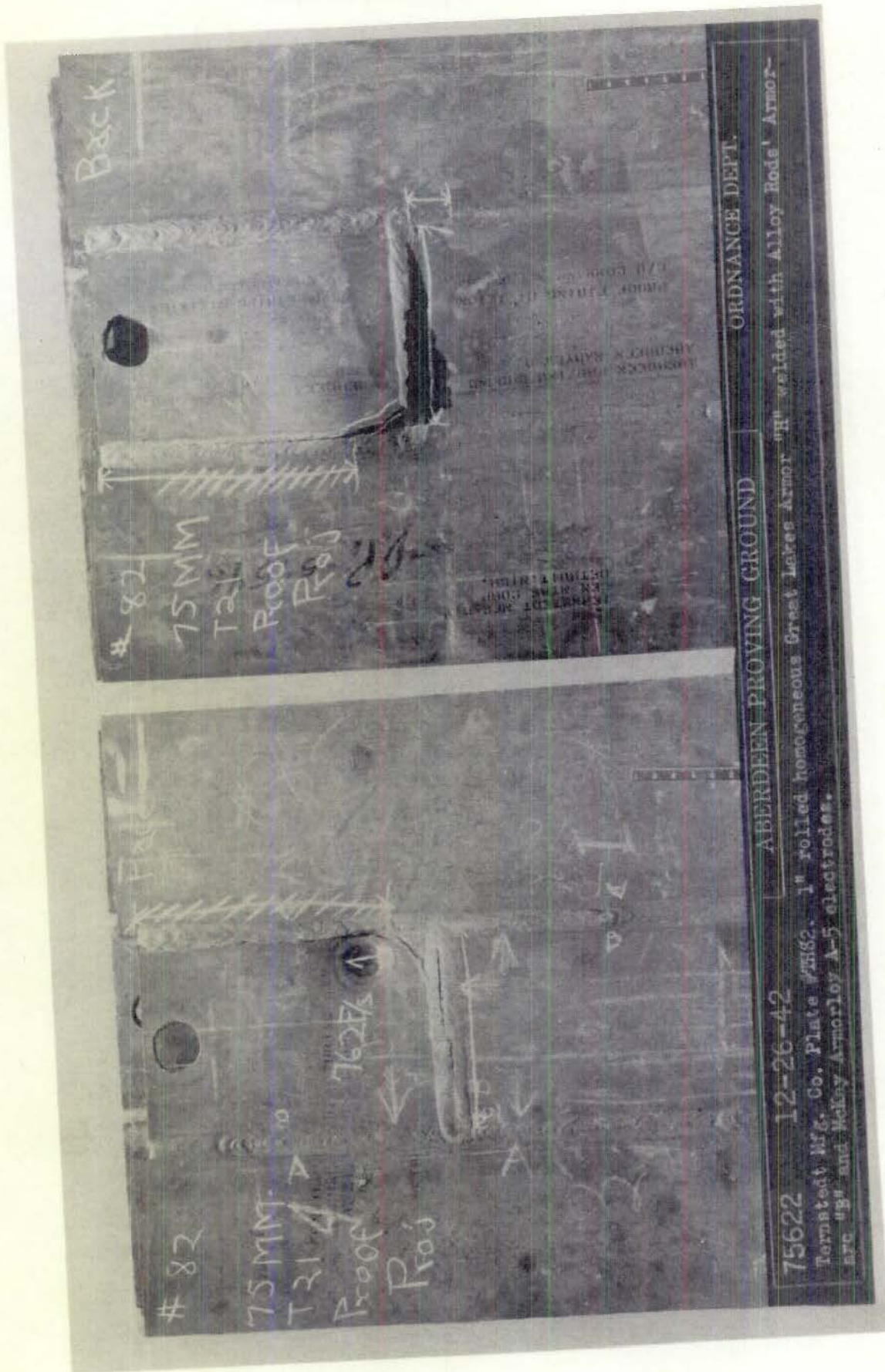
RD. VEL. FT/SEC. CROSS WELD,
 HIT OF LEG AND
 CROSS WELD CRACK FROM LEG,
 LEFT LEG CRACK WITH CROSS WELD,
 RIGHT LEG CRACK WITH CROSS WELD,

BACK LEG,
 CROSS WELD CRACK FROM CROSS WELD,
 LEFT LEG CRACK WITH CROSS WELD,
 RIGHT LEG CRACK WITH CROSS WELD,

IMPACT \odot WELD CRACKING
 FUSION ZONE CRACK (F.Z.)
 HEAT AFFECTED ZONE (H.A.Z.)

() WELDS SATISFACTORY
 (✓) WELDS UNSATISFACTORY
 () SUGGESTS REWELD

REMARKS PLATE WELDED WITH 1/4", 7/16", 1/2" ELECTRODES



ORDNANCE DEPT.

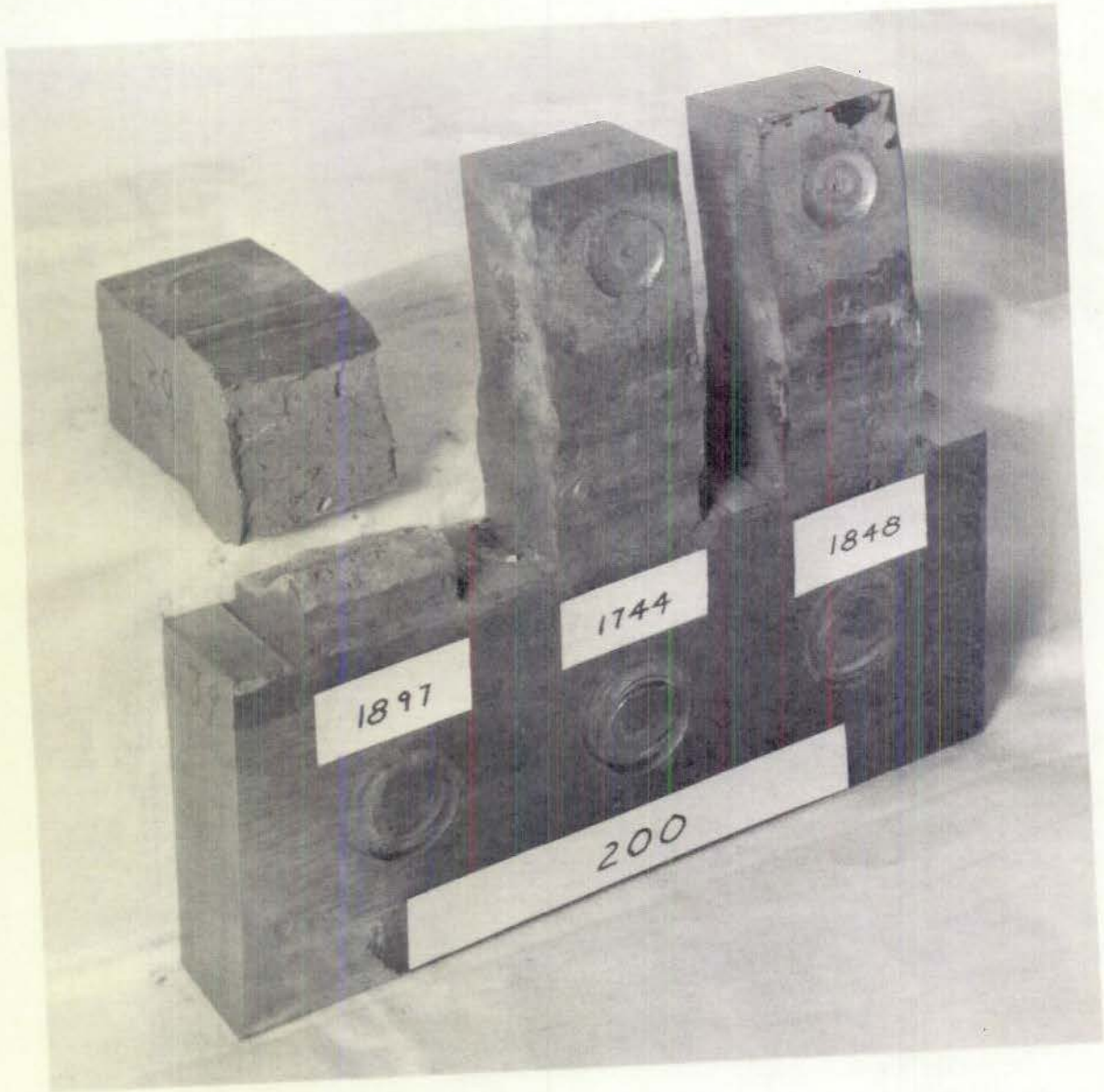
ABERDEEN PROVING GROUND

75622 12-26-42

Tornstedt Mfg. Co. Plate #3162. 1" rolled homogeneous Great Lakes Armor "R" welded with Alloy Rods' Armor-arc "g" and Moley Armorloy A-5 electrodes.

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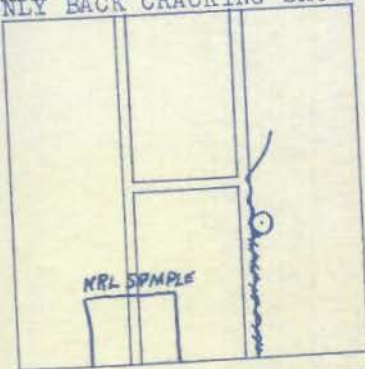
DECLASSIFIED

PLATE 36 A

DATA ON SHOCK TESTS OF WELDMENTS

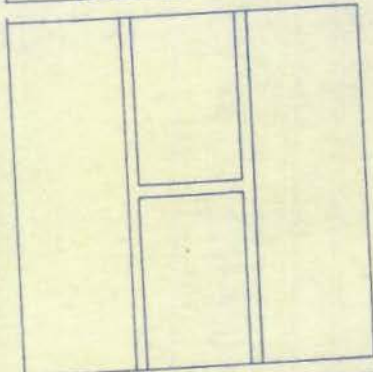
SUBMITTED BY MAREMONT AUTOMOTIVE PRODUCTS PLATE NO. H-1000
 ARMOR MFR GREAT LAKES STEEL TYPE 1" ROLLED HOMA
 ELECTRODE CRUCIBLE ARMORIZE PURPOSE QUALIFICATION
 PROJECTILE 25MM PROOF PROJECTILE T-21 DATE 12-9-42
 TEMPERATURE OF PLATE AT TIME OF TESTING 64°F

ONLY BACK CRACKING SHOWN



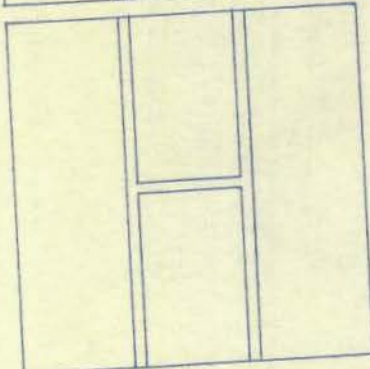
RD. 1 VEL. 762 FT/SEC.
 HIT 1/2" RIGHT OF RIGHT LEG AND 5/8" BELOW CROSS WELD
 CROSS WELD CRACK FROM LEG,
 LEFT LEG CRACK WITH CROSS WELD,
 12" RIGHT LEG CRACK WITH ALL BELOW CROSS WELD, ALL H.A.Z.
 9", 2 1/4" PLATE CRACKS

BACK CROSS WELD CRACK FROM LEG,
 LEFT LEG CRACK WITH CROSS WELD,
 18 1/4" RIGHT LEG CRACK WITH 1/4" ABOVE CROSS WELD, 1 1/2" F.Z., 6 1/2" H.A.Z.
 1" VERTICAL BULGE 6" PLATE CRACK



RD. VEL. FT/SEC.
 HIT OF LEG AND CROSS WELD
 CROSS WELD CRACK FROM LEG,
 LEFT LEG CRACK WITH CROSS WELD,
 RIGHT LEG CRACK WITH CROSS WELD,

BACK CROSS WELD CRACK FROM LEG,
 LEFT LEG CRACK WITH CROSS WELD,
 RIGHT LEG CRACK WITH CROSS WELD,



RD. VEL. FT/SEC.
 HIT OF LEG AND CROSS WELD
 CROSS WELD CRACK FROM LEG,
 LEFT LEG CRACK WITH CROSS WELD,
 RIGHT LEG CRACK WITH CROSS WELD,

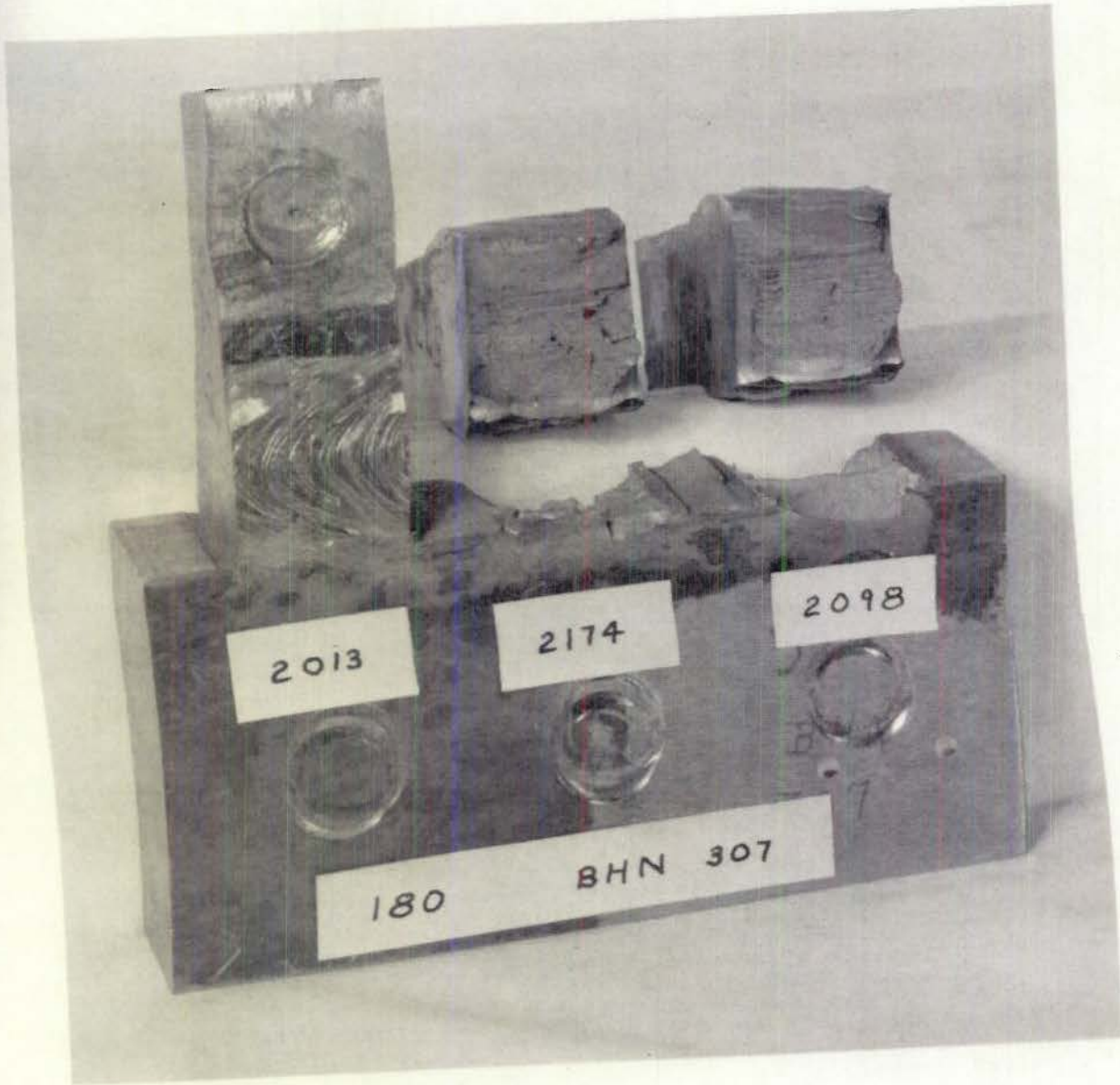
BACK CROSS WELD CRACK FROM LEG,
 LEFT LEG CRACK WITH CROSS WELD,
 RIGHT LEG CRACK WITH CROSS WELD,

IMPACT () WELD CRACKING
 FUSION ZONE CRACKING (F.Z.)
 HEAT AFFECTED ZONE (H.A.Z.)

() WELDS SATISFACTORY
 (✓) WELDS UNSATISFACTORY
 () SUGGESTS REWELD

REMARKS

DECLASSIFIED



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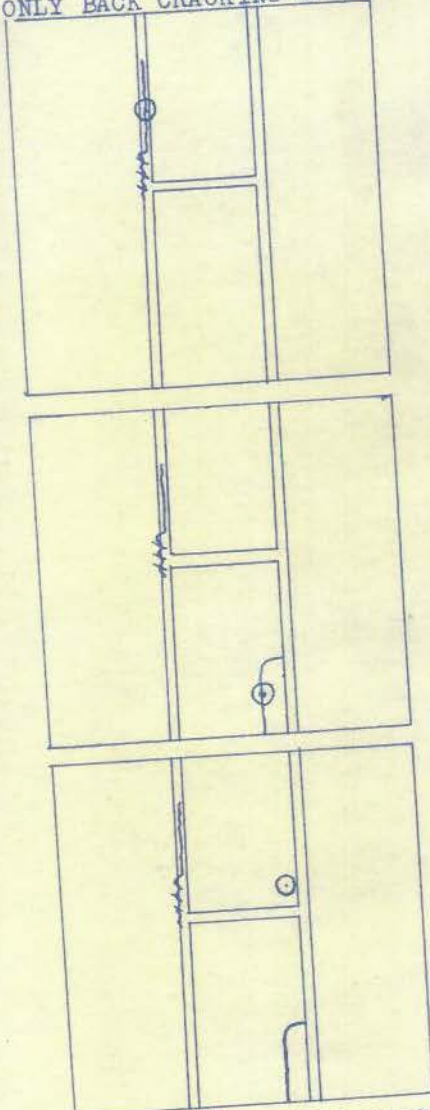
PLATE 37 A

RESTRICTED

DATA ON SHOCK TESTS OF WELDMENTS

SUBMITTED BY SOUTHERN CALIFORNIA DIV. G.M.C. PLATE NO. 33
ARMOR MFR GREAT LAKES STEEL TYPE 1" ROLLED HOMO
ELECTRODE McRAY ARMORLOY MN. MOD 18-8 AUS PURPOSE QUALIFICATION
PROJECTILE 25MM T21 PROOF PROJECTILE DATE 10-24-42
TEMPERATURE OF PLATE AT TIME OF TESTING _____

ONLY BACK CRACKING SHOWN



RD. 1 VEL. 773 FT/SEC.
HIT ON ~~OF~~ LEFT LEG AND $1\frac{1}{4}$ " ABOVE CROSS WELD

CROSS WELD CRACK FROM LEG,
 $6\frac{1}{4}$ " LEFT LEG CRACK WITH ALL ABOVE CROSS WELD,
RIGHT LEG CRACK WITH CROSS WELD,

BACK CROSS WELD CRACK FROM LEG,
 $12\frac{3}{4}$ " LEFT LEG CRACK WITH 1" BELOW CROSS WELD, 4" F.Z.
RIGHT LEG CRACK WITH CROSS WELD,
 $1\frac{1}{4}$ " HORIZONTAL BULGE $1\frac{1}{2}$ " VERTICAL BULGE

RD. 2 VEL. 677 FT/SEC.
HIT $3\frac{1}{4}$ " LEFT OF RIGHT LEG AND $1\frac{1}{2}$ " BELOW CROSS WELD

CROSS WELD CRACK FROM LEG,
 $7\frac{1}{4}$ " LEFT LEG CRACK WITH ALL ABOVE CROSS WELD, $\frac{1}{4}$ " F.Z.
RIGHT LEG CRACK WITH CROSS WELD,
 $\frac{1}{2}$ ", $3\frac{1}{2}$ " PLATE CRACKS

BACK CROSS WELD CRACK FROM LEG,
1" LEFT LEG CRACK WITH 2" BELOW CROSS WELD, 5" F.Z.
RIGHT LEG CRACK WITH CROSS WELD,
 $1\frac{1}{16}$ " HORIZONTAL BULGE $1\frac{1}{16}$ " VERTICAL BULGE
 $\frac{1}{2}$ ", 3", 2 $\frac{1}{4}$ " PLATE CRACKS

RD. 3 VEL. 677 FT/SEC.
HIT 2" LEFT OF RIGHT LEG AND 2" ABOVE CROSS WELD

CROSS WELD CRACK FROM LEG,
 $12\frac{1}{4}$ " LEFT LEG CRACK WITH $1\frac{1}{4}$ " BELOW CROSS WELD, 2 $\frac{1}{4}$ " F.Z.
RIGHT LEG CRACK WITH CROSS WELD,
8" PLATE CRACKS FROM PREVIOUS ROUND

BACK CROSS WELD CRACK FROM LEG,
 $14\frac{1}{4}$ " LEFT LEG CRACK WITH 2" BELOW CROSS WELD, 5" H.A.Z.
RIGHT LEG CRACK WITH CROSS WELD,
 $1\frac{1}{16}$ " HORIZONTAL BULGE $\frac{5}{8}$ " VERTICAL BULGE
 $10\frac{1}{4}$ " PLATE CRACKS FROM PREVIOUS ROUND

IMPACT WELD CRACKING ~~~~~
FUSION ZONE CRACKING (F.Z.) ~~~~~
HEAT AFFECTED ZONE (H.A.Z.) ~~~~~

(x) WELDS SATISFACTORY
() WELDS UNSATISFACTORY
() SUGGESTS REWELD

REMARKS PLATE ONLY 32" WIDE MUST BE 36" WIDE TO FIT INTO THE
BUTTS FOR TEST. LOCATION OF NPL SAMPLE UNKNOWN

FORM NO WAS-2

SHEET 3

SCALE 1/16

PLATE 37B

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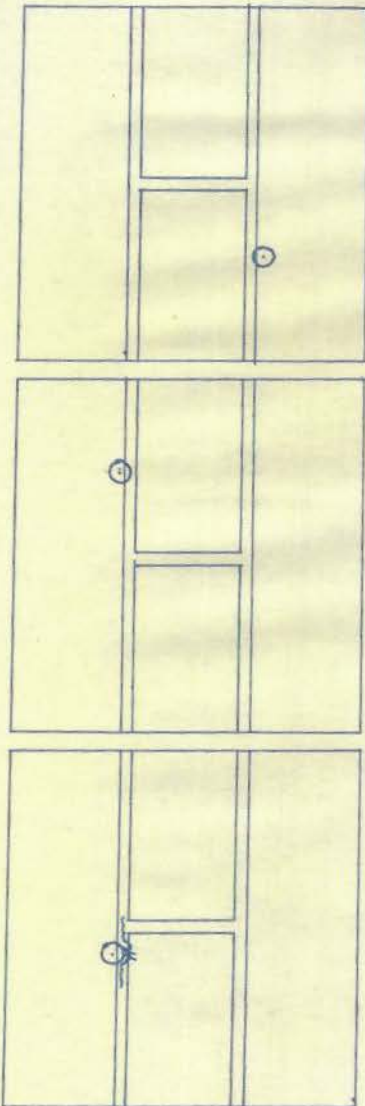
DECLASSIFIED

PLATE 38 A

RESTRICTED

DATA ON SHOCK TESTS OF WELDMENTS

SUBMITTED BY CATERPILLAR TRACTOR COMPANY PLATE NO. H-5
 ARMOR MFR GREAT LAKES STEEL TYPE 1" ROLLED HOMO
 ELECTRODE MCKAY ARMORLOY MN MAD 18-8 AUSTENITIC PURPOSE QUALIFICATION
 PROJECTILE 75MM T21 PROOF PROJECTILE DATE 10-24-42
 PREHEAT OF PLATE AT TIME OF WELDING 200°F - WELDS 182 500°F WELD 3
 TEMPERATURE OF PLATE AT TIME OF TESTING _____



RD. 1 VEL. 758 FT/SEC.
 HIT RIGHT OF RIGHT LEG AND 8 1/2" BELOW CROSS BAR
 CROSS WELD CRACK FROM LEG, (IN
 LEFT LEG CRACK WITH CROSS WELD, (FUSION
 RIGHT LEG CRACK WITH CROSS WELD, (ZONE

BACK
 CROSS WELD CRACK FROM LEG, (IN
 LEFT LEG CRACK WITH CROSS WELD, (FUSION
 RIGHT LEG CRACK WITH CROSS WELD, (ZONE
7/8" HORIZONTAL BULGE 1 3/16" VERTICAL BULGE

RD. 2 VEL. 701 FT/SEC.
 HIT 3/4" LEFT OF LEFT LEG AND 8" ABOVE CROSS BAR
 CROSS WELD CRACK FROM LEG, (IN
 LEFT LEG CRACK WITH CROSS WELD, (FUSION
 RIGHT LEG CRACK WITH CROSS WELD, (ZONE

BACK
 CROSS WELD CRACK FROM LEG, (IN
 LEFT LEG CRACK WITH CROSS WELD, (FUSION
 RIGHT LEG CRACK WITH CROSS WELD, (ZONE
7/8" HORIZONTAL BULGE 1/16" VERTICAL BULGE

RD. 3 VEL. 767 FT/SEC.
 HIT 3/4" LEFT OF LEFT LEG AND 2 1/2" BELOW CROSS BAR
 CROSS WELD CRACK FROM LEG, (IN
4 3/4" LEFT LEG CRACK WITH 3/4" ABOVE CROSS WELD, ALL (FUSION
 RIGHT LEG CRACK WITH CROSS WELD, (ZONE

BACK
 CROSS WELD CRACK FROM LEG, (IN
7 1/2" LEFT LEG CRACK WITH 1 1/2" ABOVE CROSS WELD, 1" (FUSION
 RIGHT LEG CRACK WITH CROSS WELD, (ZONE
1 1/2" HORIZONTAL BULGE 1/16" VERTICAL BULGE

(*) WELDS SATISFACTORY
 () WELDS UNSATISFACTORY
 () SUGGESTS REWELD

IMPACT 0 BACK CRACKING ~~~~~
 FUSION ZONE CRACKING ~~~~~
 REMARK LOCATION OF NPL SAMPLE UNKNOWN

DECLASSIFIED



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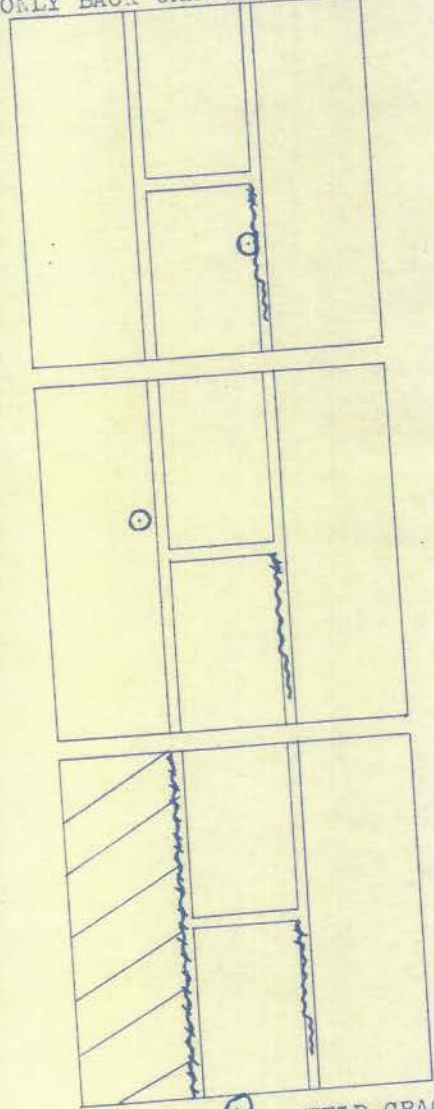
PLATE 39 A

RESTRICTED

DATA ON SHOCK TESTS OF WELDMENTS

SUBMITTED BY CADILLAC MOTOR COMPANY
ARMOR MFR YOUNGSTOWN SHEET AND TUBE
ELECTRODE MCKAY ARMORLOY MN MOD 18-8 AUS
PROJECTILE 75MM T-21 PROOF PROJECTILE
TEMPERATURE OF PLATE AT TIME OF TESTING _____
PLATE NO. 80
TYPE 1" ROLLED HOMO
PURPOSE QUALIFICATION
DATE 11-7-42

ONLY BACK CRACKING SHOWN



RD. 1 VEL. 773 FT/SEC.
HIT 1/4" LEFT OF RIGHT LEG AND 7" BELOW CROSS WELD
CROSS WELD CRACK FROM LEG,
LEFT LEG CRACK WITH CROSS WELD,
11" RIGHT LEG CRACK WITH ALL BELOW CROSS WELD, 2" F.Z.

BACK CROSS WELD CRACK FROM LEG,
LEFT LEG CRACK WITH CROSS WELD,
13 1/4" RIGHT LEG CRACK WITH ALL BELOW CROSS WELD, 1 1/2" F.Z.
1 1/2" HORIZONTAL BULGE 3/4" VERTICAL BULGE 7/8" H.A.Z.

RD. 2 VEL. 680 FT/SEC.
HIT 2 1/4" LEFT OF LEFT LEG AND 4" ABOVE CROSS WELD
CROSS WELD CRACK FROM LEG,
LEFT LEG CRACK WITH CROSS WELD,
11 3/4" RIGHT LEG CRACK WITH ALL BELOW CROSS WELD, 2" F.Z.

BACK CROSS WELD CRACK FROM LEG,
LEFT LEG CRACK WITH CROSS WELD,
13 1/4" RIGHT LEG CRACK WITH ALL BELOW CROSS WELD, 1 1/2" F.Z.
1 1/2" HORIZONTAL BULGE 3/4" VERTICAL BULGE 7/8" H.A.Z.

RD. 3 VEL. 713 FT/SEC.
HIT 1 1/4" RIGHT OF LEFT LEG AND 5 1/4" BELOW CROSS WELD
CROSS WELD CRACK FROM LEG,
36" LEFT LEG CRACK WITH 18" BELOW CROSS WELD, ALL F.Z.
11 3/4" RIGHT LEG CRACK WITH ALL BELOW CROSS WELD, 2" F.Z.

BACK CROSS WELD CRACK FROM LEG,
36" LEFT LEG CRACK WITH 18" ABOVE CROSS WELD, ALL F.Z.
13 1/4" RIGHT LEG CRACK WITH ALL BELOW CROSS WELD, 1 1/2" F.Z.
7/8" H.A.Z.

IMPACT WELD CRACKING _____
FUSION ZONE CRACKING (F.Z.) _____
HEAT AFFECTED ZONE (H.A.Z.) _____

- WELDS SATISFACTORY
- WELDS UNSATISFACTORY
- SUGGESTS REWELD

REMARKS LOCATION OF NRL SAMPLE UNKNOWN

DECLASSIFIED



DECLASSIFIED

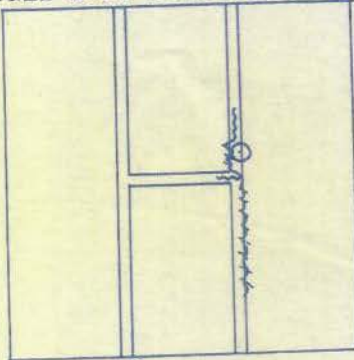
PLATE 40 A

~~RESTRICTED~~

DATA ON SHOCK TESTS OF WELDMENTS

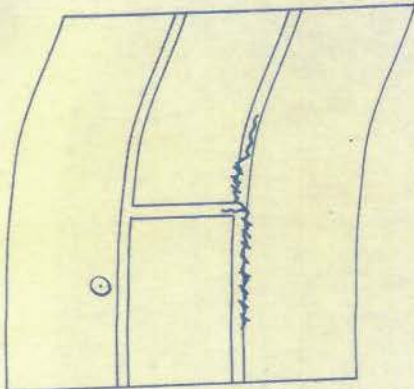
SUBMITTED BY CADILLAC MOTOR COMPANY PLATE NO. 81
 ARMOR MFR YOUNGSTOWN SHEET AND TUBE TYPE 1" ROLLED HOMO
 ELECTRODE ARMORLOY-ARMORWELD M/MOD 18-8 PURPOSE QUALIFICATION
 PROJECTILE 25MM T31 PROOF PROJECTILE DATE 11-7-42
 TEMPERATURE OF PLATE AT TIME OF TESTING _____

ONLY BACK CRACKING SHOWN



RD. 1 VEL. 775 FT/SEC.
 HIT $\frac{1}{2}$ " RIGHT OF RIGHT LEG AND $\frac{1}{2}$ " CROSS WELD
 $3\frac{1}{2}$ " CROSS WELD CRACK FROM ^{ABOVE} RIGHT LEG,
 LEFT LEG CRACK WITH CROSS WELD, —
 $15\frac{1}{2}$ " RIGHT LEG CRACK WITH $6\frac{1}{2}$ " BELOW CROSS WELD, —

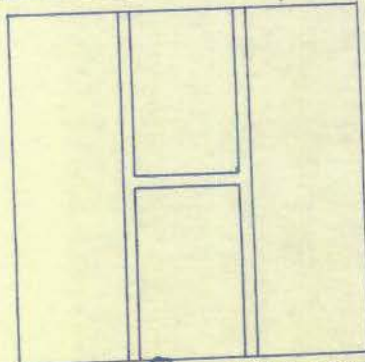
BACK
 $2\frac{1}{4}$ " CROSS WELD CRACK FROM RIGHT LEG, —
 LEFT LEG CRACK WITH CROSS WELD,
 17 " RIGHT LEG CRACK WITH $6\frac{1}{2}$ " BELOW CROSS WELD, $14\frac{1}{2}$ " F.Z.
 $1\frac{1}{2}$ " HORIZONTAL BULGE $1\frac{1}{2}$ " VERTICAL BULGE



RD. 2 VEL. 684 FT/SEC.
 HIT $2\frac{1}{2}$ " LEFT OF LEFT LEG AND 7" BELOW CROSS WELD

$3\frac{1}{2}$ " CROSS WELD CRACK FROM RIGHT LEG, —
 LEFT LEG CRACK WITH CROSS WELD,
 17 " RIGHT LEG CRACK WITH 7" BELOW CROSS WELD, —

BACK
 $2\frac{1}{4}$ " CROSS WELD CRACK FROM RIGHT LEG, —
 LEFT LEG CRACK WITH CROSS WELD,
 $18\frac{1}{4}$ " RIGHT LEG CRACK WITH $7\frac{1}{2}$ " BELOW CROSS WELD, $14\frac{1}{2}$ " F.Z.
 $13\frac{1}{16}$ " HORIZONTAL BULGE $3\frac{1}{4}$ " VERTICAL BULGE



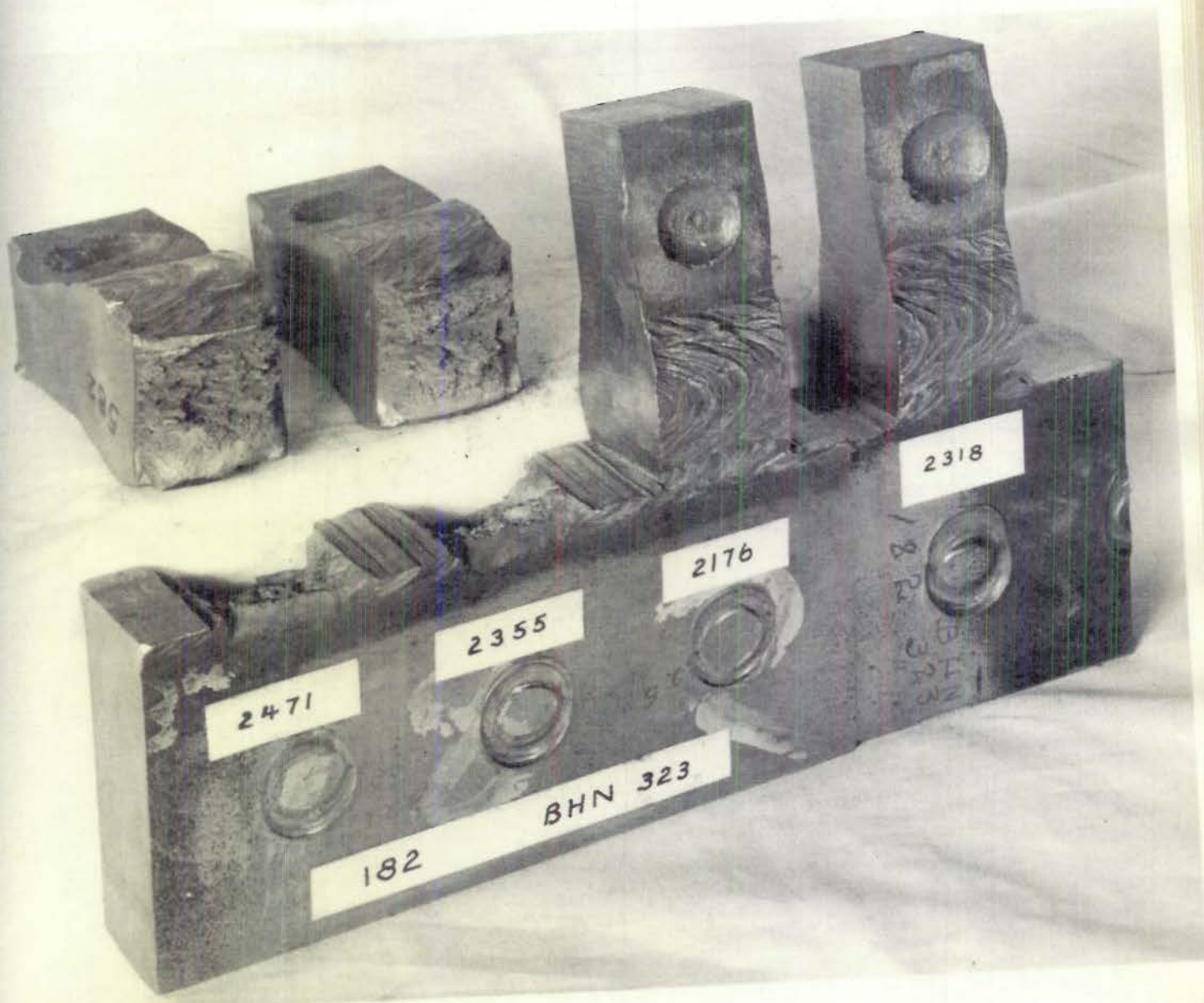
RD. VEL. FT/SEC. CROSS WELD
 HIT OF LEG AND
 CROSS WELD CRACK FROM LEG,
 LEFT LEG CRACK WITH CROSS WELD,
 RIGHT LEG CRACK WITH CROSS WELD,

BACK
 CROSS WELD CRACK FROM LEG,
 LEFT LEG CRACK WITH CROSS WELD,
 RIGHT LEG CRACK WITH CROSS WELD,

IMPACT WELD CRACKING ---
 FUSION ZONE CRACKING (F.Z.) ---
 HEAT AFFECTED ZONE (H.A.Z.) ---

() WELDS SATISFACTORY
 (✓) WELDS UNSATISFACTORY
 () SUGGESTS REWELD

REMARKS LOCATION OF NRL SAMPLE UNKNOWN



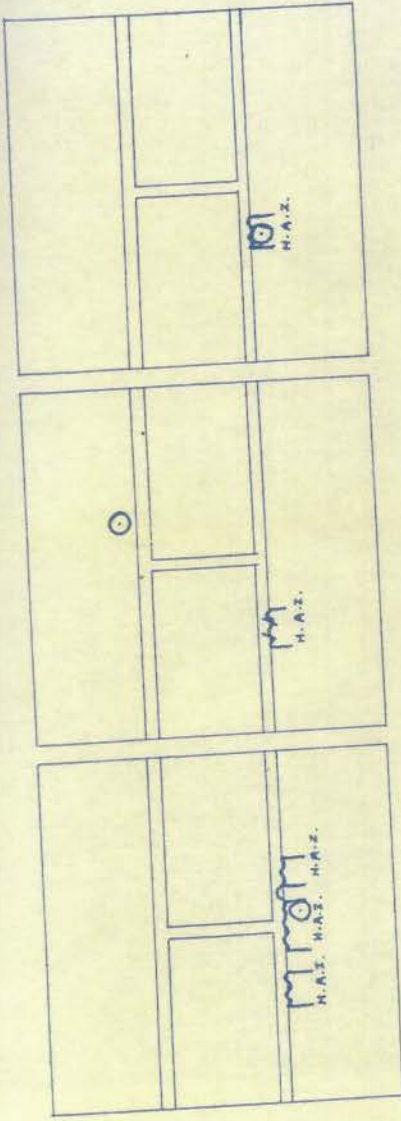
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PLATE 41 A

RESTRICTED

DATA ON SHOCK TESTS OF WELDMENTS

SUBMITTED HEIL COMPANY PLATE NO. H-12
 ARMOR MFR STANDARD STEEL SPRINGS - JONES & LAUGHLIN TYPE 1" ROLLED HOMO
 ELECTRODE HO. SMITH S.W. 164 MN MOD 18-8 PURPOSE QUALIFICATION
 PROJECTILE 75 MM T21 PROOF PROJECTILE DATE 10-8-42
 PREHEAT OF PLATE AT TIME OF WELDING NONE
 TEMPERATURE OF PLATE AT TIME OF TESTING _____



RD. 1 VEL. 759 FT/SEC.
 HIT 1 1/2" RIGHT OF RIGHT LEG AND 7/8" BELOW CROSS BAR
 CROSS WELD CRACK FROM LEG, (IN
 LEFT LEG CRACK WITH CROSS WELD, (FUSION
 RIGHT LEG CRACK WITH CROSS WELD, (ZONE

BACK
 CROSS WELD CRACK FROM LEG, (IN
 LEFT LEG CRACK WITH CROSS WELD, (FUSION
 2 1/2" RIGHT LEG CRACK WITH ALL BELOW CROSS WELD, ALL ZONE
 3/4" HORIZONTAL BULGE HAIRLINE CRACK IN HEAT AFFECTED ZONE
 3/4" VERTICAL BULGE

RD. 2 VEL. 791 FT/SEC.
 HIT 2 1/8" LEFT OF LEFT LEG AND 5/8" ABOVE CROSS BAR
 CROSS WELD CRACK FROM LEG, (IN
 LEFT LEG CRACK WITH CROSS WELD, (FUSION
 RIGHT LEG CRACK WITH CROSS WELD, (ZONE

BACK
 CROSS WELD CRACK FROM LEG, (IN
 LEFT LEG CRACK WITH CROSS WELD, (FUSION
 2 1/2" RIGHT LEG CRACK WITH ALL BELOW CROSS WELD, ALL ZONE
 1 5/16" HORIZONTAL BULGE HAIRLINE CRACK
 7/8" VERTICAL BULGE IN H.A.Z.

RD. 3 VEL. 781 FT/SEC.
 HIT 1 3/4" RIGHT OF RIGHT LEG AND 3 1/2" ABOVE CROSS BAR
 CROSS WELD CRACK FROM LEG, (IN
 LEFT LEG CRACK WITH CROSS WELD, (FUSION
 6" RIGHT LEG CRACK WITH 1" BELOW CROSS WELD, 2 1/4" ZONE

BACK
 CROSS WELD CRACK FROM LEG, (IN
 LEFT LEG CRACK WITH CROSS WELD, (FUSION
 11 1/4" RIGHT LEG CRACK WITH 4 1/4" BELOW CROSS WELD, 10 1/2" ZONE
 9 1/2" HEAT AFFECTED ZONE

- (x) WELDS SATISFACTORY
- () WELDS UNSATISFACTORY
- () SUGGESTS REWELD

IMPACT BACK CRACKING
 FUSION ZONE CRACKING
 REMARK LOCATION OF NRL SAMPLE UNKNOWN

DECLASSIFIED



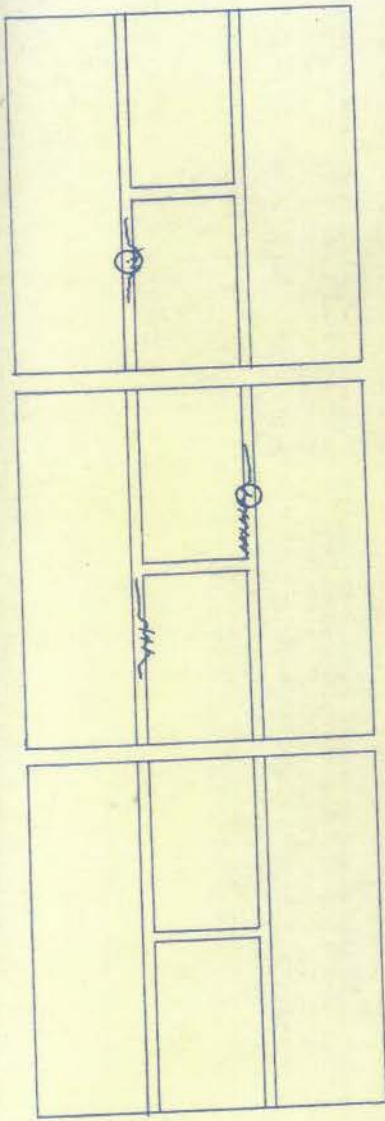
DECLASSIFIED

PLATE 42 A

RESTRICTED

DATA ON SHOCK TESTS OF WELDMENTS

SUBMITTED BY HEIL COMPANY PLATE NO. H-13
 ARMOR MFR JONES AND LAUGHLIN TYPE 1" ROLLED HOMO
 ELECTRODE LINCOLN ARMOR WELD MN MOD 18-8 AUS PURPOSE QUALIFICATION
 PROJECTILE 75 MM T21 PROOF PROJECTILE DATE 10-10-42
 PREHEAT OF PLATE AT TIME OF WELDING 150°F
 TEMPERATURE OF PLATE AT TIME OF TESTING _____



RD. 1 VEL. 802 FT/SEC.
 HIT ON ~~OF~~ LEFT LEG AND 7" CROSS BAR
 BELOW
 8 1/4" CROSS WELD CRACK FROM LEG,) IN
 LEFT LEG CRACK WITH ALL BELOW CROSS WELD,) FUSION
 RIGHT LEG CRACK WITH CROSS WELD,) ZONE

BACK
 10" CROSS WELD CRACK FROM LEG,) IN
 LEFT LEG CRACK WITH ALL BELOW CROSS WELD, 3 1/2") FUSION
 RIGHT LEG CRACK WITH CROSS WELD,) ZONE
 1 1/4" HORIZONTAL BULGE
 7/8" VERTICAL BULGE

RD. 2 VEL. 790 FT/SEC.
 HIT 1/2" LEFT OF RIGHT LEG AND 5 1/2" ABOVE CROSS BAR
 9" CROSS WELD CRACK FROM LEG,) IN
 LEFT LEG CRACK WITH ALL BELOW CROSS WELD,) FUSION
 8 1/4" RIGHT LEG CRACK WITH ALL ABOVE CROSS WELD,) ZONE

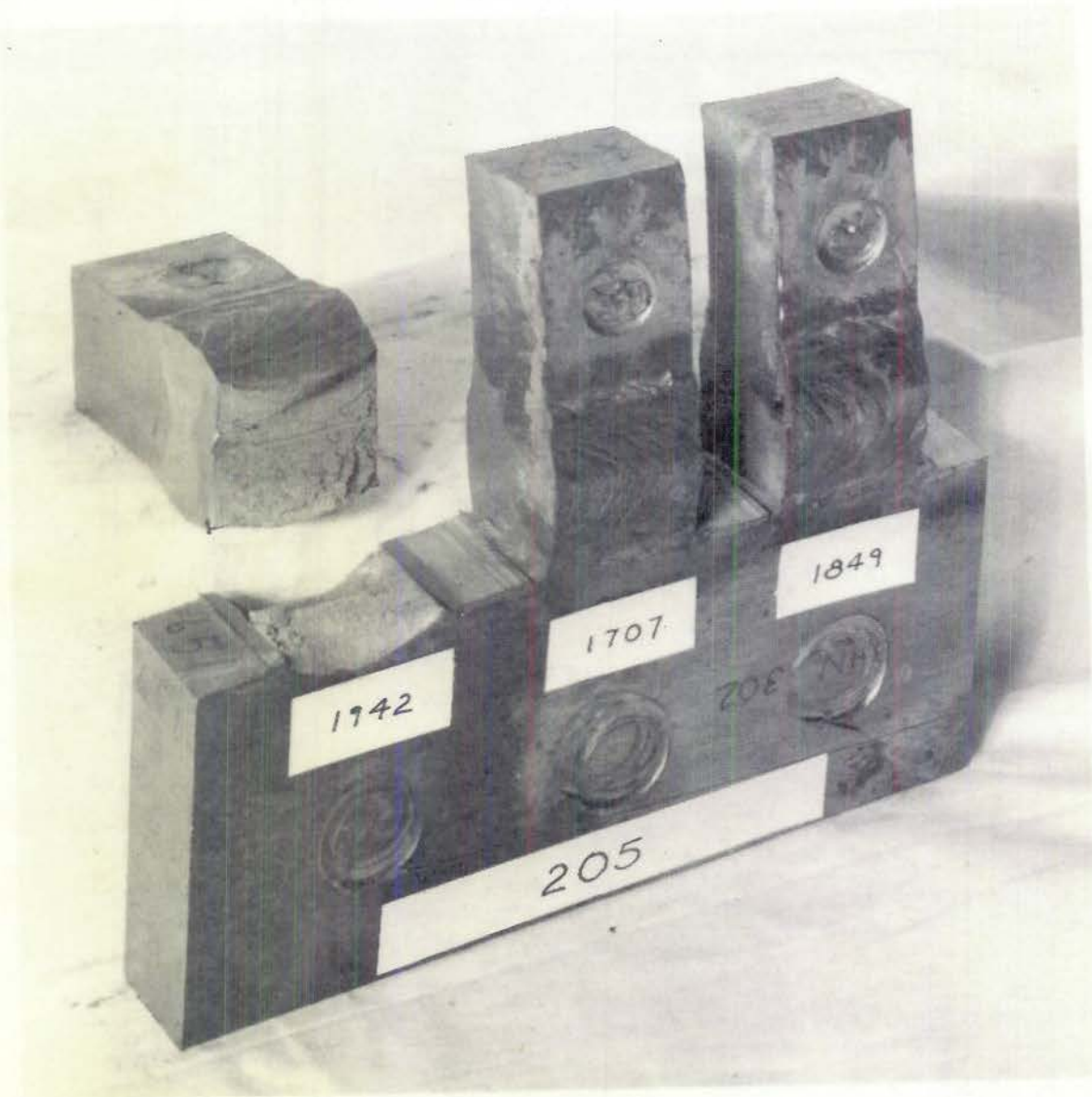
BACK
 10 1/2" CROSS WELD CRACK FROM LEG,) IN
 LEFT LEG CRACK WITH ALL BELOW CROSS WELD, 6 1/2") FUSION
 RIGHT LEG CRACK WITH ALL ABOVE CROSS WELD, 6 1/2") ZONE
 1 3/16" HORIZONTAL BULGE
 3/4" VERTICAL BULGE

RD. VEL. FT/SEC. CROSS BAR
 HIT OF LEG AND
 CROSS WELD CRACK FROM LEG,) IN
 LEFT LEG CRACK WITH CROSS WELD,) FUSION
 RIGHT LEG CRACK WITH CROSS WELD,) ZONE

BACK
 CROSS WELD CRACK FROM LEG,) IN
 LEFT LEG CRACK WITH CROSS WELD,) FUSION
 RIGHT LEG CRACK WITH CROSS WELD,) ZONE

- (x) WELDS SATISFACTORY
- () WELDS UNSATISFACTORY
- () SUGGESTS REWELD

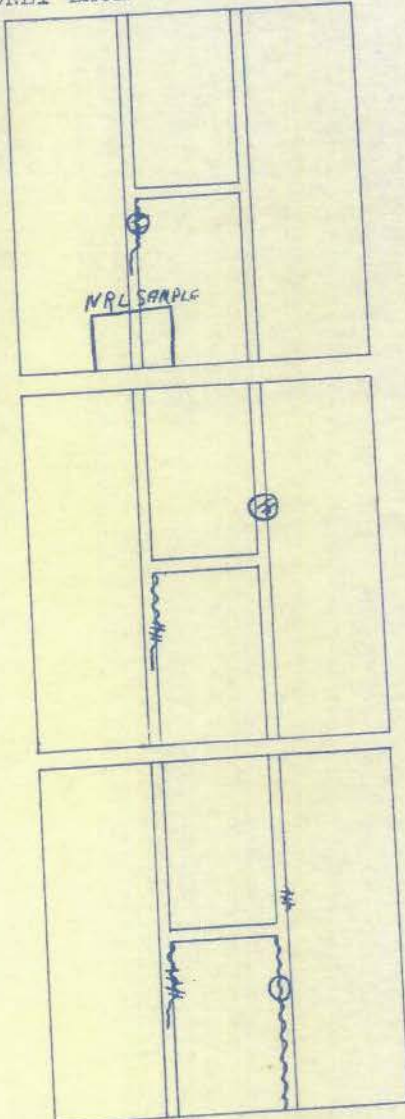
IMPACT 0 BACK CRACKING wavy
 FUSION ZONE CRACKING none
 REMARK VELOCITY OF FIRST IMPACT HIGHER THAN NECESSARY
LOCATION OF NRL SAMPLE UNKNOWN



DATA ON SHOCK TESTS OF WELDMENTS

SUBMITTED BY HEIL COMPANY PLATE NO. H-14
 ARMOR MFR GREAT LAKES STEEL COMPANY TYPE 1" ROLLED HOMO
 ELECTRODE HARNISCHFEEGER AW[#]3 PURPOSE QUALIFICATION
 PROJECTILE 35MM T-21 PROOF PROJECTILE DATE 12-3-42
 TEMPERATURE OF PLATE AT TIME OF TESTING 63° F

ONLY BACK CRACKING SHOWN



RD. 1 VEL. 758 FT/SEC.
 HIT $\frac{1}{2}$ " LEFT OF LEFT LEG AND $\frac{1}{2}$ " BELOW CROSS WELD
 CROSS WELD CRACK FROM LEG,
 $7\frac{1}{4}$ " LEFT LEG CRACK WITH ALL BELOW CROSS WELD, $3\frac{1}{2}$ " F.Z.
 RIGHT LEG CRACK WITH CROSS WELD,

BACK
 CROSS WELD CRACK FROM LEG,
 $9\frac{1}{4}$ " LEFT LEG CRACK WITH ALL BELOW CROSS WELD, $3\frac{1}{2}$ " F.Z.
 RIGHT LEG CRACK WITH CROSS WELD,
 $1\frac{1}{4}$ " HORIZONTAL BULGE $7\frac{1}{2}$ " VERTICAL BULGE

RD. 2 VEL. 772 FT/SEC.
 HIT ON OF RIGHT LEG AND $6\frac{1}{2}$ " ABOVE CROSS WELD
 CROSS WELD CRACK FROM LEG,
 $7\frac{1}{4}$ " LEFT LEG CRACK WITH ALL BELOW CROSS WELD, $3\frac{1}{2}$ " F.Z.
 RIGHT LEG CRACK WITH CROSS WELD,

BACK
 CROSS WELD CRACK FROM LEG,
 $9\frac{1}{4}$ " LEFT LEG CRACK WITH ALL ABOVE CROSS WELD, $3\frac{1}{2}$ " F.Z.
 $1\frac{1}{2}$ " RIGHT LEG CRACK WITH ALL ABOVE CROSS WELD, 1" F.Z.
 $1\frac{1}{2}$ " HORIZONTAL BULGE $3\frac{1}{4}$ " VERTICAL BULGE

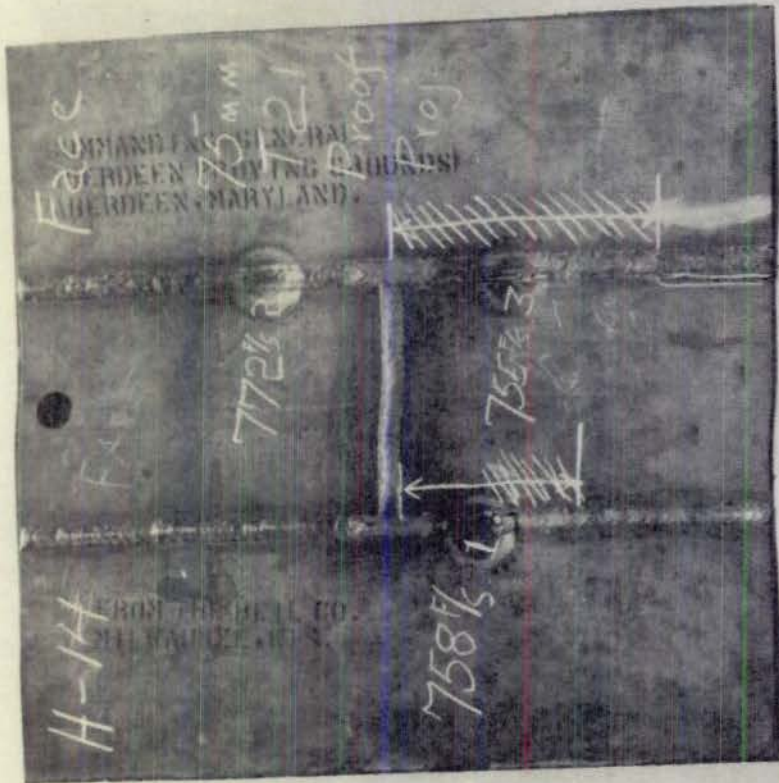
RD. 3 VEL. 755 FT/SEC.
 HIT $\frac{1}{4}$ " LEFT OF RIGHT LEG AND $6\frac{1}{2}$ " BELOW CROSS WELD
 CROSS WELD CRACK FROM LEG,
 $8\frac{1}{4}$ " LEFT LEG CRACK WITH ALL BELOW CROSS WELD, 4" F.Z.
 $12\frac{1}{4}$ " RIGHT LEG CRACK WITH ALL BELOW CROSS WELD, ALL F.Z.
 $5\frac{1}{4}$ " PLATE CRACK

BACK
 CROSS WELD CRACK FROM LEG,
 $10\frac{1}{4}$ " LEFT LEG CRACK WITH ALL BELOW CROSS WELD, $3\frac{1}{2}$ " F.Z.
 $19\frac{1}{4}$ " RIGHT LEG CRACK WITH $18\frac{1}{2}$ " BELOW CROSS WELD, $1\frac{1}{2}$ " F.Z. $18\frac{1}{2}$ " F.Z.
 $1\frac{1}{2}$ " HORIZONTAL BULGE $3\frac{1}{4}$ " VERTICAL BULGE

IMPACT WELD CRACKING
 FUSION ZONE CRACKING (F.Z.)
 HEAT AFFECTED ZONE (H.A.Z.)

(✓) WELDS SATISFACTORY
 () WELDS UNSATISFACTORY
 () SUGGESTS REWELD

REMARKS _____



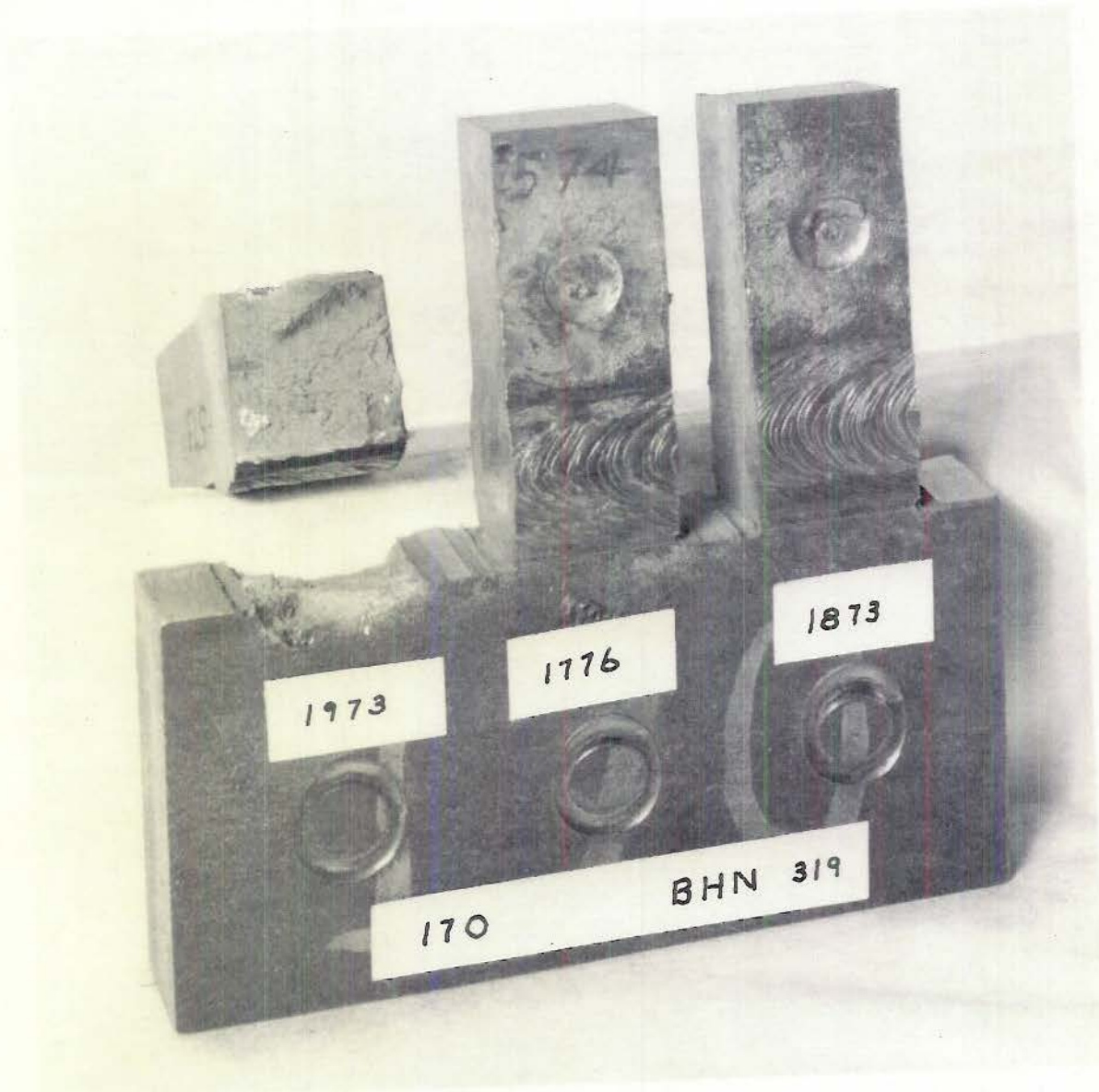
ORDNANCE DEPT.

ABERDEEN PROVING GROUND

74915 12-10-42

Hel Co. Plate #H-10. 1" rolled homogeneous Great Lakes armor "H" welded with Harnischfeger M-3.

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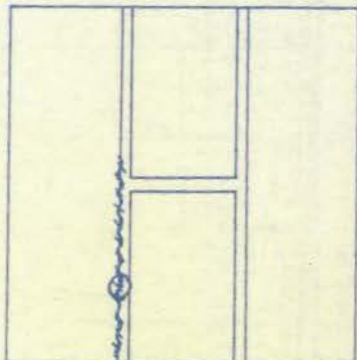
RESTRICTED

DECLASSIFIED

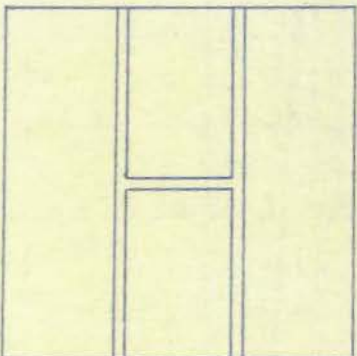
PLATE 44A

DATA ON SHOCK TESTS OF WELDMENTS

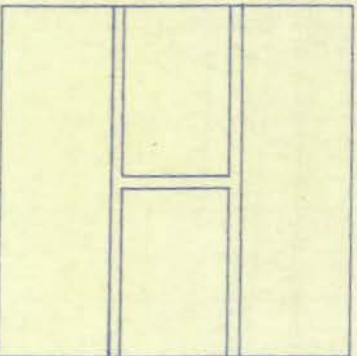
SUBMITTED BY GORDON MANUFACTURING CO PLATE NO. H-1
 ARMOR MFR GREAT LAKES STEEL TYPE 1" ROLLED HOMO
 ELECTRODE CRUCIBLE-ARMORIZE MANN MOD K-2 AWS PURPOSE QUALIFICATION
 PROJECTILE 75MM T21 PROOF PROJECTILE DATE 10-20-42
 PREHEAT OF PLATE AT TIME OF WELDING 120°F
 TEMPERATURE OF PLATE AT TIME OF TESTING _____



RD. 1 VEL. 770 FT/SEC.
 HIT 3/4" LEFT OF LEFT LEG AND 10" BELOW CROSS BAR
 CROSS WELD CRACK FROM _____ LEG, (IN
1/4" LEFT LEG CRACK WITH 1 1/2" ABOVE CROSS WELD, ALL (FUSION
 RIGHT LEG CRACK WITH _____ CROSS WELD, (ZONE
 BACK
 CROSS WELD CRACK FROM _____ LEG, (IN
20" LEFT LEG CRACK WITH 2" ABOVE CROSS WELD, ALL (FUSION
1 7/8" HORIZONTAL BULGE 1 1/2" VERTICAL BULGE CROSS WELD, (ZONE



RD. _____ VEL. _____ FT/SEC.
 HIT _____ OF _____ LEG AND _____ CROSS BAR
 CROSS WELD CRACK FROM _____ LEG, (IN
 LEFT LEG CRACK WITH _____ CROSS WELD, (FUSION
 RIGHT LEG CRACK WITH _____ CROSS WELD, (ZONE
 BACK
 CROSS WELD CRACK FROM _____ LEG, (IN
 LEFT LEG CRACK WITH _____ CROSS WELD, (FUSION
 RIGHT LEG CRACK WITH _____ CROSS WELD, (ZONE



RD. _____ VEL. _____ FT/SEC.
 HIT _____ OF _____ LEG AND _____ CROSS BAR
 CROSS WELD CRACK FROM _____ LEG, (IN
 LEFT LEG CRACK WITH _____ CROSS WELD, (FUSION
 RIGHT LEG CRACK WITH _____ CROSS WELD, (ZONE
 BACK
 CROSS WELD CRACK FROM _____ LEG, (IN
 LEFT LEG CRACK WITH _____ CROSS WELD, (FUSION
 RIGHT LEG CRACK WITH _____ CROSS WELD, (ZONE

- () WELDS SATISFACTORY
- () WELDS UNSATISFACTORY
- () SUGGESTS REWELD

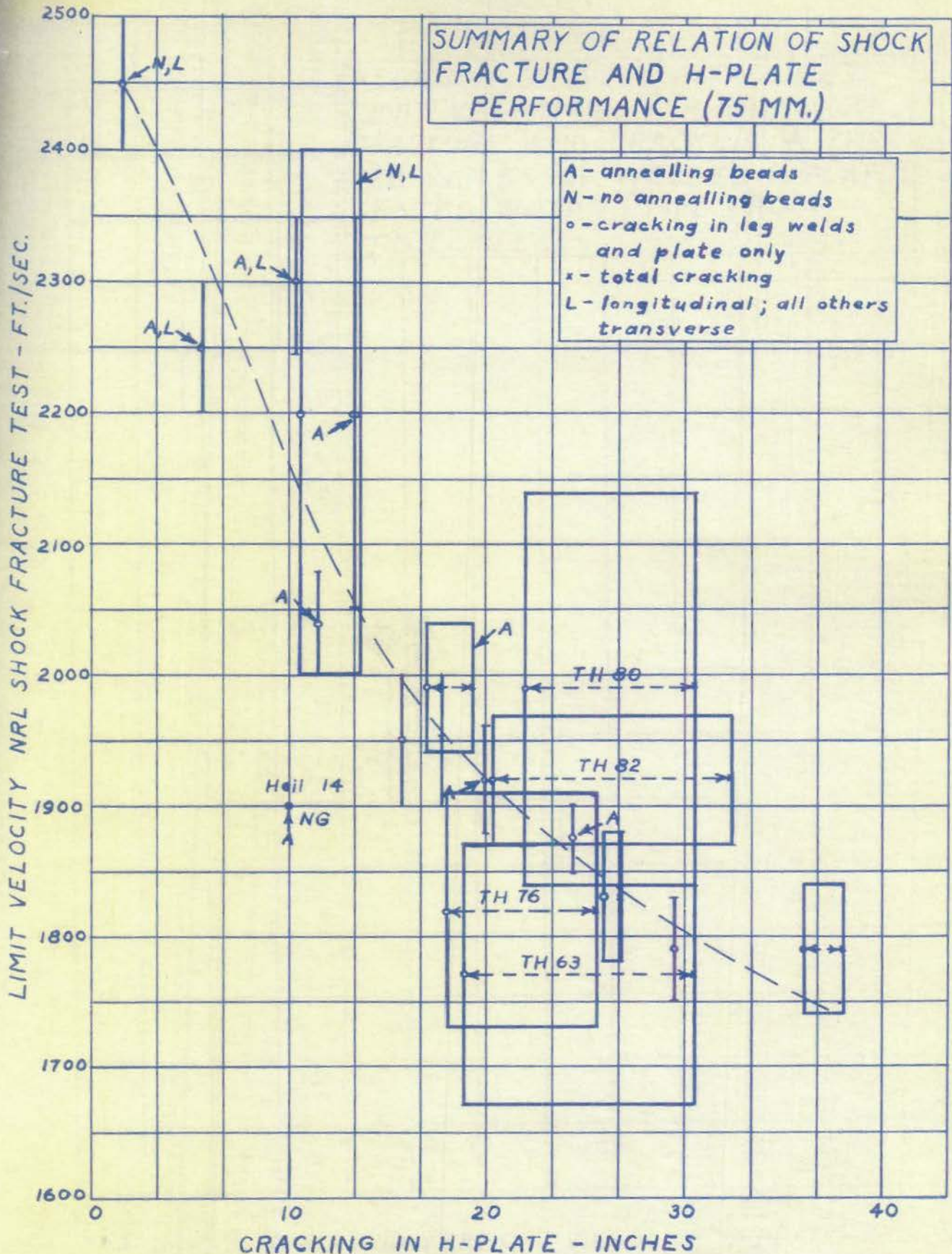
IMPACT BACK CRACKING ~~~~~

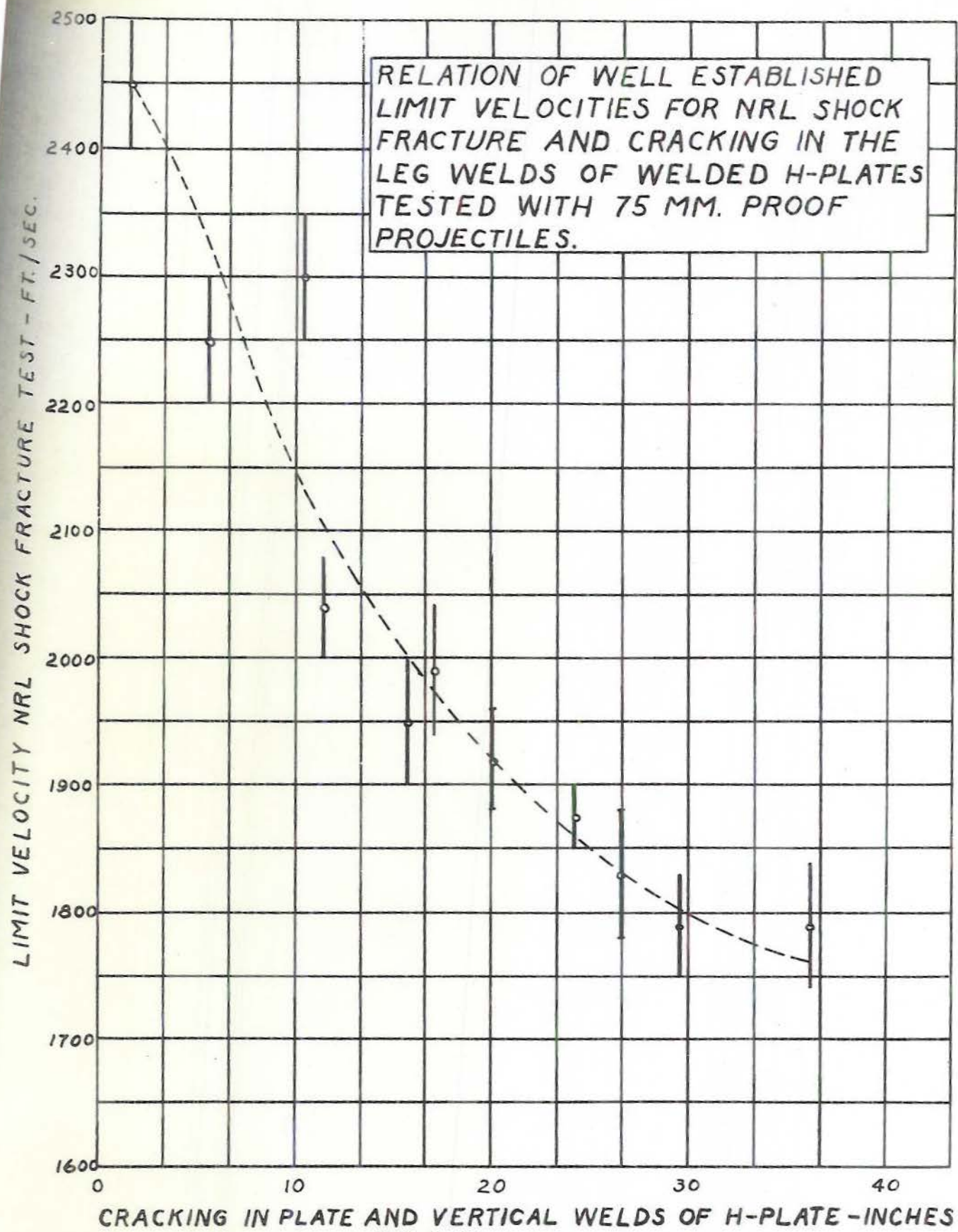
FUSION ZONE CRACKING ~~~~~

REMARK LOCATION OF NRL SAMPLE UNKNOWN

SUMMARY OF RELATION OF SHOCK FRACTURE AND H-PLATE PERFORMANCE (75 MM.)

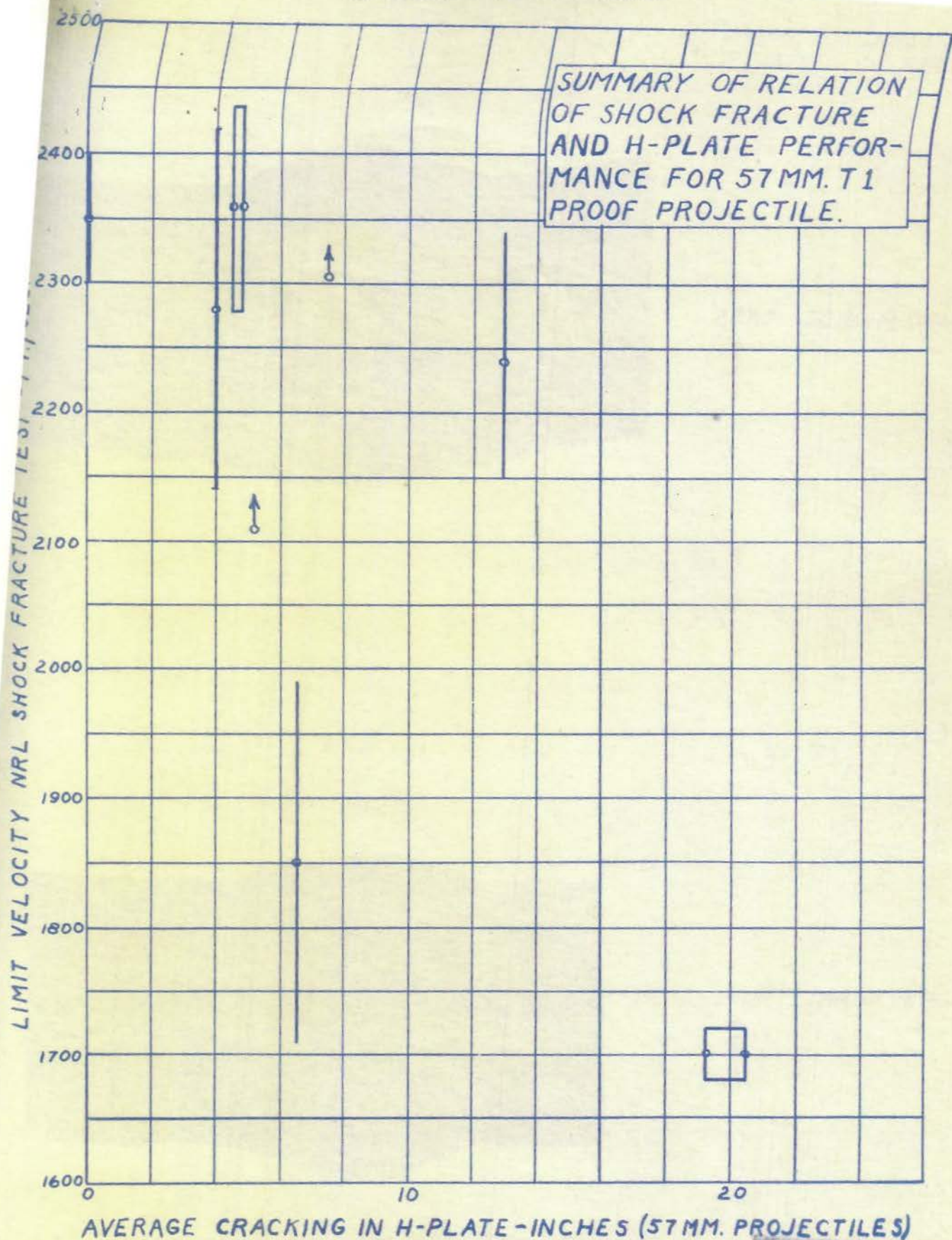
A - annealing beads
 N - no annealing beads
 o - cracking in leg welds and plate only
 x - total cracking
 L - longitudinal; all others transverse



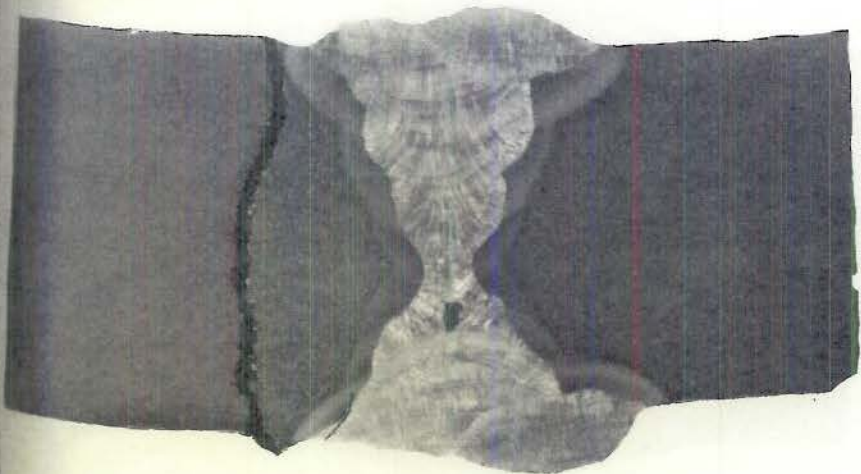


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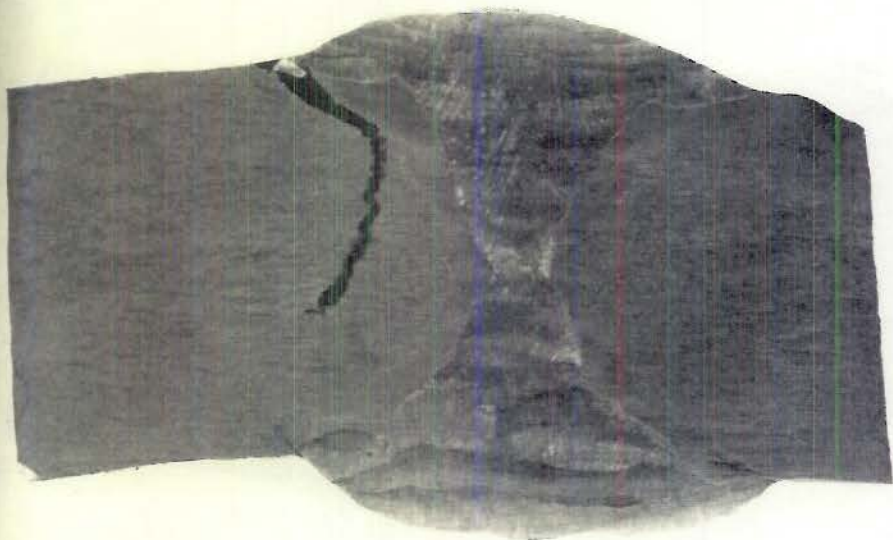
PLATE 46



IMPACT FT./SEC. DIRECTION OF ROLLING



2329 TRANSVERSE



2240 LONGITUDINAL



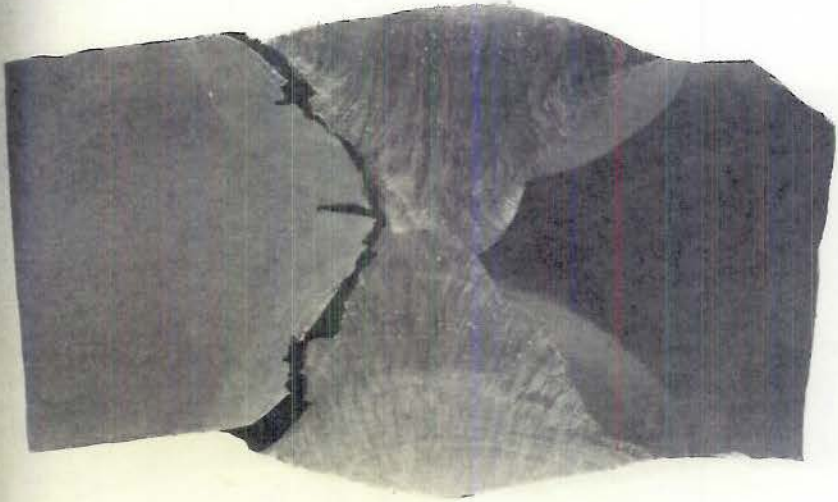
DECLASSIFIED

RESTRICTED

DECLASSIFIED

IMPACT FT./SEC. DIRECTION OF ROLLING

59



2524

LONGITUDINAL



184



2415

CAST



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RESTRICTED

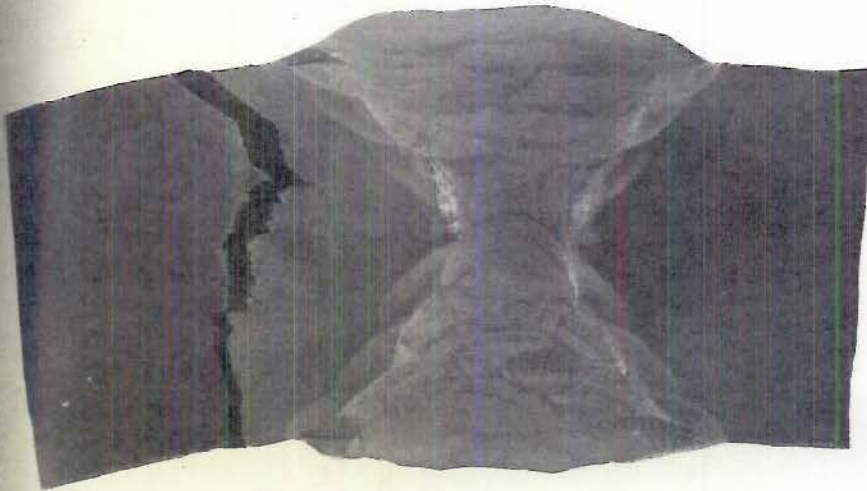
PLATE 50

DECLASSIFIED

180

IMPACT
FT./SEC.

DIRECTION
OF ROLLING

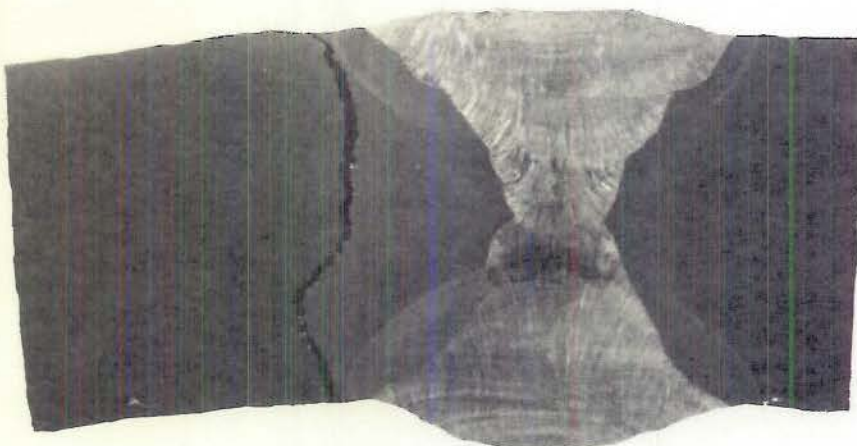


2098

TRANSVERSE



168



2000

TRANSVERSE



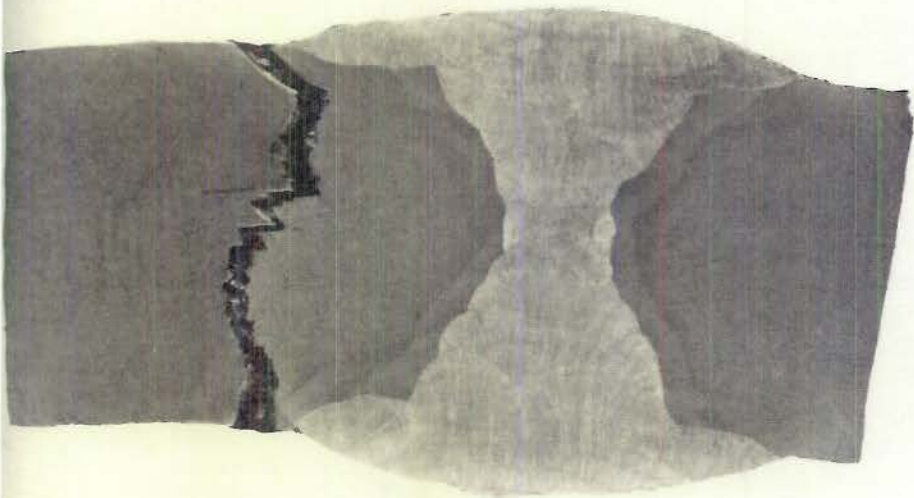
DECLASSIFIED

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PLATE 51

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IMPACT
FT./SEC. DIRECTION
 OF ROLLING



2355
↓

LONGITUDINAL

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APPENDIX A - Experimental Development.

1. A considerable number of test pieces were studied in the development of a suitable experimental technique for shock-fracture testing of armor and weld joints. In the preliminary study, test pieces (3" x 8" x 1" thick) (Plate 53) welded with an austenitic electrode of the 19-9 type were supported at each end. Caliber .50 ball M-1 ammunition was used at normal impact on the face of the single V-groove. Considerable damage and gouging out of weld metal to the extent of 1-3/8" x 1/2" x 3/8" occurred with very little bending of the specimen and no damage to the root. It was suggested that the stress at the narrow root might be increased by impact with a caliber .50 AP dart. A second specimen was supported in a manner similar to that of the first. Complete penetration with an opening 5/8" x 3/4" occurred with a velocity of 3240 ft./sec, and produced no damage to the root and only a slight bending of the specimen (Plate 53). Obviously, use of a specimen of this type would not solve the problem.

2. In order to increase the stress at the root of the weld, a number of ballistic test specimens were prepared from a corner joint (Plate 54). This type of test specimen was ideal when considered from the ballistic test standpoint. A limit velocity at which a finger is just removed may be obtained from two impacts, one above and one below the velocity necessary to fracture the test specimen. An increase in the number of impacts enables a more accurate determination of limit velocity of the test specimen. In order to reduce the energy absorbed by deformation of the long finger, subsequent testing was performed on specimens with shorter fingers (Plate 55). The range of limit velocities has been reduced. The test piece, however, is difficult to prepare and gives a joint with non-uniform heat distribution. Also the section of plate material which forms the base of the test piece is stressed in a direction through the thickness of the plate.

3. Another type of specimen was a strip 2" wide cut across the weld mounted in a jig as shown in Plate 56. This specimen and mounting proved unsatisfactory as the greater portion of the energy was absorbed in deforming the plate material adjacent to the weld. Even the specimen shown at the extreme left in Plate 66 which was clamped with the short end of the plate material extended from the jig proved unsatisfactory. A reduction in the section of the specimen to be broken as shown in Plate 57 did not increase the stress on the weld sufficiently except in the case of the second specimen from the left which showed a defective weld.

4. The most satisfactory test piece from a welding standpoint is a single-V or double-V butt joint. All further efforts after completing the above preliminary studies were directed toward the development of a test specimen using armor or a butt joint with either a single-V or double-V groove,

5. Certain difficulties were encountered in the early specimens prepared from butt joints. A typical specimen is shown in

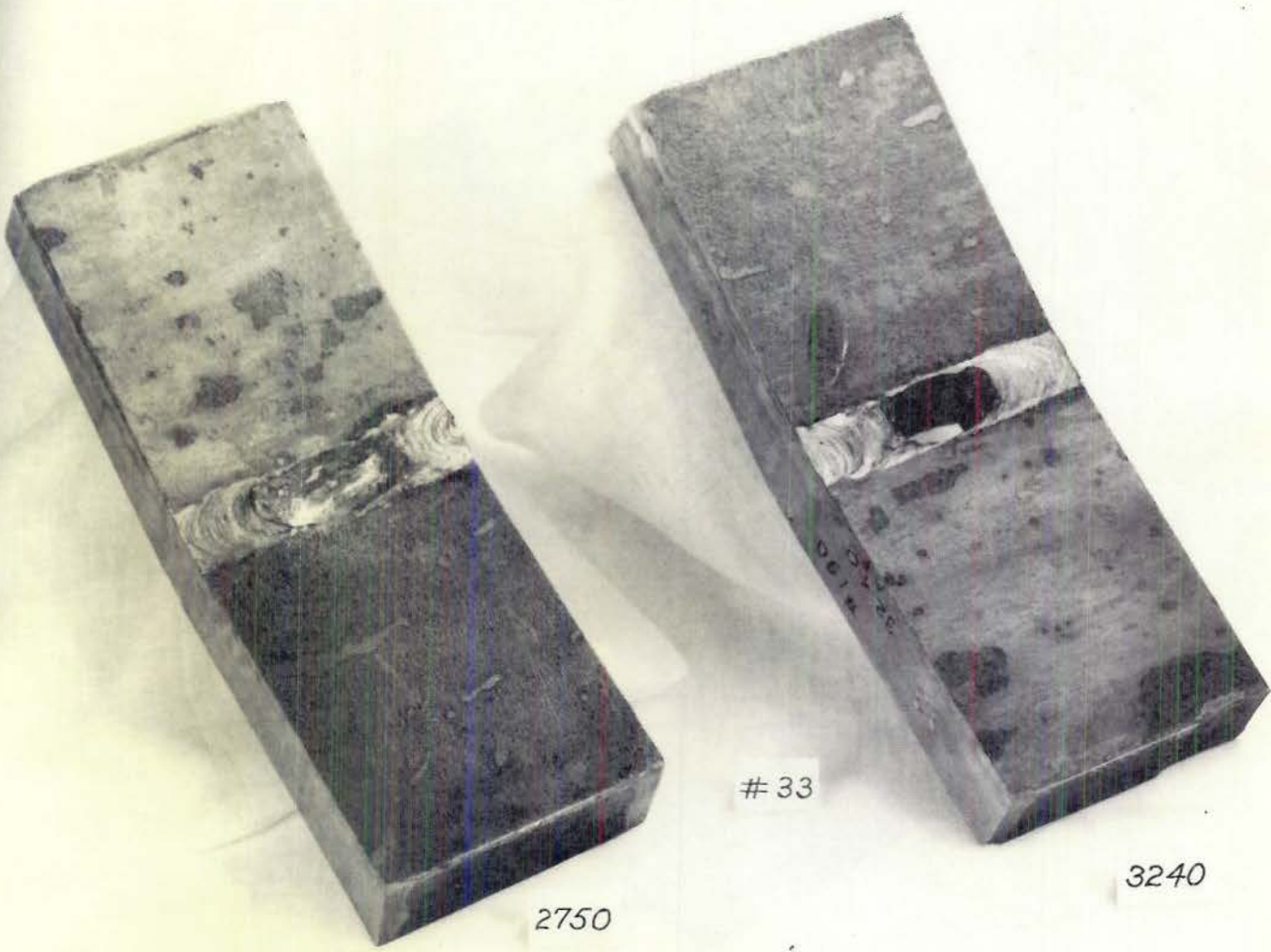
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Plate 58 in which it is to be noted a large amount of deformation of the finger is present. In fact, side deformation of the center finger was so great that binding occurs between the fingers. An increase in the separation between the fingers by use of a double hack-saw blade was not sufficient to eliminate the difficulty (Plate 59). A second factor which discouraged the use of this particular type of test specimen was that the energy available with impacts at maximum velocity was insufficient to fracture the finger of unwelded specimens. A reduction of width of the finger to one inch, a reversal of the projectile in the gun, and the spacing of the fingers finally produced a specimen which performed satisfactorily.

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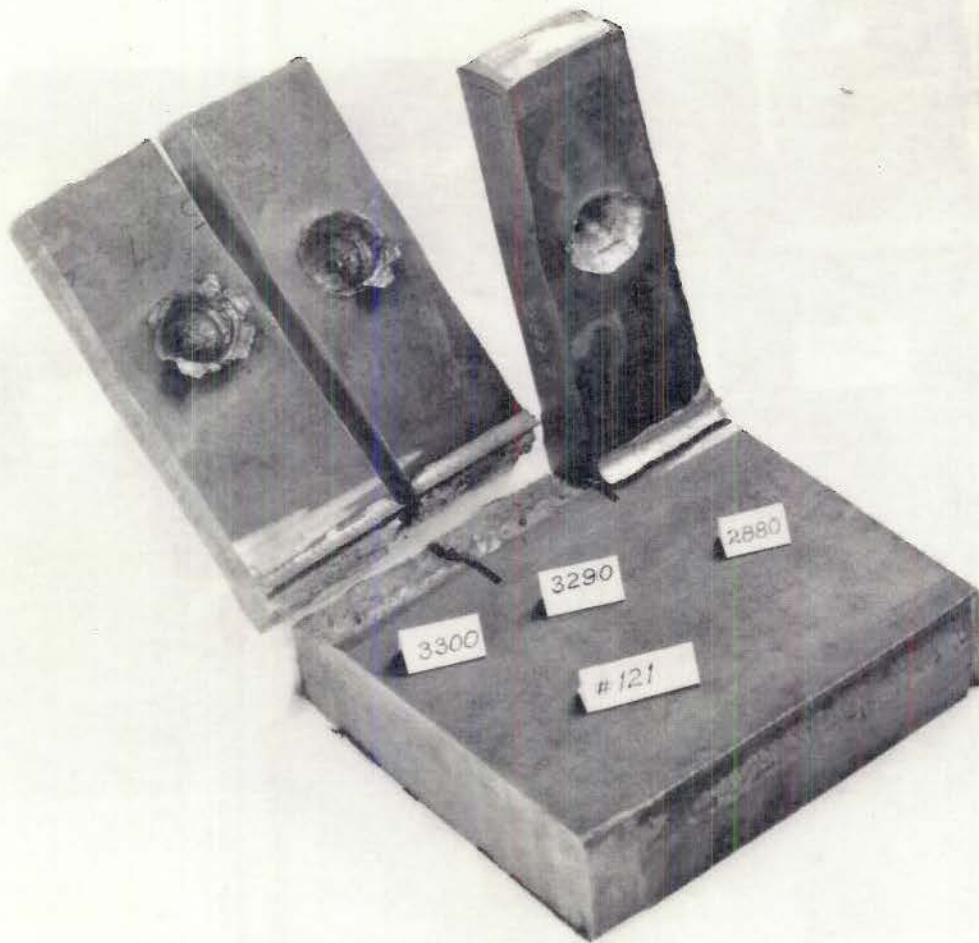


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PLATE 53

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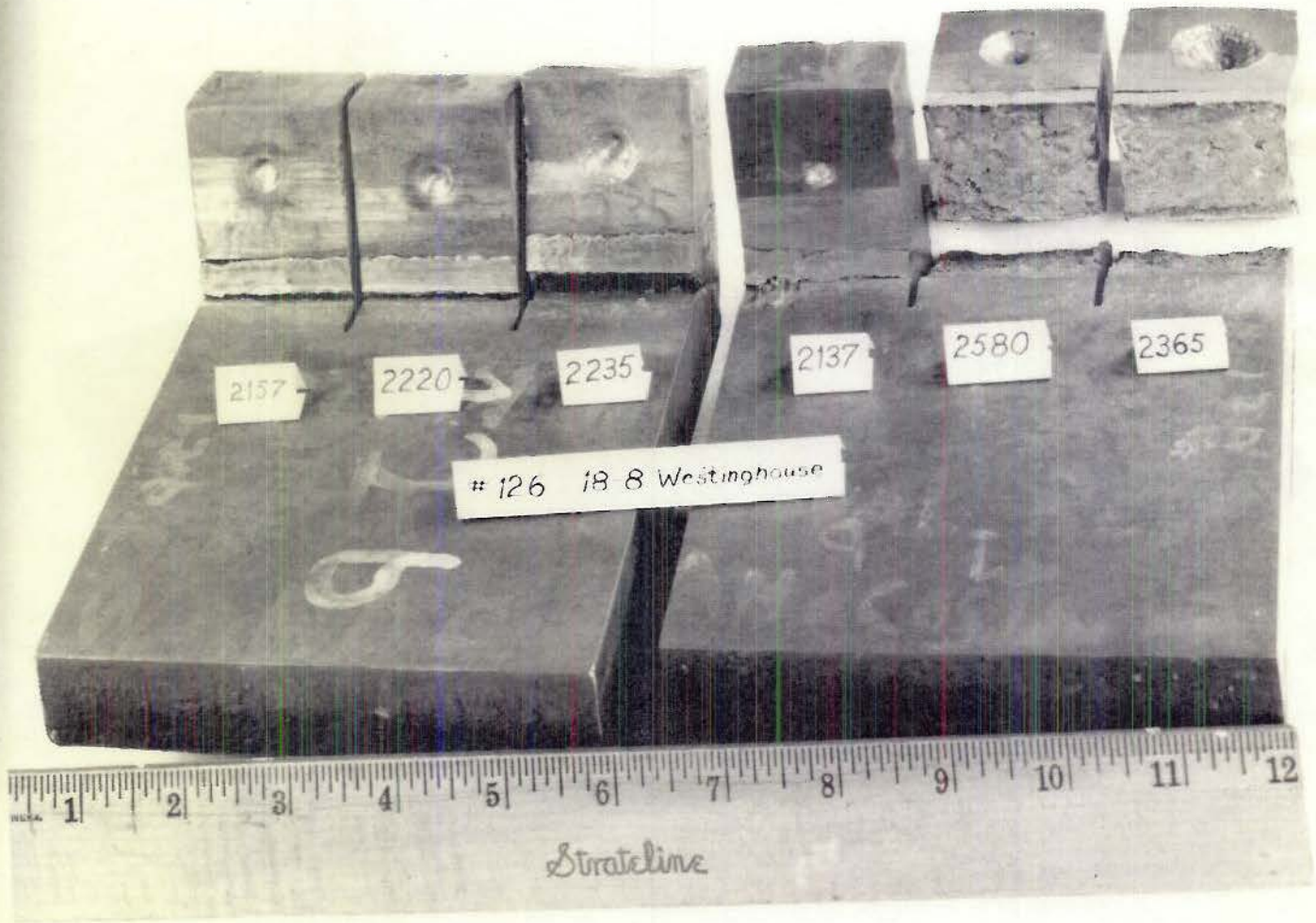


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PLATE 54

RESTRICTED

DECLASSIFIED

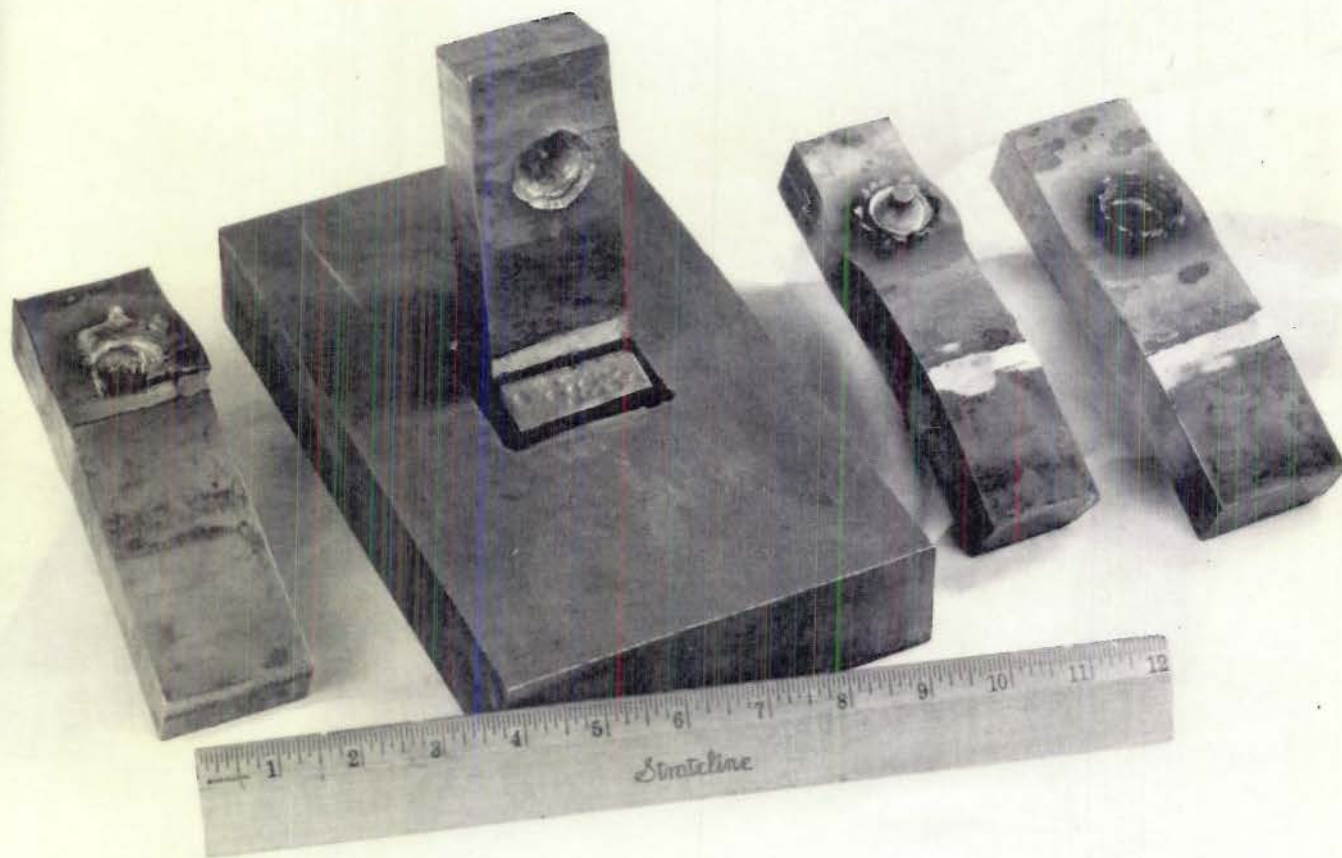


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PLATE 55

RESTRICTED

DECLASSIFIED

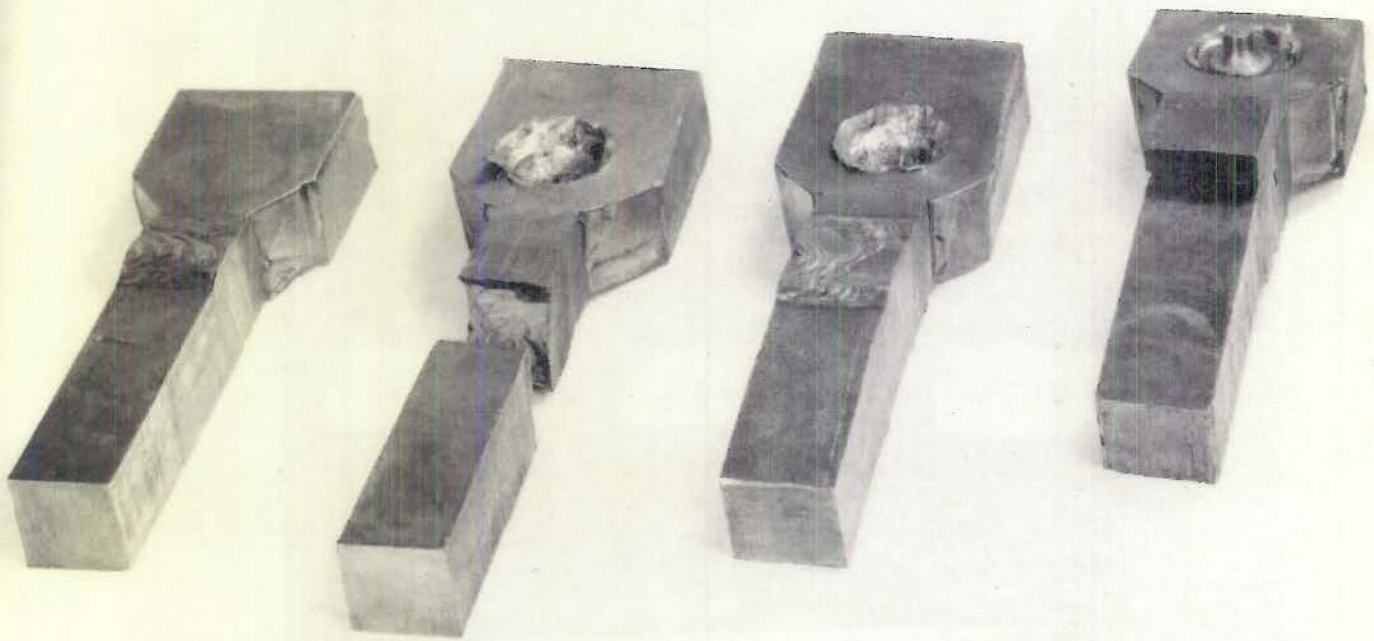


DECLASSIFIED

PLATE 56

DECLASSIFIED

DECLASSIFIED

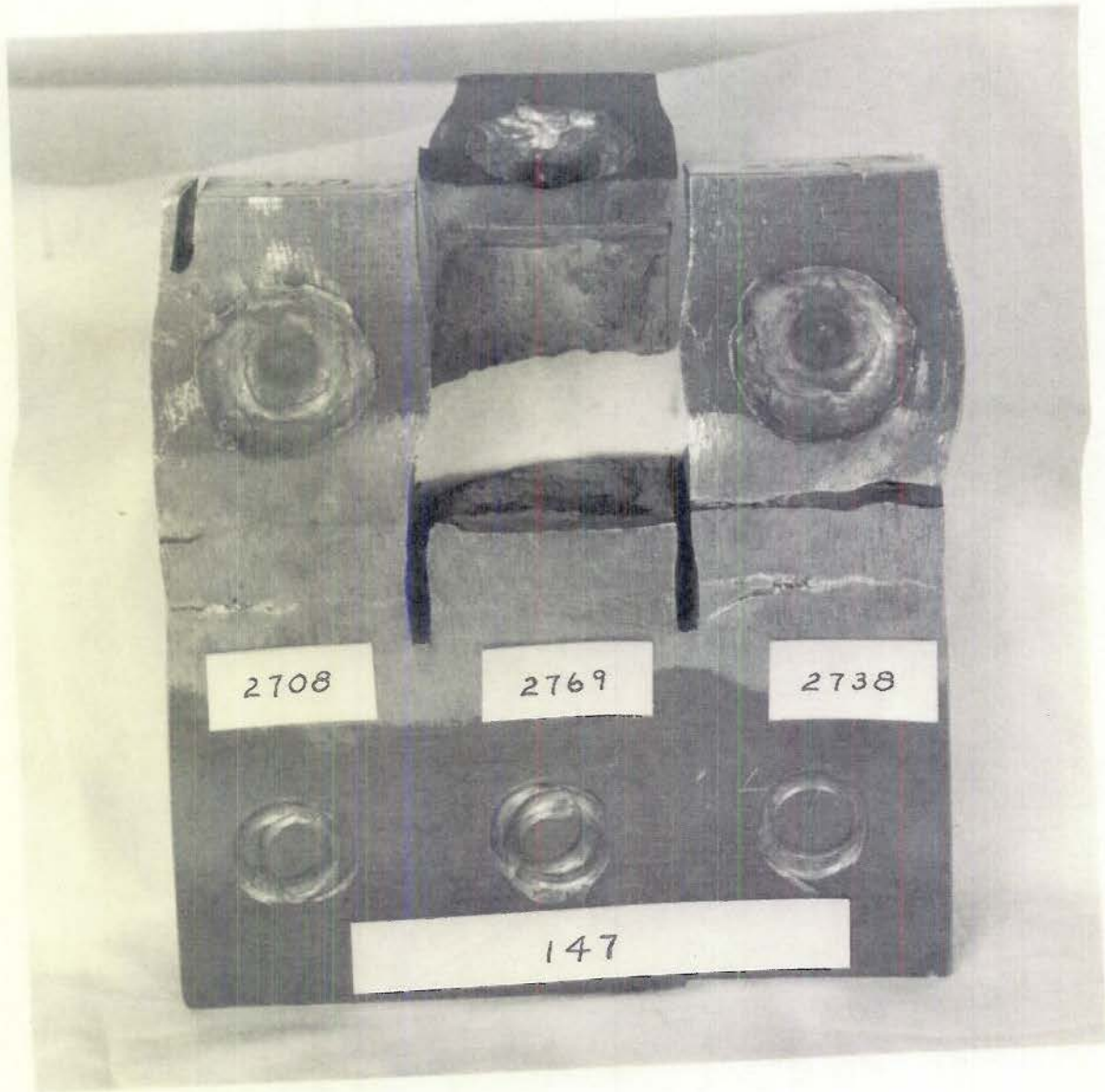


DECLASSIFIED

PLATE 57

RESTRICTED

DECLASSIFIED

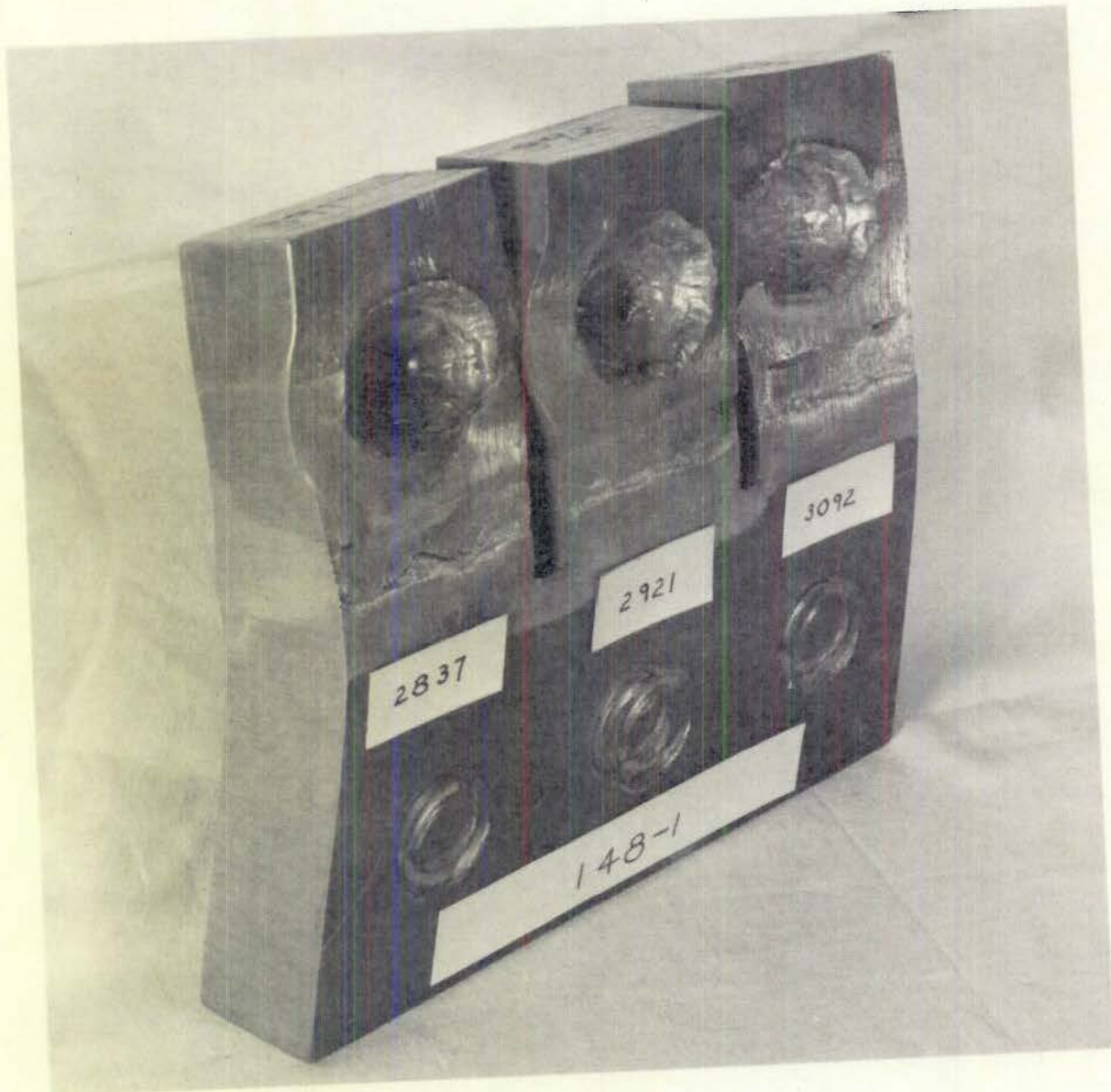


DECLASSIFIED

PLATE 58

RESTRICTED

DECLASSIFIED



DECLASSIFIED

PLATE 59

RESTRICTED