UNCLASSIFIED

AD NUMBER
AD473866
CLASSIFICATION CHANGES
TO: unclassified
FROM: restricted
LIMITATION CHANGES
TO: Approved for public release, distribution unlimited
FROM: Distribution: Further dissemination only as directed by Watertown Arsenal Labs, MA; 28 Sep 1942 or higher DoD authority.
AUTHORITY
E.O. 10501, 5 NOV 1953.; USAMMRC ltr, 9 Oct 1984.

THIS PAGE IS UNCLASSIFIED

UNCLASSIFIED

ROLLED ARMOR. BALLISTIC PROPERTIES OF ROLLED FACE HARDENED ARMOR AND ROLLED HOMOGENEOUS ARMOR OF VARIOUS HARDNESSESS AT NORMAL INCIDENCE AND AT VARIOUS OBLIQUITIES.

AD473866

WATERTOWN ARSENAL LABS MA

28 SEP 1942

UNCLASSIFIED

Reproduced From
Best Available Copy

RESTRICTED

Report No. 710/456
Watertown Arsen[redacted]ember 28, 1942
September, 23, 1943

ROLLED ARMOR

Ballistic Properties of Rolled Face Hardened Armor and
Rolled Homogeneous Armor of Various Hardnesses
at Normal Incidence and at Various Obliquities

U.S. ARMY [illegible]

OBJECT

1. To determine the relationship between the ballistic limit of a plate based upon the Army criterion and its limit based upon the Navy criterion.

2. To determine the effect of various hardnesses on resistance to penetration.

3. To determine the relative resistance to penetration of rolled face hardened and rolled homogeneous armor.

4. To determine the effect of various hardnesses on resistance to spalling.

5. To determine the maximum hardness imparting optimum simultaneous resistance to spalling and penetration for armor plate of various thicknesses and at various degrees of obliquity.

6. To determine the relative resistance to spalling of rolled face hardened and homogeneous armor.

7. To determine the effect of obliquity on resistance to penetration.

8. To determine the effect of obliquity on resistance to spalling.

RESTRICTED

9. To determine whether there is an obliquity at which armor could be tested to determine what its behavior would be under attack from any quadrant.

10. To observe the effects of induced projectile yaw.

REFERENCES

W.A. 470.5/3915

W.A. 470.5/4874

The basic correspondence pertaining to this investigation is included in Appendix C.

CONCLUSIONS

1. Against caliber .50 AP M2 projectiles, the ratio between the ballistic limits of plates based on Navy criterion and those based on the Army criterion (N/A) decreases with an increase in obliquity or in plate thickness. (Table I, Chart F.)

2. Under fire of caliber .50 AP M2 projectiles, while the ratio of plate thickness to projectile diameter (e/d) is greater than .83, resistance to penetration increases with increasing plate hardness until spalling effects a decrease in effective plate thickness. (Table II, Charts A to E.)

3. Under impact of caliber .50 AP M2 projectiles, at normal incidence or at low obliquity, the resistance to penetration (Army or Navy criterion) of face hardened armor is superior to that of homogeneous armor. At 20° and higher obliquity the resistance to penetration (Navy criterion), and at 30° and higher obliquity the resistance to penetration (Army criterion) of hard rolled homogeneous armor is substantially equal to that of face hardened armor. (Charts

A to E.) This equality of resistance to penetration coupled with the superior ductility inherent in homogeneous armor plate and viewed in the light of the time advantage in production of this type armor dictates the use of hard homogeneous armor in those areas where attack is likely to be from obliquities and with fire of the above order.

4. There is a critical range of hardness (BHN 360 to BHN 400) for plates in the thickness range 3/8" to 1" above which resistance to spalling breaks down under impact with caliber .50 AP M2 projectiles. Within this blanket range, a specific range, in inverse correlation with thickness, exists for each plate thickness. (Table II.)

5. Inasmuch as resistance to penetration increases with plate hardness, the critical hardness range cited above will define the maximum hardness which will impart optimum simultaneous resistance to spalling and penetration.

6. The degree of spalling in face hardened armor is greater than in homogeneous armor of a hardness affording comparable resistance to penetration under oblique impact. Spalling tendency, in general, is considerably greater in face hardened armor than in homogeneous armor.

7. Mounting armor in an installation at an obliquity to the anticipated direction of attack will result in a substantial increase in resistance efficiency on the one hand, or a substantial reduction in weight without protection loss, on the other hand:

a. Plate mounted at 45° obliquity offers resistance to penetration equal to that of a plate 1.9 times as heavy at normal incidence.

b. Plate mounted at 40° obliquity offers resistance to penetration equal to that of a plate 1.5 times as heavy at normal incidence.

c. Plate mounted at 30° obliquity offers resistance to penetration equal to that of a plate 1.3 times as heavy at normal incidence.

d. Plate mounted at 20° obliquity offers resistance to penetration equal to that of a plate 1.25 times as heavy at normal incidence.

e. Plate mounted at 10° obliquity offers somewhat greater resistance to penetration than the same plate at normal incidence, but because of projectile yaw, in some instances it may offer less resistance.

8. Spalling tendencies tend to be revealed with increasing obliquity.

9. No one obliquity will serve as a criterion for armor behavior at every obliquity, but high obliquity tests tend to reveal inherent spalling characteristics.

10. Light plate screened by Dural sheet in such a manner as to tip the projectile in flight so that it impacts the plate with a yaw of approximately 90° offers resistance to penetration equal to that of plate twice as heavy as the combined weight of the armor and Dural screens.

J. Sullivan

J. Sullivan
Statistical Clerk

Approved:

H. H. ZORNIG
Colonel, Ord. Dept.
Director of Laboratory

TABLE OF CONTENTS

INTRODUCTION.....9

TEST PROCEDURE:

Ballistic Tests.....12

Physical Tests.....13

RESULTS OF TESTS:

Ballistic Tests.....14

Physical Tests.....14

DISCUSSION:

I. Relation between Ballistic Limits Based on Army and Navy Criteria.....14

II. Effect of Hardness on Resistance to Penetration.....16

III. Relative Resistance to Penetration of Rolled Face-Hardened and Homogeneous Armor.....17

IV. Effect of Hardness on Resistance to Spalling.....19

V. Maximum Hardness Imparting Optimum Simultaneous Resistance to Penetration and Spalling.....20

VI. Relative Resistance to Spalling of Rolled Face-Hardened and Homogeneous Armor.....20

VII. Effect of Obliquity on Resistance to Penetration:

A. Cal..50 AP M2 Projectiles

1. Army Criterion

a. Obliquity - 10°.....21

b. Obliquity - 20°.....21

c. Obliquity - 30°.....22

d. Obliquity - 40°.....22

e. Obliquity - 45°.....23

TABLE OF CONTENTS Cont'd

2. Navy Criterion.....23

B. 37MM AP M51 Projectiles.....23

C. In General.....23

VIII. Effect of Obliquity on Resistance to Spalling.....24

IX. Optimum Obliquity for Plate Testing.....25

X. Effects of Projectile Yaw.....25

TABLES AND FIGURES

TABLE I

Effect of Obliquity on Ratio of Average Navy/Army Ballistic Limits - Caliber .50 AP M2 Projectiles.

TABLE II

Summary of Ballistic Results.

TABLE III

Effect of Obliquity on Ratio of Resistance to Penetration of Face Hardened Armor to that of the Best Homogeneous Armor - Tested with Caliber .50 AP M2 Projectiles.

TABLE IV

Effect of Obliquity on Average Ballistic Limits - Homogeneous Plate - Caliber .50 AP M2 Projectiles.

TABLE V

Percentage Increase in Resistance to Penetration Produced by Plate Obliquity.

TABLE VI

Effect of Obliquity on Resistance to Spalling.

TABLE VII

Ballistic Limit, Plate Normal, Projectile Normal vs. Ballistic Limit, Plate Normal, Projectile Yawed.

FIGURE I

Average Ballistic Limit vs. Obliquity.

CHART A

3/8" Plate - Ballistic Limit vs. Brinell Hardness - Ballistic Limit vs. Obliquity.

CHART B

1/2" Plate - Ballistic Limit vs. Brinell Hardness - Ballistic Limit vs. Obliquity.

CHART C

5/8" Plate - Ballistic Limit vs. Brinell Hardness - Ballistic Limit vs. Obliquity.

CHART D

3/4" Plate - Ballistic Limit vs. Brinell Hardness - Ballistic Limit vs. Obliquity.

CHART E

1" Plate - Ballistic Limit vs. Brinell Hardness - Ballistic Limit vs. Obliquity.

CHART F

Comparison of Plates of Different Thicknesses - Ballistic Limit vs. Brinell Hardness - All Plates Tested at 0°.

INCLOSURES

INCLOSURE A

Method of Inducing 90° Yaw in Caliber .50 AP M2 Projectiles.

INCLOSURE B

Computations.

APPENDICES

APPENDIX A

Ballistic Test Results.

APPENDIX B

Physical Test Results.

APPENDIX C

Correspondence.

INTRODUCTION

For some time it has been wondered whether the superior resistance to penetration of face-hardened armor over rolled homogeneous armor apparent in tests conducted with the plate normal to the line of fire warranted the additional expenditure of man-hours incidental to its production.

Inasmuch as most ballistic testing to determine the resistance to penetration of armor plate is conducted in this manner, even though a major portion of armor plate is installed at obliquities to the line of expected fire, it has further been wondered whether this superiority of face-hardened armor at normal incidence would be maintained when the line of fire was varied away from the perpendicular, or whether it would diminish or increase by such alteration. It was felt that the advantage of the face-hardened plate would be diminished as the obliquity of attack was increased, but insufficient data were available to confirm the contention.

Speculation as to the relative merits of the Army and Navy criteria of limit resistance to penetration has long been rampant and information concerning the relationship between ballistic limits based on each criterion was thought to be of value.

Whereas armor plate is installed in positions based on designs contemplating attack from a particular angle and with a particular caliber of projectile, it was considered worthwhile to investigate the effect of attack on such plate with projectiles of unexpected caliber.

There has been some question of the custom of testing armor for resistance to penetration at normal incidence when in service it may

be installed at obliquity. The "happy solution" would seem to be to test plate at the obliquity at which it would be used in service. However, plates of the same lot represented at the proving grounds by a single test plate may be installed in various positions and at various obliquities. Thus was the "happy solution" routed and the following query posed:

Is there an obliquity which might induce in a plate ballistic performance of a nature suitable to serve as a criterion of the performance of that plate at any obliquity?

It was further known that a divided armor construction consisting of an armor plate screened by dural sheet so as to tip the projectile in its flight and cause it to impact the armor at high yaw induced in the armor a great increase over its inherent resistance to penetration.

Previous observation had been made that when the relationship between plate thickness and projectile diameter (e/d) was greater than 1.0 resistance to penetration increased with increasing plate hardness. On the other hand it had been observed that when the projectile diameter was greatly in excess of the plate thickness, resistance to penetration decreased with increasing plate hardness. There naturally was aroused some curiosity concerning the value of e/d at which this inversion arose.

In view of these and other considerations a program of cooperation with the Carnegie-Illinois Steel Corporation was agreed to with the following ends in mind:

1. To determine the relationship between the ballistic limit of a plate based upon the Army criterion and its limit based upon the

Navy criterion.

2. To determine the effect of various hardnesses on resistance to penetration.

3. To determine the relative resistance to penetration of rolled face-hardened and rolled homogeneous armor.

4. To determine the effect of various hardnesses in homogeneous armor on resistance to spalling.

5. To determine the maximum hardness imparting optimum simultaneous resistance to penetration and to spalling for armor plate of various thicknesses and at various stages of obliquities.

6. To determine the relative resistance to spalling of rolled face-hardened and rolled homogeneous armor.

7. To determine the effect of obliquity upon resistance to penetration.

8. To determine the effect of obliquity upon resistance to spalling.

9. To determine whether any obliquity exists at which armor plate could be tested to determine what its behavior would be under attack from any quarter.

10. To observe the effects of induced projectile yaw.

Accordingly the following heat treated plates of rolled homogeneous nickel-chrome armor were shipped by the manufacturer, Carnegie-Illinois Steel Corporation:

Six (6) plates - 3/8"x36"x36"
Five (5) plates - 1/2"x36"x36"
Five (5) plates - 5/8"x36"x36"
Eight (8) plates - 3/4"x36"x36"
Ten (10) plates - 1" x 36"x36"

In addition there were on hand at this arsenal three face-hardened nickel-molybdenum armor plates as follows.

One (1) plate - [illegible]8"x36"
One (1) plate - [illegible]6"x36"
One (1) plate - 1/2"x36"x36"

By requisition from Aberdeen Proving Ground the following face-hardened nickel-molybdenum armor plates were received.

One (1) plate - 3/8"x36"x36"
One (1) plate - 5/8"x36"x36"
One (1) plate - 3/4"x36"x36"

All the face-hardened plates were of Henry Disston and Sons manufacture.

The homogeneous plates were of various hardnesses, as follows:

3/8" - BHN 2[illegible],245,[illegible]29,331,341,415
1/2" - BHN 241,282,302,331,415
5/8" - BHN 255,302,353,409,415
3/4" - BHN 259,2[illegible]1,302,304,363,378,388,398
1" - BHN 244,263,272,279,304,361,363,368,370,387

TEST PROCEDURE

Ballistic Tests

Ballistic tests were conducted on a one-hundred yard indoor firing range, using a caliber .50 Browning Machine Gun Barrel mounted in a rest permitting horizontal and vertical orientation of the gun to control the placement of shots on the target and compensate for any fluctuation in trajectory incidental to a variation in velocity. A 37 MM gun mounted in a 3" field piece permitting similar maneuverability was used for heavier fire.

Striking velocities were determined by the use of a pair of Aberdeen Chronographs connected to screens of metal foil mounted on

wooden frames. By this arrangement the average velocity of the projectile over the distance between the screens is determined from which the striking velocity can be computed from prepared correction tables.

Before firing, powder charges were estimated to produce the required striking velocity for each round and rounds were accordingly assembled from the following components:

Cal..50:

Projectiles - AP M2 Bullets, F.A. lot 418
Primed Cases- M1, F.A.
Powder - H.P. Co., Lot 4505, 1941 for 37 mm, M3

37 mm:

Projectiles - APC M51 Shot, P.A. lot 2737-15B, 1941
- TP M51 Shot, P.A. lot 3023-1, 1941
Cases - M16
Primers - M23A1
Powder - H.P. Co., Lot 4507, 1941 for 37 mm, M3

Plates were mounted in a stand designed to allow subjection to oblique fire by tilting backward.

Results produced on plates by projectile impact were recorded immediately after each round. Results produced on projectiles were recorded when determinable.

Physical Tests

Two sets of test specimens were cut out of each homogeneous plate at right angles to each other and Yield Strength, Tensile Strength, Elongation and Reduction in Area determined on one specimen by the Divider method and on the other specimen by the Recorder method.

Five impressions with a Standard Brinell machine using 3000 Kg. load were read on the plate cross-section and an average of these readings taken as the representative Brinell hardness number for

purposes of correlation.

RESULTS OF TESTS

Ballistic Tests

A summary of the ballistic test results obtained accompany the text as Table II, graphically represented in Charts A to F. Detailed firing records for each plate appear in Appendix A.

Physical Tests

A summary of the physical test results obtained appear as Table VIII in Appendix B.

DISCUSSION

I. Relation between Ballistic Limits Based on Army and Navy Criteria

The ballistic limit of a test plate is usually estimated by averaging two values. One of these is the highest velocity at which the plate resists complete penetration, and the other is the lowest velocity at which such resistance breaks down. Firing is usually continued until the difference between the two values is 50 feet per second or less. Thus the ballistic limit so estimated will vary from the actual theoretical ballistic limit by no more than ± 25 feet per second.

However the Army and the Navy have different criteria of complete penetration. The Army view is that penetration is complete when the nose of the projectile breaks through the rear of the plate sufficiently to allow the passage of a beam of light upon the removal of the projectile. The Navy, on the other hand, views as complete that type of penetration which is in effect a complete perforation, —

when the entire projectile, or a major portion of it, passes all the way through the plate and out through the rear.

Thus the same plate will have two ballistic limits, one based on the Army criterion of complete penetration and the other based on the Navy criterion, so long as there is a difference in the plate's resistance to penetration and to perforation.

Table I is a summary of the values obtained by dividing the average ballistic limit of plates of the same thickness based upon the Navy criterion by their ballistic limit based on the Army criterion.

It will be observed that as the obliquity of the plate is increased, this ratio diminishes, indicating a decrease in the lag between penetration and perforation. This same effect is evident as plate thickness is increased.

This lag between penetration and perforation apparently is dependent (in homogeneous plate) on the relationship between the effective thickness of the plate (which increases with plate obliquity) and the ogive height of the projectile. The lag is greatest when the ratio between effective plate thickness and ogive height is small.

In face-hardened plate, however, there is scarcely any lag between penetration and perforation. The projectile continually shatters upon impact against the hard case of the armor until a critical velocity is reached whereupon a very slight increase in velocity apparently imparts to the projectile a property of resistance to shattering. (This velocity may depend on its relation to the rate of deformation of the projectile.) Then and not until then does the projectile properly undertake its function of penetration. The velocity attained by this time is more than that necessary for mere penetration and is

often more than sufficient for perforation. Thus, in many cases, perforation and penetration coincide in face-hardened armor, resulting in a unity of Army and Navy ballistic limits.

As to a relative evaluation of the merits of each criterion it can only be said that each has advantages and disadvantages. The Army criterion lends itself more easily to determination and is accordingly an easier tool with which to work in ballistic testing. The Navy criterion is difficult of determination, unless special equipment is employed, and so is not so universally adaptable for testing. The Navy criterion however, is more adaptable to mathematical treatment than the Army criterion. Each test has its particular field, therefore, - the Army test for proof firing, and the Navy test for research firing.

II. Effect of Hardness on Resistance to Penetration

In all thicknesses of plate and at all obliquities, an increase in hardness was accompanied, in general, by an increase in resistance to penetration, when impact was made with caliber .50 AP M2 projectiles. (Table II.) This is in keeping with the contention that increasing plate hardness increases resistance to penetration until a point of hardness is reached at which severe spalling lessens the effective thickness of the plate and, thereby, its resistance. The hardnesses encountered in this study were evidently not of the order to induce spalling of such severity as to effect the resistance of the plate to penetration to any great extent.

In the case of those plates which were impacted with 37 mm APC M51 projectiles, their resistance to penetration by this caliber

projectile diminished as plate hardness increased, even in the range of hardness where spalling was not attendant.

When plates were tested with caliber .50 AP M2 projectiles the ratio of plate thickness to projectile diameter (e/d) ranged from .83 upward. In the case of the 37 mm APC M51 tests against 1" plate the ratio was .686. This would seem to indicate a value for e/d between .83 and .686 at which the correlation between plate hardness and resistance to penetration is inverted. However, inasmuch as the mass effect of the 37 mm APC M51 is much greater for the same value of e/d than that of the caliber .50 AP M2 and because the two projectiles are of different construction this indication may be of slight significance.

Further tests with caliber .50 AP M2 projectiles against 1/4" plate (where e/d $<$.686) would be helpful in resolving this question.

III. Relative Resistance to Penetration of Rolled Face-Hardened and Homogeneous Armor

The face-hardened plate tested at normal incidence with caliber .50 AP M2 projectiles offered greatly superior resistance to penetration than the best of the homogeneous plates so tested. This superiority was greater in the case of light plate than in the case of heavier plate. (Tables II, III.)

Except in the case of 3/8" plate, where the difference was considerable, there was no remarkable difference between the resistance to perforation of face-hardened plate and the best of the homogeneous plate, although there still was considerable range between the performance of the poorest and best homogeneous plate.

In the case of 3/4" plate all plates offered comparable resistance to perforation at normal incidence.

As the obliquity was increased, however, the superiority of face-hardened plate diminished, until at 20° the resistance to perforation, and at 30° the resistance to penetration of the best of the homogeneous plate and the face-hardened plate was substantially equal. However, there was still considerable range from the poorest to the best plate, so that on the whole the resistance of the face-hardened plate was superior to that of the homogeneous.

In general, an increase in obliquity or an increase in plate thickness tended to render more comparable the resistance of both types. It was also observed that relative resistance to perforation of the two types tended to be closer than their relative resistance to penetration.

This trend is attributable to two factors operating conjunctively. On the one hand, as effective plate thickness increases plate resistance may be more dependent on plate mass than on any physical property. At the same time, on the other hand, the projectile velocities necessary to effect penetration of heavy plate probably exceed that range where the hard case of face-hardened plate effects projectile shattering.

In the case of plate tested with 37 mm APC M51, the softer homogeneous plate exhibited slightly superior resistance to penetration and perforation than did the face-hardened. In general, however, the resistance of both types was similar.

IV. Effect of Hardness on Resistance to Spalling

It has long been believed that resistance to spalling decreases as plate hardness increases. The results of this study confirm this contention. Further, some light may be shed on the question of critical hardness on the basis of resistance to spalling.

In all thicknesses tested with caliber .50 AP M2 projectiles plates of Brinell hardness less than BHN 360 resisted spalling. A 1" plate of BHN 368, on the other hand, spalled under impact with this caliber projectile. All plates of Brinell hardness in excess of BHN 400 showed poor ductility. (Table II.)

This would indicate a critical range from BHN 360 to BHN 400 for plates in the thickness range 3/8" to 1", on the basis of resistance to spalling upon impact with caliber .50 AP M2 projectiles. Previous observation has indicated that the critical hardness for plates of lighter gauge would lie in the higher section of such a range and in the lower section for plates of heavier gauge. A poor distribution of hardness among the plates of lighter gauge resulting in no light plates within this range precludes confirmation of the first half of this observation by this study. However, the results in the case of 1" plate indicate that the latter part of the observation was well made, — a critical hardness around BHN 365 being indicated for this plate thickness and this armor composition.

In the case of impacts with 37 mm projectiles, resistance to spalling in plates considerably overmatched broke down at very low hardness. However as plate thickness (at 1") afforded a semblance of match for the projectile, no failures below BHN 300 were recorded.

V. Maximum Hardness Imparting Optimum Simultaneous Resistance to Penetration and Spalling

Inasmuch as an increase in plate hardness produces an increase in resistance to penetration up to the point when spalling decreases the effective thickness of the plate, the maximum hardness imparting optimum simultaneous resistance to penetration and spalling in plates in the thickness range 3/8" to 1" under impact with caliber .50 AP M2 projectiles will lie within the hardness range critical to resistance to spalling suggested above. (Section IV.)

There is, thus, an inclusive range, from BHN 360 to BHN 400 for plates of the entire thickness range in this study, with a probable specific range around BHN 365 for 1" plate, and higher specific ranges within the inclusive range in inverse correlation with plate thickness.

Against 37 mm APC M51 impact, inasmuch as resistance to spalling and resistance to penetration vary inversely with hardness, a much lower plate hardness would seem to furnish optimum resistance properties.

VI. Relative Resistance to Spalling of Rolled Face-Hardened and Homogeneous Armor

As was expected, homogeneous plate of low hardness showed much greater resistance to spalling under impact with caliber .50 AP M2 projectiles than did face-hardened plate. However, plates of light gauge, even though of low hardness, sometimes spalled under the impact of greatly overmatching 37 mm projectiles. (Table II.)

Homogeneous plate of high hardness, on the other hand, exhibited no considerably greater resistance to spalling than face-

hardened plate. The face-hardened plate spalling, however, was generally of a more serious degree than that of homogeneous plate.

The degree of spalling may well be a measure of the relative merits of both types of armor.

VII. Effect of Obliquity on Resistance to Penetration

A. Cal..50 AP M2 Projectiles

1. Army Criterion

a. Obliquity - 10°

At 10° obliquity the average plate offered greater resistance to penetration than at normal incidence (Table IV, V, Figure 1) but in some cases (Plate 194273B4 and Plate 194275C3, Table II) a plate offered less resistance at 10° than it did at normal.

This apparent discrepancy in results is not without the realm of explanation, however. Bullets in normal flight, especially when impeded in their course by some slight obstruction such as that afforded by the metal foil of a chronograph screen, may yaw as much as 7 degrees. This maximum yaw operating against a plate installed at normal would result in an effective yaw of the same order - 7°; whereas operating against a plate set at 10° obliquity it could produce an effective yaw ranging from 3° to 17°. A combination of the 3° effective yaw against the plate set at 10° and a 7° yaw against the normally installed plate could well result in the inverted values reported.

b. Obliquity - 20°

At 20° obliquity the average 3/4" plate was equal in resistance to penetration to the average 1" plate at normal

incidence; the average 5/8" plate was much better than the average 3/4" plate at normal, and the average 1/2" plate was much better than the average 5/8" plate at normal.

In the light of these observations it seems reasonable to conclude that homogeneous armor plate installed at 20° obliquity offers resistance to penetration equal to that of armor plate 1.25 times as thick at normal incidence. (See Inclosure B.)

The 3/8" face-hardened plate No. 12 offered less resistance at 20° than it did at normal, but this phenomenon doubtless is attributable to the high spalling tendency of this plate.

c. Obliquity - 30°

At 30° obliquity the average 5/8" plate offered considerably greater resistance to penetration than the average 1" plate at normal incidence; the average 1/2" plate was very much better than the average 3/4" plate at normal, and the average 3/8" plate is about as effective as an average 9/16" plate at normal would be, estimated from the performance of 1/2" and 5/8" plate at normal.

Thus we may imply that homogeneous armor plate installed at 30° obliquity offers resistance to penetration equal to that of plate 1.3 as heavy at normal.

d. Obliquity - 40°

At 40° obliquity the average 1/2" plate was greatly superior to the average 1" plate at normal, and the 3/8" plate was equivalent to the 3/4" plate at normal.

Thus armor plate installed at 40° obliquity offers resistance to penetration equal to that of plate 1.5 times as heavy at normal.

e. Obliquity - 45°

At 45° obliquity the average 3/8" plate was equal to the average 1" plate at normal.

This would seem to indicate that homogeneous armor installed at 45° obliquity offers resistance equal to that of plate 1.9 times as heavy at normal.

2. Navy Criterion

In general, the increase in resistance to perforation engendered by increasing the obliquity was of the same order as the increase in resistance to penetration.

In the case of 3/8" plate at 30°, however, the average resistance to perforation was equal to that of 5/8" plate at normal. There was thus a slightly higher increase in resistance to perforation than in resistance to penetration effected in this plate thickness by this increase in obliquity.

B. 37 MM AP M51 Projectiles

At 20° there was an average increase in resistance to penetration of 10%, and an average increase in resistance to perforation of 14% in 1" plates tested with 37 MM AP M51 projectiles.

C. In General

While a great amount of weight may apparently be saved by installing plate at obliquities to the line of expected fire, the possibility of fire from an unexpected quarter should not be overlooked. Projectiles fired from the above or propelled from the ground with high trajectories may well wreak havoc on installations designed to withstand horizontal fire alone.

VIII. Effect of Obliquity on Resistance to Spalling

In the case of some of the plates which failed to resist spalling when impacted with caliber .50 AP M2 projectiles, for example, 3/8" face-hardened plate No. 12, 1/2" homogeneous plate No. 181206A2, and 3/4" homogeneous plate No. 194273F, this failure was evident at normal incidence, and continued through all obliquities encountered. In the case of 5/8" homogeneous plate No. 196198-7, spalling occurred at normal incidence, was resisted at 20°, but reappeared at 30°. The 3/4" face-hardened plate No. 10 spalled at normal incidence, but at obliquities 10°, 20°, and 30° resisted spalling. (Table VI.)

In all other cases spalling was resisted at normal but occurred at obliquity.

All the plates impacted with 37 mm projectiles which spalled under such impact, exhibited this weakness at all obliquities and at normal incidence.

In general then, it may be observed that an increase in obliquity will tend to reveal in a plate any inherent spalling propensity, although it may not be evident at normal incidence or at low obliquity.

Although the behavior of homogeneous plate No. 196198-7 and face-hardened plate No. 10 does not align with this principle, it is felt there is an explanation.

Spalling tendency may be localized in some plates, and inasmuch as impacts in this study were directed, as far as possible, at different areas of a plate for each obliquity, such localized spalling proclivities could effect results of the nature obtained.

IX. Optimum Obliquity for Plate Testing

From the results observed in this study, it appears that no one obliquity will serve as a criterion of the behavior of a plate in each and every position relative to the line of fire. It is to be noted, however, that spalling tendencies, if at all inherent, tend to be revealed under fire at high obliquity.

Whenever feasible, then, it would seem that plate should be tested at as nearly as possible the obliquity at which it will be installed in service.

Where plate of the same heat or lot is to be installed randomly, as is frequently the case, it would appear reasonable that a statistically sound sample of such plate be subjected to test at various representative obliquities. In this way any tendency toward spalling, incapable of discovery in a test at normal incidence, could be revealed.

X. Effects of Projectile Yaw

By placing a sheet of 1/8" Dural at an obliquity of 40°, seven feet, six inches in front of the principal armor, and another sheet of 1/8" Dural at 0° obliquity three feet in front of the armor, it was possible to induce in a caliber .50 AP M2 projectile yaw which at the point of impact with the armor amounted to 90° approximately. This divided armor construction offered much greater resistance to penetration than would a single piece of armor of the same weight at normal incidence. (Table VII.) It afforded protection, equal to that of a plate (at normal incidence) twice as heavy as the combined weights of its components.

Where divided armor of this type is feasible and where fire may be expected from a specific quadrant, a great saving in armor weight and/or a great increase in protection may be effected by such an arrangement.

However, the weakness in this type of protective device lies in its depth, inasmuch as fire from an unanticipated quarter, directed at a target behind the principal armor would not be directed through the tipping screens and the projectile, although impacting the plate obliquely, would be unyawed.

TABLES AND FIGURES

TABLE I

Effect of Obliquity on Ratio of Average Navy/Army Ballistic Limits

Caliber .50 AP M2 Projectiles

Plate Gauge	Obliquity 0°	10°	20°	30°	40°	45°
3/8"	-	-	-	1.43	1.29	1.12
1/2"	1.31	-	1.26	1.07	1.02	-
5/8"	1.27	-	1.12	1.06	-	-
3/4"	1.21	1.16	1.10	1.04	-	-
1"	1.11	1.11	1.03	-	-	-

TABLE II

Summary of Ballistic Results

Plate No.	Type	Gage	BHN	Proj.	Ballistic Limits: Army 0°	Army 10°	Army 20°	Army 30°	Army 40°	Army 45°	Navy 0°	Navy 10°	Navy 20°	Navy 30°	Navy 40°	Navy 45°	Ductility: Pen.	Ductility: Shock
90585A11	Homo	3/8"	241	.50	969	-	1048	1130	1575	2120	1464	-	1642	1994	2095	2406	O.K.	-
186383B4	Homo	3/8"	245	.50	-	-	-	1165	1732	2203	1407	-	1646	1880	2405	2585	O.K.	-
90585A10	Homo	3/8"	329	.50	-	-	-	1507	-	2405	1522	-	-	2135	-	2629	O.K.	-
186383A2	Homo	3/8"	331	.50	-	-	-	1818	1919	2530	1472	-	2182	2126	2627	2715	O.K.	-
186383B3	Homo	3/8"	341	.50	-	-	-	1315	2113	2491	1511	-	1899	2027	2645	2801	O.K.	-
186383B1	Homo	3/8"	415	.50	-	-	-	1970	2348	2521	1500	-	2165	2260	2639	2899	Sp	-
P303-#12	F.H.	3/8"	601/375	.50	2069	-	2050	2140	2308	2721	2101	-	2271	2331	2308	2721	Sp	-
194268B7	Homo	1/2"	261	.50	1267	-	1488	1922	2427	-	1748	-	2192	2397	2427	-	O.K.	O.K.
194268B8	Homo	1/2"	282	.50	1320	-	-	-	-	-	1770	-	-	-	-	-	O.K.	-
194268B5	Homo	1/2"	302	.50	1339	-	1521	2259	2602	-	1840	-	2247	2287	2726	-	O.K.	Sp
194268B1	Homo	1/2"	321	.50	1415	-	1860	2402	2796	-	1901	-	2206	2402	2796	-	O.K.	O.K.
181206A2	Homo	1/2"	415	.50	1350	-	1902	2470	2800	-	1522	-	1902	2636	2883	-	Sp	Sp
#330	F.H.	1/2"	653/363	.50	2144	2253	2395	2681	2968	-	2144	2253	2395	2681	2968	-	O.K.	Sp
196198-1	Homo	5/8"	255	.50	1439	-	1838	2046	2530	-	1896	-	2610	2785	-	-	O.K.	O.K.
196198-3	Homo	5/8"	302	.50	1523	-	1870	2442	2729	-	1996	-	2176	2442	2757	-	O.K.	Sp
196198-5	Homo	5/8"	359	.50	1646	-	2161	2688	-	-	2177	-	2161	2688	-	-	O.K.	O.K.
196198-7	Homo	5/8"	409	.50	1639	-	2355	2773	-	-	2024	-	2355	2799	-	-	Sp	Sp
196198-8	Homo	5/8"	415	.50	1640	-	2219	2881	-	-	1999	-	2464	2881	-	-	O.K.	Broke
P303	F.H.	5/8"	-	.50	2311	-	2596	2726	-	-	2311	-	2623	-	-	-	O.K.	-
194273B1	Homo	3/4"	269	.50	1798	1786	2010	2415	-	-	2185	2174	2438	2513	-	-	O.K.	Sp
194273B2	Homo	3/4"	271	.50	1742	1739	2176	2336	-	-	2130	2164	2303	2572	-	-	O.K.	O.K.
194273B3	Homo	3/4"	302	.50	1825	1907	2269	2601	-	-	2242	2293	2552	2863	-	-	O.K.	-
194273B4	Homo	3/4"	304	.50	1877	1809	2218	2618	-	-	2250	2264	2721	2870	-	-	O.K.	O.K.
194273B6	Homo	3/4"	363	.50	1921	1959	2451	2932	-	-	2316	2316	2638	2932	-	-	O.K.	Sp
194273B7	Homo	3/4"	378	.50	1924	2133	2682	3025	-	-	2272	2412	2851	3070	-	-	Sp	Sp
194273B5	Homo	3/4"	388	.50	1886	2005	2570	2897	-	-	2318	2341	2792	-	-	-	Sp	-
194273B8	Homo	3/4"	388	.50	1890	2367	2560	-	-	-	2263	2394	2617	-	-	-	O.K.	Cracks
G303-#10	F.H.	3/4"	597/435	.50	2277	2627	2858	3024	-	-	2277	2627	2858	3024	-	-	Sp	Sp

TABLE II (Cont'd)

Plate No.	Type	Gage	BHN	Proj.	Ballistic Limits Army 0°	10°	20°	30°	40°	45°	Navy 0°	10°	20°	30°	40°	45°	Ductility Pen.	Shock
194275C2	Homo	1"	263	.50	2208	2256	-	-	-	-	2471	2505	-	-	-	-	O.K.	O.K.
194275C1	Homo	1"	272	.50	2205	2265	2354	-	-	-	2475	2734	2647	-	-	-	O.K.	O.K.
194275C	Homo	1"	279	.50	2173	-	-	-	-	-	2444	-	-	-	-	-	O.K.	O.K.
194275C3	Homo	1"	304	.50	2269	2287	2647	-	-	-	2548	2620	2756	-	-	-	O.K.	O.K.
194275C5	Homo	1"	361	.50	2509	2465	2868	-	-	-	2705	2742	2956	-	-	-	O.K.	Sp
194275C8	Homo	1"	363	.50	2441	2505	2703	-	-	-	2698	2696	2829	-	-	-	O.K.	O.K.
194275C6	Homo	1"	368	.50	2480	2481	2869	-	-	-	2713	2872	2906	-	-	-	Sp	Sp
194275C4	Homo	1"	370	.50	2486	2577	2893	-	-	-	2711	2687	2913	-	-	-	O.K.	Cracks
194275C7	Homo	1"	387	.50	2451	2577	2932	-	-	-	2728	2772	2932	-	-	-	Sp	-
#293	F.H.	1"	601/363	.50	2882	-	-	-	-	-	2978	-	-	-	-	-	Sp	Sp
194275C9	Homo	1"	244	37 MM	1279	-	-	1446	-	-	1418	-	-	1584	-	-	O.K.	-
194275C2	Homo	1"	263	37 MM	1223	-	1243	-	-	-	1384	-	1608	-	-	-	O.K.	-
194275C	Homo	1"	279	37 MM	-	-	1278	1379	-	-	.	-	1518	1540	-	-	O.K.	-
194275C3	Homo	1"	304	37 MM	1142	-	1334	-	-	-	1382	-	1457	-	-	-	O.K.	-
194275C5	Homo	1"	361	37 MM	1071	-	1254	-	-	-	1289	-	1344	-	-	-	Sp	-
194275C6	Homo	1"	368	37 MM	947	-	1143	-	-	-	1008	-	1231	-	-	-	Sp	-
#7	F.H.	1"	555/384	37 MM	1224	-	1437	1419	-	-	1380	-	1686	-	-	-	Sp	-

TABLE III

Effect of Obliquity on Ratio of Resistance to Penetration of Face-Hardened Armor to That of the Best Rolled Homogeneous Armor*

Plate Gauge	Army						Navy					
	0°	10°	20°	30°	40°	45°	0°	10°	20°	30°	40°	45°
3/8"	-	-	-	1.09	1.03	1.08	1.38	-	1.04	1.03	.87	.94
1/2"	1.52	-	1.26	1.09	1.06	-	1.13	-	1.07	1.02	1.03	-
5/8"	1.40	-	1.10	.95	-	-	1.06	-	1.05	-	-	-
3/4"	1.18	1.11	1.07	1.00	-	-	.98	1.09	1.00	.99	-	-
1"	1.15	-	-	-	-	-	1.09	-	-	-	-	-

*Tested with caliber .50 AP M2 projectiles.

TABLE IV

Effect of Obliquity on Average Ballistic Limits - Homogeneous Plate

Caliber "0 AP M2 Projectiles

Plate Gauge	0°	10°	20°	30°	40°	45°
			Army			
3/8"	-	-	-	1450	1917	2378
1/2"	1338	-	1692	2263	2656	-
5/8"	1577	-	2088	2566	-	-
3/4"	1857	1963	2367	2689	-	-
1"	2358	2426	2752	-	-	-
			Navy			
3/8"	1479	-	1906	2070	2482	2672
1/2"	1756	-	2136	2430	2708	-
5/8"	2018	-	2333	2719	-	-
3/4"	2247	2291	2614	2803	-	-
1"	2610	2703	2848	-	-	-

TABLE V

Percentage Increase in Resistance to Penetration Produced by Plate Obliquity

Plate Gauge	Army					Navy				
	10°	20°	30°	40°	45°	10°	20°	30°	40°	45°
3/8"	-	-	-	-	-	-	29%	40%	68%	81%
1/2"	-	26%	69%	99%	-	-	21%	38%	54%	-
5/8"	-	32%	62%	-	-	-	16%	35%	-	-
3/4"	6%	27%	45%	-	-	2%	16%	25%	-	-
1"	3%	16%	-	-	-	4%	9%	-	-	-

TABLE VI

Effect of Obliquity on Resistance to Spalling

Plate No.	Gauge	Type	BHN	Proj.	Obliquity 0°	10°	20°	30°	40°	45°
186383E1	3/8"	Homo	415	.50	O.K.	-	O.K.	O.K.	Sp	Sp
P303-#12	3/8"	F.H.	601/375	.50	Sp	-	Sp	Sp	Sp	Sp
181206A2	1/2"	Homo	415	.50	Sp	-	Sp	Sp	Sp	-
196198-7	5/8"	Homo	409	.50	Sp	-	O.K.	Sp	-	-
194273B7	3/4"	Homo	378	.50	Sp	Sp	Sp	Sp	-	-
194273B5	3/4"	Homo	388	.50	O.K.	Sp	Sp	Sp	-	-
C303-#10	3/4"	F.H.	597/435	.50	Sp	O.K.	O.K.	O.K.	-	-
194275C6	1"	Homo	368	.50	O.K.	O.K.	Sp	-	-	-
194275C7	1"	Homo	387	.50	O.K.	O.K.	Sp	-	-	-
#293	1"	F.H.	601/363	.50	Sp	-	-	-	-	-
194275C5	1"	Homo	361	37 MM	Sp	-	Sp	-	-	-
194275C6	1"	Homo	368	37 MM	Sp	-	Sp	-	-	-
#7	1"	F.H.	555/384	37 MM	Sp	Sp	Sp	-	-	-

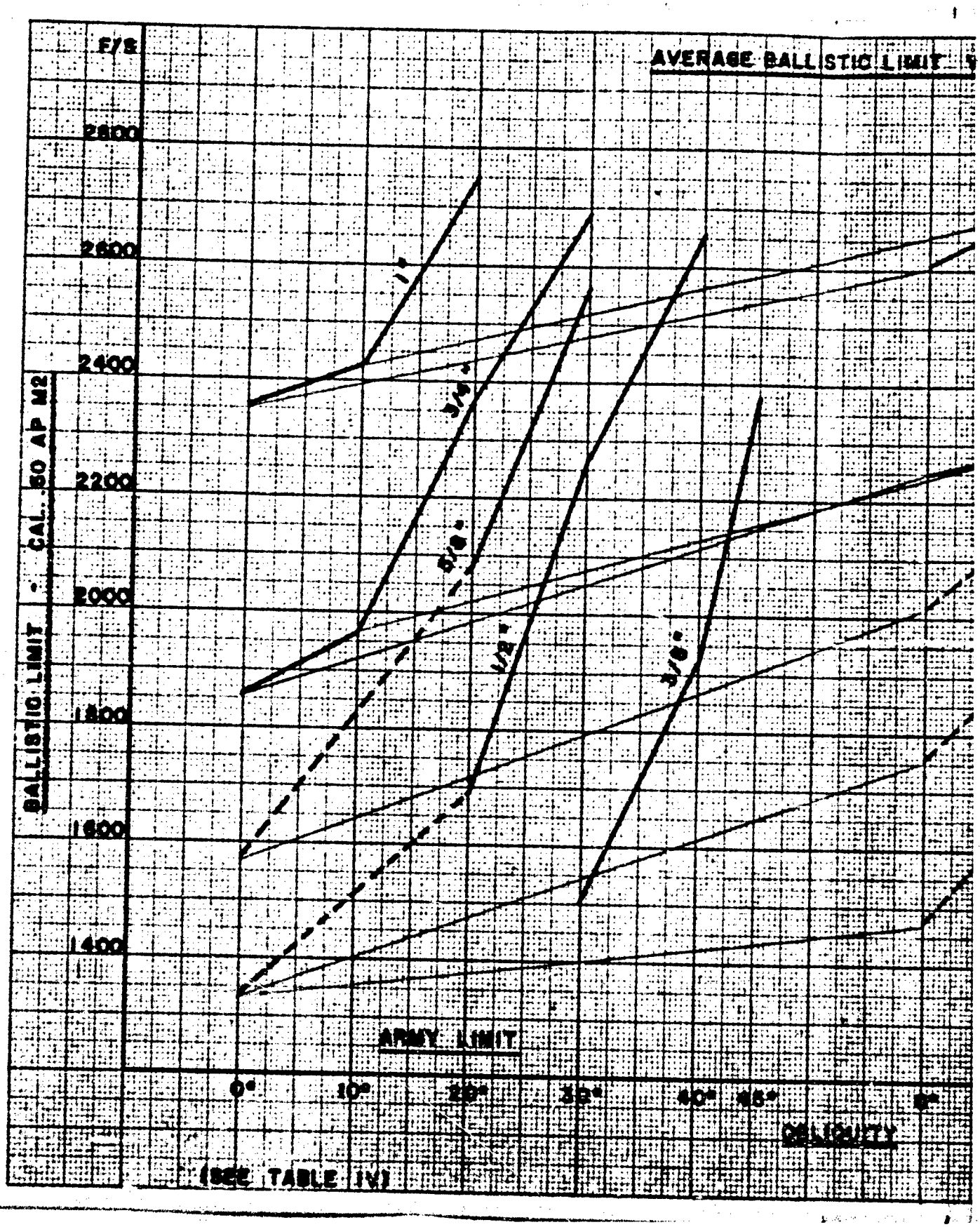
TABLE VII

Ballistic Limit, Plate Normal, Projectile Normal

vs

Ballistic Limit, Plate Normal, Projectile Yawed

Plate No.	Plate Thickness	Type	BHN	Army Normal Impact	Army Yawed Impact	Navy Normal Impact	Navy Yawed Impact
90585A10	3/8"	Homo	329	—	2706	—	—
186383E1	3/8"	Homo	415	—	2422	1500	2436
P303-#12	3/8"	F.H.	601/375	2069	2314	2101	2380


F/S
AVERAGE BALLISTIC LIMIT
2800
2600
2400
2200
2000
1800
1600
1400
BALLISTIC LIMIT - CAL. .50 AP M2
1"
3/4"
5/8"
1/2"
3/8"
ARMY LIMIT
0°
10°
20°
30°
40°
45°
OBLIQUITY
(SEE TABLE IV)

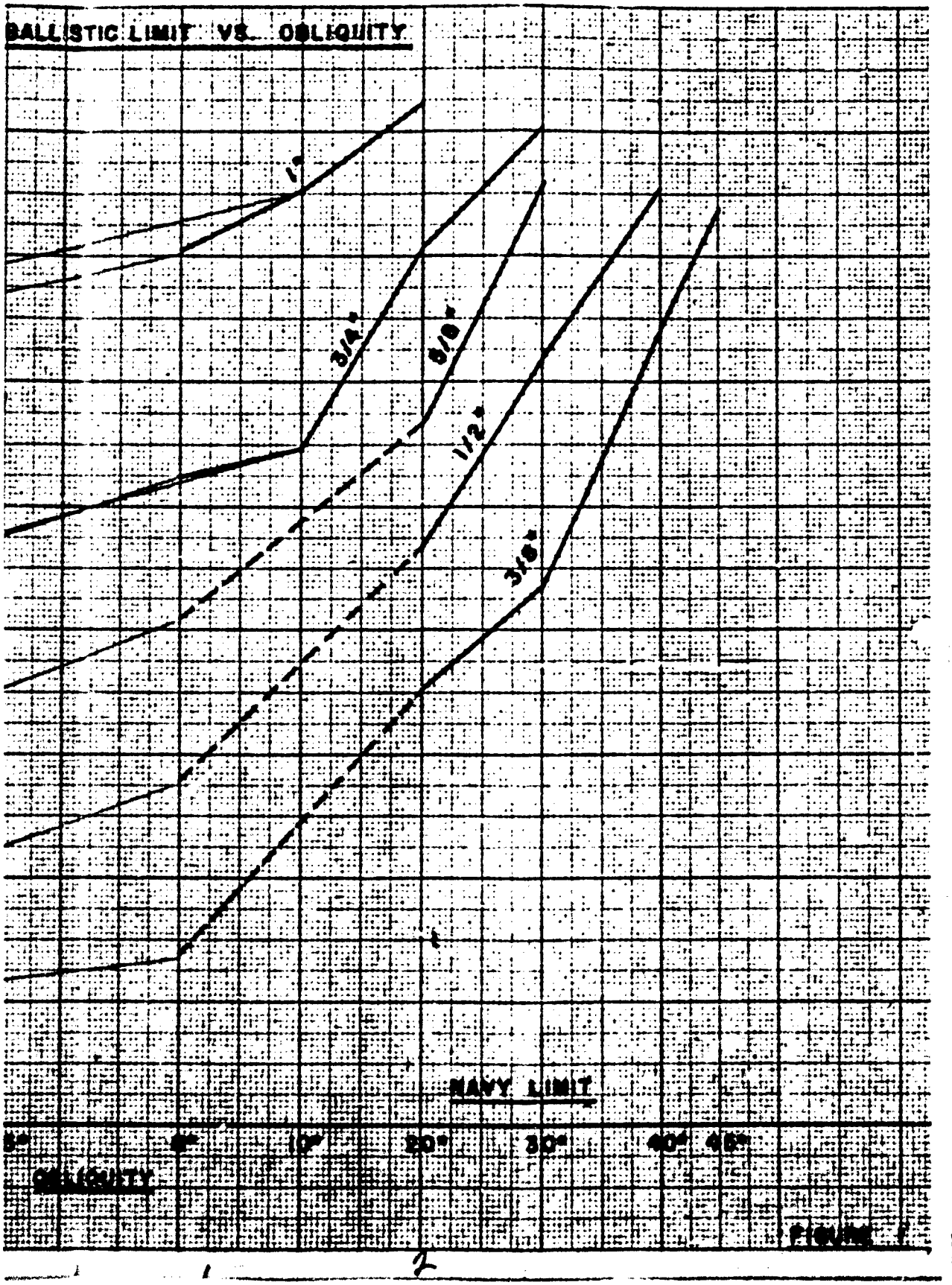
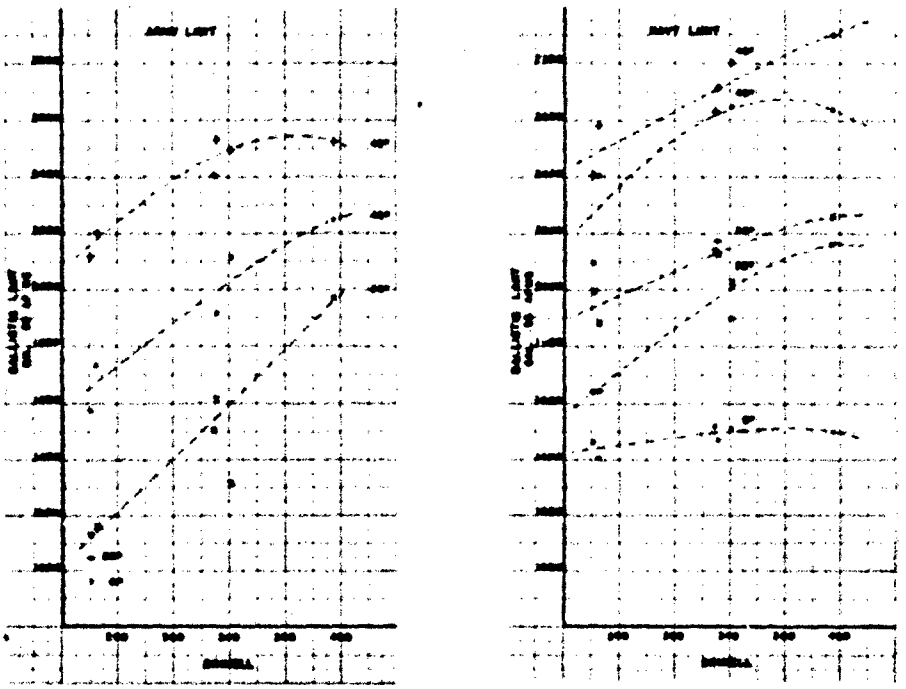
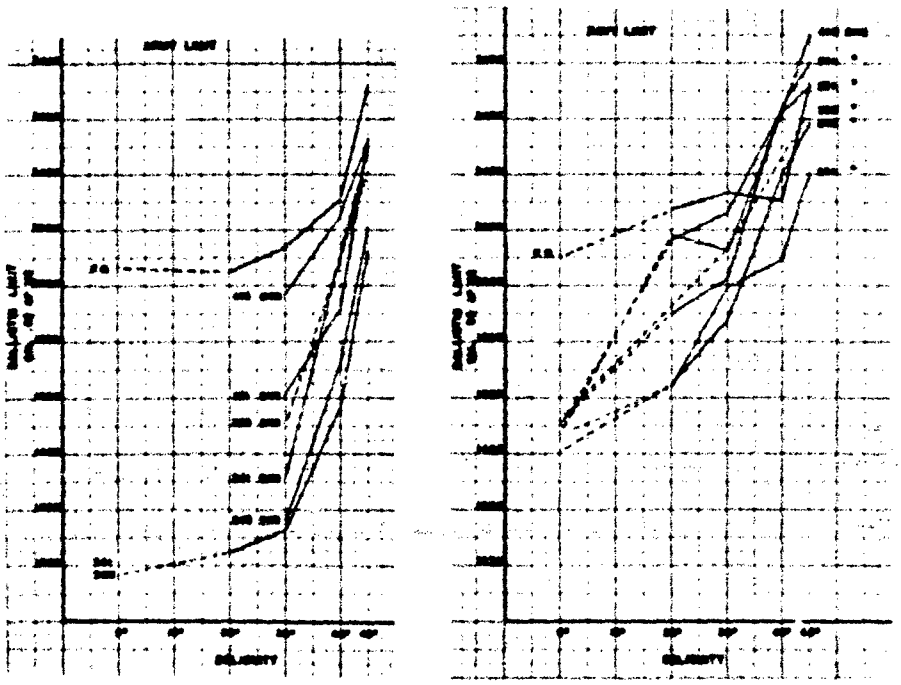

BALLISTIC LIMIT VS. OBLIQUITY
1"
3/4"
5/8"
1/2"
3/8"
NAVY LIMIT
0°
5°
10°
20°
30°
40°
45°
OBLIQUITY

FIGURE 1

3/8" PLATE

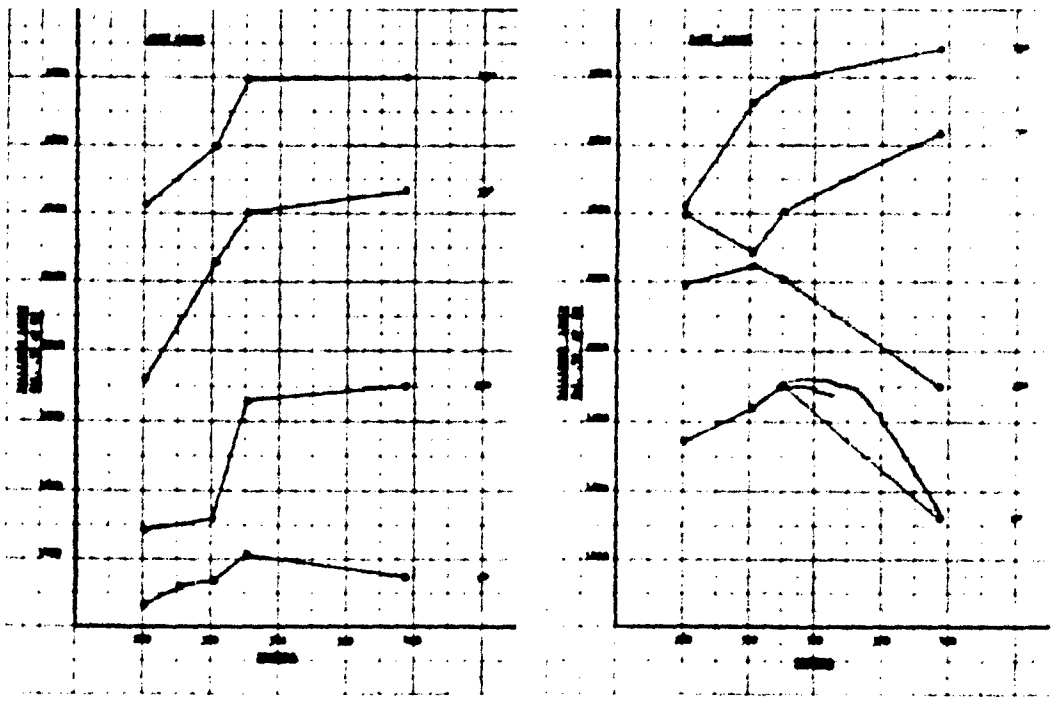


BALLISTIC LIMIT vs BRINELL HARDNESS

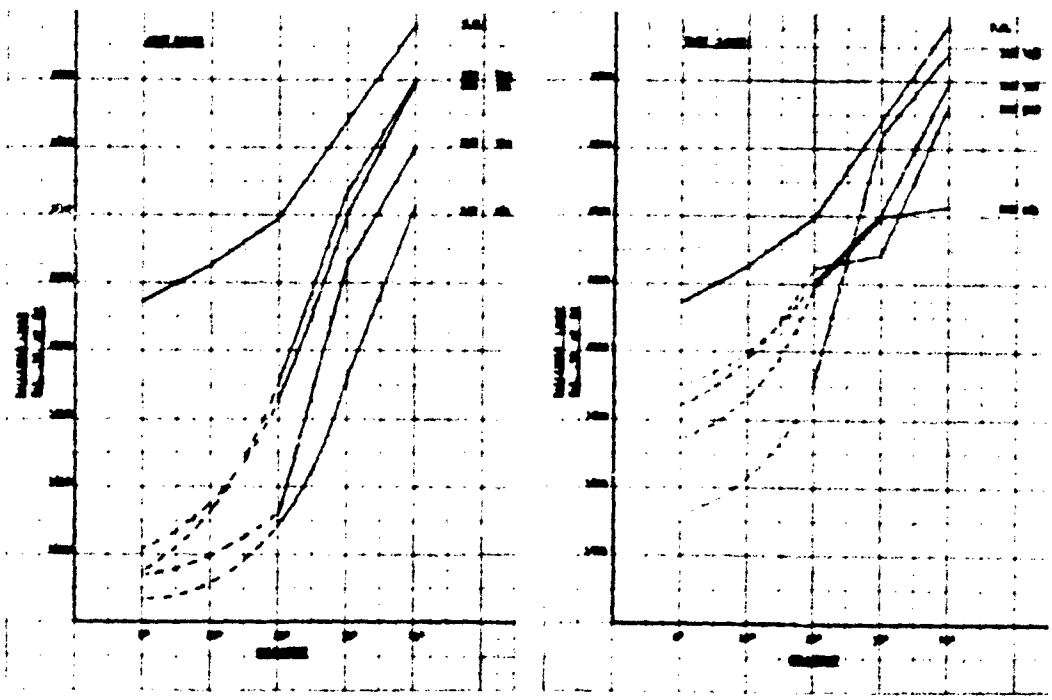


W.A.63-4279 BALLISTIC LIMIT vs OBLIQUITY CHART A

1/2" PLATE



BALLISTIC LIMIT vs BRINELL HARDNESS

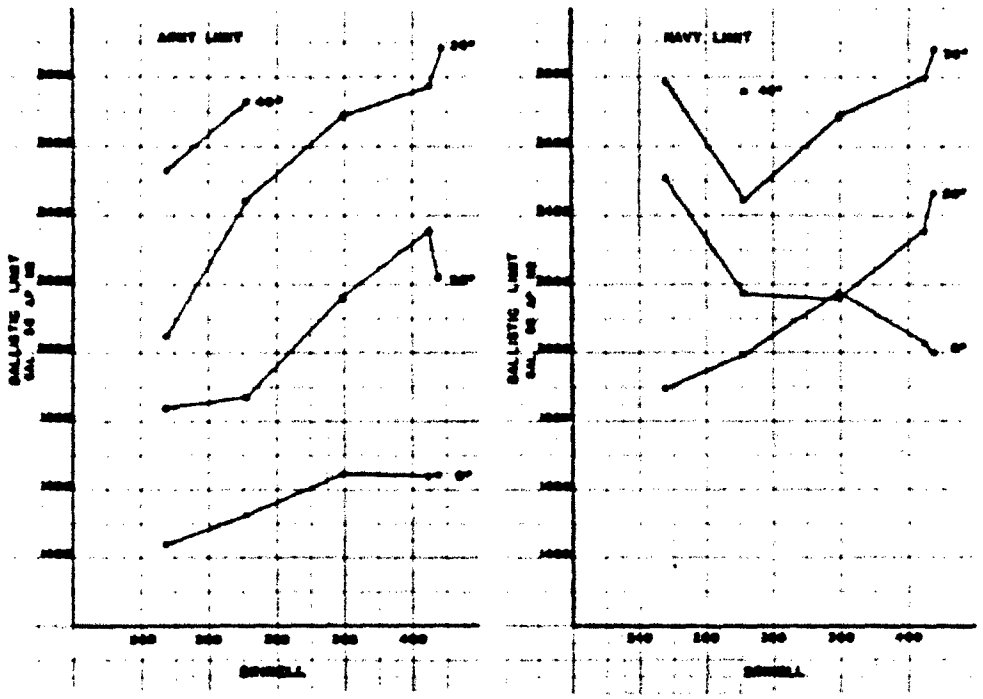


W.A.639-4180

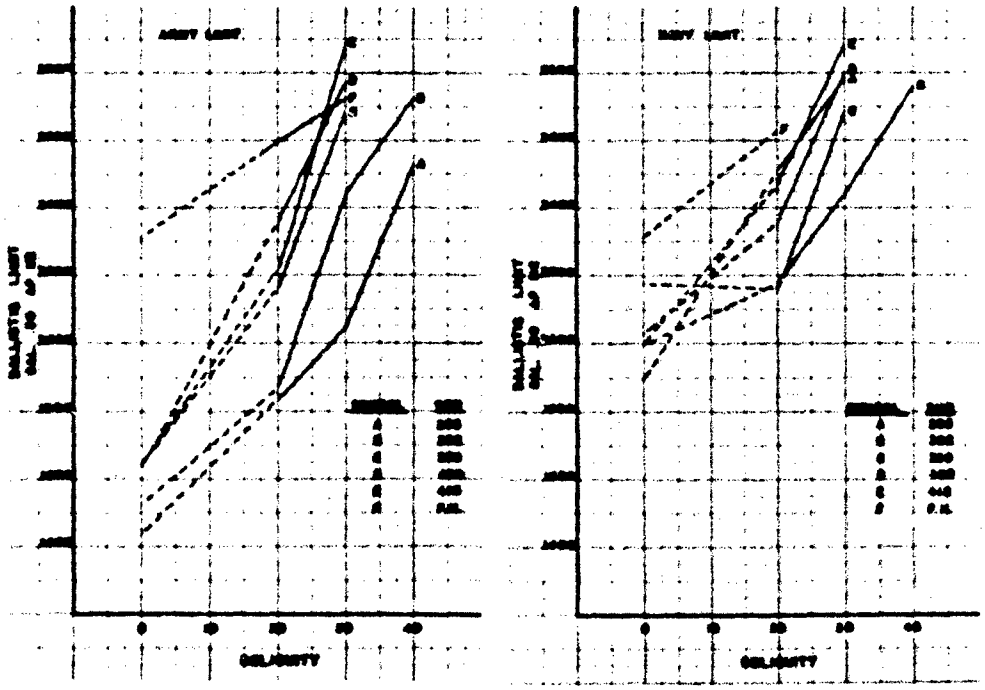
BALLISTIC LIMIT vs OBLIQUITY

CHART B

5/8" PLATE

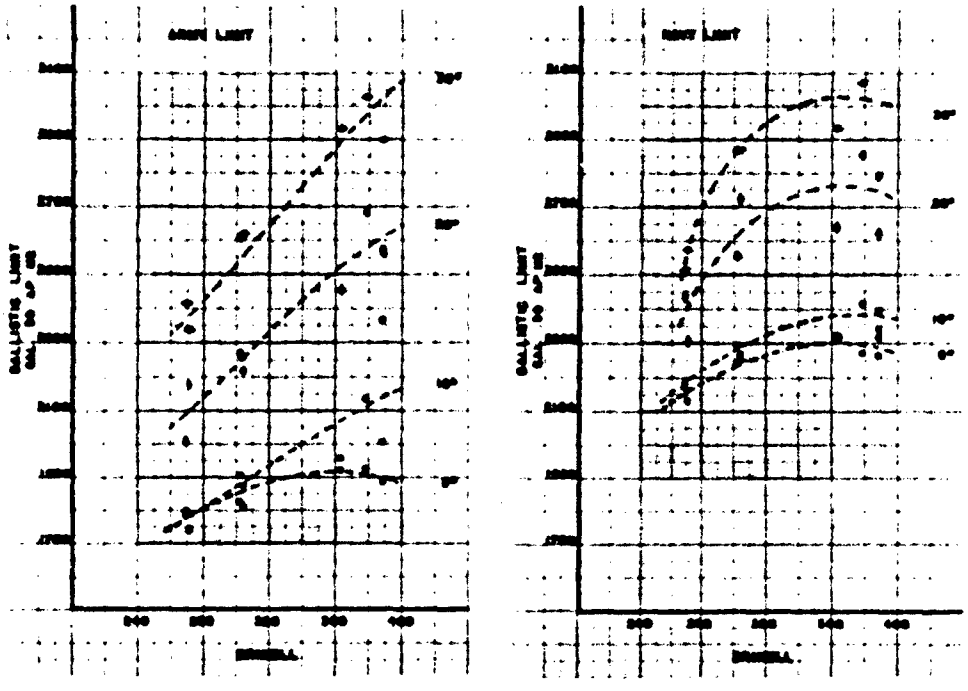


BALLISTIC LIMIT vs BRINELL HARDNESS

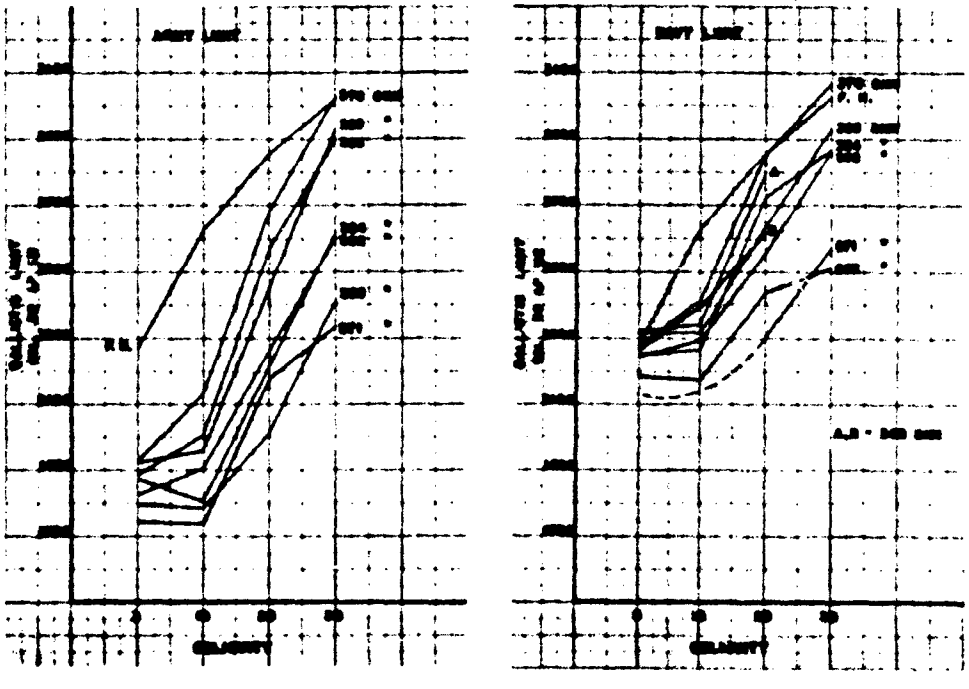


W.S.63-4281 BALLISTIC LIMIT vs OBLIQUITY CHART C

3/4" PLATE

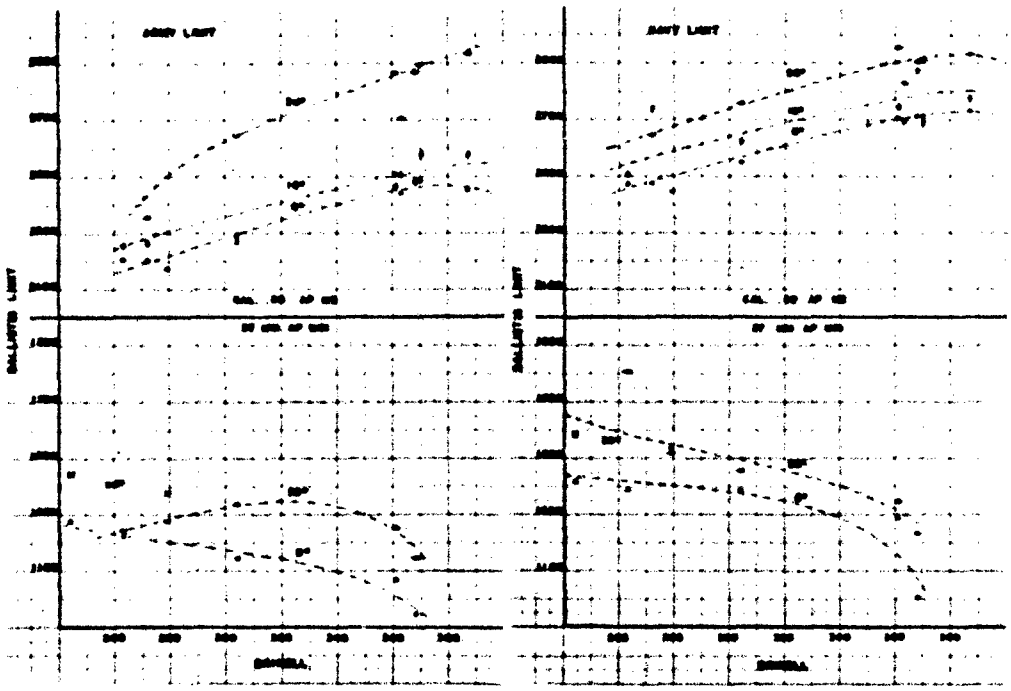


BALLISTIC LIMIT vs BRINELL HARDNESS

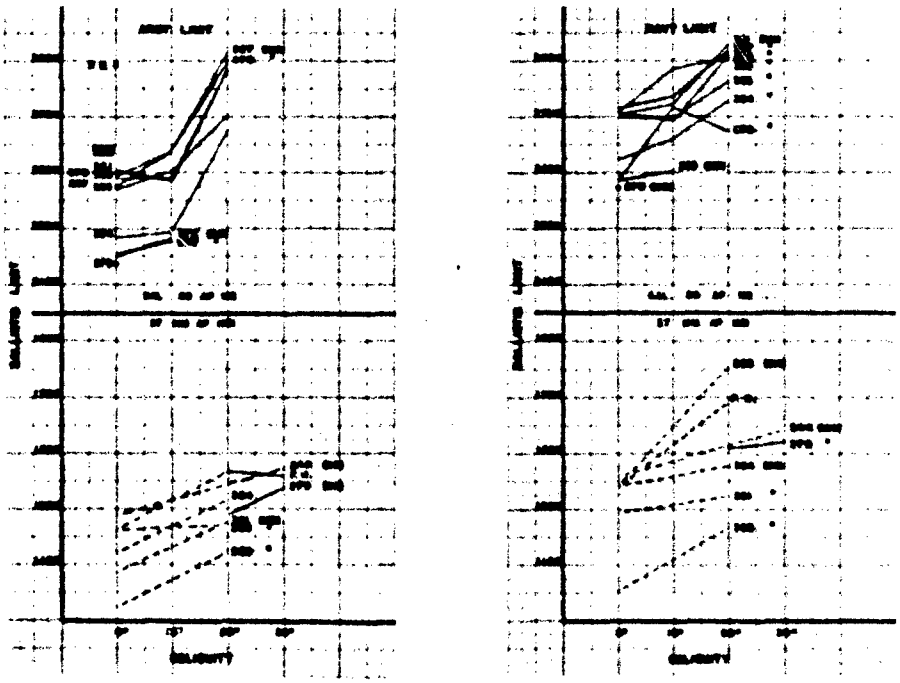


W.A.639-4212 BALLISTIC LIMIT vs OBLIQUITY CHART D

1" PLATE

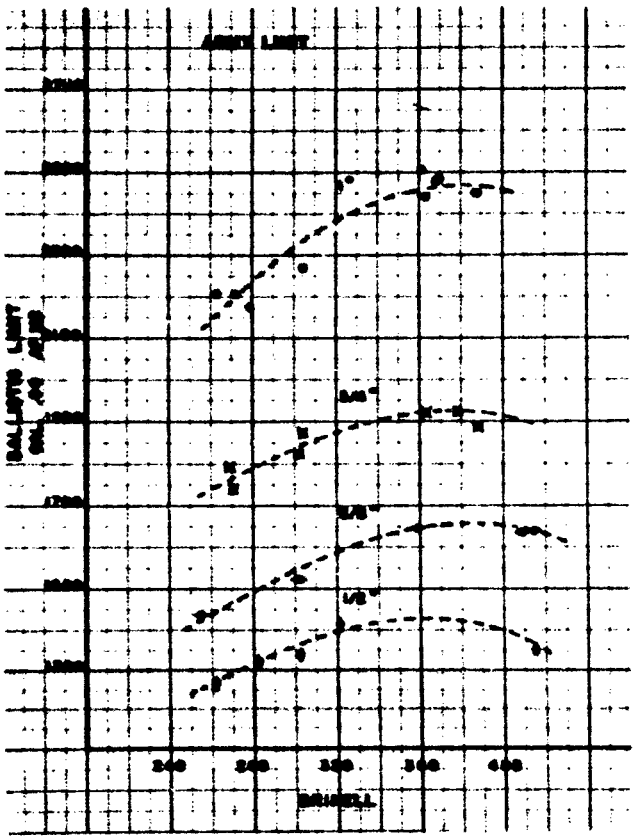


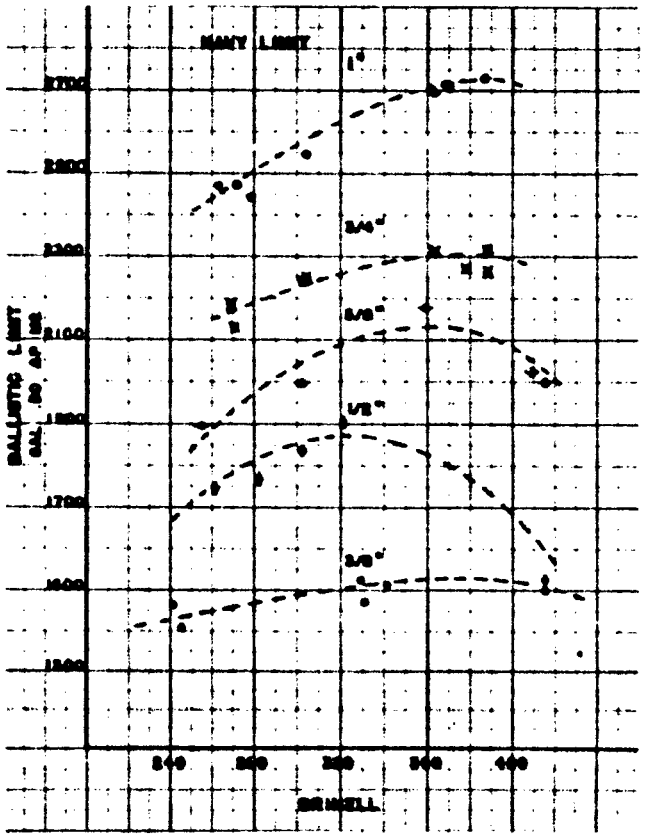
BALLISTIC LIMIT vs BRINELL HARDNESS



W.A.639-4283 BALLISTIC LIMIT vs OBLIQUITY CHART E

COMPARISON OF PLATES OF DIFFERENT THICKNESSES





BALLISTIC LIMIT vs BRINELL HARDNESS

ALL PLATES TESTED AT 0°

CHART F

Inclosure A

Method of Inducing 90° Yaw in Cal. .50 AP M2 Projectiles

In order to observe the effects of yawed impacts on armor, it was desirable to induce in the caliber .50 AP M2 projectile employed a consistent degree of yaw in the face of fluctuating velocities.

To this end several arrangements were unsuccessfully experimented with until the setup illustrated below was tested.

This design induced in the projectile a generally consistent yaw of 90° as it impacted the main armor and afforded a legitimate determination of the ballistic limit of the armor under yawed impacts.

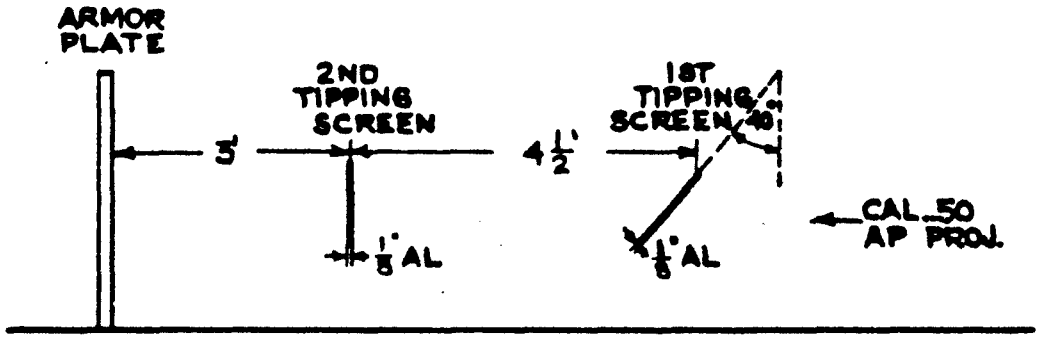


Figure 2
Method of Inducing 90° Yaw in Caliber .50 APM2 Projectiles

Inclosure B

Computations

I.

When armor is installed at an obliquity in order to increase its resistance to attack from a given quadrant it is necessary to employ a greater area of plate to protect a unit area normal to the path of attack than would be needed to protect the same area if the armor were installed normal to the line of fire.

So, in computing the relative resistance (on a weight-for-weight basis) of plates of different thickness installed at normal and at obliquities, it is fitting that there be taken into consideration the relative areas of plate needed to afford protection to a unit area normal to the line of attack.

It will readily be conceded that the area of plate needed to shield a unit area normal to the path of the bullet will vary as the secant of the obliquity of the protective material. (See Figures 3, 4.)

Thus, if we have plates of equal density at different obliquities and of different thicknesses providing equivalent resistance to penetration from fire from a given angle, we may compute the ratio the weights needed to shield an equal area normal to the path of fire from the following:

$$\frac{e_1 \sec \theta_1}{e_1 \sec \theta_2}$$

where e_1= thickness of plate 1

e_2= thickness of plate 2

θ_1= obliquity of plate 1

θ_2= obliquity of plate 2

From Figure 1 it may be noted that at 45° the average 3/8" plate was equivalent in resistance to penetration to the average 1" plate

normal to the line of fire. Thus,

$$\frac{e_1 \sec \theta_1}{e_2 \sec \theta_2} = \frac{1 \cdot 1}{.375 \cdot 1.414} = 1.89$$

At 40° the average 1/2" plate was equivalent in resistance to penetration to the average 1" plate normal to the line of fire, and the average 3/8" plate at this obliquity was equivalent in resistance to the average 3/4" plate at normal. So,

$$\frac{e_1 \sec \theta_1}{e_2 \sec \theta_2} = \frac{1 \cdot 1}{.5 \cdot 1.305} = 1.53$$

or

$$\frac{e_1 \sec \theta_1}{e_2 \sec \theta_2} = \frac{.75 \cdot 1}{.375 \cdot 1.305} = 1.53$$

At 30° the average 1/2" plate was equivalent in resistance to the average 3/4" plate at normal. Thus,

$$\frac{e_1 \sec \theta_1}{e_2 \sec \theta_2} = \frac{.75 \cdot 1}{.5 \cdot 1.155} = 1.298$$

At 20° the average 3/4" plate was equivalent in resistance to the average 1" plate at normal, so,

$$\frac{e_1 \sec \theta_1}{e_2 \sec \theta_2} = \frac{1 \cdot 1}{.75 \cdot 1.064} = 1.25$$

II.

In comparing a divided armor structure (using materials of different density) such as is shown in Figure 5 with a plate as illustrated in Figure 3 affording equivalent resistance to penetration we may compute the ratio of weights needed to shield an equal area normal to the line of fire from the following:

$$\frac{e_1 D_1 \sec \theta_1}{e_3 D_3 \sec \theta_3 + e_4 D_4 \sec \theta_4 + e_5 D_5 \sec \theta_5}$$

where e_1 = thickness of plate 1

e_3 = thickness of plate 3

e_4 = thickness of plate 4

e_5 = thickness of plate 5

D_1 = density of plate 1

D_3 = density of plate 3

D_4 = density of plate 4

D_5 = density of plate 5

θ_1 = obliquity of plate 1

θ_3 = obliquity of plate 3

θ_4 = obliquity of plate 4

θ_5 = obliquity of plate 5

It was found that a divided armor structure consisting of a 3/8" steel plate at normal plus a 1/8" aluminum plate at normal plus a 1/8" aluminum plate at 40° (arranged in the manner set out in Inclosure A) afforded resistance to penetration equivalent to a single 1" plate normal to the line of fire. The ratio of the density of steel to that of aluminum is taken as 2.8. Thus,

$$\frac{e_1 D_1 \sec \theta_1}{e_3 D_3 \sec \theta_3 + e_4 D_4 \sec \theta_4 \; e_5 D_5 \sec \theta_5}$$

$$= \frac{1 \cdot 2.8 \cdot 1}{.375 \cdot 2.8 \cdot 1 + .125 \cdot 1 \cdot 1 + .125 \cdot 1 \cdot 1.305}$$

$$= 2.09$$

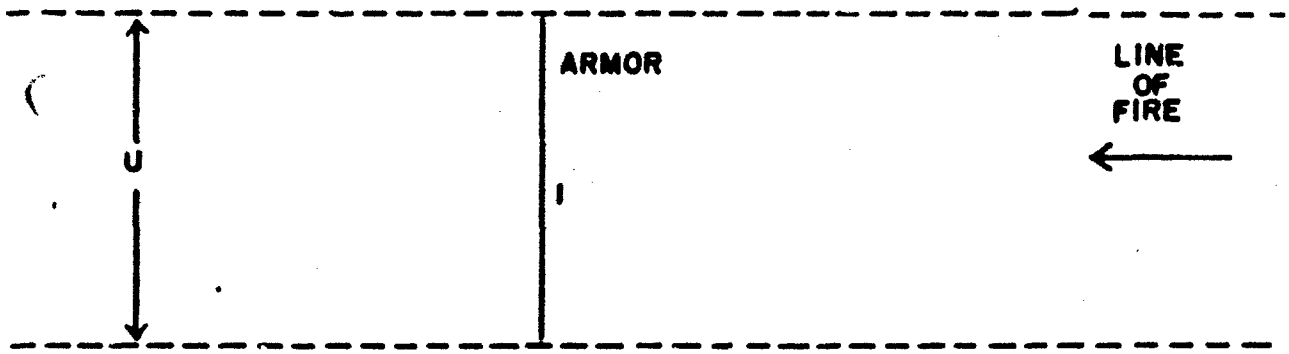


FIG. 3. ARMOR NORMAL TO LINE OF FIRE

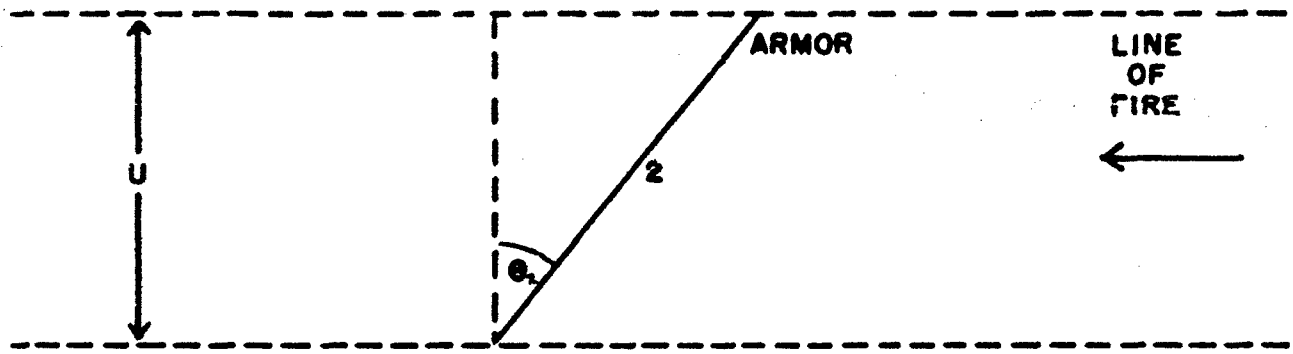


FIG. 4. ARMOR AT OBLIQUITY TO LINE OF FIRE

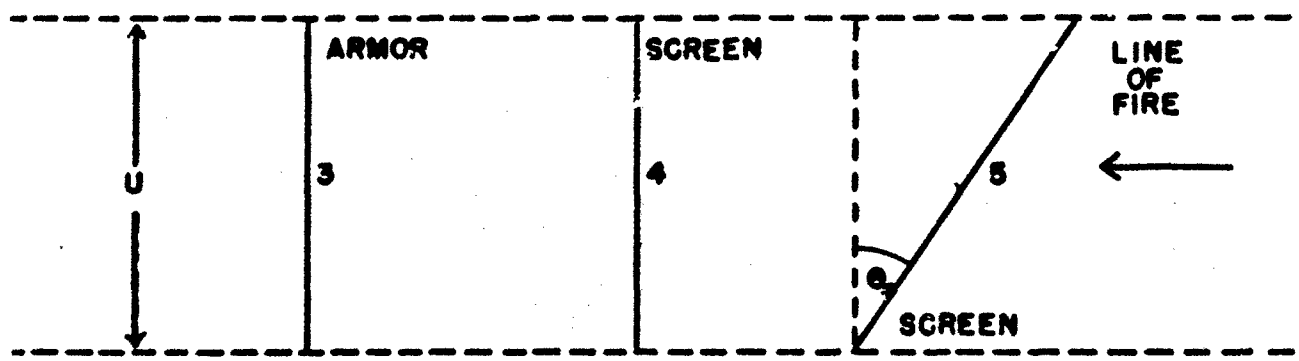


FIG. 5. YAW-INDUCING ARMOR STRUCTURE

U - CONSTANT DIMENSION

APPENDIX A

Ballistic Test Results

[illegible] ABBREVIATIONS

Effects on Plate

CP	-	Complete penetration
PP	-	Partial penetration
SCP	-	Score in plate
Pun S	-	Punching started
SB	-	Slight bulge on back
LB	-	Large bulge on back
MB	-	Medium bulge on back
NB	-	No bulge on back
BS	-	Back spall
FS	-	Face spall
FP	-	Face petalling
BP	-	Back petalling
Inc.	-	Incomplete
BC	-	Star crack
BC	-	Back crack

Effects on Projectile

PTP	-	Passed thru plate
NPTP	-	Failed to pass thru plate
DD	-	Base destroyed
DD	-	Base Destroyed
BI	-	Base intact
BI	-	Base intact

Note: Unless otherwise specified, the powder charge was measured in grains

Ballistic Data Sheet No. 1

Carnegie-Illinois Plate 90585A11 - 3/8" x36"x36" Ni-Cr Homogeneous
BHN 241 - T.S. 124500 - Photographs W.A. 710-1856, W.A. 710-1857

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
0°	1	58.0	1192	CP - CL 1/4"x1/4" Back opening
0°	2	54.0	lost	CP - CL Core intact
0°	3	50.0	841	PP - MB " "
0°	4	52.0	917	PP - LB " "
0°	5	54.0	962[a]	PP - LB " "
0°	6	56.0	1097	CP Backed by support - Disregard
0°	7	55.0	976[a]	CP - CL 1/16"x1/16" Back opening
0°	8	85.0	1316	CP - CL 1/4"x1/4" Back opening Core intact
0°	9	80.0	1297	CP - CL 3/16"x3/16" Back opening Core intact
0°	10	75.0	1288	CP - CL 3/16"x3/16" Back opening Core intact
0°	11	90.0	1438	CP - CIP 1/3 of projectile thru plate
0°	12	95.0	1478[b]	CP - PTP Full petalling
0°	13	93.0	1449[b]	CP - CIP 2/3 of projectile thru plate
[a]Army limit at 0° - 969 f/s; [b]Navy limit at 0° - 1464 f/s				
20°	14	120.0	1748	CP - PTP Full petalling Core intact
20°	15	115.0	1686[b]	CP - PTP
20°	16	110.0	1631	CP - CIP ND
20°	17	112.0	1652[b]	CP - CIP BD - ND
20°	18	95.0	1465	CP - CIP 3/8"x3/8" Back opening BD - ND
20°	19	90.0	1373	Hit Rd. #17 - Disregard
20°	20	90.0	1385	CP - CIP BD
20°	21	85.0	1316	CP - CIP BD
20°	22	80.0	1468	CP - PTP
20°	23	75.0	1402	CP - CIP
20°	24	80.0	1316	CP
20°	25	75.0	1163	CP - 1/8"x1/8" Back opening Core intact
20°	26	70.0	1119	CP - CIP BD
20°	27	65.0	1066[a]	CP 1/8"x1/8" Back opening Core intact
20°	28	60.0	1035[a]	PP - MB Core intact
[a]Army limit at 20° - 1048 f/s; [b]Navy limit at 20° - 1642 f/s				
30°	29	90.0	1349	Hit edge of plate - Disregard
30°	30	90.0	1340	CP
30°	31	85.0	1249	CP - CIP BD
30°	32	80.0	1184	CP - CIP BD
30°	33	75.0	1144[a]	CP - CIP BD
30°	34	70.0	1207	CP - CIP BD
30°	35	65.0	1156	PP - MB

Ballistic Data Sheet No. 1 (Cont'd)

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
30°	36	68.0	1293	PP - CIP BD
30°	37	110.0	1640	CP - CIP BD
30°	38	115.0	1669	CP - CIP BD - ND
30°	39	120.0	1739	CP - CIP BD - ND
30°	40	125.0	1806	CP - CIP BD - ND
30°	41	130.0	1860	CP - CIP BD - ND
30°	42	60.0	1115[a]	PP - NB
30°	43	140.0	1981[n]	CP - CIP BD - ND
30°	44	145.0	2006[n]	CP - PTP Core intact
30°	45	65.0	1273	CP - CIP BD

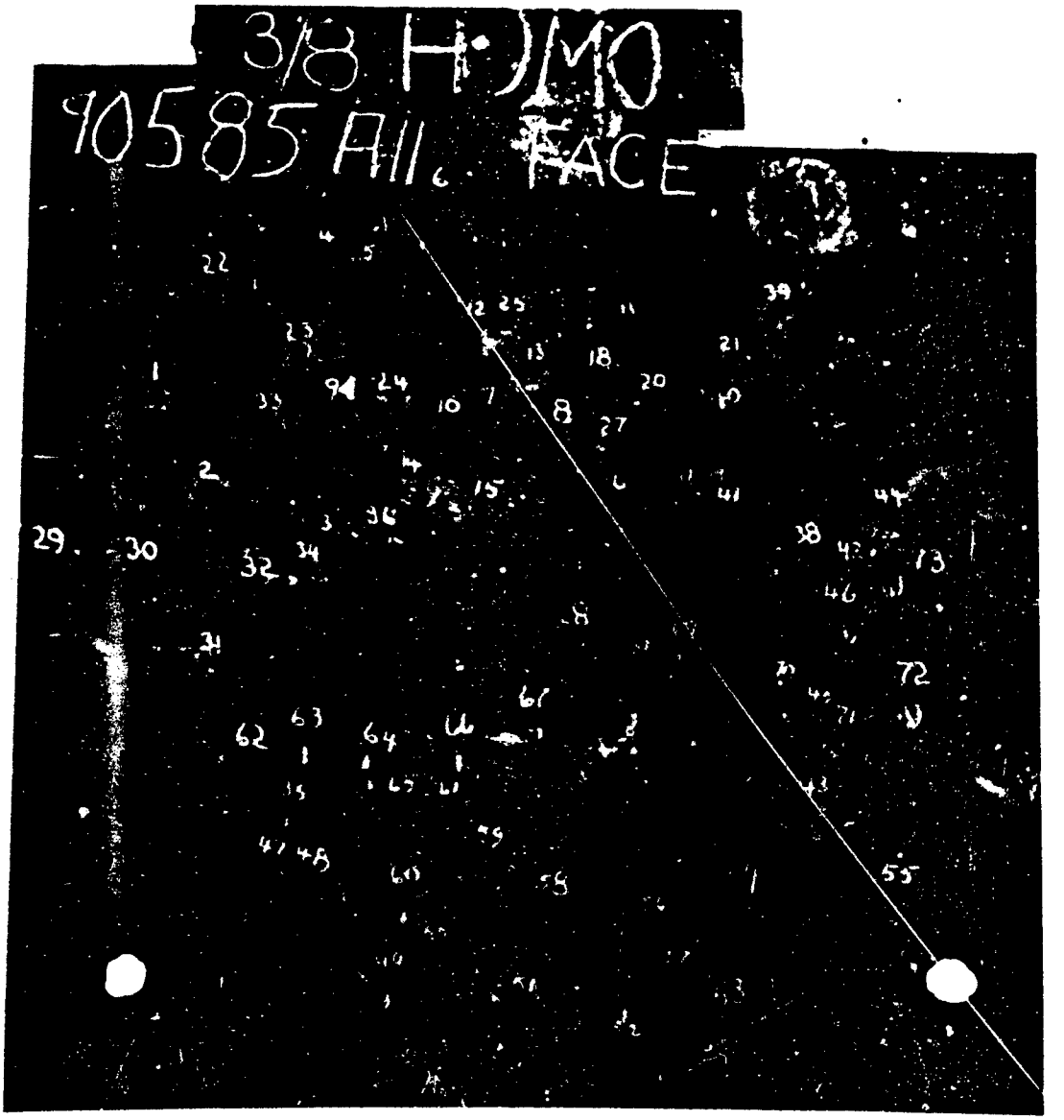
[a]Army limit at 30° - 1130 f/s; [n]Navy limit at 30° - 1994 f/s

40°	46	165.0	2358	CP - PTP
40°	47	155.0	2249	CP - PTP 3/8"x1/4" Back petalling
40°	48	145.0	2107[n]	CP - PTP
40°	49	140.0	2032	CP - CIP BD - ND
40°	50	143.0	2083[n]	CP - CIP BD - ND
40°	51	120.0	1792	CP - CIP BD - ND
40°	52	110.0	1690	PP - MB
40°	53	115.0	1739	CP - PPTP
40°	54	113.0	1676	CP - CIP BD - ND
40°	55	108.0	1690	CP - CIP
40°	56	105.0	1613	CP - CIP
40°	57	103.0	1574	Hit Rd. #55 - Disregard
40°	58	102.0	1589[a]	CP - CIP
40°	59	97.0	1502	PP - Pun S
40°	60	100.0	1468	PP - MB
40°	61	100.0	1560[a]	PP - LB

[a]Army limit at 40° - 1575 f/s; [n]Navy limit at 40° - 2095 f/s

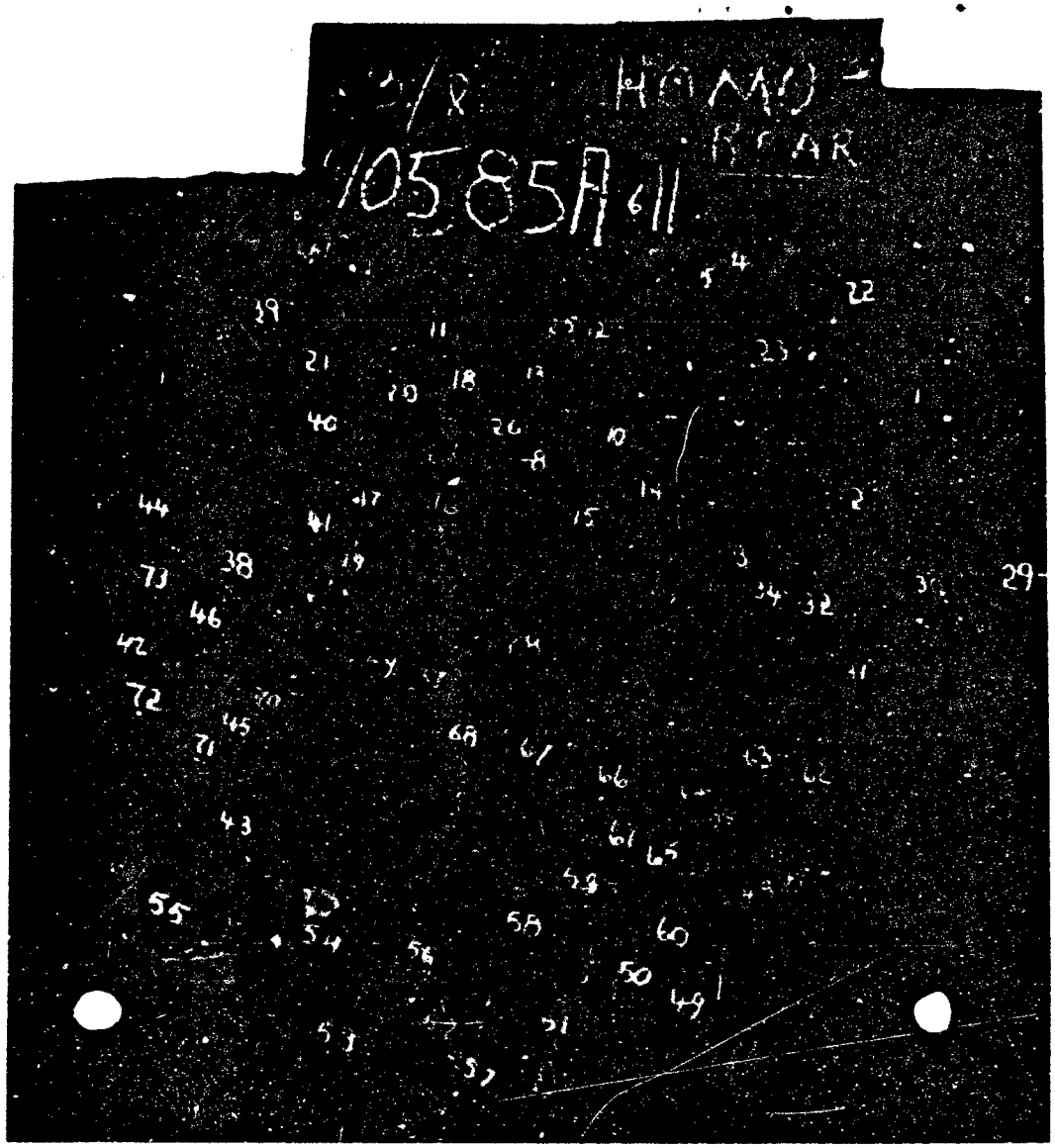
45°	62	110.0	1657	PP - SB
45°	63	120.0	1748	PP - CIP - MB BD
45°	64	125.0	1826	PP - MB
45°	65	130.0	1890	PP - MB
45°	66	135.0	1927	PP - SB
45°	67	145.0	2061	PP - LB
45°	68	148.0	2109[a]	PP - LB
45°	69	150.0	2130[a]	CP - CIP BD - ND
45°	70	170.0	2353	CP - CIP BD - ND
45°	71	173.0	lost	CP - PTP
45°	72	171.0	2402[n]	CP - CIP BD - ND
45°	73	173.0	2410[n]	CP - PTP

[a]Army limit at 45° - 2120 f/s; [n]Navy limit at 45° - 2406 f/s



WATERTOWN ARSENAL

PLATE 90585-A11. 3/8" HOMO, NI-CR. T.S. 124,500; BRINELL 241. TESTED AT 0°, 20°, 30°, 40° AND 45° OBLIQUITIES WITH CAL .50 AP M2. FRONT
MAY 16 1942
W.A.710-1856



WATERTOWN ARSENAL

PLATE 90585-A11. 3/8" HOMO. Ni-CR. T.S. 124,500.
BRINELL 241. BACK MAY 16 1942 W.A.710-1857

Ballistic Data Sheet No. 2

Carnegie-Illinois Plate 186383E4 - 3/8"x36"x36" Ni-Cr Homogeneous
BHN 245 - T.S. 132000 - No Photographs

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AF M2 Firings:				
0°	1	95.0	1501	CP - PTP Full petalling
0°	2	90.0	1459	CP - PTP Full petalling
0°	3	85.0	1412[n]	CP - PTP
0°	9	90.0	1439	CP - PTP Full petalling
0°	10	80.0	1402[n]	CP - CIP
0°	11	70.0	1400	CP - CIP Hit Rd. #6
0°	12	60.0	1106	CP - CL
[n]Navy limit at 0° - 1407 f/s; Army limit not determined				
20°	38	130.0	1855	CP - PTP
20°	39	100.0	1510	CP - FPTP
20°	40	105.0	1560	CP - FPTP
20°	41	110.0	1632[n]	CP - CIP
20°	42	115.0	1686	CP - PTP
20°	43	112.5	1659[n]	CP - PTP
[n]Navy limit at 20° - 1646 f/s; Army limit not determined				
30°	4	120.0	lost	PP - SB
30°	5	120.0	1846	CP - CIP ND - BD
30°	6	110.0	1689	CP - CIP ND - BD Full petalling
30°	7	100.0	1611	CP - CIP ND - BD Full petalling
30°	13	60.0	1264	CP - CIP BD
30°	—	50.0	lost	Missed plate
30°	14	50.0	919	PP - SB
30°	15	57.0	1168[a]	CP - CIP BD
30°	16	55.0	1161[a]	PP - LB
30°	17	125.0	1861	CP - CIP
30°	18	130.0	1871[n]	CP - CIP
30°	19	135.0	1889[n]	CP - PTP
[a]Army limit at 30° - 1165 f/s; [n]Navy limit at 30° - 1880 f/s				
40°	20	95.0	1444	PP - NB
40°	21	175.0	2389[n]	CP - FPTP
40°	22	195.0	2624	CP - PTP Full petalling
40°	23	185.0	lost	Hit Rd. #22 - Disregard
40°	24	185.0	2501	CP - PTP Full petalling
40°	25	180.0	2420[n]	CP - PTP
40°	26	125.0	1846	CP - FPTP
40°	27	110.0	1725[a]	PP - NB
40°	28	115.0	1739[a]	CP - CIP ND - BD
[a]Army limit at 40° - 1732 f/s; [n]Navy limit at 40° - 2405 f/s				

Ballistic Data Sheet No. 2 (Cont'd)

Plate Obliqu'ty	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
45°	29	150.0	2144	PP - LB
45°	30	160.0	2218[a]	CP - CIP ND
45°	31	155.0	2188[a]	PP - LB
45°	32	185.0	2497	CP - CIP BD
45°	33	157.0	2225	Excessive yaw - disregard
45°	34	187.0	2537	CP - FPTP
45°	35	190.0	lost	CP - PTP Hit adjacent to Rd. #34 - Disregard
45°	36	189.0	2583[b]	CP - FPTP
45°	37	189.0	2586[b]	CP - PTP

[a]Army limit at 45° - 2203 f/s; [b]Navy limit at 45° - 2585 f/s

Ballistic Data Sheet No. 3

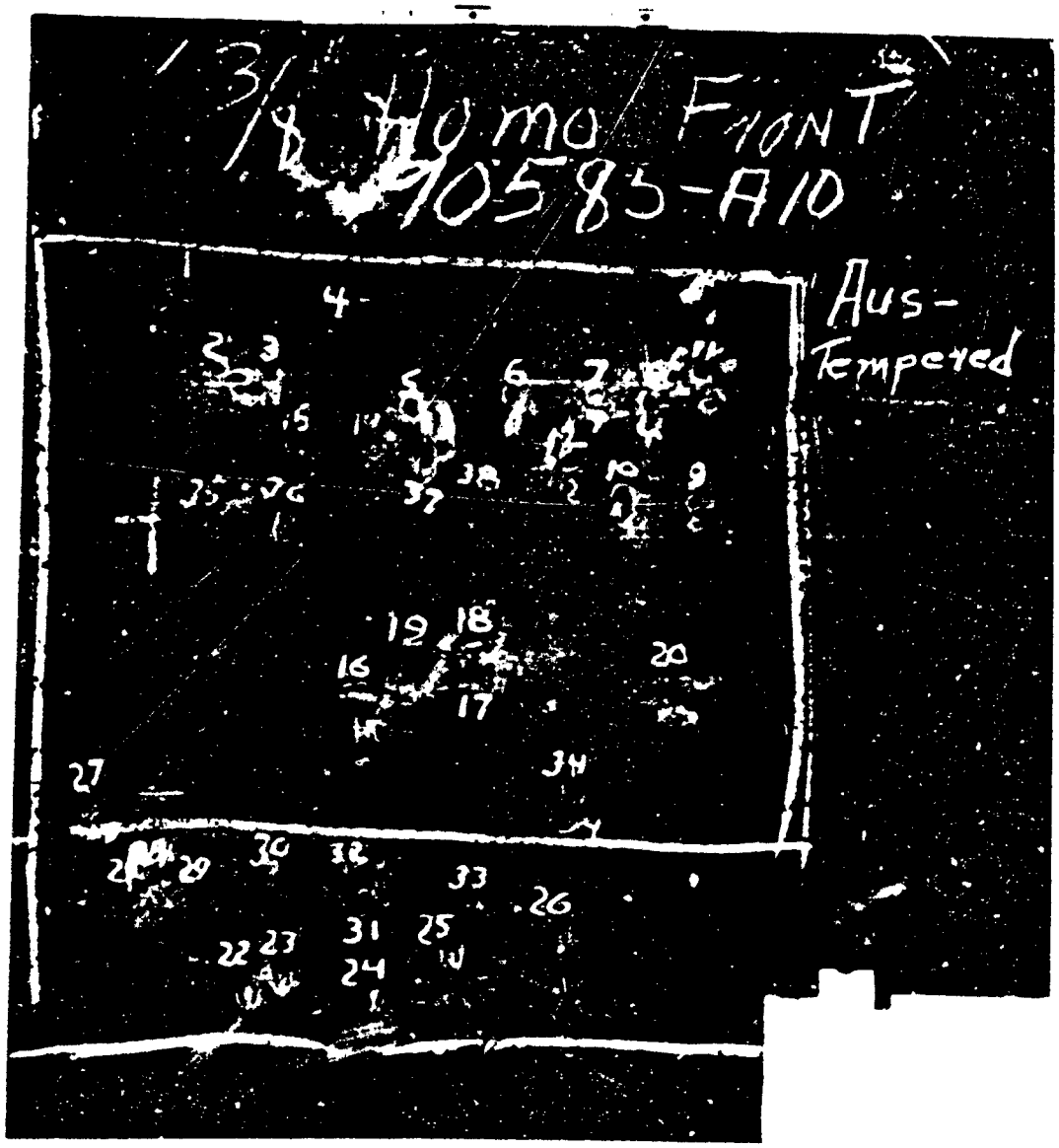
Carnegie-Illinois Plate 90585A10 - 3/8"x36x36 Ni-Cr Homogeneous - Austempered
BHN 329 - T.S. 164000 - Photographs W.A. 710-1854, W.A. 710-1855

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
0°	1	100.0	1980	CP - PTP Full petalling
0°	2	80.0	1555	CP - PTP
0°	3	70.0	1407	CP - FPTP 3/16"x3/16" Back opening
0°	4	75.0	lost	CP - PTP
0°	5	75.0	1428	CP - CIP Core intact
0°	6	78.0	1584	CP - PTP
0°	7	76.0	1441	CP - CIP Core intact
0°	8	77.0	lost	CP - PTP Broke off core of Rd. #7
0°	9	77.0	lost	CP - FPTP
0°	10	77.0	1411	CP - FPTP 3/16"x3/16" Back opening
0°	11	80.0	lost	CP - PTP
0°	12	80.0	lost	CP - CIP Core intact
0°	13	80.0	1445	CP - FPTP
0°	14	80.0	1497[n]	CP - CIP Core intact
0°	15	81.0	1546[n]	CP - PTP
[n]Navy limit at 0° - 1522 f/s; Army limit not determined				
30°	27	100.0	lost	CP - CIP BD - ND
30°	28	95.0	1647	CP - Hit within 1 cal. of Rd.#27, disregard
30°	29	95.0	1541	CP - Hit within 1 cal. of Rd.#28, disregard
30°	30	100.0	1671	CP - CIP BD - ND
30°	31	95.0	1526[a]	CP - CIP BD
30°	32	90.0	1536	CP - Hit with 2 cals. of Rd. #31, disregard
30°	33	80.0	1488[a]	PP - LB
30°	34	155.0	2150[n]	CP - PTP
30°	35	135.0	1973	CP - FPTP 5/16"x5/16" Back opening
30°	36	140.0	2027	CP - CIP BD
30°	37	150.0	2160	CP - FPTP
30°	38	145.0	2120[n]	CP - FPTP
[a]Army limit at 30° - 1507 f/s; [n]Navy limit at 30° - 2135 f/s				
45°	21	175.0	2491	CP - 1/2"x5/16" Back opening
45°	22	165.0	2382	PP - LB
45°	23	170.0	2427[a]	CP - CIP BD
45°	24	168.0	2382[a]	PP - LB
45°	25	192.0	2643[n]	CP - PTP
45°	26	190.0	2614[n]	CP - FPTP
[a]Army limit at 45° - 2405 f/s; [n]Navy limit at 45° - 2629 f/s				

Ballistic Data Sheet No. 3 (Cont'd)

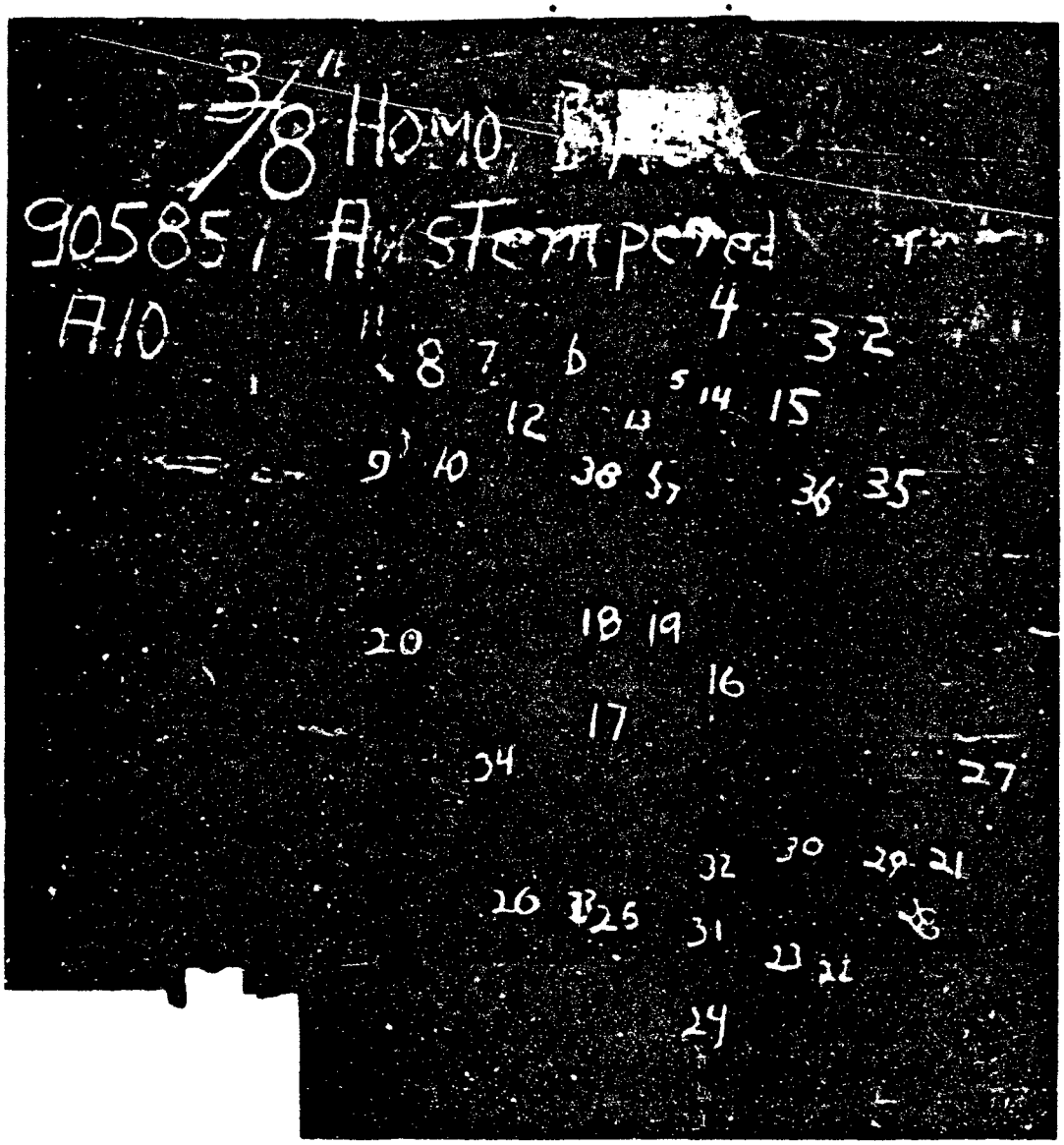
Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Plate at 0° Projectiles tipped through 1/8" aluminum screen set at 40°, 7'6" in front of plate, then through second screen set at 0°, 3' in front of plate.				
0°	16	185.0	2510	PP - LB
0°	17	190.0	2594	PP - LB Pun S
0°	18	195.0	2648	PP - LB
0°	19	200.0	2721[a]	CP - 1-1/2"x1/2" Back opening
0°	20	191.0	2691[a]	PP - LB

[a]Army limit with yawed projectiles at 0° - 2706 f/s;
Navy limit not determined.



WATERTOWN ARSENAL

PLATE 90585-A10. 3/8" HOMO. NI-CR-AUSTEMPERED. T.S. 164,000; BRINELL 329. TESTED AT 30° AND 45° WITH CAL .50 AP M2. ALSO TESTED AT NORMAL WITH YAWED CAL .50 AP M2. FRONT MAY 16 1942 W.A.710-1654



WATERTOWN ARSENAL

PLATE 90585-A1C. 3/8" HOMO. NI-CR-AUSTEMPERED. T.S. 164,000.
BRINELL 329. BACK MAY 16 1942 W.A.710-1855

Ballistic Data Sheet No. 4

Carnegie-Illinois Plate 1863832 - 3/8"x36"x36" Ni-Cr Homogeneous
BHN 331 - T.S. 166,800 - Photographs W.A. 710-1852, W.A. 710-1853

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
0°	1	80.0	lost	CP - CL
0°	2	80.0	1289	CP - CL
0°	3	90.0	1387	CP - LB - SC .2"x.2" Back opening
0°	4	95.0	1449	CP - LB - SC
0°	5	100.0	lost	CP - CIP
0°	6	100.0	1534	CP - PTP
0°	7	100.0	1485	CP - PTP
0°	8	100.0	1546	CP - PTP
0°	9	95.0	1468	CP - PTP
0°	10	95.0	1487	CP - PTP
0°	11	92.0	1484[a]	CP - PTP
0°	12	90.0	1459[a]	CP - FPTP

(Round 12 appears on photographs as Rd.#1 on face, Rd.#10 on back.)
[a]Navy limit at 0° - 1472 f/s; Army limit not determined

20°	71	100.0	1642	CP - FPTP
20°	72	110.0	1650	CP - FPTP
20°	73	115.0	1667	CP - CIP ND
20°	74	120.0	lost	CP - CIP ND - BD
20°	75	130.0	lost	CP - FPTP
20°	76	140.0	1952	CP - FPTP
20°	77	150.0	2076	CP - FPTP
20°	78	160.0	2169[a]	CP - CIP ND
20°	79	170.0	2288	CP - PTP
20°	80	165.0	2231	CP - PTP
20°	81	162.5	2224	CP - PTP
20°	82	161.0	2195[a]	CP - PTP

[a]Navy limit at 20° - 2182 f/s; Army limit not determined

30°	13	120.0	1769	CP - CIP ND - BD
30°	14	145.0	lost	FP - MB
30°	15	145.0	2046	CP - FPTP
30°	16	155.0	2148[a]	CP - PTP
30°	17	150.0	2104[a]	CP - CIP ND - BD
30°	18	115.0	1732	CP - FPTP
30°	19	110.0	1632[a]	CP - FPTP
30°	20	105.0	1603	FP - MB

[a]Army limit at 30° - 1618 f/s; [b]Navy limit at 30° - 2126 f/s

40°	21	155.0	2209	CP - FPTP .3"x.35" Back opening
40°	22	185.0	2555	CP - FPTP .3"x.45" Back opening;.7"x.4" BS
40°	23	200.0	2731	CP - PTP
40°	24	195.0	2675	CP - PTP
40°	25	192.0	2621[a]	CP - FPTP .4"x.7" BS

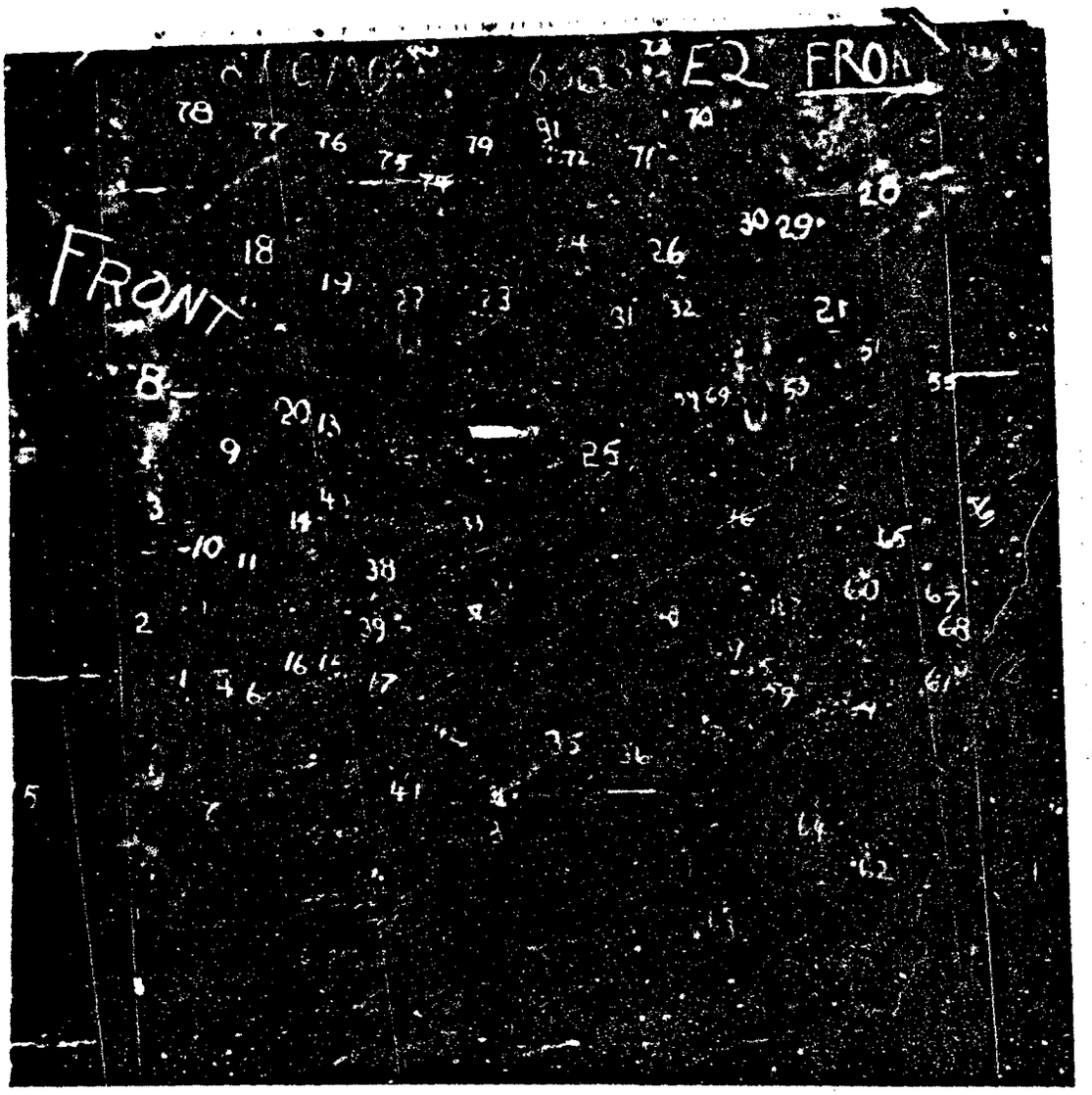
Ballistic Data Sheet No. 4 (Cont'd)

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
40°	26	194.0	2653	CP - PTP 4" crack on back
40°	27	193.0	2633[n]	CP - PTP
40°	28	135.0	1951	CP - .25"x.15" Back opening
40°	29	125.0	1920[a]	CP - .15"x.15" Back opening
40°	30	123.0	1836	PP - SB
40°	31	125.0	1838	PP - SB
40°	32	125.0	1918[a]	PP - MB
[a]Army limit at 40° - 1919 f/s; [n]Navy limit at 40° - 2627 f/s				
45°	59	187.0	2548[a]	CP - FPTP
45°	60	185.0	2512[a]	PP - MB
45°	61	Service	2920	CP - PTP
45°	62	200.0	2645	CP - FPTP
45°	63	210.0	2836	CP - PTP
45°	64	205.0	2785	CP - PTP
45°	65	203.0	lost	CP - PTP
45°	66	202.0	2755	Hit earlier rd.
45°	67	202.0	lost	CP - PTP
45°	68	201.0	2727[n]	CP - PTP
45°	69	200.5	2702[n]	CP - FPTP
[a]Army limit at 45° - 2530 f/s; [n]Navy limit at 45° - 2715 f/s				
Plate Reversed:				
40°	51	170.0	2379	CP - FPTP
40°	52	165.0	2323	CP - FPTP
40°	53	160.0	2263	CP - FPTP
40°	54	145.0	2056	PP - CIP - LB BD
40°	55	152.5	2163	PP - LB
40°	56	156.0	2207[a]	CP - FPTP
40°	57	154.0	2189[a]	PP - LB - Pun S
40°	58	156.0	2213	CP - FPTP
[a]Army limit at 40° (plate reversed) 2198f/s; Navy limit not determined.				
Plate Reversed and Rotated through 90°				
40°	44	150.0	2135	PP - MB
40°	45	155.0	2178	PP - LB
40°	46	160.0	2233	PP - LB
40°	47	165.0	2327	PP - LB
40°	48	170.0	2368	PP - LB Pun S Back cracking
40°	49	175.0	2408[a]	CP - CIP BD - BD
40°	50	172.5	2408[a]	PP - LB Pun S (almost completed)
[a]Army limit at 40° (Plate reversed and rotated through 90°) 2408 f/s Navy limit not determined.				

Ballistic Data Sheet No. 4 (Cont'd)

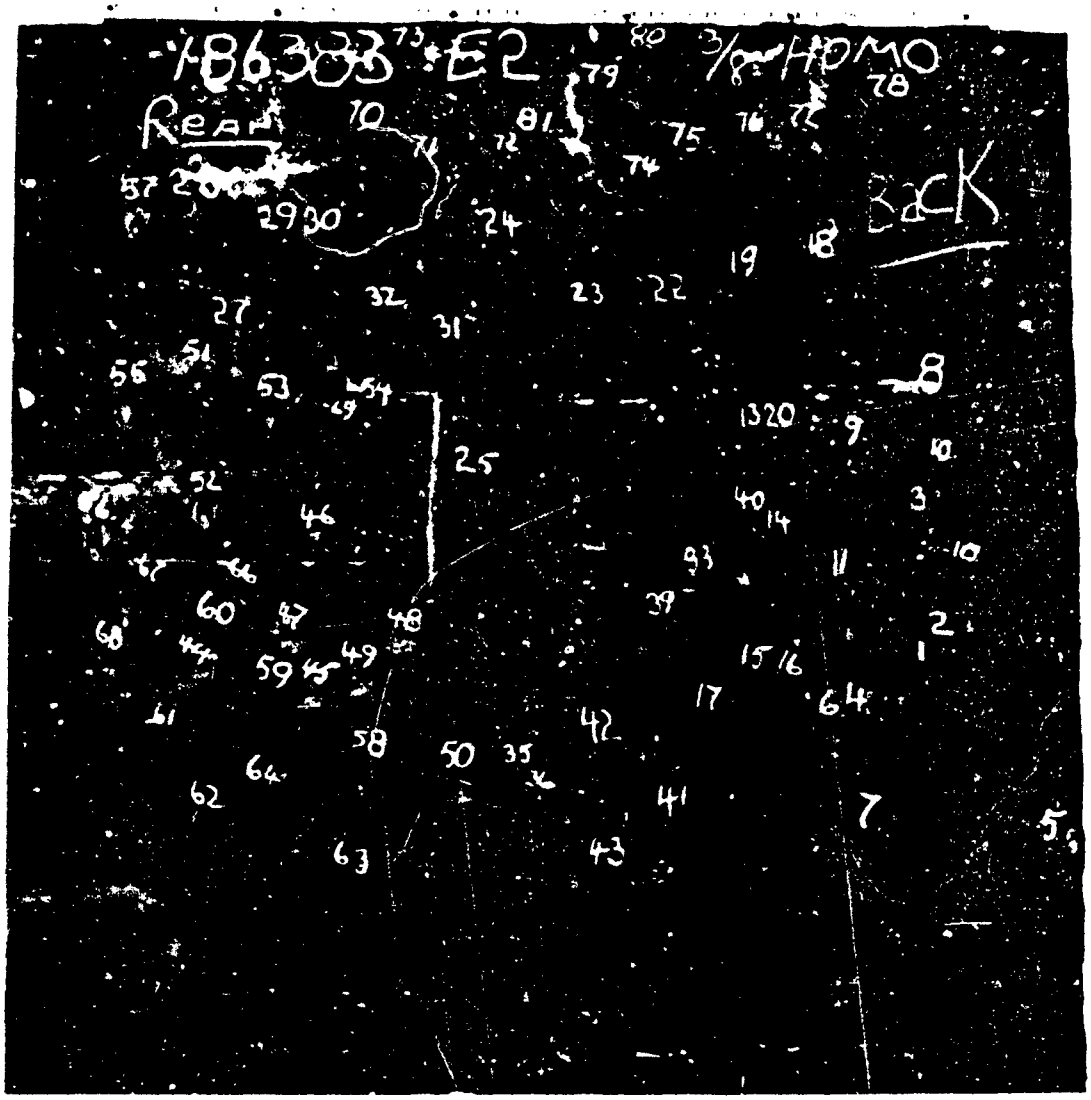
Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Plate Rotated through 90°:				
40°	33	125.0	1916	PP - SB
40°	34	125.0	1900	PP - SB
40°	35	127.5	1920	PP - MB
40°	36	129.0	1928	PP - MB
40°	37	135.0	lost	PP - SB
40°	38	135.0	lost	PP - MB
40°	39	140.0	1973	PP - SB
40°	40	150.0	lost	Hit earlier rd.
40°	41	150.0	2158[a]	PP - LB Cracking started
40°	42	155.0	lost	Hit earlier rd.
40°	43	155.0	2189[a]	CP - FPTP

[a]Army limit at 40° (Plate rotated through 90°) 2174 f/s
Navy limit not determined.



WATERTOWN ARSENAL

PLATE 166383-E2. 3/8" HOMO, NI-CR. T.S. 166,800; BRINELL 331.
TESTED AT 0°, 20°, 30°, 40°, 45° WITH CAL .50 AP M2. FRONT
MAY 16 1942 W.A.710-1852



WATERTOWN ARSENAL

PLATE 166383—E2. 3/8" HOMO. NI-CR. T.S. 166,800; BRINELL 331
MAY 16 1942 BACK W.A.710-1853

Ballistic Data Sheet No. 5

Carnegie-Illinois Plate 186383E3 - 3/8"x36"x36" Ni-Cr Homogeneous
BHN 341 - T.S. 164000 - No Photographs

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
0°	1	100.0	1622	CP - PTP
0°	2	90.0	1416	CP - CIP 1/2"x1/4" Back petal
0°	3	95.0	1482	CP - CIP
0°	4	100.0	1594	CP - PTP
0°	5	90.0	1507[a]	CP - CIP
0°	6	95.0	1515[a]	CP - PTP
[a]Navy limit at 0° - 1511 f/s; Army limit not determined				
20°	64	150.0	2071	CP - PTP
20°	65	145.0	2041	CP - PTP
20°	66	140.0	1963	CP - PTP
20°	67	130.0	1851	CP - CIP
20°	68	135.0	1903[a]	CP - PTP
20°	69	132.5	1895[a]	CP - CIP
[a]Navy limit at 20° - 1899 f/s; Army limit not determined				
30°	7	80.0	1330[a]	CP - FPTP 1/8"x1/8" Back opening
30°	8	70.0	1350	CP - CIP
30°	9	70.0	1225	PP - NB
30°	10	75.0	1241	PP - NB
30°	11	80.0	1271	PP - NB
30°	12	80.0	1299[a]	PP - NB
30°	13	100.0	lost	Excessively yawed - Disregard
30°	14	100.0	1499	PP - NB
30°	15	125.0	1787	CP - CIP
30°	16	135.0	1933	CP - CIP
30°	17	145.0	2051	CP - FPTP
30°	18	150.0	lost	CP - PTP
30°	19	150.0	2110	CP - PTP
30°	20	147.5	lost	CP - PTP
30°	21	147.0	2041	CP - PTP
30°	22	146.0	1993	Missed plate
30°	23	146.0	2040[a]	CP - PTP
30°	24	150.0	2091	CP Hit within 2 calibers of Rd. #23 - Disregard
30°	25	145.0	2045	CP - FPTP
30°	26	140.0	1993	CP - FPTP
30°	27	140.0	2013[a]	CP - FPTP
[a]Army limit at 30° - 1315 f/s; [b]Navy limit at 30° - 2027 f/s				
40°	28	165.0	2305	CP - FPTP
40°	29	165.0	2315	CP - FPTP
40°	30	190.0	2641[a]	CP - CIP ND - BD
40°	31	195.0	2667	CP - PTP

Ballistic Data Sheet No. 5 (Cont'd)

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
40°	32	190.0	2639	Hit on Rd. #31 - Disregard
40°	33	190.0	2600	CP - FPTP
40°	34	192.5	2645	Hit on Rd. #29
40°	35	192.5	2642	Hit on Rd. #34
40°	36	192.5	2649[n]	CP - PTP
40°	37	140.0	2049	PP - MB
40°	38	145.0	2069	PP - CLP BD
40°	39	150.0	2100[a]	PP - LB Back cracking
40°	40	155.0	2169	Hit holding clamp - Disregard
40°	41	155.0	2126[a]	CP - CL
[a]Army limit at 40° - 2113 f/s; [n]Navy limit at 40° - 2645 f/s				
45°	47	180.0	2473	Backed by support - Disregard
45°	48	210.0	2848	Hit within 2 calibers of Rd. #41, disregard
45°	49	210.0	2879	CP - PTP
45°	50	205.0	2782[n]	CP - FPTP
45°	51	207.5	2819[n]	CP - PTP
45°	52	175.0	2427	PP - LB
45°	53	180.0	2476[a]	PP - LB
45°	54	185.0	2589	CP
45°	55	182.5	2505[a]	CP
[a]Army limit at 45° - 2491 f/s; [n]Navy limit at 45° - 2801 f/s				
Plate Reversed:				
40°	42	150.0	2106[a]	PP - MB
40°	43	155.0	2134	CP - CLP Hit Rd. #33 - Disregard
40°	44	155.0	2132[a]	CP - CL
[a]Army limit at 40° (plate reversed) 2119 f/s; Navy limit not determined				
Plate Reversed and Rotated through 90°:				
40°	45	155.0	2135[a]	CP - Pun S
40°	46	150.0	2107[a]	PP - CLP - LB BD
[a]Army limit at 40° (plate reversed and rotated through 90°) 2121 f/s; Navy limit not determined.				
Plate Rotated through 180°:				
45°	56	185.0	2471	Hit Rd. #54 - Disregard
45°	57	190.0	lost	CP - FPTP
45°	58	190.0	2574	CP - FPTP
45°	59	195.0	2630	CP - FPTP
45°	60	206.0	2787	CP - PTP
45°	61	200.0	2699[n]	CP - FPTP
45°	62	204.0	2760	CP - PTP
45°	63	201.0	2729[n]	CP - PTP
[n]Navy limit at 45° (plate rotated through 180°) 2714 f/s; Army limit not determined.				

Ballistic Data Sheet No. 6

Carnegie-Illinois Plate 186383E1 - 3/8"x36"x36" Ni-Cr Homogeneous
BHN 415 - T.S. 204,800 - Photographs W.A. 710-1850, W.A. 710-1851

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
0°	1	100.0	1955	CP - PTP
0°	2	100.0	1594	CP - PTP
0°	3	100.0	1543	CP - PTP
0°	4	90.0	1492[n]	CP - CIP
0°	5	90.0	1507[n]	CP - PTP
[n]Navy limit at 0° - 1500 f/s; Army limit not determined				
20°	39	150.0	2061	CP - FPTP
20°	40	165.0	2229	CP - PTP
20°	41	157.5	2179[n]	CP - PTP
20°	42	152.5	2151[n]	CP - FPTP
[n]Navy limit at 20° - 2165 f/s; Army limit not determined				
30°	6	140.0	1976[a]	CP - FPTP
30°	7	150.0	2091	CP - FPTP
30°	8	165.0	2273[n]	CP - PTP
30°	9	155.0	2193	CP - FPTP
30°	10	160.0	2230	FP - SB - Excessively yawed - Disregard
30°	11	160.0	2247[n]	CP - FPTP
30°	12	135.0	1964[a]	FP - MB
[a]Army limit at 30° - 1970 f/s; [n]Navy limit at 30° - 2260 f/s				
40°	13	180.0	2451	CP - FPTP - BS .6"x.6"
40°	14	200.0	2730	CP - PTP - BS .6"x.8"
40°	15	190.0	2624[n]	CP - FPTP
40°	16	195.0	2653[n]	CP - PTP BS 1.6"x1.1"
40°	17	160.0	2235[a]	FP - SB
40°	18	170.0	2358	CP - FPTP
40°	19	165.0	lost	FP - MB
40°	20	165.0	2328	CP - FPTP
40°	21	162.5	2261[a]	CP - FPTP
[a]Army limit at 40° - 2248 f/s; [n]Navy limit at 40° - 2639 f/s				
45°	22	215.0	2889[n]	CP - FPTP .55"x.45" BS
45°	23	220.0	2959	CP - PTP .9"x.7" BS
45°	24	205.0	2783	CP - CIP
45°	25	217.5	2919[n]	CP - PTP
45°	26	200.0	2711	CP - FPTP
45°	27	195.0	2682	CP - FPTP
45°	28	180.0	2476	FP - MB
45°	29	190.0	2583	CP - FPTP
45°	30	185.0	2555	CP - FPTP
45°	31	182.5	2515[a]	FP - MB
45°	32	183.5	2527	CP - FPTP
[a]Army limit at 45° - 2521 f/s; [n]Navy limit at 45° - 2899 f/s				

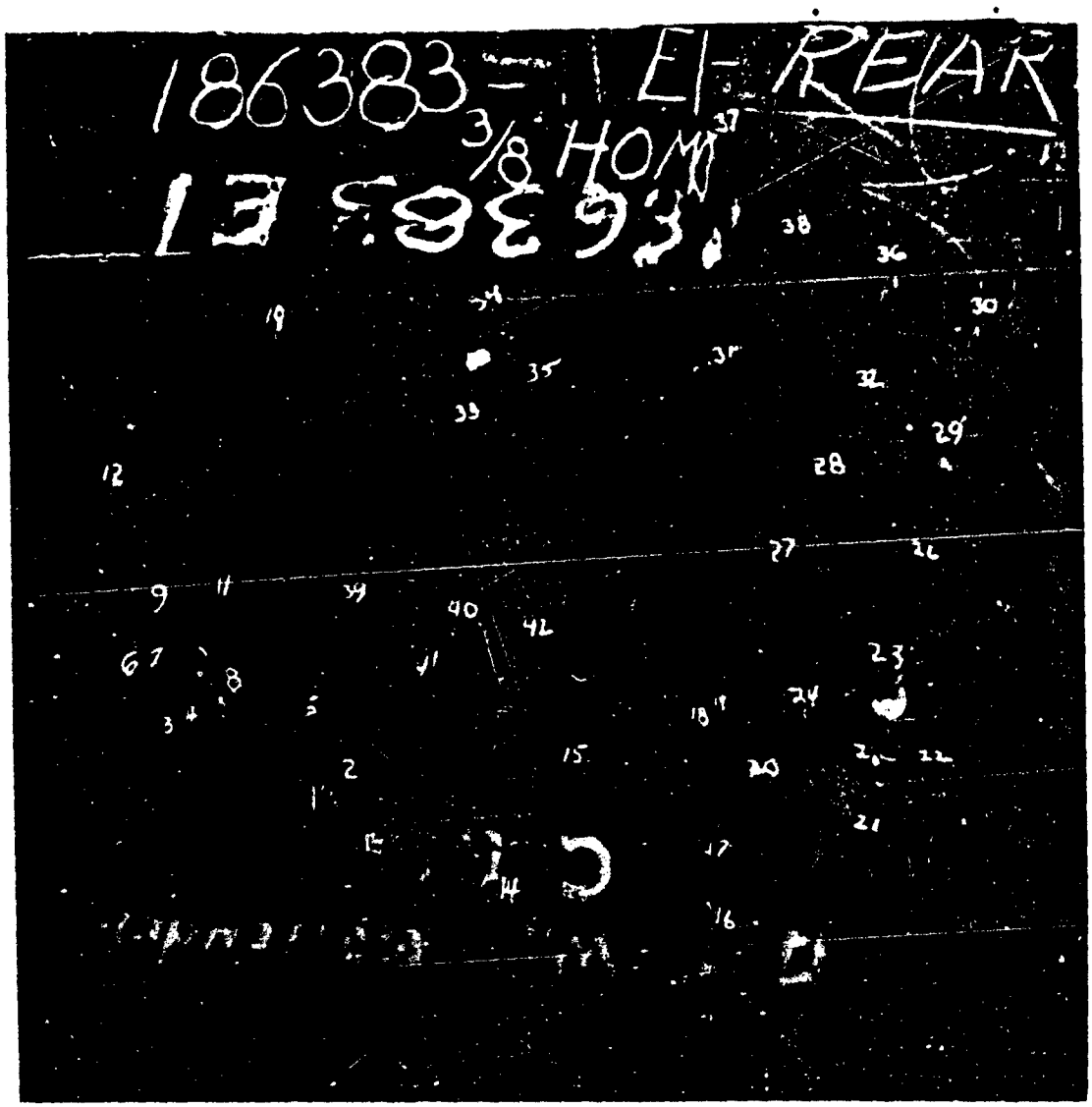
Ballistic Data Sheet No. 6 (Cont'd)

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
Plate at 0° - Projectiles tipped through 1/8" aluminum screen set at 40°, 7'6" in front of plate, then through second screen set at 0°, 3' in front of plate.				
0°	33	187.0	2545[n]	CP - PTP 1.7"x.55" Back opening
0°	34	180.0	2454	CP - PTP 1.7"x.55" Back opening
0°	35	175.0	lost	PP - SB
0°	36	177.0	2417[a]	PP - LB Pun S
0°	37	178.5	2427[a,n]	CP - FPTP
0°	38	178.5	2456	CP - FPTP

[a]Army limit at 0° (projectiles yawed approximately 90°) 2422 f/s
[n]Navy limit at 0° (projectiles yawed approximately 90°) 2438 f/s

WATERTOWN ARSENAL

PLATE 186383-E1, 3/8" HOMO. NI-CR. T.S. 204,800; BRINELL 415. TESTED AT 20°, 30°, 40°, AND 45° OBLIQUITIES WITH CAL .50 AP M2. TESTED WITH YAWED CAL .50 AP M2. FRONT MAY 16 1942 W.A.710-1850



WATERTOWN ARSENAL

PLATE 186383-E1. 3/8" HOMO. NI-CR. T.S. 204,800; BRINELL 415
MAY 16 1942 BACK W.A.710-1851

Ballistic Data Sheet No. 7

Diaston Plate P303 - 3/8"x36"x36" Ni-Mo Face-Hardened
BHN: Face 601, Rear 363-388 - Photographs W.A. 710-1848, W.A. 710-1849

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
0°	1	140.0	2047	PP - CIP - LB Pun S BD
0°	2	145.0	2061[n]	PP - CIP - LB Pun S BD
0°	3	150.0	2125[a]	CP - PTP .5"x.7" BS
0°	4	147.5	2076[a,n]	CP - CIP ND
[a]Army limit at 0° - 2069 f/s; [n]Navy limit at 0° - 2101 f/s				
20°	42	160.0	2194	CP - FPTP
20°	43	170.0	2293	CP - PTP .9"x.65" BS
20°	44	165.0	2259[n]	CP - FPTP
20°	45	167.5	2282[n]	CP - PTP .7"x.8" incomplete BS; 1/2"x1" face crack
20°	46	140.0	1983	PP - SB
20°	47	155.0	2096	CP - FPTP
20°	48	150.0	2110	CP - FPTP
20°	49	145.0	2047[a]	PP - LB Pun S
20°	50	147.0	2053[a]	CP - FPTP
[a]Army limit at 20° - 2050 f/s; [n]Navy limit at 20° - 2271 f/s				
30°	5	175.0	2397	CP - PTP
30°	6	170.0	2417	CP - PTP 1.1"x1.15" BS
30°	7	165.0	2318	CP - FPTP
30°	8	160.0	2254	CP - FPTP 1/8"x1/8" Back petal
30°	9	155.0	2197	CP - FPTP
30°	10	150.0	2160[a]	CP - FPTP
30°	11	145.0	2119[a]	PP - MB
30°	12	167.5	2348	CP - FPTP
30°	13	168.5	2353	CP - PTP .6"x.65" BS
30°	51	180.0	2510	CP - PTP 1-1/16"x9/16" BS
30°	52	170.0	2417	CP - PTP 1"x13/16" BS
30°	53	160.0	2278	CP - FPTP
30°	54	165.0	2318[n]	CP - FPTP
30°	55	168.0	2343[n]	CP - PTP
[a]Army limit at 30° - 2140 f/s; [n]Navy limit at 30° - 2331 f/s				
40°	14	160.0	2219	PP - MB
40°	15	210.0	2819	CP - FPTP
40°	16	215.0	2846	CP - PTP .9"x.85" BS
40°	17	180.0	2505	CP - PTP 1.1"x1.1" BS
40°	18	180.0	2476	CP - PTP
40°	19	170.0	lost	Missed plate
40°	20	170.0	2318[a,n]	CP - PTP
40°	21	165.0	2298[a,n]	PP - SB
[a]Army limit at 40° - 2308 f/s; [n]Navy limit at 40° - 2308 f/s				

Ballistic Data Sheet No. 7 (Cont'd)

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 APM2 Firings:				
45°	22	210.0	2829	CP - PTP
45°	23	185.0	2540	PP - M3 - Back crack
45°	24	200.0	2721[a,n]	PP - LB
45°	25	205.0	2794	CP - PTP - Hit Rd. #7 - Disregard
45°	26	205.0	2796	CP - FPTP
45°	27	215.0	2909	CP - FPTP
45°	28	Max.	3020	CP - PTP 1.0"x1.1" BS
45°	29	215.0	2929	CP - FPTP 3.1" and 3.25" Face cracks
45°	30	220.0	2985	CP - PTP 1"x1" BS
45°	31	217.5	2933	CP - FPTP
45°	32	219.0	2963	CP - PTP
45°	33	218.5	2921	CP - FPTP
45°	34	200.0	2721[a,n]	CP - PTP

[a]Army limit at 45° - 2721 f/s; [n]Navy limit at 45° - 2721 f/s

Plate at 0° - Projectiles tipped through 1/8" aluminum screen set at 40°, 7' 6" in front of plate, then through second screen set at 0°, 3' in front of plate.

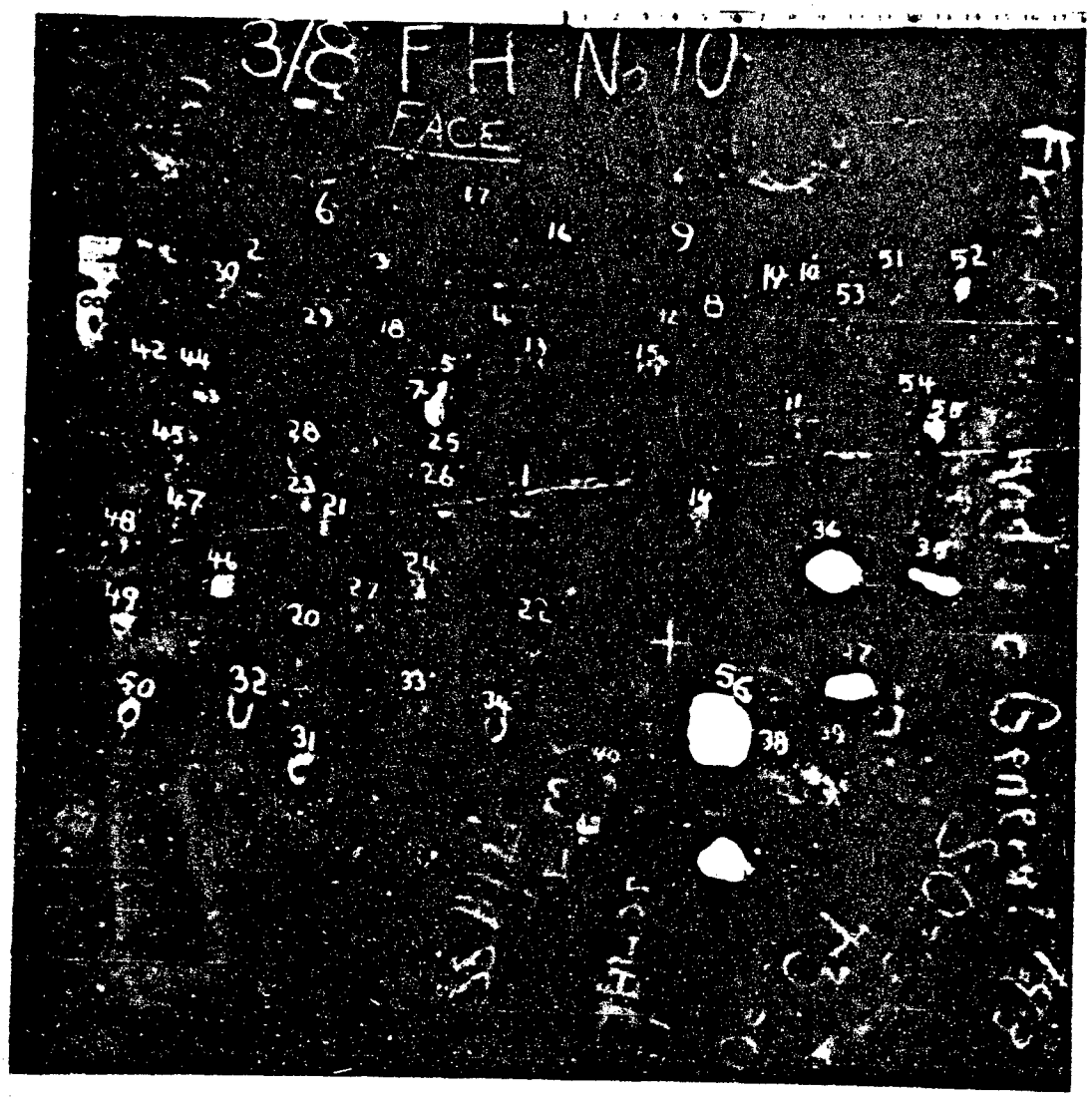
0°	35	187.0	2560	CP - PTP
0°	36	178.0	2444	CP - PTP 2.4"x2.1" BS
0°	37	175.0	2412	CP - PTP 2.15"x2.85" BS
0°	38	165.0	2288[a]	PP - LB Pun S 2.3"x1.6" FS
0°	39	170.0	2340[a]	CP - FPTP 3.5"x4.5" Face crack
0°	40	172.5	2362[n]	CP - FPTP 2.5"x2.8" Face crack
0°	41	174.0	2397[n]	CP - PTP 1.8"x1.75" BS

[a]Army limit at 0° (Projectiles yawed approximately 90°) 2314 f/s

[n]Navy limit at 0° (Projectiles yawed approximately 90°) 2380 f/s

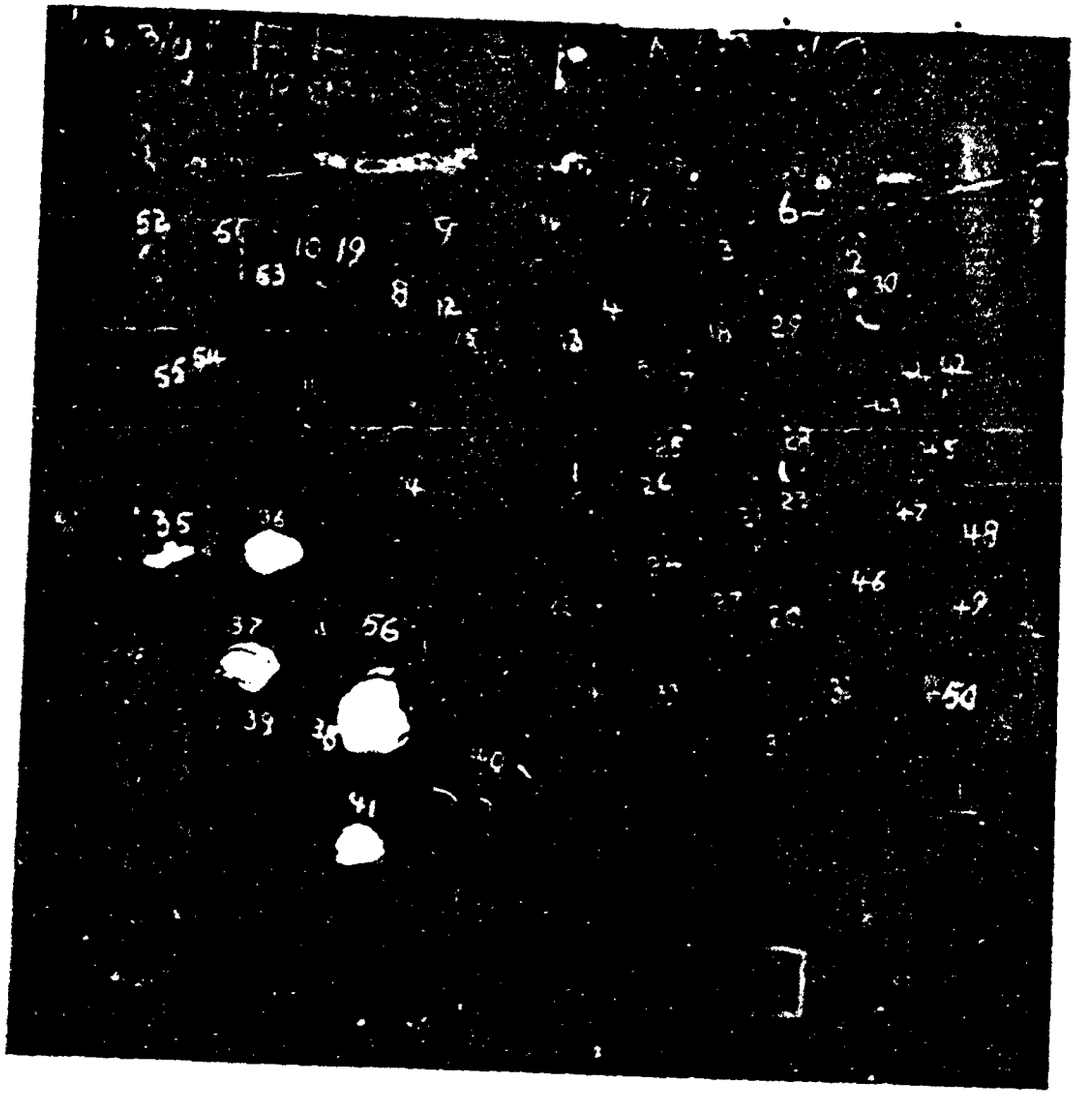
37 MM TP M51 Firing:

30°	56	3 oz.	1736	CP - PTP 3-1/4"x3" BS



WATERTOWN ARSENAL

PLATE 10. 3/8" F.H.; NI-MO. BRINELL FACE 601, BACK 363-388. TESTED AT 0°, 20°, 30°, 40°, 45° OBLIQUITIES WITH CAL .50 AP M2. TESTED WITH YAWED CAL .50 AP M2. SHOCK TESTED WITH 37MM M51 T.P. FRONT MAY 16 1942 W.A.71C-1848



WATERTOWN ARSENAL

PLATE 10. 3/8" F.H.; NI-MO. BRINELL FACE 601, BACK 363-388
MAY 16 1942 BACK W.A.710-1640

Ballistic Data Sheet No. 8

Carnegie-Illinois Plate 19426237 - 1/2" Ni-Cr Homogeneous
BHN 261 - T.S. 132,000 - No Photographs

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
0°	1	85.0	1384	CP - FPTP
0°	2	82.0	1329	CP - FPTP
0°	3	80.0	1248[a]	PP - MB
0°	4	81.0	1287[a]	PP - LB
0°	5	130.0	1869	CP - PTP
0°	6	125.0	1831	CP - PTP
0°	7	120.0	1766[n]	CP - PTP
0°	8	115.0	1729[n]	CP - CIP
0°	9	120.0	1806	CP - PTP
Army limit at 0° - 1268 f/s; Navy limit at 0° - 1748 f/s				
20°	10	130.0	lost	CP - CIP ND
20°	11	125.0	lost	CP - CIP
20°	12	120.0	lost	CP - CIP ND BD
20°	13	120.0	1752	CP - CIP BD
20°	14	125.0	1854	CP - CIP ND
20°	15	130.0	1885	CP - CIP ND BD
20°	16	133.0	lost	CP - CIP ND BD
20°	17	135.0	1988	CP - CIP ND BD
20°	18	140.0	2009	CP - CIP ND
20°	19	145.0	2081	CP - CIP ND BD
20°	20	150.0	2120	CP - CIP ND BD
20°	21	155.0	2207[n]	CP - PTP
20°	22	153.0	2177[n]	CP - CIP ND
20°	23	115.0	1686	CP - CIP BD
20°	24	105.0	1589	CP - FPTP
20°	25	100.0	1570	CP - FPTP
20°	26	95.0	1478[a]	PP - CIP - SB BD
20°	27	98.0	1497[a]	CP - FPTP
[a]Army limit at 20° - 1488 f/s; [n]Navy limit at 20° - 2192 f/s				
30°	28	125.0	1870	PP - SB
30°	29	135.0	1929[a]	CP - CIP BD
30°	30	130.0	1885	PP - MB
30°	31	122.0	1816	PP - MB
30°	32	133.0	1914[a]	PP - CIP - LB Pun S
30°	33	150.0	2115	CP - CIP BD ND
30°	34	155.0	2194	CP - CIP BD ND
30°	35	160.0	lost	CP - CIP BD ND
30°	36	170.0	2387[n]	CP - CIP BD ND
30°	37	175.0	2437	CP - PTP
30°	38	173.0	2407[n]	CP - PTP
Army limit at 30° - 1922 f/s; [n]Navy limit at 30° - 2397 f/s				

Ballistic Data Sheet No. 8 (Cont'd)

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
40°	39	155.0	2204	PP - SB
40°	40	165.0	2318	PP - SB
40°	41	175.0	2437[a,n]	CP - PTP
40°	42	170.0	2392	PP - MB
40°	43	173.0	2417[a,n]	PP - MB

[a]Army limit at 40° - 2427 f/s; [n]Navy limit at 40° - 2427 f/s

37 MM TP M51 Firing:

30°	44	3 oz.	1736	CP - PTP

Ballistic Data Sheet No. 9

Carnegie-Illinois Plate 194268B8 - 1/2"x36"x36" Ni-Cr Homogeneous
BHN 282 - T.S. 132,500 - No Photographs

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
0°	1	125.0	1895	CP - PTP Full petalling
0°	2	115.0	1758[a]	CP - CIP
0°	3	120.0	1782[b]	CP - PTP Full petalling
0°	4	90.0	1462	Backed by support - Disregard
0°	5	95.0	1528	CP - FPTP
0°	6	92.0	1508	CP - FPTP
0°	7	90.0	1385	CP - FPTP
0°	8	85.0	1328[a]	CP - FPTP
0°	9	80.0	1311[a]	PP - LB

[a]Army limit at 0° - 1770 f/s; [b]Navy limit at 0° - 1320 f/s

Ballistic Data Sheet No. 10

Carnegie-Illinois Plate 19426835 - 1/2"x36"x36" Ni-Cr Homogeneous
BHN 302 - T.S. 150,000 - No Photographs

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
0°	1	92.0	lost	CP - FPTP
0°	2	90.0	1460	CP - FPTP
0°	3	87.0	1492	CP - FPTP
0°	4	85.0	1400	CP - FPTP
0°	5	83.0	1327	PP - LB
0°	6	85.0	lost	CP - FPTP
0°	7	84.0	lost	PP - LB
0°	8	84.0	1300	PP - LB
0°	9	87.0	1327[a]	PP - LB
0°	10	89.0	1414	CP - FPTP
0°	11	87.0	1428	CP - FPTP
0°	12	85.0	1351[a]	CP - FPTP
0°	13	135.0	1927	CP - PTP
0°	14	130.0	1864	CP - PTP
0°	15	125.0	1811	CP - CIP
0°	16	128.0	1912	CP - PTP
0°	17	128.0	1863[n]	CP - PTP
0°	18	125.0	1816[n]	CP - CIP
[a]Army limit at 0° - 1339 f/s; [n]Navy limit at 0° - 1840 f/s				
20°	19	160.0	2233[n]	CP - CIP BD
20°	20	165.5	2288	CP - PTP 5/8"x1/4" Back petal
20°	21	163.0	2298	Hit Rd. #3 - Disregard
20°	22	161.0	2260[n]	CP - PTP
20°	23	135.0	1990	CP - FPTP 1/2"x1/4" Back petal 3/4"x1/4" Back petal
20°	24	125.0	1836	CP - FPTP
20°	25	115.0	1729	CP - FPTP
20°	26	105.0	1650	CP - FPTP
20°	27	95.0	1508[a]	PP - SB
20°	28	98.0	1535[a]	CP - FPTP
[a]Army limit at 20° - 1522 f/s; [n]Navy limit at 20° - 2247 f/s				
30°	29	125.0	1851	PP - SB
30°	30	130.0	1918	PP - SB
30°	31	135.0	1984	Hit edge of plate - Disregard
30°	32	135.0	1939	PP - SB
30°	33	140.0	2017	PP - MB
30°	34	145.0	2061	PP - MB
30°	35	155.0	2100	PP - MB
30°	36	165.0	2301[n]	CP - PTP
30°	37	160.0	2273[a,n]	CP - CIP BD ND
30°	38	155.0	2244[a]	PP - MB
[a]Army limit at 30° - 2259 f/s; [n]Navy limit at 30° - 2287 f/s				

Ballistic Data Sheet No. 10 (Cont'd)

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
40°	39	180.0	2505	PP - SB
40°	40	190.0	2609[a]	CP - CLP BD ND
40°	41	185.0	2555	PP - MB
40°	42	188.0	2594[a]	PP - MB
40°	43	195.0	2662	PP - LB
40°	44	205.0	2775	Hit Rd. #35 - Disregard
40°	45	205.0	2782	CP - PTP
40°	46	200.0	2731[a]	CP - PTP
40°	47	198.0	2721[a]	PP - LB

[a]Army limit at 40° - 2602 f/s; [a]Navy limit at 40° - 2726 f/s

37 MM TP M51 Firing:

30°	48	3 oz.	1736	CP - PTP 3-1/4"x2-1/2" BS

Ballistic Data Sheet No. 11

Carnegie-Illinois Plate 19426#B1 - 1/2"x36"x36" Ni-Cr Homogeneous
BHN 321 - T.S. 164,500 - No Photographs

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
0°	1	85.0	1366	PP - LB
0°	2	88.0	1390[a]	PP - LB
0°	3	90.0	1367	PP - LB
0°	4	92.0	1440[a]	CP - PPTP
0°	5	110.0	1638	CP - PPTP
0°	6	125.0	lost	CP - PPTP
0°	7	135.0	1950	CP - PTP 3/8"x1/4" Back petal
0°	8	130.0	1[illegible]	PP - Hit Rd. #7 - Disregard
0°	9	132.0	19[illegible][a]	CP - PTP
0°	10	130.0	1882[a]	CP - CIP
[a]Army limit at 0° - 1415 f/s; [b]Navy limit at 0° - 1901 f/s				
20°	11	165.0	2293	CP - PTP
20°	12	160.0	2220[a]	CP - PTP
20°	13	155.0	lost	Hit Rd. #11 - Disregard
20°	14	150.0	2150	CP - CIP 3/8"x3/4" Back petal
20°	15	155.0	2199	Hit Rd. #14 - Disregard
20°	16	154.0	2191[a]	CP - CIP 3/4"x1/4" Back petal
20°	17	115.0	1748	PP - SB
20°	18	120.0	1768	PP - SB
20°	19	125.0	1847[a]	PP - Pun S
20°	20	128.0	1873[a]	CP - CIP
[a]Army limit at 20° - 1850 f/s; [b]Navy limit at 20° - 2206 f/s				
30°	21	170.0	2358	PP - Pun S
30°	22	175.0	2437	CP - PTP
30°	23	172.5	2407[a,b]	CP - PTP
30°	24	171.0	2397[a,b]	PP - MB
[a]Army limit at 30° - 2402 f/s; [b]Navy limit at 30° - 2402 f/s				
40°	25	200.0	2680	PP - MB
40°	26	205.0	2783[a,b]	PP - MB
40°	27	210.0	2849	CP - PTP 3/4"x5/8" Pun
40°	28	208.0	2808[a,b]	CP - PTP 3/8"x5/8" Pun
[a]Army limit at 40° - 2796 f/s; [b]Navy limit at 40° - 2796 f/s				
37 MM TP M51 Firing:				
30°	29	3 oz.	1736	CP - PTP

Ballistic Data Sheet No. 12

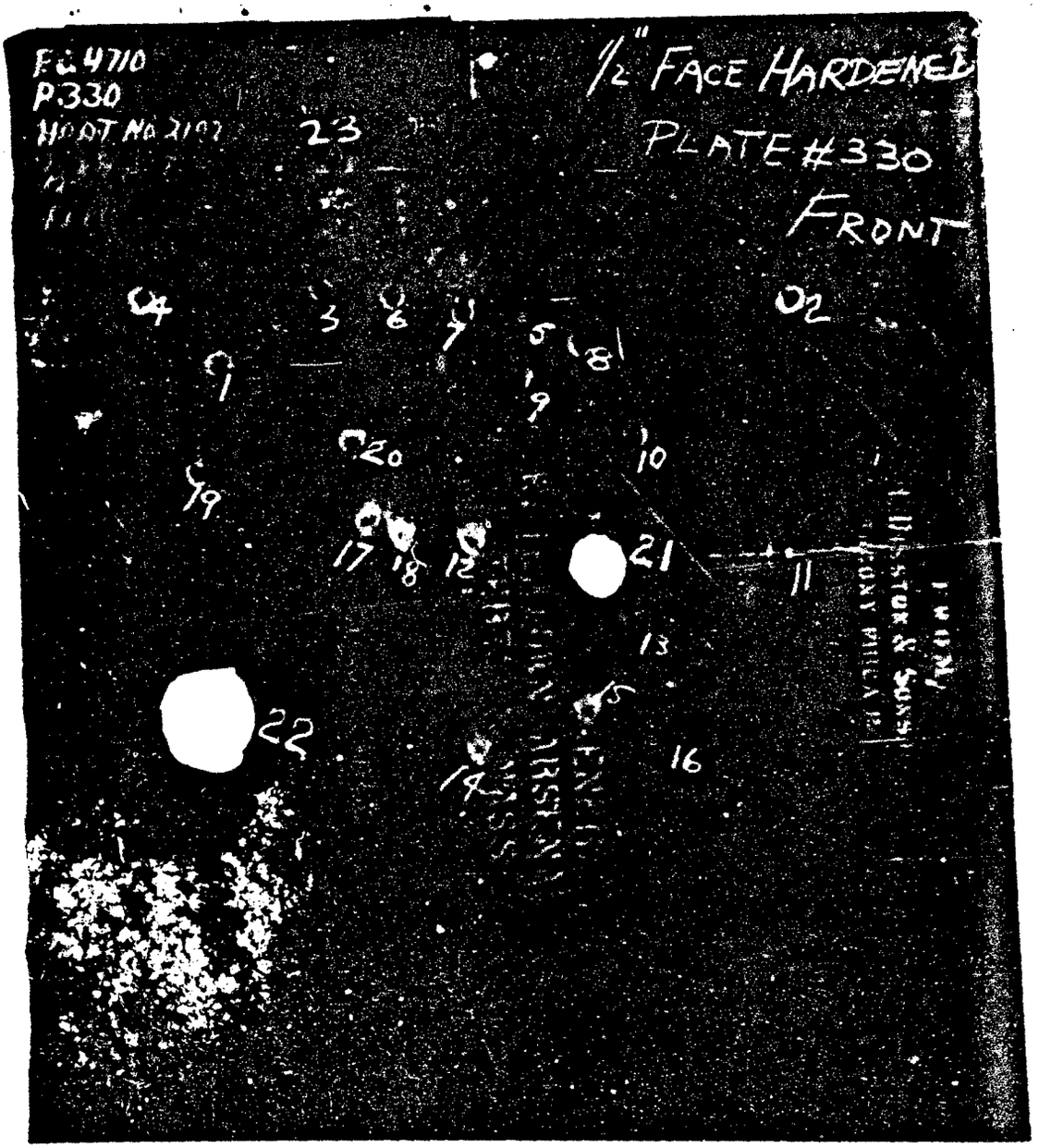
Carnegie-Illinois Plate 181206A2 - 1/2"x36"x36" Ni-Cr Homogeneous
BHN 415 - T.S. 210,500 - No Photographs

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
0°	1	92.0	1407	CP - FPTP 9/16"x3/8" Pun
0°	2	105.0	lost	CP - PTP
0°	3	100.0	lost	CP - FPTP 5/8"x3/8" Pun
0°	4	100.0	1515[a]	CP - FPTP 1/2"x3/8" Pun
0°	5	105.0	1528[a]	CP - PTP 2/3"x1/2" BS
0°	6	85.0	1325[a]	PP - LB - Pun S
0°	7	89.0	1375[a]	CP - FPTP 1/2"x3/8" Pun
[a]Army limit at 0° - 1350 f/s; [b]Navy limit at 0° - 1522 f/s				
20°	8	130.0	1890[a,b]	PP - MB
20°	9	140.0	1988	CP - FPTP 5/8"x3/8" Pun
20°	10	135.0	1914[a,b]	CP - PTP 1-3/4"x1-1/4" BS
[a]Army limit at 20° - 1902 f/s; [b]Navy limit at 20° - 1902 f/s				
30°	11	160.0	2259	PP - MB
30°	12	170.0	2367	PP - SB
30°	13	175.0	2457[a]	PP - LB
30°	14	178.0	2482[a]	CP - CIP 3/8"x1/8" Pun BD
30°	15	185.0	2545	CP - CIP 3/8"x3/8" Pun BD
30°	16	190.0	2491	PP - LB
30°	17	195.0	2648[a]	CP - PTP 1-1/4"x3/4" BS
30°	18	190.0	2624[a]	CP - CIP 3/8"x3/8" Pun BD, ND
[a]Army limit at 30° - 2470 f/s; [b]Navy limit at 30° - 2636 f/s				
40°	19	205.0	2799	Hit Rd. #12 - Disregard
40°	20	205.0	2812[a]	CP - CIP BD - ND
40°	21	209.0	2869[a]	CP - CIP BD - ND
40°	22	212.0	2897[a]	CP - PTP 3/4"x5/8" BS
40°	23	200.0	2721	PP - MB
40°	24	203.0	2787[a]	PP - Pun S
[a]Army limit at 40° - 2800 f/s; [b]Navy limit at 40° - 2883 f/s				
37 MM TP M51 Firing:				
30°	25	3 oz.	1736	CP - PTP 6-1/4"x4-1/2" BS Cracking started

Ballistic Data Sheet No. 13

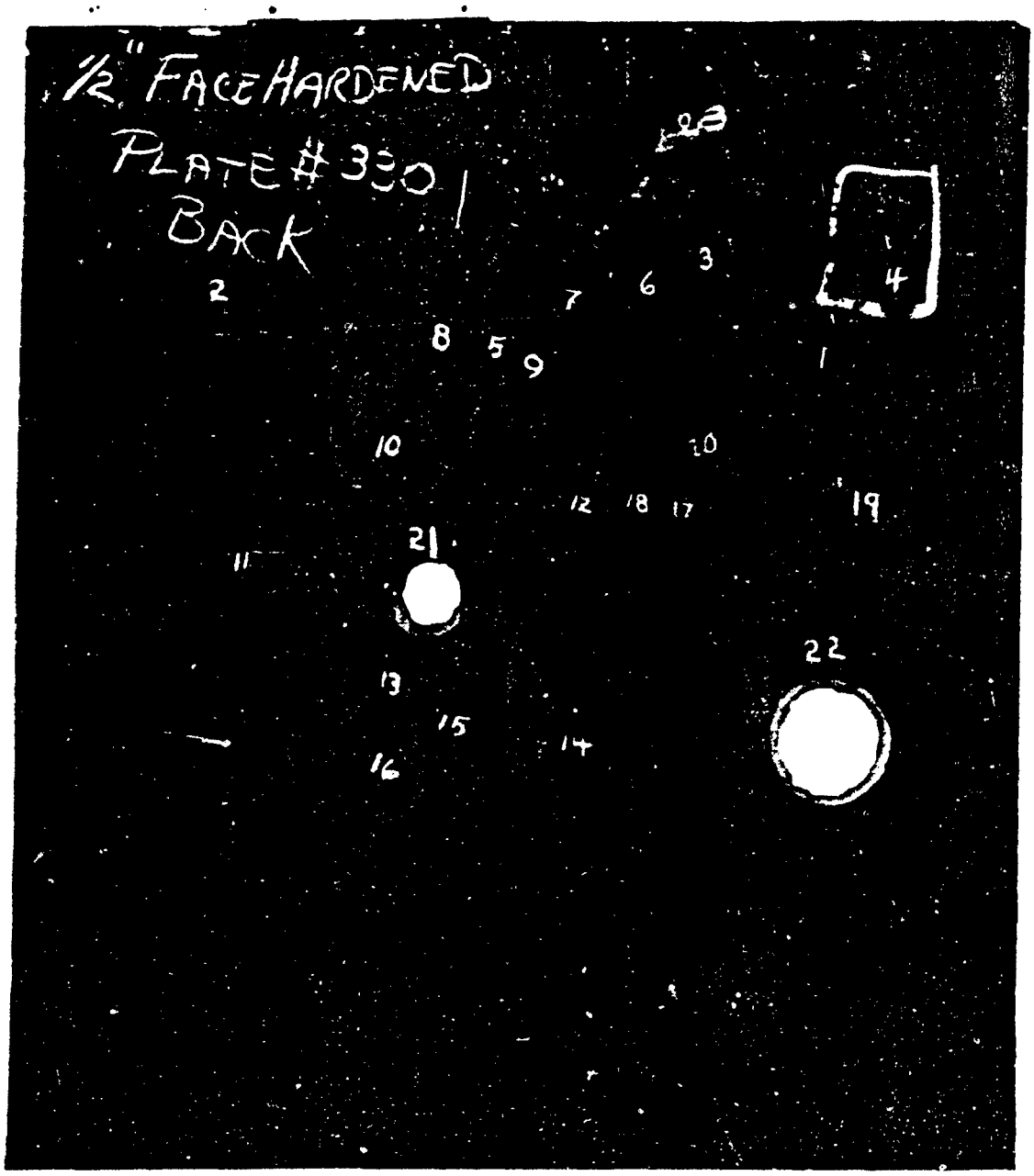
Diseton Plate 330 - 1/2"x36"x36" Ni-Mo Face Hardened
BHN: Face 653, Back 363 - Photographs W.A. 710-1846, W.A. 710-1847

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
0°	1	155.0	2066	FP - SB
0°	2	165.0	2207	CP - PTP
0°	3	160.0	2140	Missed plate
0°	4	160.0	2132[a,n]	FP - CIP - MB Pun S
0°	5	165.0	2203	CP - PTP
0°	6	162.5	2155[a,n]	CP - PTP
[a]Army limit at 0° - 2144 f/s; [n]Navy limit at 0° - 2144 f/s				
10°	23	170.0	2238	Missed plate
10°	24	170.0	2239[a,n]	FP - SB
10°	25	175.0	2287[a,n]	CP - PTP
[a]Army limit at 10° - 2253 f/s; [n]Navy limit at 10° - 2253 f/s				
20°	7	190.0	2471	CP - FPTP
20°	8	185.0	2456	CP - PTP .85"x.7" FS, 1/8" Back petal
20°	9	180.0	2382[a,n]	FP - CIP - SB BD
20°	10	182.5	2407[a,n]	CP - PTP .85"x.7" FS
[a]Army limit at 20° - 2395 f/s; [n]Navy limit at 20° - 2395 f/s				
30°	11	205.0	2735	CP - PTP
30°	12	200.0	2671[a,n]	FP - SB
30°	13	202.5	2691[a,n]	CP - PTP
[a]Army limit at 30° - 2681 f/s; [n]Navy limit at 30° - 2681 f/s				
40°	14	210.0	2770	FP - SB
40°	15	215.0	2849	FP - SB
40°	16	Preload	2969[a,n]	CP - PTP .7"x.95" FS
40°	17	"	2909	FP - SB
40°	18	"	2829	FP - SB
40°	19	"	2967[a,n]	FP - SB
[a]Army limit at 40° - 2968 f/s; [n]Navy limit at 40° - 2968 f/s				
37 MM AP M51 Firing:				
30°	20	4.5oz.	2234	CP - PTP 2.13"x2.65" BS
37 MM TP M51 Firings:				
30°	21	3.75oz.	1994	FP - Supported - 1.95"x1.85" Entrance Diameter, 2.10"x2.45" Exit Diameter including BS
30°	22	98grams	1895	CP - PTP 3"x3.25" Entrance Diameter, 3-7/8"x4" Exit Diameter including BS



WATERTOWN ARSENAL

PLATE 330, HEAT 21927, 1/2" F.H.; NI-MO. BRINELL FACE 653, BACK 363. TESTED AT 0°, 10°, 20°, 30°, 40° OBLIQUITIES. SHOCK TESTED WITH 37MM M51 A.P.C. AND 37MM M51 T.P. FRONT MAY 16 1942 W.A.710-1846



WATERTOWN ARSENAL

PLATE 330, HEAT 21927, 1/2" F.H.; NI-MO. BRINELL FACE 653, BACK 363
MAY 16 1942 BACK W.A.71C-1947

Ballistic Data Sheet No. 14

Carnegie-Illinois Plate 196198-1 - 5/8"x36"x36" Ni-Cr Homogeneous
BHN 255 - T.S. 129,500 - No Photographs

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
0°	1	125.0	1846	CP - CIP
0°	2	135.0	1949	CP - PTP Full petalling
0°	3	130.0	1885[n]	CP - FPTP
0°	4	133.0	1907[n]	CP - PTP
0°	5	105.0	1622	CP - FPTP
0°	6	100.0	1584	CP - FPTP
0°	7	95.0	1507	CP - FPTP
0°	8	90.0	1426[a]	PP - LB
0°	9	93.0	1468	CP - FPTP
0°	10	91.0	1451[a]	PP - LB
[a]Army limit at 0° - 1439 f/s; [n]Navy limit at 0° - 1896 f/s				
20°	11	125.0	1836[a]	PP - CIP Pun S BD
20°	12	130.0	1875	CP - CIP
20°	13	128.0	1885	Backed by support - Disregard
20°	14	127.0	1840[a]	CP - CIP BD
20°	15	140.0	1998	CP - CIP BD ND
20°	16	145.0	2053	CP - CIP BD ND
20°	17	150.0	2120	CP - CIP BD ND
20°	18	155.0	2179	CP - CIP BD ND
20°	19	160.0	2244	CP - CIP BD ND
20°	20	170.0	2367	CP - CIP BD ND
20°	21	180.0	2496[n]	CP - CIP BD ND
20°	22	190.0	2624	CP - PTP
20°	23	185.0	2523[n]	CP - PTP
[a]Army limit at 20° - 1838 f/s; [n]Navy limit at 20° - 2510 f/s				
30°	24	145.0	2050[a]	CP - CIP 3/8"x5/8" Pun ND BD
30°	25	135.0	1988	PP - MB
30°	26	140.0	2017	PP - LB - CIP BD
30°	27	143.0	2042[a]	PP - SB
30°	28	200.0	2692	Hit within 1 cal. of Rd.#25 - Disregard
30°	29	210.0	2849	CP - PTP
30°	30	205.0	2789[n]	CP - PTP 3/8"x1/4" Back petal
30°	31	202.0	2780[n]	CP - CIP BD ND
[a]Army limit at 30° - 2046 f/s; [n]Navy limit at 30° - 2785 f/s				
40°	32	175.0	2495	PP - SB
40°	33	185.0	2545[a]	CP - CIP BD
40°	34	181.0	2535	CP - Hit Rd.#33 - Disregard
40°	35	180.0	2515[a]	PP - SB
40°	36	215.0	2900	CP - CIP Projectile shattered
[a]Army limit at 40° - 2530 f/s; Navy limit not determined				
37 MM TP M51 Firing:				
30°	37	3.75oz.	1870	CP - PTP

Ballistic Data Sheet No. 15

Carnegie-Illinois Plate 196198-3 - 5/8"x36"x36" Ni-Cr Homogeneous
BHN 302 - T.S. 149,000 - No Photographs

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
0°	1	140.0	2020	CP - CIP
0°	2	150.0	2125	CP - PTP Full petalling Hit within 1 caliber of Rd. # 1 - Disregard
0°	3	145.0	2115	CP - PTP
0°	4	135.0	1985[n]	CP - CIP
0°	5	138.0	2007[n]	CP - PTP
0°	6	105.0	1655	CP - FPTP
0°	7	100.0	1594	CP - FPTP
0°	8	95.0	1488	PP - LB
0°	9	98.0	1534[a]	CP - FPTP
0°	10	96.0	1511[a]	PP - LB
[a]Army limit at 0° - 1523 f/s; [n]Navy limit at 0° - 1996 f/s				
20°	11	180.0	2505	CP - CIP Projectile shattered
20°	12	185.0	2535	CP - PTP Full petalling
20°	13	165.0	2315	CP - CIP BD ND
20°	14	155.0	2190[n]	CP - PTP 3/4"x5/8" Back petal
20°	15	150.0	2130	CP - CIP 1/2"x1/4" Back petal BD ND
20°	16	140.0	2042	CP - CIP BD
20°	17	130.0	1885[a]	CP - FPTP
20°	18	125.0	1855[a]	PP - NB
20°	19	153.0	2161[n]	CP - FPTP
[a]Army limit at 20° - 1870 f/s; [n]Navy limit at 20° - 2176 f/s				
30°	20	160.0	2219	PP - NB
30°	21	175.0	2427[a,n]	PP - Pun S
30°	22	180.0	2505	CP - CIP Projectile shattered
30°	23	177.0	2456[a,n]	CP - PTP
[a]Army limit at 30° - 2442 f/s; [n]Navy limit at 30° - 2442 f/s				
40°	24	200.0	2714[a]	PP - SB
40°	25	215.0	2949	CP - PTP
40°	26	208.0	2771[n]	CP - PTP
40°	27	202.0	2799	PP - NB
40°	28	201.0	2743[a,n]	CP - CIP BD
[a]Army limit at 40° - 2729 f/s; [n]Navy limit at 40° - 2758 f/s				
37 MM TP M51 Firing:				
30°	29	3 oz.	1741	CP - PTP 2-1/4"x3-1/2" BS

Ballistic Data Sheet No. 16

Carnegie-Illinois Plate 196198-5 - 5/8"x36"x36" Ni-Cr Homogeneous
BHN 359 - T.S. 175,000 - No Photographs

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
0°	1	135.0	1963	CP - FPTP 5/8"x1/4" Face petal
0°	2	145.0	2056	CP - FPTP 5/8"x3/8" Face petal
0°	3	155.0	2190	CP - CIP Backed by support - Disregard
0°	4	155.0	2185[a]	CP - PTP 5/8"x3/8" Face petal - 3/8"x3/8" BS
0°	5	152.0	2169[a]	CP - CIP 3/4"x5/8" BP; 3/8"x3/8" FP
0°	6	120.0	1776	CP - FPTP
0°	7	110.0	1660[a]	CP - FPTP
0°	8	105.0	1584	PP - MB
0°	9	108.0	1632[a]	PP
[a]Army limit at 0° - 1646 f/s; [b]Navy limit at 0° - 2177 f/s				
20°	10	140.0	1993	PP - SB
20°	11	145.0	2032	PP - MB
20°	12	150.0	2100	PP - MB
20°	13	155.0	2169[a,b]	CP - PTP
20°	14	153.0	2153[a,b]	PP - SB
[a]Army limit at 20° - 2161 f/s; [b]Navy limit at 20° - 2161 f/s				
30°	15	165.0	2387	PP - SB
30°	16	175.0	2466	PP - SB
30°	17	185.0	2564	Hit Rd. #11 - Disregard
30°	18	195.0	2663	PP - MB
30°	19	205.0	2789	CP - PTP
30°	20	200.0	2731	CP - PTP
30°	21	198.0	2701[a,b]	CP - PTP
30°	22	196.0	2683	Backed by support - Disregard
30°	23	196.0	2675[a,b]	PP - LB
[a]Army limit at 30° - 2688 f/s; [b]Navy limit at 30° - 2688 f/s				
40°	24	215.0	2924	PP - MB
37 MM TP M51 Firing:				
30°	25	2.5 oz.	1470	PP - LB

Ballistic Data Sheet No. 17

Carnegie-Illinois Plate 196198-7 - 5/8"x36"x36" Ni-Cr Homogeneous
BHN 409 - T.S. 203,500 - No Photographs

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
0°	1	130.0	1902	CP - CIP 1-3/4"x1-3/4" BS
0°	2	135.0	1934	CP - CIP 3/8"x3/8" BS
0°	3	140.0	2012[n]	CP - CIP 2" Pun S
0°	4	145.0	2045	Hit Rd. #3 - Disregard
0°	5	145.0	2039[n]	CP - PTP
0°	6	105.0	1625[a]	PP - MB
0°	7	110.0	1652[a]	CP - FPTP
[a]Army limit at 0° - 1639 f/s; [n]Navy limit at 0° - 2024 f/s				
20°	8	155.0	2189	PP - SB
20°	9	160.0	2244	PP - SB
20°	10	165.0	2318	Hit within 2 calibers of Rd. #9
20°	11	165.0	2293	PP - SB
20°	12	170.0	2367[a,n]	CP - PTP
20°	13	168.0	2343[a,n]	PP - SB
[a]Army limit at 20° - 2355 f/s; [n]Navy limit at 20° - 2355 f/s				
30°	14	180.0	2535	PP - SB
30°	15	185.0	2565	PP - MB
30°	16	190.0	2614	PP - MB
30°	17	195.0	2667	PP - MB
30°	18	200.0	2721	PP - SB
30°	19	205.0	2785[a,n]	CP - CIP 3" crack on back
30°	20	202.0	2760[a]	PP - SB
30°	21	210.0	2868	CP - PTP 2/3"x5/8" BS
30°	22	208.0	2848	CP - PTP 5/8"x3/8" BP
30°	23	206.0	2812[a]	CP - PTP
[a]Army limit at 30° - 2773 f/s; [n]Navy limit at 30° - 2799 f/s				
40°	24	215.0	2909	PP - MB
37 MM TP M51 Firings:				
30°	25	3.5 oz.	1895	CP - PTP 5½"x4" BS Two 10" radial cracks. One 8" radial crack.

Ballistic Data Sheet No. 18

Carnegie-Illinois Plate 196198-S - 5/8"x36"x36" Ni-Cr Homogeneous
BHN 415 - T.S. 205,000 - Photographs W.A. 710-1844, W.A. 710-1845

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
0°	1	140.0	1987[n]	CP - CIP BD
0°	2	150.0	2055	CP - PTP 3/8"x5/8" BP; 3/4"x3/4" FP
0°	3	145.0	2010[n]	CP - PTP 2/3"x2/3" BS; 2/3"x3/8" FP
0°	4	100.0	1574	PP - MB
0°	5	105.0	1628[a]	PP - LB
0°	6	110.0	1651[a]	CP - FPTP
[a]Army limit at 0° - 1640 f/s; [n]Navy limit at 0° - 1999 f/s				
20°	7	150.0	2012	PP - NB
20°	8	160.0	2229[a]	CP - CIP BD
20°	9	155.0	2169	PP - NB
20°	10	158.0	2209[a]	PP - NB
20°	11	170.0	2369	PP - LB
20°	12	180.0	2476[n]	CP - PTP
20°	13	175.0	2452[n]	PP - MB
[a]Army limit at 20° - 2219 f/s; [n]Navy limit at 20° - 2464 f/s				
30°	14	180.0	2500	PP - NB
30°	15	190.0	2614	PP - NB
30°	16	200.0	2711	PP - NB
30°	17	210.0	2894[a,n]	CP - PTP
30°	18	205.0	2770	PP - NB
30°	19	208.0	2814	PP - MB
30°	20	209.0	2868[a,n]	PP - SB
[a]Army limit at 30° - 2881 f/s; [n]Navy limit at 30° - 2881 f/s				
40°	21	215.0	2909	PP - SB
37 MM TP M51 Firing:				
30°	22	3oz.	1726	CP - PTP - Plate broke up

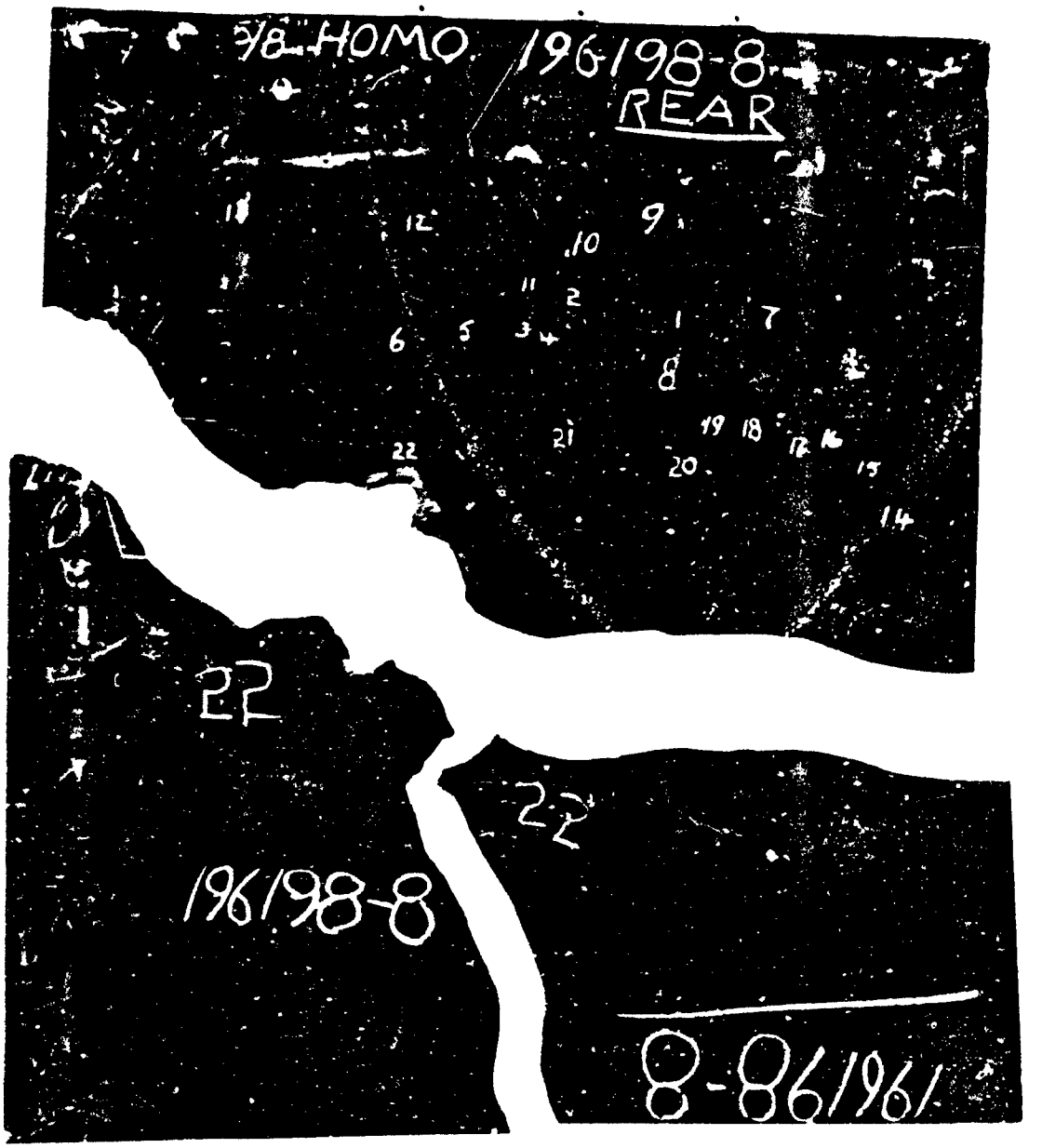
Ballistic Data Sheet No. 19

Disston Plate 303 - 5/8"x36"x36" Ni-Mo Face Hardened
BHN (Not Determined) - No Photographs

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
0°	1	160.0	2303[a,n]	PP - NB
0°	2	170.0	2417	CP - CIP
0°	3	165.0	2338	Hit earlier shot - Disregard
0°	4	165.0	2318[a,n]	CP - PTP
0°	5	180.0	2466	CP - PTP
[a]Army limit at 0° - 2311 f/s; [n]Navy limit at 0° - 2311 f/s				
20°	6	190.0	2599[a,n]	CP - CIP
20°	7	180.0	2480	PP - NB
20°	8	185.0	2592[a]	PP - NB
20°	9	195.0	2647[n]	CP - PTP
[a]Army limit at 20° - 2596 f/s; [n]Navy limit at 20° - 2623 f/s				
30°	10	200.0	2701[a]	PP - NB
30°	11	210.0	2839	CP - CIP
30°	12	205.0	2750[a]	CP - CIP
30°	13	215.0	2889	CP - CIP
[a]Army limit at 30° - 2726 f/s; Navy limit not determined				

WATERTOWN ARSENAL

PLATE 196198-8. 5/8" HOMO. NI-CR. T.S.205,000; BRINELL 415. TESTED WITH CAL .50 AP M2 AT 0°, 20° AND 30° OBLIQUITIES. SHOCK TESTED WITH 37 MM M51 TP. FRONT MAY 16 1942 W.A.710-1644



WATERTOWN ARSENAL

PLATE 196198-8. 5/8" HOMO. NI-CR. T.S. 205,000; BRINELL 415
MAY 16 1942 BACK W.A.710-1645

Ballistic Data Sheet No. 20

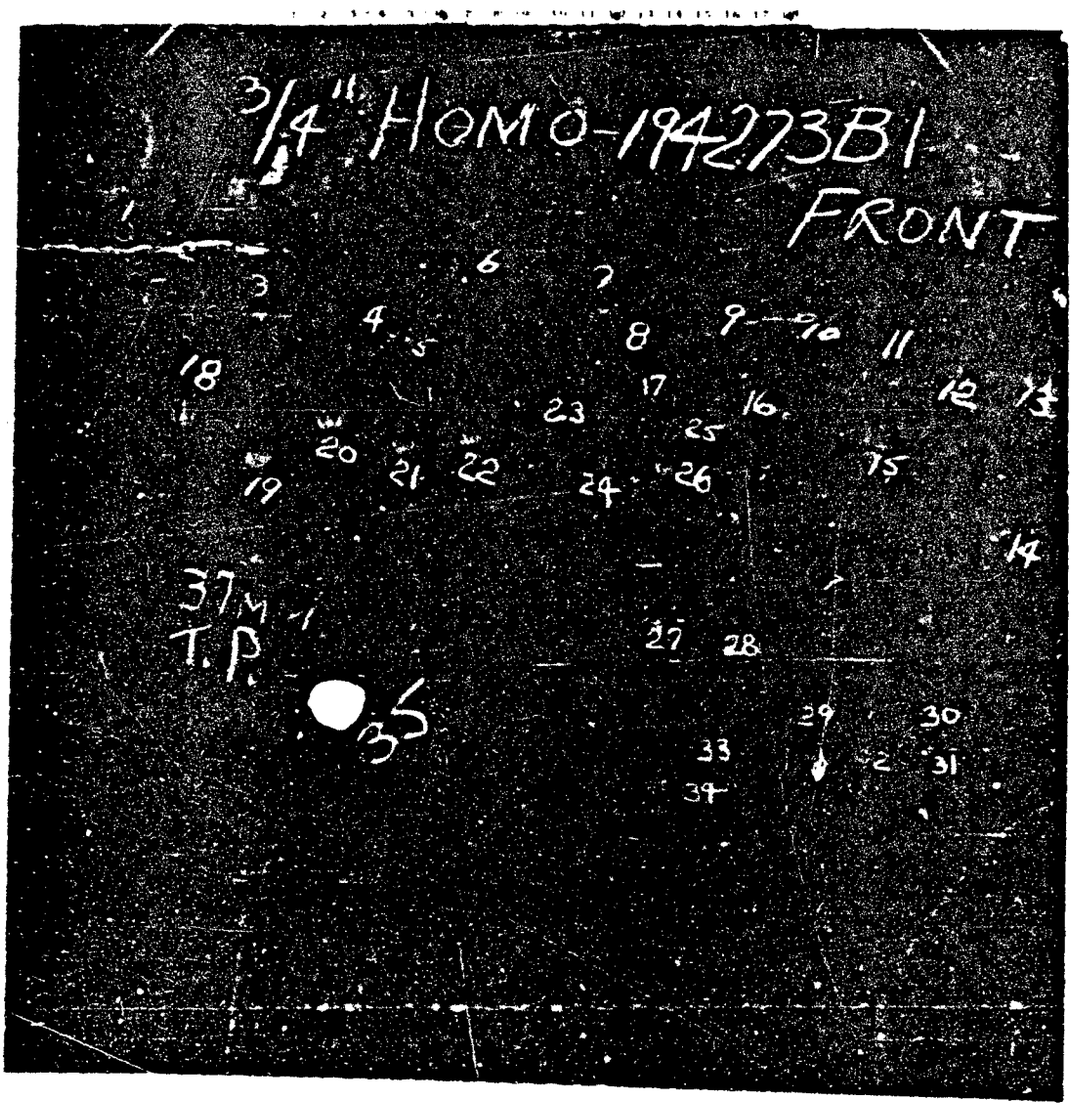
Carnegie-Illinois Plate 194273-B1 - 3/4"x36"x36" Ni-Cr Homogeneous
BHN 269 - T.S. 130,500 - Photographs W.A. 710-1824, W.A. 710-1825

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
0°	1	150.0	2115	CP - FPTP
0°	2	160.0	2197[n]	CP - PTP
0°	3	155.0	2138	CP - CIP
0°	4	157.5	2172[n]	CP - CIP
0°	5	125.0	1785[a]	PP - MB Radial cracks
0°	6	128.0	1811[a]	CP - FPTP
[a]Army limit at 0° - 1798 f/s; [n]Navy limit at 0° - 2185 f/s				
10°	27	145.0	1881	CP - FPTP - SC
10°	28	140.0	1834	CP - FPTP 1/4" diametric crack
10°	29	135.0	1771[a]	PP - LB 3/8"x1/8" FP
10°	30	137.5	1801[a]	CP - FPTP - SC
10°	31	160.0	2106	CP - CIP
10°	32	165.0	2186[n]	CP - PTP Full petalling
10°	33	162.5	2151	CP - CIP
10°	34	164.0	2161[n]	CP - CIP
[a]Army limit at 10° - 1786 f/s; [n]Navy limit at 10° - 2174 f/s				
20°	7	165.0	2289	CP - CIP
20°	8	170.0	2352	CP - CIP 3/4"x1/8" FP
20°	9	175.0	2407	CP - FPTP
20°	10	176.0	2425[n]	CP - FPTP
20°	11	177.0	2451[n]	CP - FTP 1/2"x3/8" BP
20°	12	160.0	2239	CP - CIP 7/8"x1/8" FP BD
20°	13	150.0	2110	CP - FPTP 7/8"x1/8" FP
20°	14	147.5	2061	CP - CIP 1/2"x1/8" FP
20°	15	145.0	2051	CP - CIP 3/4"x1/8" FP
20°	16	142.5	2024[a]	CP - FPTP
20°	17	142.0	1996[a]	PP - LB
[a]Army limit at 20° - 2010 f/s; [n]Navy limit at 20° - 2438 f/s				
30°	18	160.0	2224	PP - MB
30°	19	190.0	2555	CP - PTP 5/8"x1/4" FP
30°	20	180.0	2427[a]	CP - CIP 1/2"x1/4" FP
30°	21	185.0	2488	CP - CIP 1"x1/4" FP
30°	22	187.5	2526[n]	CP - PTP
30°	23	185.5	2500[n]	CP - CIP 1"x1/4" FP
30°	24	170.0	2323	PP - MB Hit Rd. #23
30°	25	175.0	2388	PP - MB 7/8"x1/4" FP
30°	26	177.0	2402[a]	PP - LB - CIP Pun S
[a]Army limit at 30° - 2415 f/s; [n]Navy limit at 30° - 2513 f/s				
37 MM TP M51 Firing:				
0°	35	3 oz.	1811	CP - PTP 2½"x2" BS 1½" Radial crack

Ballistic Data Sheet No. 21

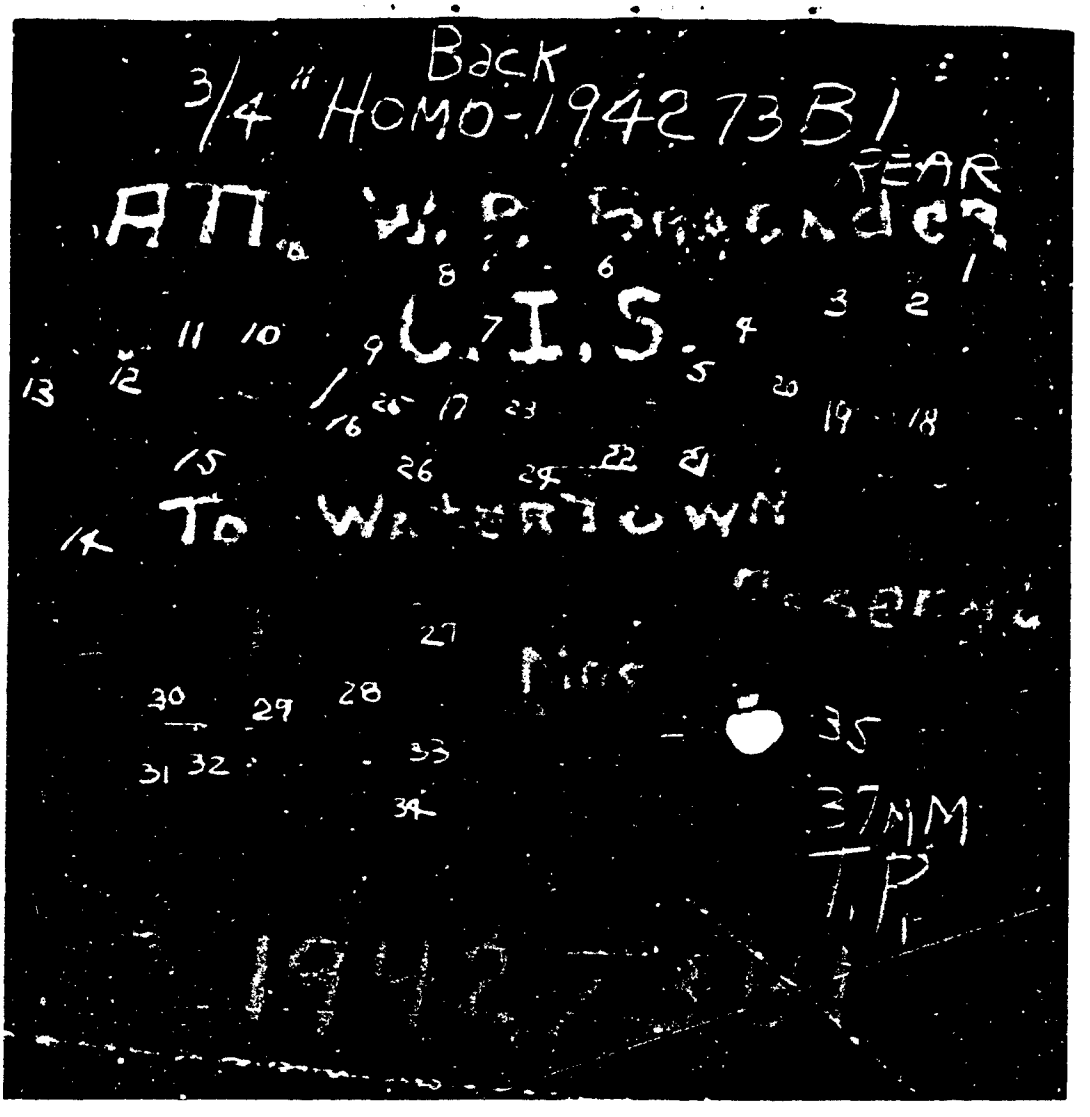
Carnegie-Illinois Plate 194273-B2 - 3/4"x36"x36" Ni-Cr Homogeneous
BHN 271 - T.S. 131,000 - Photographs W.A. 710-1826, W.A. 710-1827

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
0°	1	120.0	1774	CP - FPTP
0°	2	120.0	1700	PP - LB
0°	3	122.0	1729[a]	PP - LB
0°	4	124.0	1754[a]	CP - FPTP
0°	5	150.0	2076	CP - CIP
0°	6	160.0	lost	Hit Rd. #5 - Disregard
0°	7	160.0	2199	CP - PTP
0°	8	155.0	2140[b]	CP - PTP
0°	9	152.5	2120[b]	CP - CIP
[a]Army limit at 0° - 1742 f/s; [b]Navy limit at 0° - 2130 f/s				
10°	29	165.0	2225	CP - PTP
10°	30	155.0	2075	CP - CIP
10°	31	160.0	2148[b]	CP - CIP BD
10°	32	140.0	1855	CP - FPTP
10°	33	135.0	1832	CP - FPTP
10°	34	125.0	1686	PP - MB
10°	35	128.0	1748[a]	CP - FPTP
10°	36	126.0	1730[a]	PP - LB
10°	37	165.0	2397	PTP
10°	38	170.0	2367	PTP
10°	39	155.0	2249	CP - PTP
10°	40	155.0	2179[b]	CP - PTP
[a]Army limit at 10° - 1739 f/s; [b]Navy limit at 10° - 2164 f/s				
20°	10	140.0	2011	PP - SB - CIP BD
20°	11	155.0	2162[a]	PP - LB - CIP BD
20°	12	160.0	2189[a]	PP - CIP BD
20°	13	162.5	2222	CP - CIP
20°	14	165.0	2287[b]	CP - FPTP
20°	15	167.0	2319[b]	CP - PTP 1/4"x1/2" EP
[a]Army limit at 20° - 2176 f/s; [b]Navy limit at 20° - 2303 f/s				
30°	18	170.0	2323	Banked by support - Disregard
30°	19	170.0	2324[a]	PP - MB 1/4"x3/4" FP
30°	20	190.0	2564[a]	CP - FPTP 1/2"x1/4" FP
30°	21	195.0	2603	CP - FPTP
30°	22	200.0	2682	CP - FPTP 1"x1/4" FP
30°	23	205.0	2750	CP - PTP 1"x1/2" FP
30°	24	190.0	2579[b]	CP - PTP
30°	25	180.0	2437	CP - CIP
30°	26	175.0	lost	CP - CIP 1"x1/4" FP
30°	27	190.0	2560	CP - CIP
30°	28	172.5	2348[a]	CP - CIP 1"x1/4" FP
[a]Army limit at 30° - 2336 f/s; [b]Navy limit at 30° - 2572 f/s				
37 MM AP M51 Firings:				
40°	16	2.8 oz.	1608	CP - PTP
40°	17	2.5 oz.	1508	CP - PTP



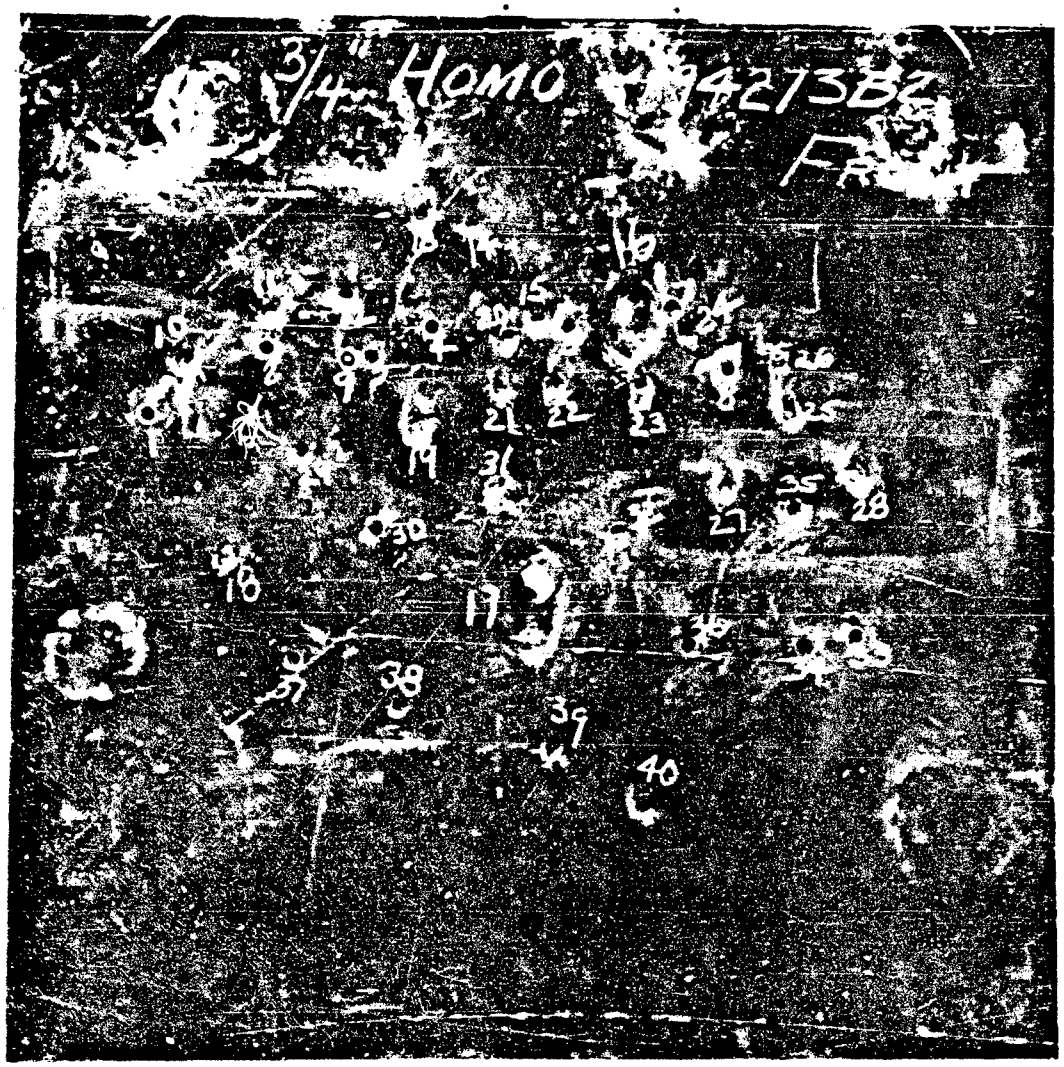
WATERTOWN ARSENAL

PLATE 194273-B1. 3/4" HOMO. NI-CR. T.9. 130,500; BRINELL 269. TESTED AT 0°, 10°, 20°, 30° OBLIQUITIES WITH CAL .50 AP M2. SHOCK TESTED WITH 37 MM M51 TP. FRONT MAY 16 1942 W.A.710-1824



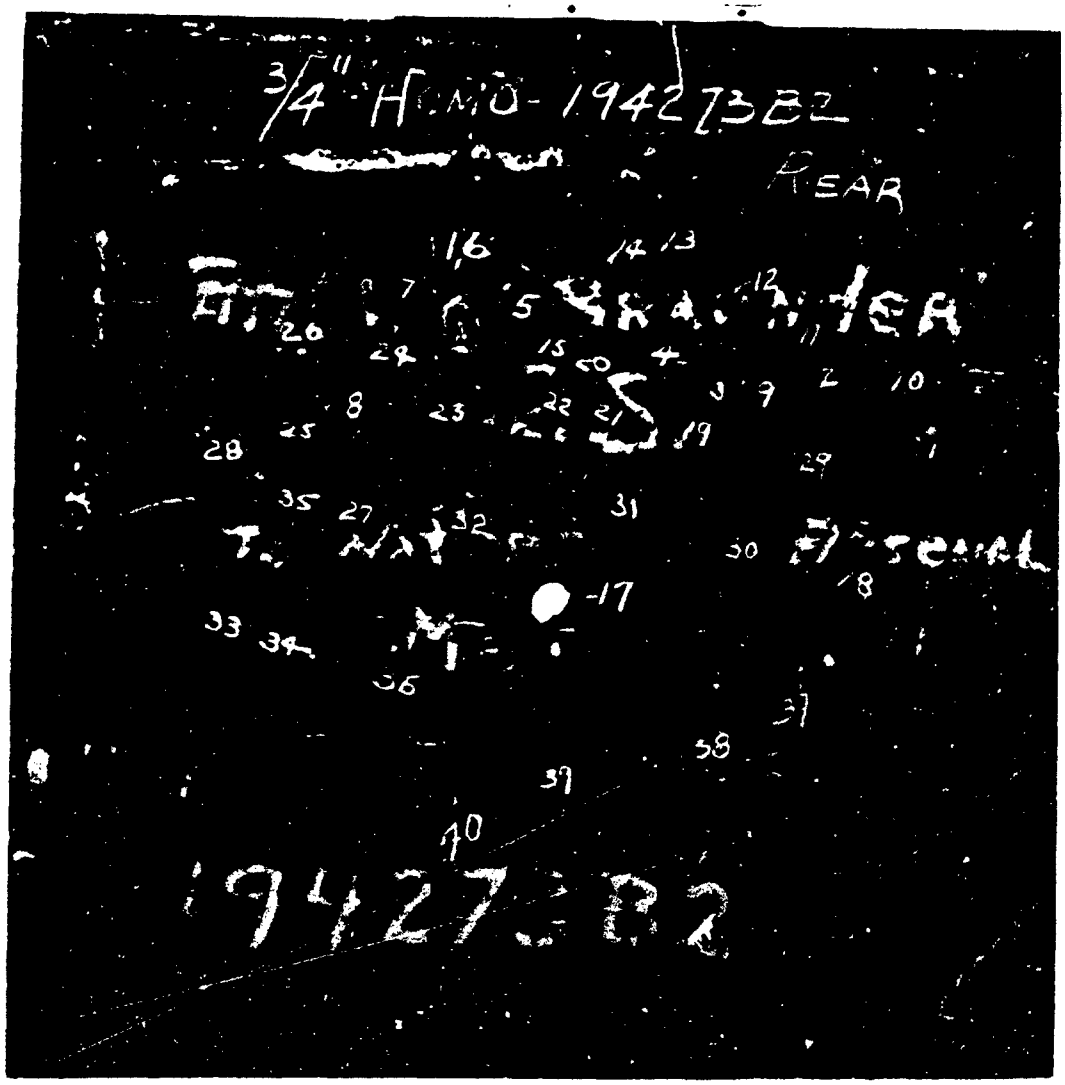
WATERTOWN ARSENAL

PLATE 194273-B1. 3/4" HOMO. NI-CR. T.S. 130,500; BRINELL 269
MAY 16 1942 BACK W.A.710-1825



WATERTOWN ARSENAL

PLATE 194273-B2. 3/4" HOMO. NI-CR. T.S. 131,000; BRINELL 271. TESTED AT 0°, 10°, 20°, 30° OBLIQUITIES WITH CAL .50 AP M2. IMPACTED AT 40° OBLIQUITY WITH 37MM M51 A.P.C. FRONT MAY 16 1942 W.A.710-1826



WATERTOWN ARSENAL

PLATE 194273-B2. 3/4" HOMO. Ni-Cr. T.S. 131,000; BRINELL 271
MAY 16 1942 BACK W.A.716-1827

Ballistic Data Sheet No. 22

Carnegie-Illinois Plate 19427353 - 3/4"x36"x36" Ni-Cr Homogeneous
BHN 302 - T.S. 154,000 - Photographs W.A. 710-1825, W.A. 710-1829

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
0°	1	122.5	1764	PP - MB
0°	2	125.0	1772	PP - MB
0°	3	130.0	1812[a]	PP - LB
0°	4	135.0	1885	CP - FPTP
0°	5	132.5	1838[a]	CP - FPTP
0°	6	165.0	2244[n]	CP - PTP
0°	7	155.0	2150	Hit screen and yawed - Disregard
0°	8	160.0	2204	CP - FPTP
0°	9	162.5	2240[n]	CP - CIP
[a]Army limit at 0° - 1825 f/s; [n]Navy limit at 0° - 2242 f/s				
10°	29	150.0	2002	CP - FPTP
10°	30	147.0	lost	Missed plate
10°	31	145.0	lost	CP - FPTP
10°	32	140.0	1920[a]	CP - FPTP
10°	33	137.0	lost	PP - MB
10°	34	137.0	1885	PP - LB
10°	35	138.0	1893[a]	PP - LB
10°	36	160.0	lost	CP - FPTP
10°	37	170.0	2278[n]	CP - FPTP
10°	38	171.0	2308[n]	CP - PTP
[a]Army limit at 10° - 1907 f/s; [n]Navy limit at 10° - 2293 f/s				
20°	10	185.0	2500	CP - PTP Adjacent to Rd.#9 - Disregard
20°	11	185.0	2488	CP - CIP ND
20°	12	190.0	2539[n]	CP - CIP ND
20°	13	195.0	2591	CP - PTP
20°	14	192.5	2564[n]	CP - PTP
20°	15	140.0	1985	PP - MB
20°	16	155.0	2160	PP - SB - CIP ND
20°	17	160.0	2200	PP - SB - CIP 1"x1/4" FP
20°	18	170.0	2299	CP - FPTP Pun S
20°	19	165.0	2283[a]	CP - FPTP
20°	20	162.5	2255[a]	PP - MB
[a]Army limit at 20° - 2269 f/s; [n]Navy limit at 20° - 2552 f/s				
30°	21	180.0	2450	PP - SB
30°	22	190.0	2560	PP - MB
30°	23	200.0	2633	CP - CIP
30°	24	Service	2848[n]	CP - CIP
30°	25	Max.	2909	CP - PTP 1/2"x1/2" BP
30°	26	Max.	2877[n]	CP - PTP 1/2"x1/4" FP; 3/8"x3/8" BP
30°	27	195.0	2594[a]	PP - MB
30°	28	197.5	2607[a]	CP - CIP
[a]Army limit at 30° - 2601 f/s; [n]Navy limit at 30° - 2863 f/s				

Ballistic Data Sheet No. 23

Carnegie-Illinois Plate 19427334 - 3/4"x36"x36" Ni-Cr Homogeneous
BHN 304 - T.S. 154,000 - Photographs W.A. 710-1830, W.A. 710-1831

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
0°	1	130.0	lost	CP - FPTP
0°	2	120.0	1700	PP - SB
0°	3	165.0	2214	CP - CIP
0°	4	175.0	2343	CP - PTP
0°	5	165.0	2260[n]	CP - PTP
0°	6	155.0	2115	CP - FPTP
0°	7	160.0	2179	CP - FPTP
0°	8	162.5	2229	CP - CIP
0°	9	164.0	2239[n]	CP - FPTP
0°	10	125.0	1801	PP - LB
0°	11	130.0	lost	CP - CIP Hit Rd.49 - Disregard
0°	12	130.0	1836	CP - MB
0°	13	132.5	1865[a]	[illegible] - LB
0°	14	135.0	1888[a]	CP - FPTP
0°	15	185.0	2468	CP - PTP
0°	16	185.0	2506	CP - PTP
[a]Army limit at 0° - 1877 f/s; [n]Navy limit at 0° - 2250 f/s				
10°	48	170.0	2304	CP - PTP Full petalling
10°	49	165.0	2249[n]	CP - CIP
10°	50	170.0	2278[a]	CP - PTP Full petalling
10°	51	155.0	2120	CP - FPTP .45"x.15" incomplete FP
10°	52	145.0	1940	CP - FPTP .45"x.15" incomplete FP Radial cracks
10°	53	140.0	1855	CP - FPTP .45"x.10" incomplete FP Radial cracks
10°	54	138.0	1822[a]	CP - FPTP .6"x.3" incomplete FP .4"DC
10°	55	135.0	1795[a]	PP - LB
[a]Army limit at 10° - 1809 f/s; [n]Navy limit at 10° - 2264 f/s				
20°	17	165.0	2278	CP - FPTP 5/8"x1/4" FP
20°	18	165.0	2283	CP - FPTP 5/8"x1/4" FP
20°	19	167.0	2259	CP - FPTP 5/8"x1/4" FP
20°	20	160.0	2231[a]	CP - FPTP 1/2"x1/4" FP
20°	21	158.0	2205[a]	PP - MB 3/4"x1/4" FP
20°	22	185.0	2506	CP - CIP 3/4"x1/8" FP
20°	23	195.0	2633	CP - CIP
20°	24	205.0	2760	CP - PTP
20°	25	200.0	2711[n]	CP - CIP ND
20°	26	200.0	2709	CP - CIP
20°	27	202.5	2731	CP - PTP 2/3"x1/8" FP - 1/2"x1/2" BP
[a]Army limit at 20° - 2218 f/s; [n]Navy limit at 20° - 2721 f/s				

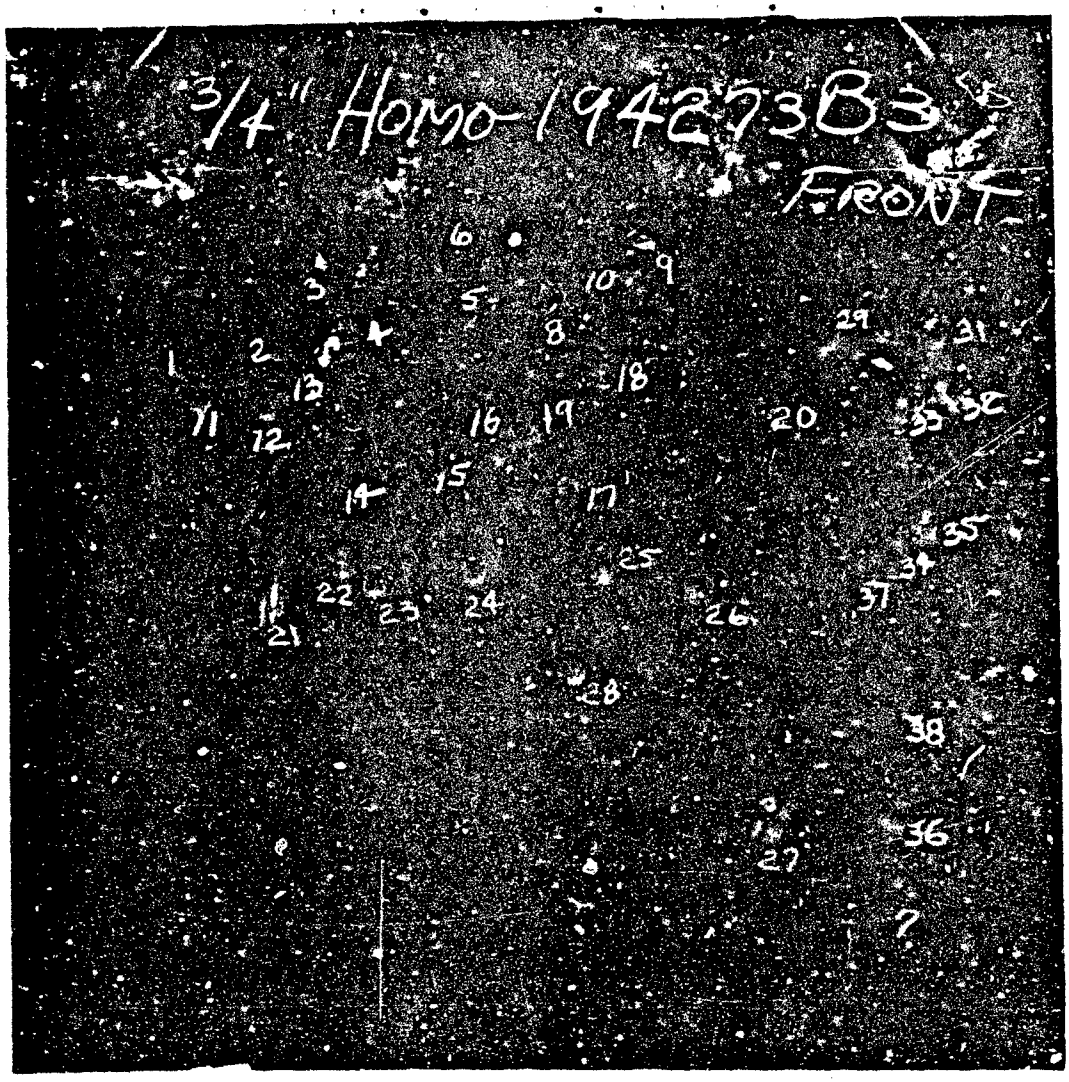
Ballistic Data Sheet No. 23 (Cont'd)

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
30°	28	175.0	2388	PP - SB
30°	29	180.0	2437	PP - MB
30°	30	185.0	2486	PP - MB
30°	31	Service	2900	CP - PTP Hit Rd.#28 - Disregard
30°	32	Service	lost	Hit clamp - Disregard
30°	33	Service	2834	CP - CIP
30°	34	Service	3034	CP - PTP 5/16"x1/2" BP
30°	35	220.0	2952	CP - CIP
30°	36	220.0	2942	CP - PTP 3/8"x1/2" BP; 3/8"x1/8" FP
30°	37	215.0	2876[n]	CP - PTP 1/2"x2/3" BP
30°	38	213.0	2863[n]	CP - CIP 3/8"x5/8" BP
30°	39	210.0	2814	CP - PTP Hit within 3 calibers of Rd. #35 - Disregard
30°	40	210.0	2809	CP - CIP 3/8"x5/8" BS
30°	41	190.0	2589	PP - CIP - MB
30°	42	200.0	2682	CP - FPTP
30°	43	195.0	2614	PP - NB Hit Rd. #17 - Disregard
30°	44	195.0	2604[a]	PP - CIP - LB Pun S
30°	45	197.5	2632[a]	CP - FPTP Pun S
[a]Army limit at 30° - 2618 f/s; [n]Navy limit at 30° - 2870 f/s				
37 MM TP M51 Firings:				
0°	46	3.5oz.	1983	CP - PTP 3"x1/2" adjacent punching started
0°	47	3.0oz.	1816	PP - LB

Ballistic Data Sheet No. 24

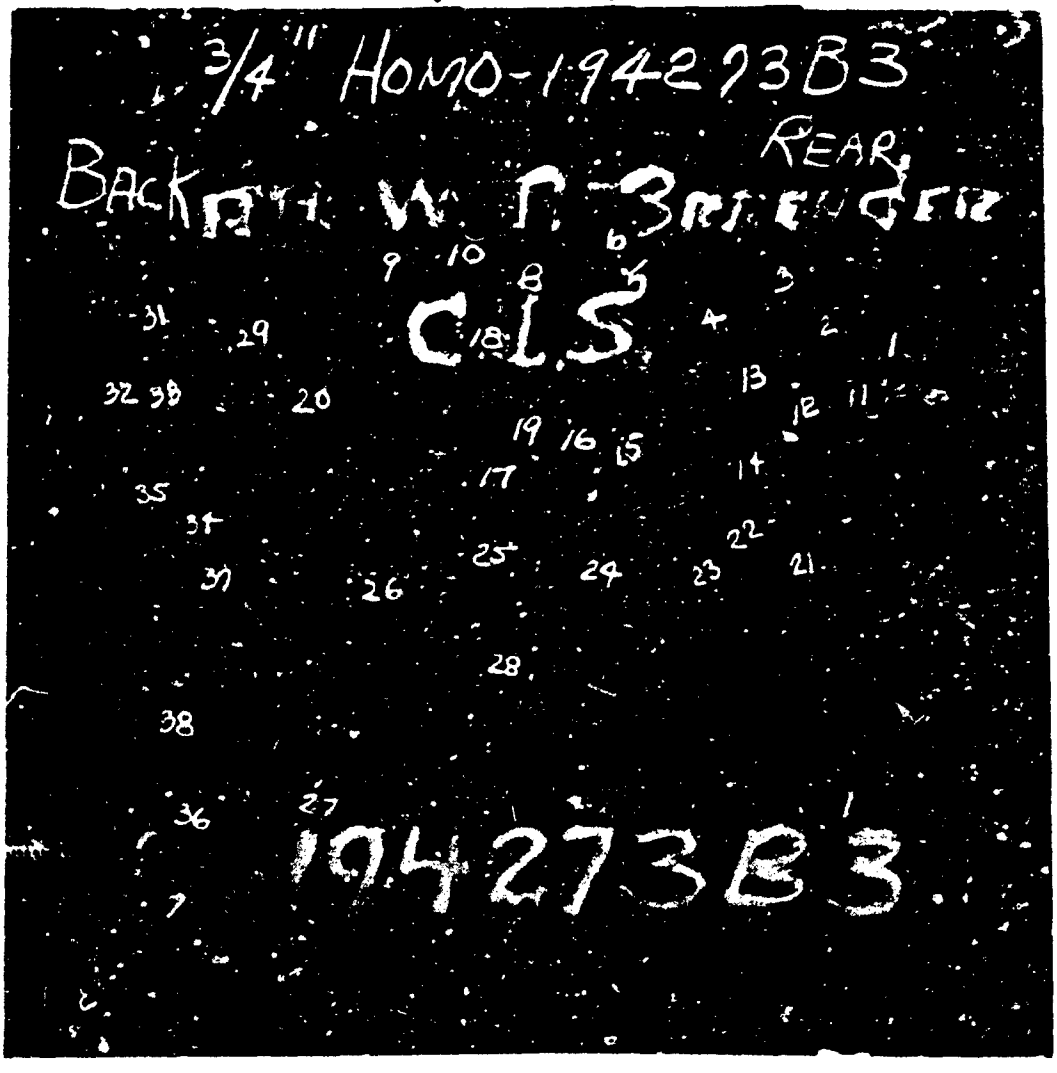
Carnegie-Illinois Plate 19427336 - 3/4"x36"x36" Ni-Cr Homogeneous
BHN 363 - T.S. 181,500 - Photographs W.A. 710-1834, W.A. 710-1835

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
0°	1	130.0	1841	PP - MB
0°	2	134.0	1894	PP - LB
0°	3	138.0	1914[a]	PP - LB - SC
0°	4	140.0	1928[a]	CP - FPTP
0°	5	170.0	2302[a]	CP - CIP
0°	6	175.0	2352	CP - PTP
0°	7	172.5	2330[a]	CP - PTP
[a]Army limit at 0° - 1921 f/s; [b]Navy limit at 0° - 2316 f/s				
10°	22	Pre-Load	2229	CP - CIP
10°	23	170.0	2259	CP - CIP
10°	24	175.0	2331[a]	CP - PTP
10°	25	172.5	2301[a]	CP - CIP
10°	26	160.0	2169	CP - FPTP
10°	27	155.0	2075	CP - FPTP
10°	28	150.0	2033	CP - FPTP
10°	29	145.0	1973[a]	CP - FPTP
10°	30	140.0	1846	PP - MB
10°	31	143.0	1944[a]	PP - SB
[a]Army limit at 10° - 1959 f/s; [b]Navy limit at 10° - 2316 f/s				
20°	8	185.0	2562	CP - FPTP .5"x.3" BP
20°	9	185.0	2586	CP - CIP 7/8"x5/8" BP
20°	10	190.0	lost	PP - MB Pun 8
20°	11	190.0	2624[a]	CP - FPTP 1"x1/4" FP
20°	12	192.5	2651[a]	CP - PTP 5/8"x5/8" BP
20°	13	180.0	2466[a]	CP - CIP 3/8"x1/2" BP
20°	14	175.0	2407	PP - MB
20°	15	177.5	2435[a]	PP - MB
[a]Army limit at 20° - 2451 f/s; [b]Navy limit at 20° - 2638 f/s				
30°	16	Service	2809	PP - MB
30°	17	210.0	lost	PP - MB
30°	18	max.	2909[a,b]	PP - LB
30°	19	max.	2954[a,b]	CP - PTP 5/8"x1" Pun
[a]Army limit at 30° - 2932 f/s; [b]Navy limit at 30° - 2932 f/s				
37 MM TP M51 Firings:				
0°	20	3.0oz.	1806	PP - LB
0°	21	3.5oz.	1973	CP - PTP 2-18/32"x1-1/2" BS



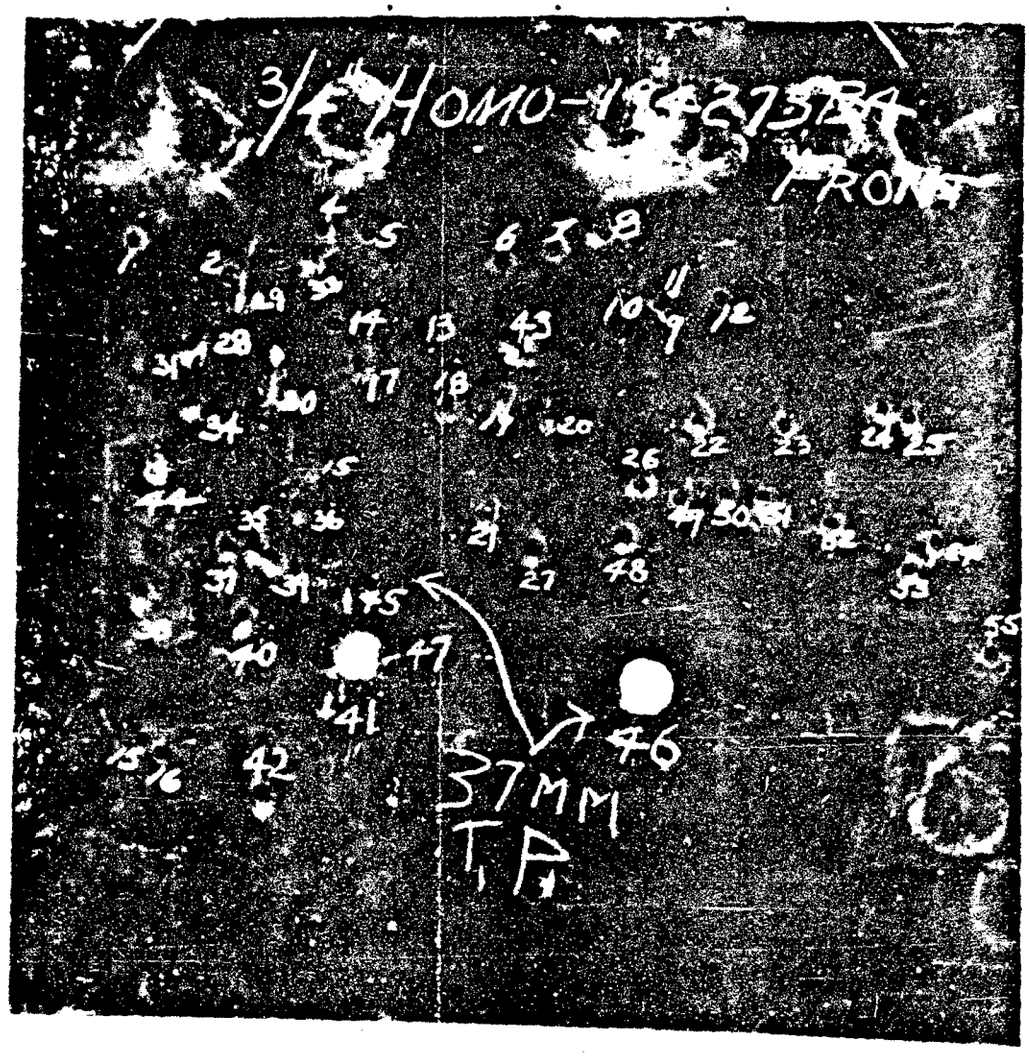
WATERTOWN ARSENAL

PLATE 194273-B3. 3/4" HOMO. NI-CR. T.S.154,00; BRINELL 302. TESTED AT 0°, 10°, 20° AND 30° OBLIQUITIES WITH CAL .50 AP M2. FRONT
MAY 16 1942 W.A.710-1828



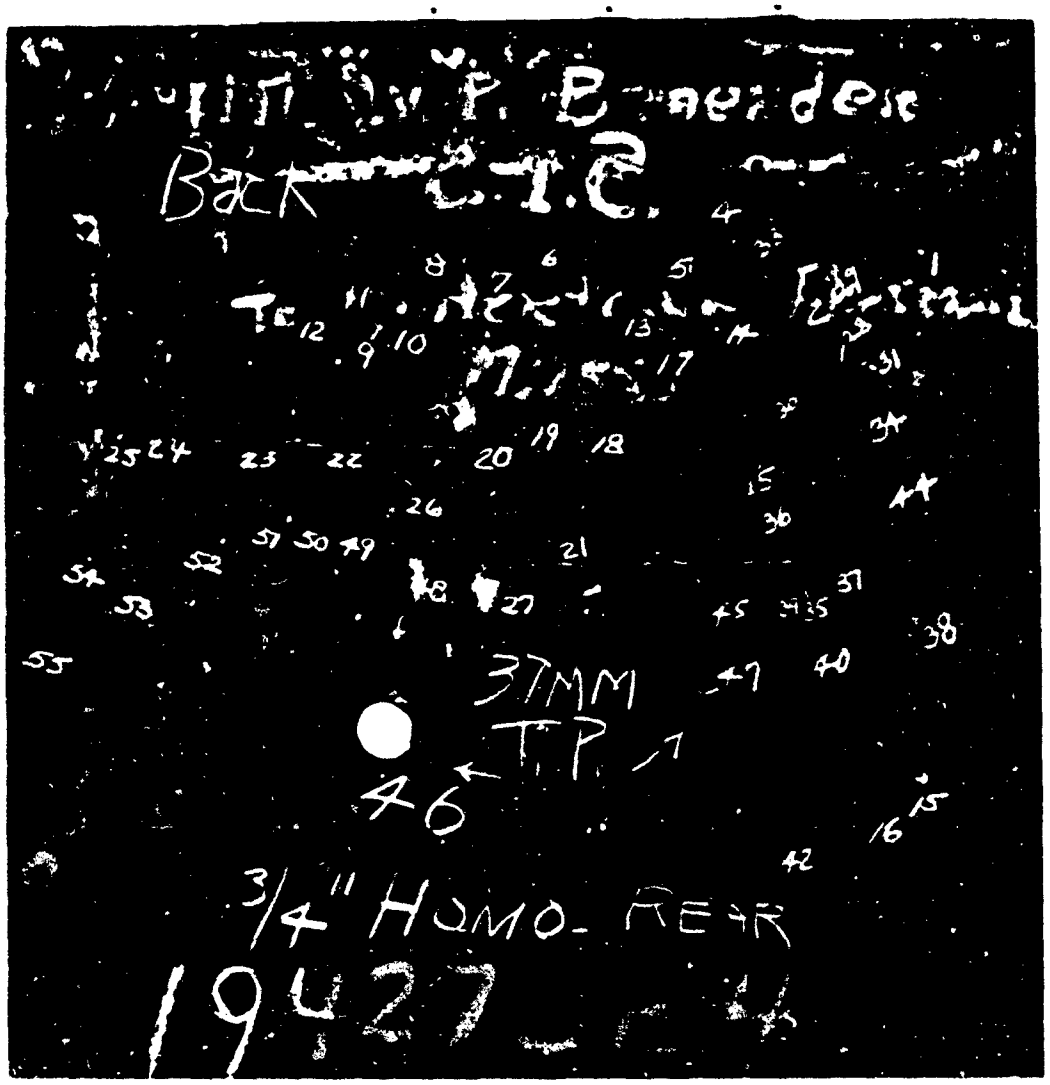
WATERTOWN ARSENAL

PLATE 194273-B3. 3/4" HOMO. NI-CR. T.A. 154,000 BRINELL 302
MAY 16 1942 BACK W.A.710-1829



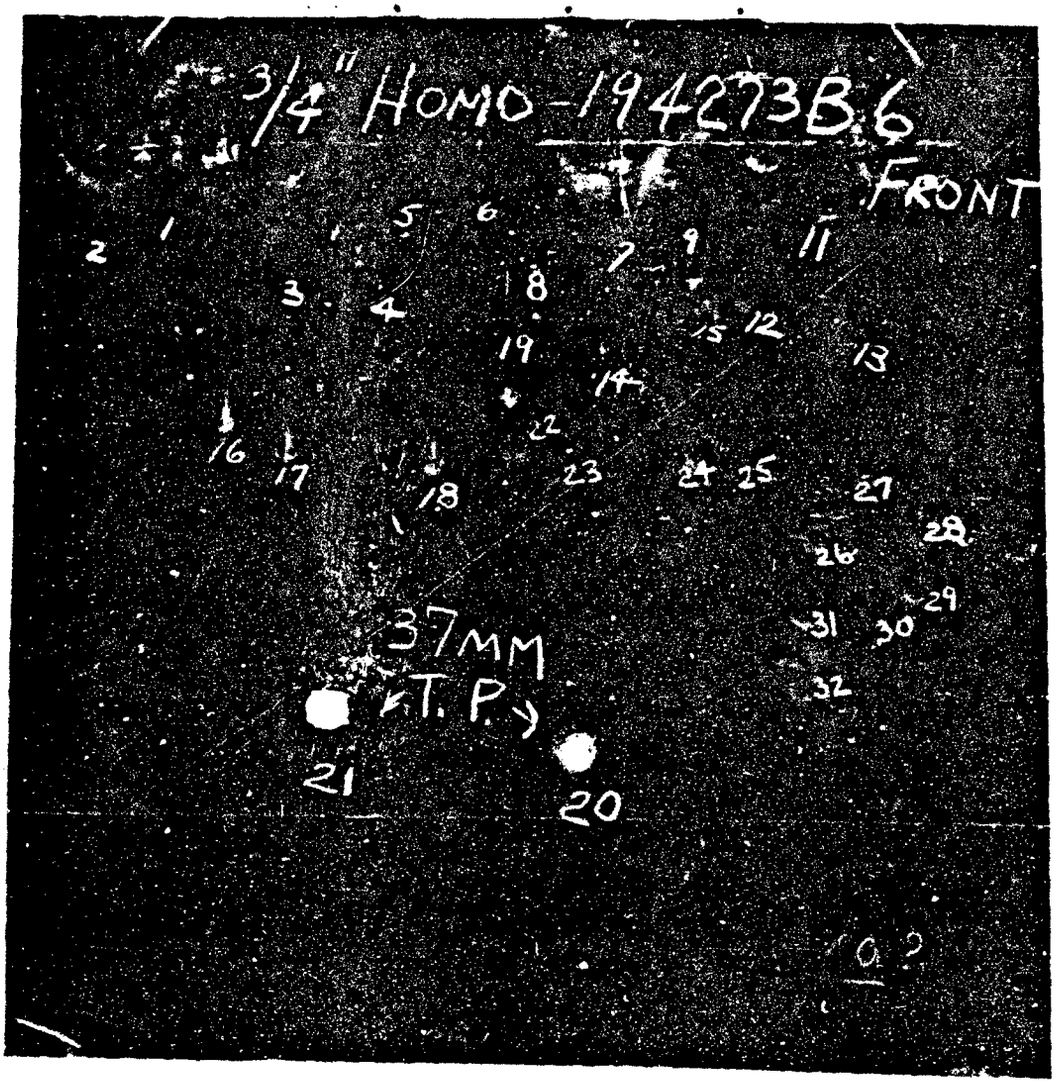
WATERTOWN ARSENAL

PLATE 194273-84. 3/4" HOMO. NI-CR. T.S. 154,000; BRINELL 304. TESTED AT 0°, 10°, 20°, 30° OBLIQUITIES WITH CAL .50 AP M2. SHOCK TESTED WITH 37 MM M51 T.P. FRONT MAY 16 1942 W.A.710-1830



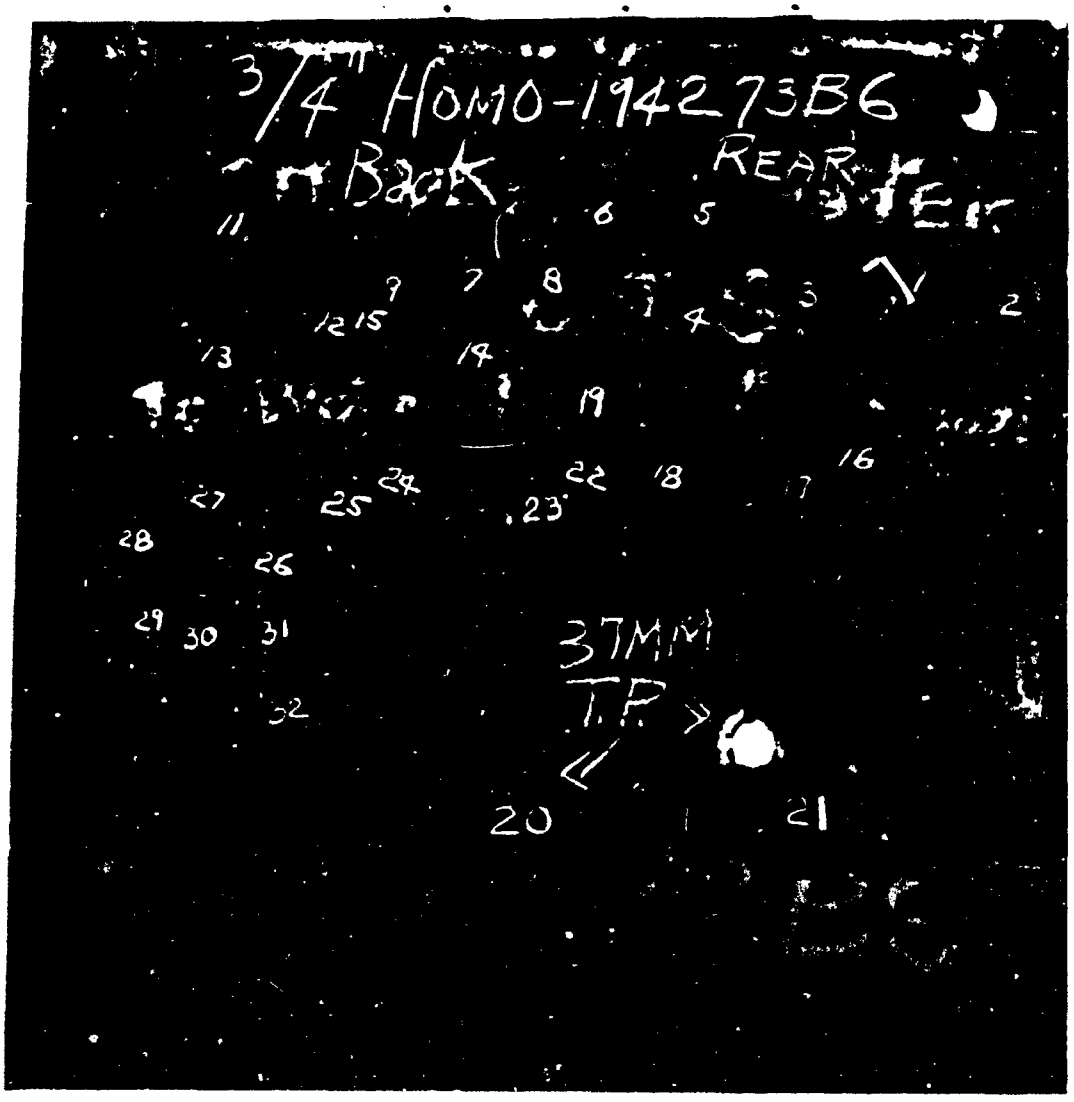
WATERTOWN ARSENAL

PLATE 194273-84. 3/4" HOMO. NI-CR. T.S. 154,000; BRINELL 304
MAY 16 1942 BACK W.A.710-1831



WATERTOWN ARSENAL

PLATE 194273-86. 3/4" HOMO. NI-CR. T.S. 181,500; BRINELL 363. TESTED AT 0°, 10°, 20°, 30° OBLIQUITIES WITH CAL .50 AP M2. SHOCK TESTED WITH 37 MM M51 T.P. FRONT MAY 16 1942 W.A.710-1834



WATERTOWN ARSENAL

PLATE 194273-B6. 3/4" HOMO. NI-CR. T.S. 161,500; BRINELL 363
MAY 16 1942 BACK W.A.710-1835

Ballistic Data Sheet No. 25

Carnegie-Illinois Plate 194273B7 - 3/4"x36"x36" Ni-Cr Homogeneous
BHN 378 - T.S. 185,000 - Photographs W.A. 710-1836, W.A. 710-1837

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
0°	1	125.0	1847	PP - MB
0°	2	130.0	1857	PP - LB - SC
0°	3	132.0	1870	PP - LB - SC
0°	4	135.0	1890	PP - LB - SC
0°	5	137.5	1912[a]	PP - LB
0°	6	140.0	1936[a]	CP - FPTP
0°	7	170.0	2313	Hit Rd. #6 - Disregard
0°	8	175.0	2332	CP - PTP 1-1/4"x1-1/4" BS
0°	9	170.0	2312	CP - PTP 3/4"x1-1/4" BS
0°	10	165.0	2273	CP - PTP 7/8"x1-3/8" BS
0°	11	165.0	2259[n]	CP - CIP
0°	12	170.0	2284[n]	CP - PTP
		Shot #12 lettered #13 in photograph.		
[a]Army limit at 0° - 1924 f/s; [n]Navy limit at 0° - 2272 f/s				
10°	26	165.0	2234	CP - FPTP .35"x.45" BS
10°	27	170.0	2308	CP - FPTP
10°	28	173.0	2353	PP - SB - Excessively yawed - Disregard
10°	29	173.0	2328	CP - CIP 1/4"x3/8" BS
10°	30	175.0	lost	CP - CIP
10°	31	177.0	2372	CP - FPTP .6"x.6" Punching
10°	32	178.0	2382	CP - CIP 1/4"x1/2" BS
10°	33	180.0	2427[n]	CP - PTP .8"x.65" BS
10°	34	179.0	2397[n]	CP - FPTP
10°	35	160.0	2179	CP - CIP
10°	36	159.0	lost	Missed plate
10°	37	159.0	2151[a]	CP - FPTP
10°	38	158.0	2118[a]	PP - LB
[a]Army limit at 10° - 2133 f/s; [n]Navy limit at 10° - 2412 f/s				
20°	13	185.0	2510	PP
20°	14	195.0	2633	PP - SB
20°	15	205.0	2751	CP - FPTP .7"x.5" incomplete BS
20°	16	210.0	[illegible]	CP - FPTP .65"x.85" Pun S
20°	17	215.0	2852[n]	CP - PTP
20°	18	200.0	lost	CP - CIP
20°	19	205.0	2789	CP - FPTP 1"x7/8" Punching
20°	20	200.0	2762	CP - FPTP .85"x.9" incomplete BS
20°	21	195.0	2665[a]	PP - SB
20°	22	197.5	2698[a]	CP - FPTP .8"x.6" BS
[a]Army limit at 20° - 2682 f/s; [n]Navy limit at 20° - 2851 f/s				

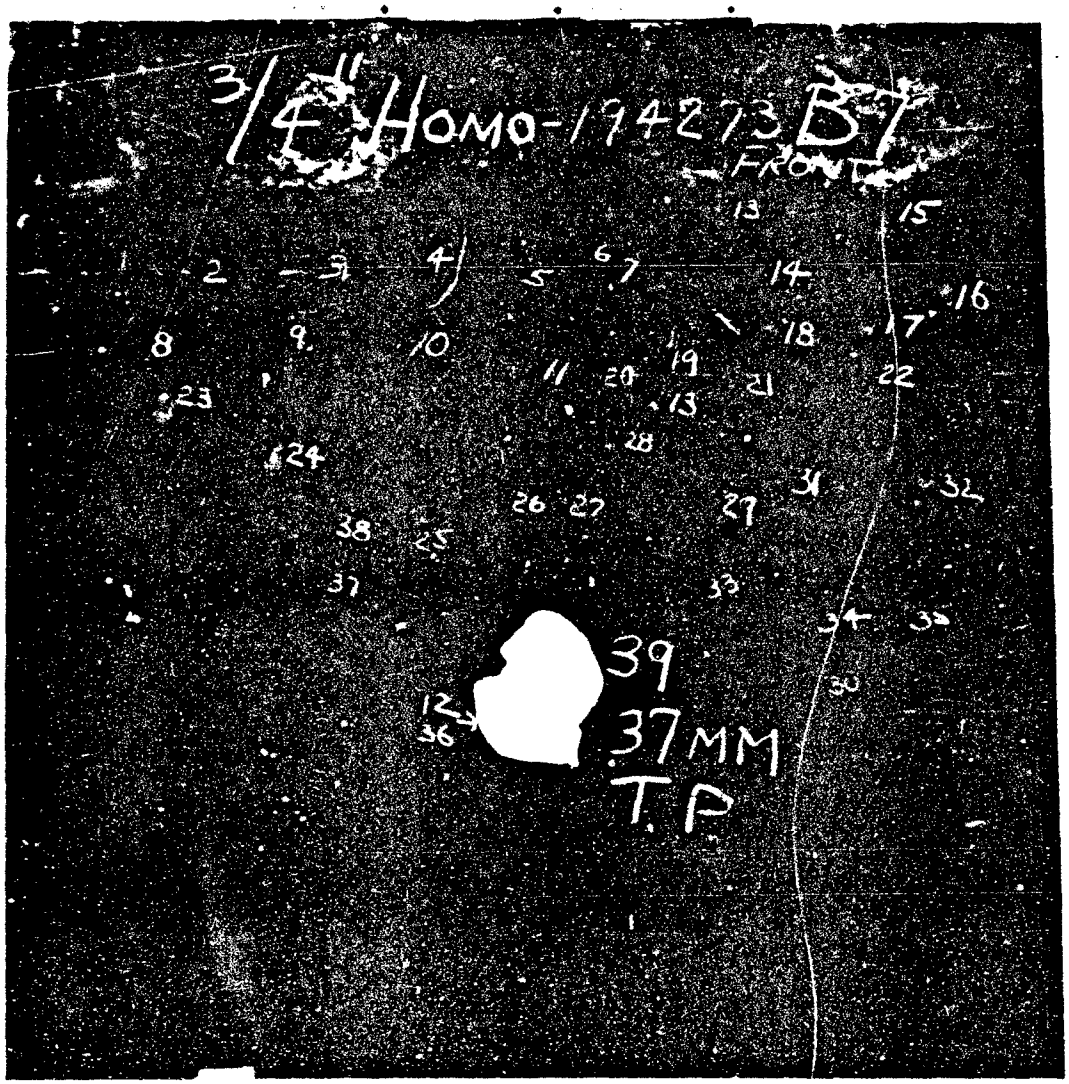
Ballistic Data Sheet No. 25 (Cont'd)

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
30°	23	max.	3047[a,b]	CP - CIP 13/16"x1/2" Punching
30°	24	max.	3003[a]	PP - MB
30°	25	max.	3093[b]	CP - PTP 1-1/8"x7/8" Punching

[a]Army limit at 30° - 3025 f/s; [b]Navy limit at 30° - 3070 f/s

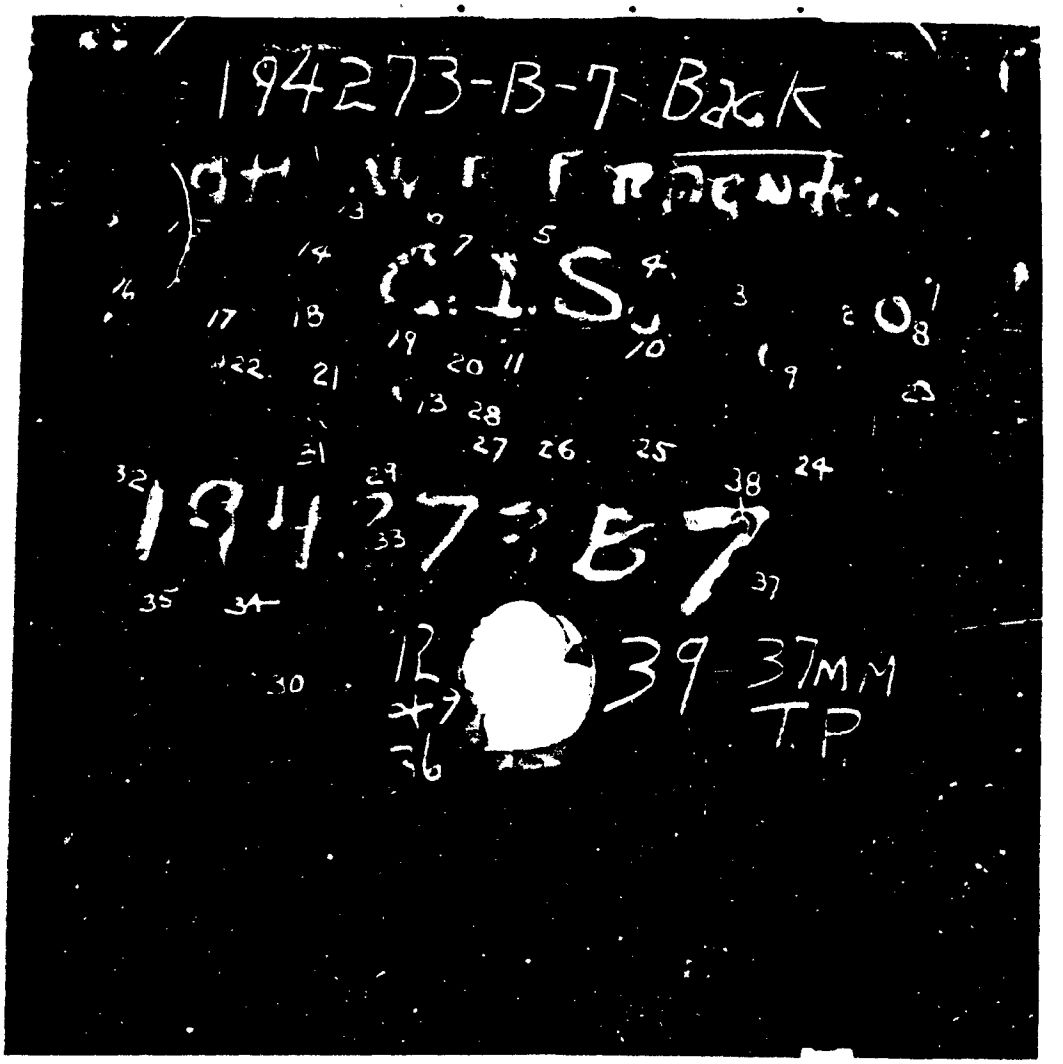
37 MM TP M51 Firings:				
0°	39	3.0 oz.	1816	CP - PTP Exit diameter, including BS 4-3/4"x5-7/8".

(Photograph erroneously indicates Rds. #12 and #36 as having impacted in area broken out by Rd. #39. No impact other than Rd. #39 impacted this area.)



WATERTOWN ARSENAL

PLATE 194273-B7. 3/4" HOMO. NI-CR. T.S. 165,000; BRINELL 378. TESTED AT 0°, 10°, 20°, 30° OBLIQUITIES WITH CAL .50 AP M2. SHOCK TESTED WITH 37 MM M51 TP. FRONT MAY 16 1942 W.A.710-1836



WATERTOWN ARSENAL

PLATE 194273-B7. 3/4" HOMO. NI-CR. T.S. 185,000; BRINELL 378
MAY 16 1942 BACK W.A.710-1E37

Ballistic Data Sheet No. 26

Carnegie-Illinois Plate No. 19427335 - 3/4"x36"x36" Ni-Cr Homogeneous
BHN 388 - T.S. 184,500 - Photographs W.A. 710-1832, W.A. 710-1833

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
0°	1	135.0	1899[a]	CP - FPTP
0°	2	132.5	1872[a]	PP - LB
0°	3	170.0	2307[n]	CP - CIP
0°	4	172.0	2328[n]	CP - PTP
[a]Army limit at 0° - 1886 f/s; [n]Navy limit at 0° - 2318 f/s				
10°	23	175.0	2352[n]	CP - PTP
10°	24	172.5	2329[n]	CP - FPTT .7"x.25" BS
10°	25	175.0	2357	CP - PTP
10°	26	152.0	lost	Hit on Rd. #25
10°	27	152.0	2076	CP - FPTP
10°	28	151.0	2066	CP - FPTP
10°	29	150.0	2050	CP - FPTP
10°	30	149.0	2042	CP - FPTP
10°	31	147.0	2017[a]	CP - FPTP
10°	32	145.0	1968	Hit on Rd. #31
10°	33	146.0	2032	CP - FPTP
10°	34	145.0	1993[a]	PP - LB - SC
[a]Army limit at 10° - 2005 f/s; [n]Navy limit at 10° - 2341 f/s				
20°	5	185.0	2564	PP - CIP .7"x.65" Pun S
20°	6	205.0	lost	Hit Rd. #5. Knocked out punching. Disregard
20°	7	205.0	lost	Hit Rds. #5, #6 - Disregard
20°	8	205.0	2775[n]	CP - FPTP 5/8"x1/2" Punching
20°	9	210.0	2859	CP - PTP .5"x.85" BP
20°	10	207.5	lost	PP - Pun S Backed by support - Disregard
20°	11	207.5	2813	CP - PTP .8"x.7" BP
20°	12	206.5	2808[n]	CP - PTP 1.0"x.3" FP; .8"x.55" BP
20°	13	185.0	2565[a]	PP - CIP - Pun S
20°	14	187.0	2598	CP - FPTP 1.55"x1" BS
20°	15	186.0	2575[a]	CP - FPTP 1"x5/8" BP
[a]Army limit at 20° - 2570 f/s; [n]Navy limit at 20° - 2792 f/s				
30°	16	Service	2849	PP - MB
30°	17	215.0	2909[a]	CP - CIP Pun S
30°	18	218.0	2884[a]	PP - MB
30°	19	220.0	2921	PP - LB
30°	20	max.	2925	CP - CIP 7/8"x1/2" Pun
30°	21	max.	2995	CP - FPTP 2/3"x1" BS
30°	22	max.	2933	PP - Pun S 3/4"x3/4" FS

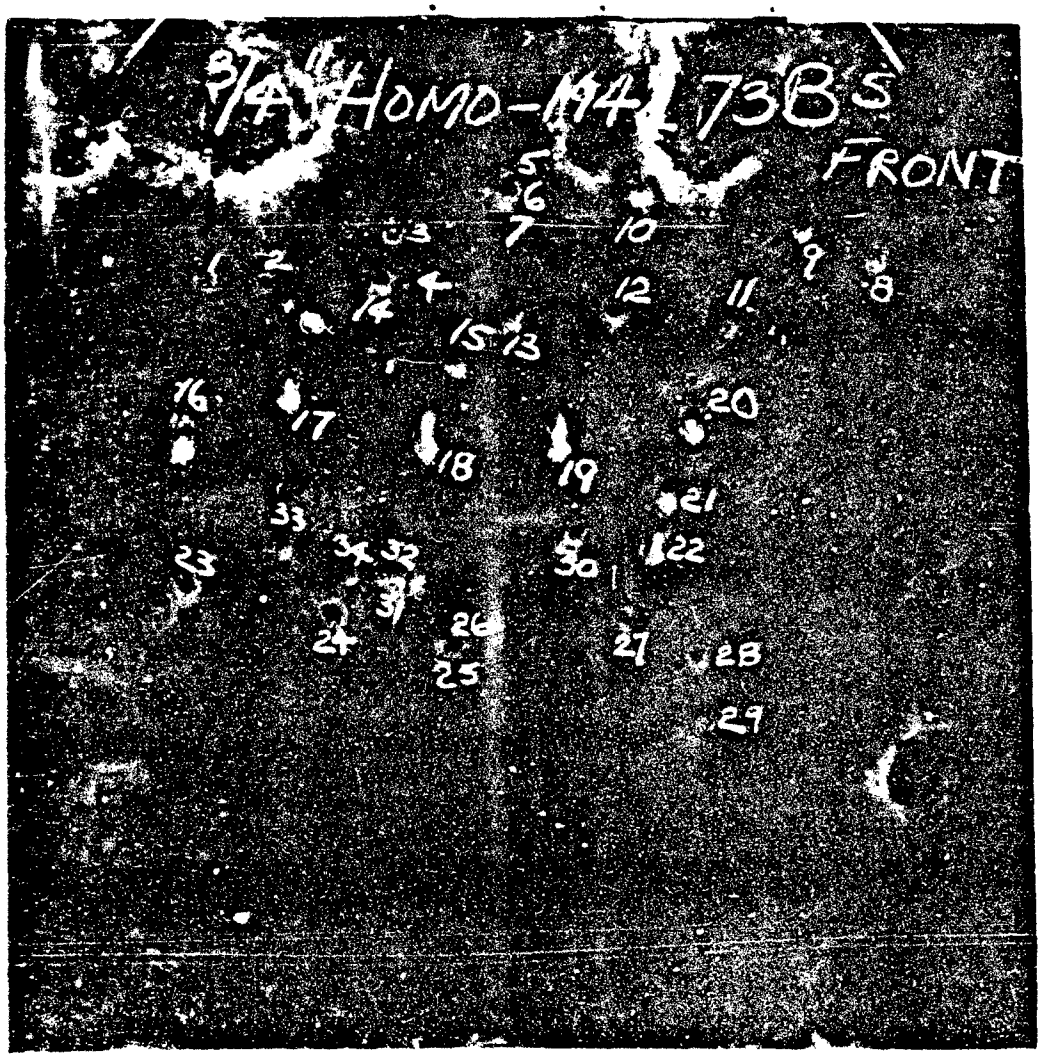
[a]Army limit at 30° - 2897 f/s; Navy limit not determined.

Ballistic Data Sheet No. 27

Carnegie-Illinois Plate 19427388 - 3/4"x36"x36" Ni-Cr Homogeneous
MIM 388 - S.S. 199,500 - Photographs W.A. 710-1838, W.A. 710-1839

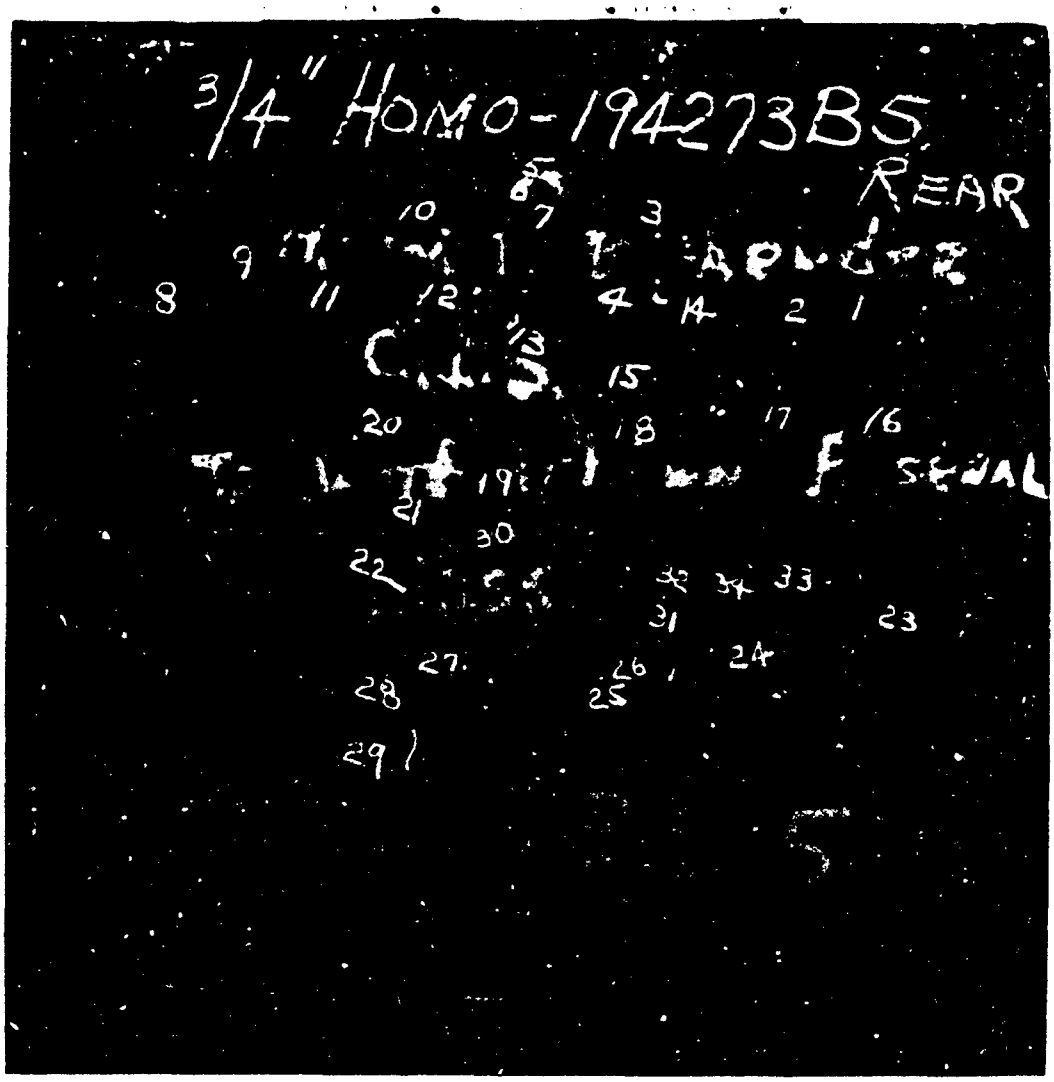
Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 A.P. M2 Firings:				
0°	1	130.0	1899[a]	CP - FPTP
0°	2	130.0	1880[a]	PP - LB - SC
0°	3	165.0	2249[a]	CP - CIP ND
0°	4	175.0	2367	CP - PTP
0°	5	170.0	2318	CP - CIP - Overlapped Rd. #4 - Disregard
0°	6	172.5	2322	CP - PTP
0°	7	167.5	2276[a]	CP - PTP
[a]Army limit at 0° - 1890 f/s; [n]Navy limit at 0° - 2263 f/s				
10°	21	170.0	2268	PP - MB
10°	22	175.0	2353[a]	PP - CIP - MB 1/2" DC BD
10°	23	180.0	2407[n]	CP - PTP
10°	24	177.0	lost	PP - CIP - MB BD
10°	25	177.5	2381[a,n]	CP - CIP BD ND
[a]Army limit at 10° - 2367 f/s; [n]Navy limit at 10° - 2394 f/s				
20°	8	210.0	2809	CP - PTP 1/2"x1/4" FP; 9/16"x9/16" BP
20°	9	180.0	2453	PP - MB
20°	10	185.0	2505	PP - MB
20°	11	190.0	2621[n]	CP - PTP 3/4"x7/16" BP
20°	12	187.5	2565[a]	CP - FPTP 2/3"x5/8" BP
20°	13	188.5	lost	Missed plate
20°	14	186.5	2555[a]	PP - MB
20°	15	189.0	2550	PP - MB
20°	16	189.0	2585	PP - SB
20°	17	190.0	2613[n]	PP - SB
[a]Army limit at 20° - 2560 f/s; [n]Navy limit at 20° - 2617 f/s				
30°	18	max.	3008	PP - MB
30°	19	max.	3030	PP - MB

Neither Army nor Navy limits determined at 30°.



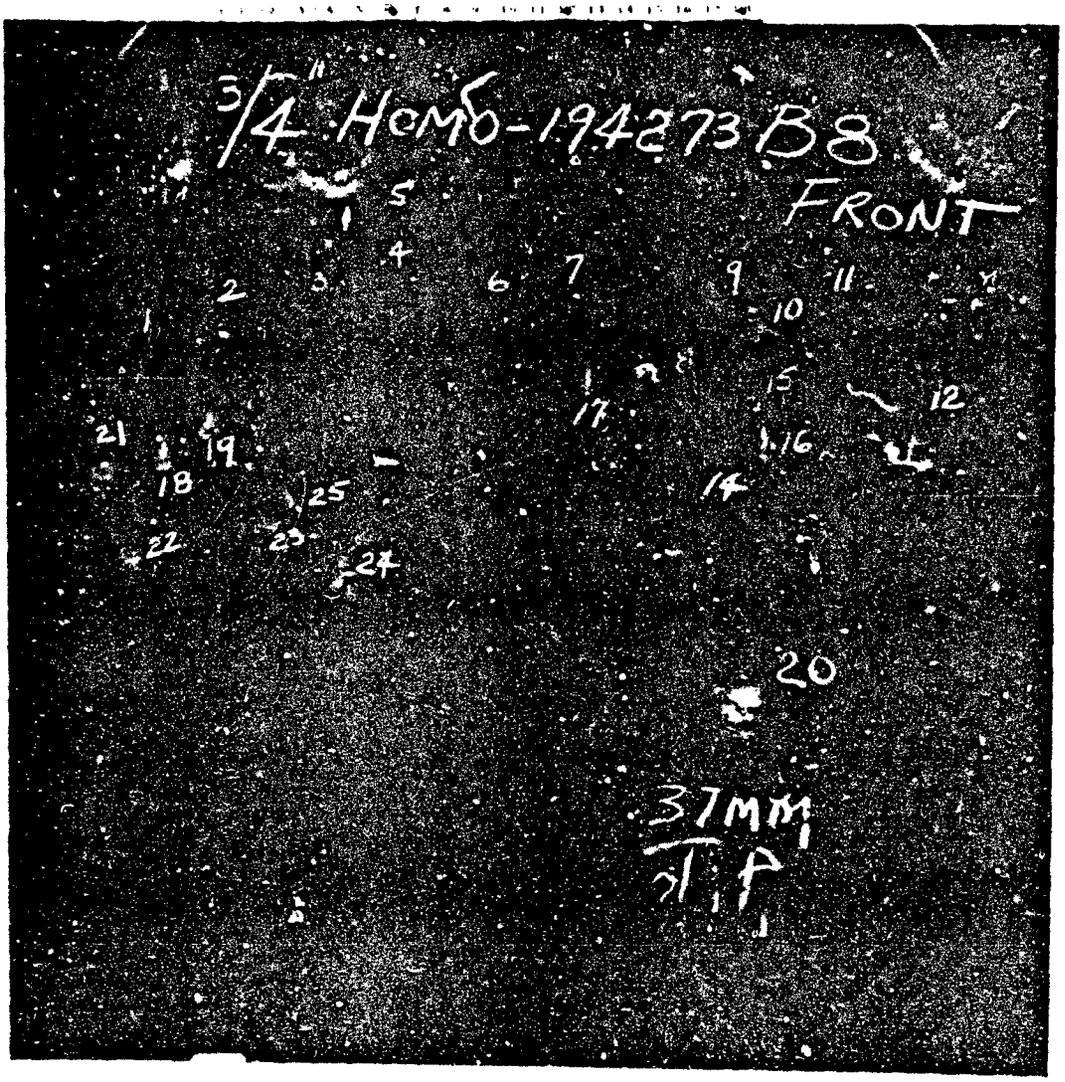
WATERTOWN ARSENAL

PLATE 194273-85. 3/4" HOMO. NI-CR. T.S. 184,500; BRINELL 388. TESTED AT 0°, 10°, 20° AND 30° OBLIQUITIES WITH CAL .50 AP M2. FRONT
MAY 16 1942 W.A.710-1832



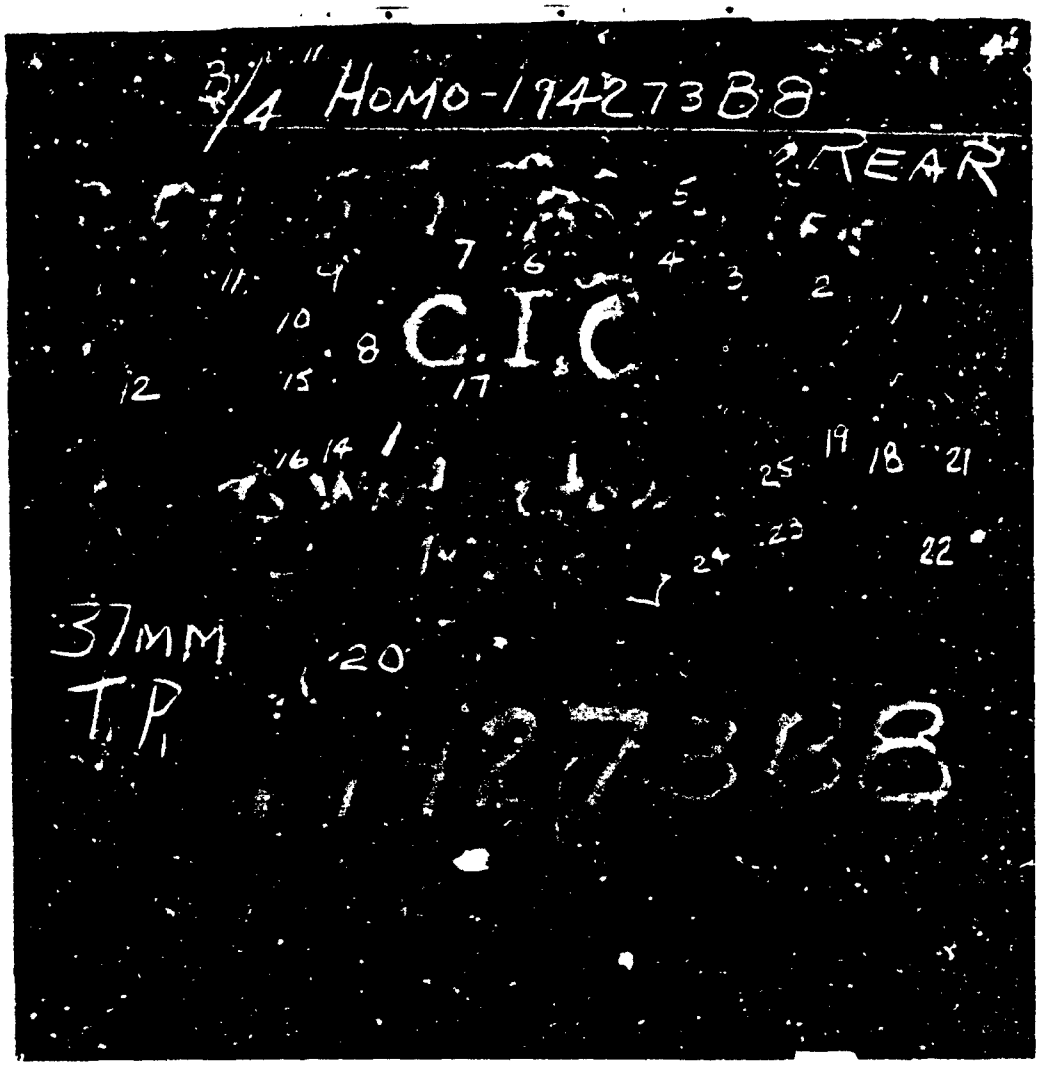
WATERTOWN ARSENAL

PLATE 194273-B5. 3/4" HOMO. NI-CR. T.S. 184,500; BRINELL 388
MAY 16 1942 BACK W.A.71C-1833



WATERTOWN ARSENAL

PLATE 194273-B8. 3/4" HOMO. NI-CR. T.S. 199,500; BRINELL 388. TESTED AT 0°, 10°, AND 20° OBLIQUITIES WITH CAL .50 AP M2. SHOCK TESTED WITH 37 MM M51 TP. FRONT MAY 10 1942 W.A.710-1838



WATERTOWN ARSENAL

PLATE 194273-88. 3/4" HOMO. NI-CR. T.S. 199,500; BRINELL 388
MAY 16 1942 BACK W.A.71C-1839

Ballistic Data Sheet No. 28

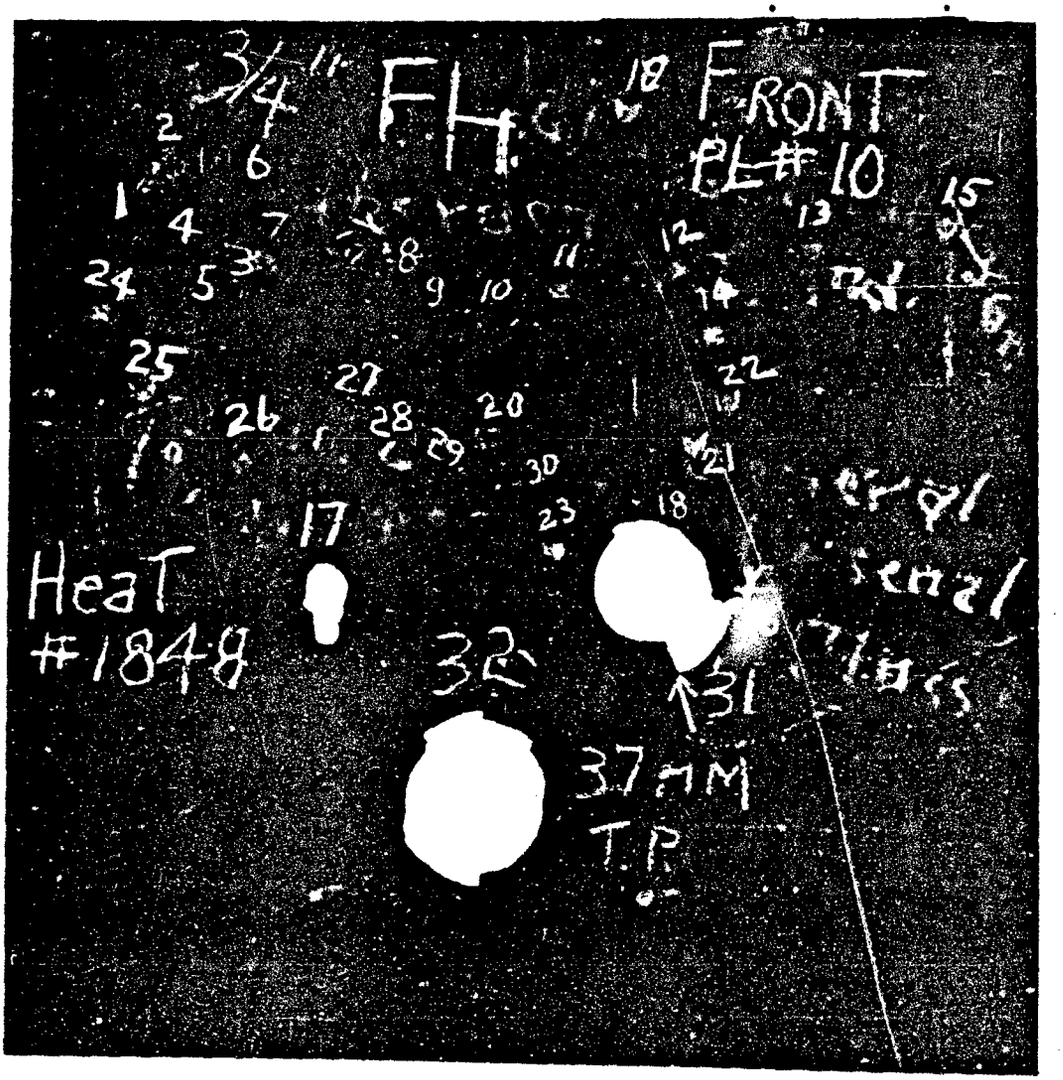
Disston Plate 10 - 3/4"x36"x36" Ni-Mo Face Hardened
BHN: Face 593-601; Rear 415-455 - Photographs W.A. 710-1822, W.A.710-1823

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
0°	1	210.0	2782	CP - CIP
0°	2	212.0	2809	CP - PTP
0°	3	212.0	2811	CP - PTP FS .8"x.8"; Inc. BS,9"x1.1"
0°	4	187.5	2530	CP - PTP FS .9"x.9"; BS .85"x.8"
0°	5	165.0	2268	Hit Rd. #4 - Disregard
0°	6	165.0	2244	Hit support - Disregard
0°	7	165.0	2266[a,n]	PP - SB
0°	8	175.0	2392	CP - CIP Inc. BS .6"x.75"
0°	9	170.0	2338	CP - PTP
0°	10	167.5	2288[a,n]	CP - PTP
[a]Army limit at 0° - 2277 f/s; [n]Navy limit at 0° - 2277 f/s				
10°	24	190.0	lost	PP - MB
10°	25	190.0	2482	PP - MB
10°	26	200.0	2581	PP 5/8"x5/8" Pun S
10°	27	205.0	2672	CP - PTP
10°	28	202.5	2613[a,n]	PP - Pun S
10°	29	205.0	2662	Hit Rd. #28 knocking out punching - Disregard
10°	30	205.0	2640[a,n]	CP - PTP
[a]Army limit at 10° - 2627 f/s; [n]Navy limit at 10° - 2627 f/s				
20°	11	195.0	2662	PP - SB
20°	12	205.0	2781	PP - MB
20°	13	210.0	2829	PP - LB 9/16"x1/2" Pun S
20°	14	210.0	2853[a,n]	PP - SB
20°	15	212.5	2851	PP - LB .5"x.85" Pun S
20°	16	214.0	2863[a,n]	CP - PTP
[a]Army limit at 20° - 2858 f/s; [n]Navy limit at 20° - 2858 f/s				
30°	18	Service	2849	PP - SB
30°	19	max.	2960	PP - Backed by support - Disregard
30°	20	max.	3028[a,n]	CP - PTP
30°	21	220.0	2931	PP - SB
30°	22	223.0	2979	PP - MB
30°	23	225.0	3020[a,n]	PP - SB
[a]Army limit at 30° - 3024 f/s; [n]Navy limit at 30° - 3024 f/s				
37MM TP M51 Firings:				
0°	31	3.5oz.	1973	CP - PTP BS 6-1/2"x6-3/4" overlapping 4-15/16"x5-1/4" punching, in which was secondary 1-7/16"x1-7/8" punching. Concentric face cracks 8-1/2".
0°	32	3.0oz.	1801	CP - PTP 6"x7" BS
37 MM AP M51 Firing:				
40°	17	2.8oz.	1596	CP - PTP Pen. Diam. 3"x1-5/8"

Ballistic Data Sheet No. 29

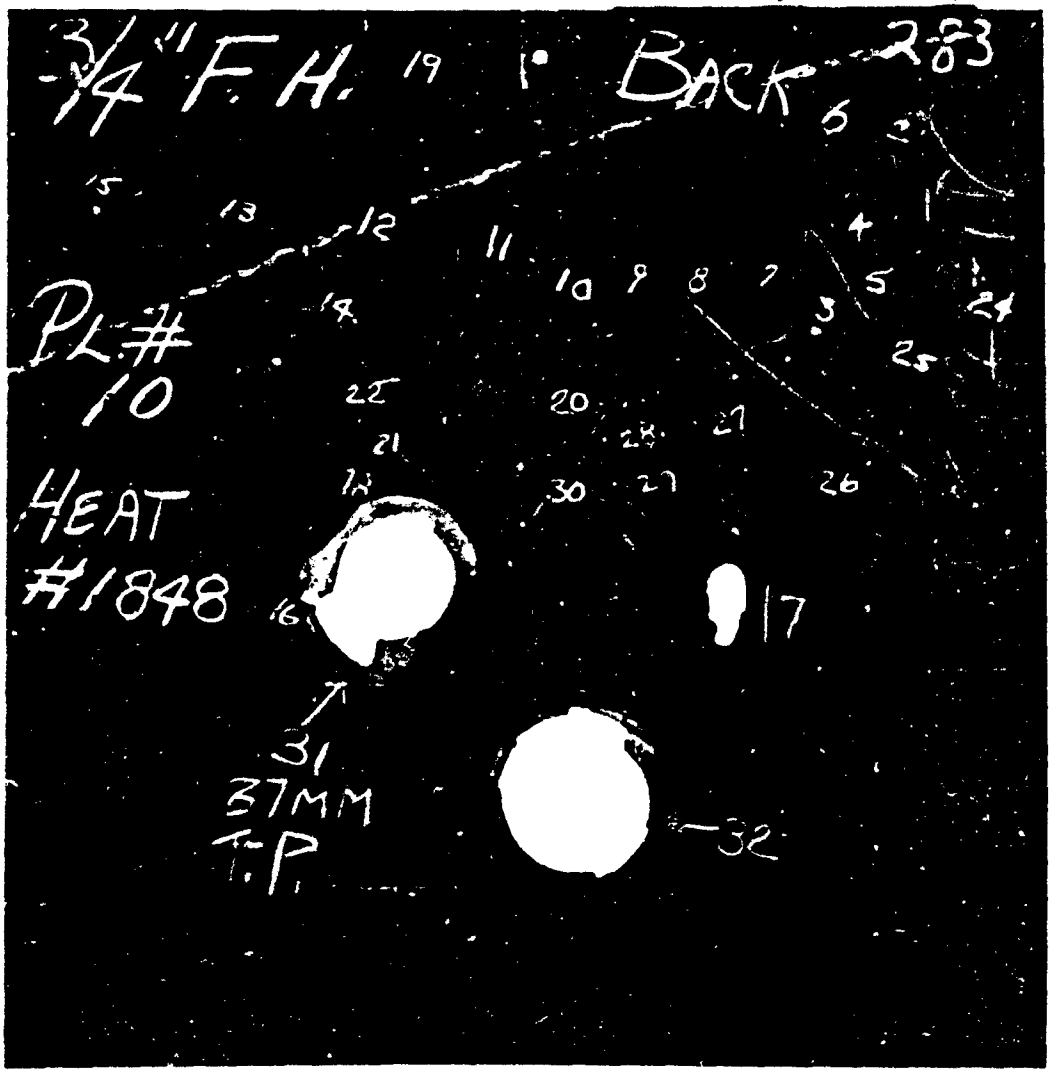
Carnegie-Illinois Plate 19427509 - 1"x36"x36" Ni-Cr Homogeneous
BHN 244 - T.S. 120,000 - Photographs W.A. 710-1842, W.A. 710-1843

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
37 MM AP M51 Firings:				
0°	1	2.0oz.	1367	CP - CIP
0°	2	1.85oz.	1302[a]	CP - FPTP
0°	3	1.7oz.	1256[a]	PP - LB Slight cracking
0°	4	2.15oz.	1425[a]	CP - PTP
0°	5	2.08oz.	1411[a]	CP - CIP
[a]Army limit at 0° - 1279 f/s; [b]Navy limit at 0° - 1415 f/s				
30°	6	2.10oz.	1426[a]	PP - MB
30°	7	4.75oz.	1310	CP - PTP
30°	8	2.80oz.	1667	CP - PTP
30°	9	2.65oz.	1635	Overlapped Rd. #8 - Disregard
30°	10	2.60oz.	1608[a]	CP - PTP
30°	11	2.40oz.	1524	PP - LB
30°	12	2.50oz.	1560[a]	CP - CIP
30°	13	2.25oz.	1466[a]	CP - FPTP
[a]Army limit at 30° - 1446 f/s; [b]Navy limit at 30° - 1584 f/s				



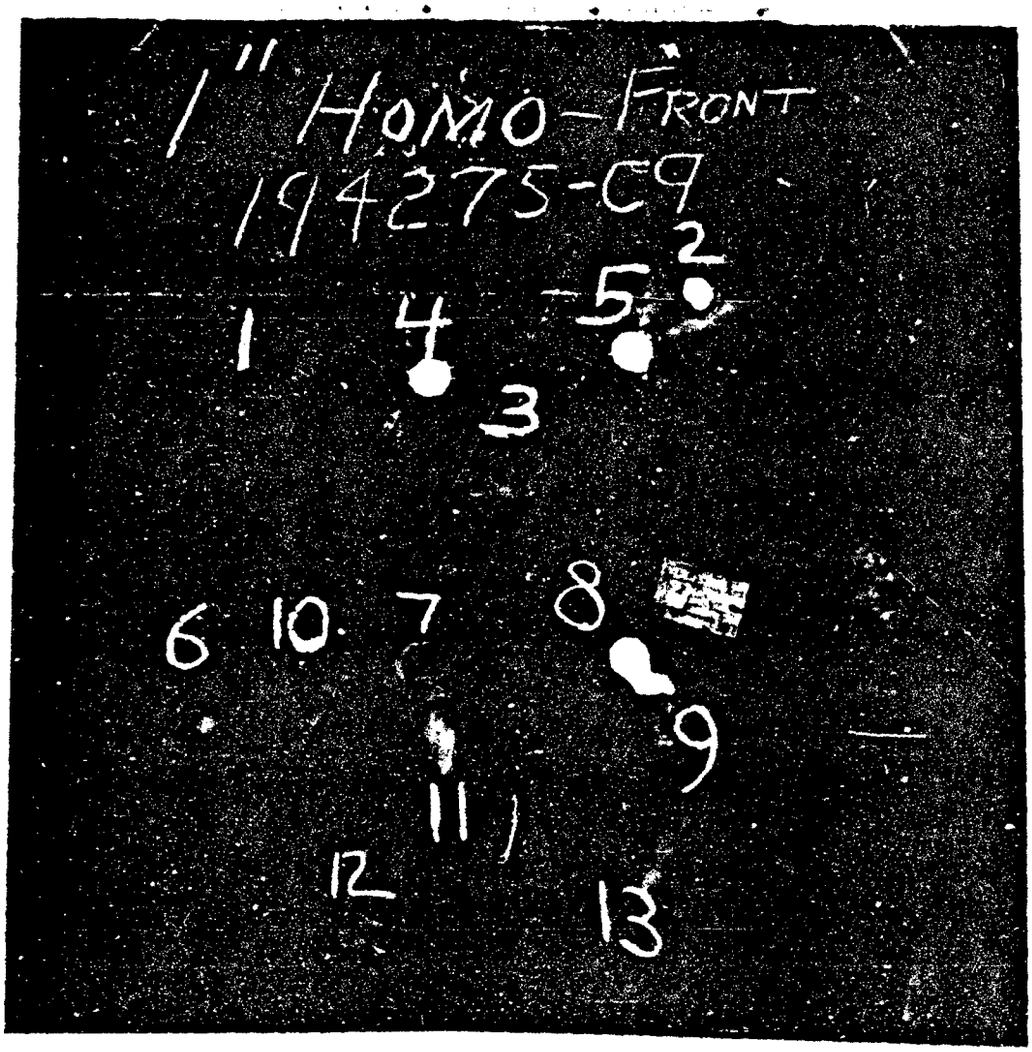
WATERTOWN ARSENAL

HEAT 1848, PLATE 10. 3/4" F.H.; NI-MO. BRINELL FACE 593-601, REAR 415-455. TESTED AT 0°, 10°, 20°, 30°, OBLIQUITIES WITH CAL .50 AP M2. SHOCK TESTED WITH 37 MM M51 A.P.C. AND 37 MM M51 T.P. FRONT MAY 16 1942 W.A.710-1822



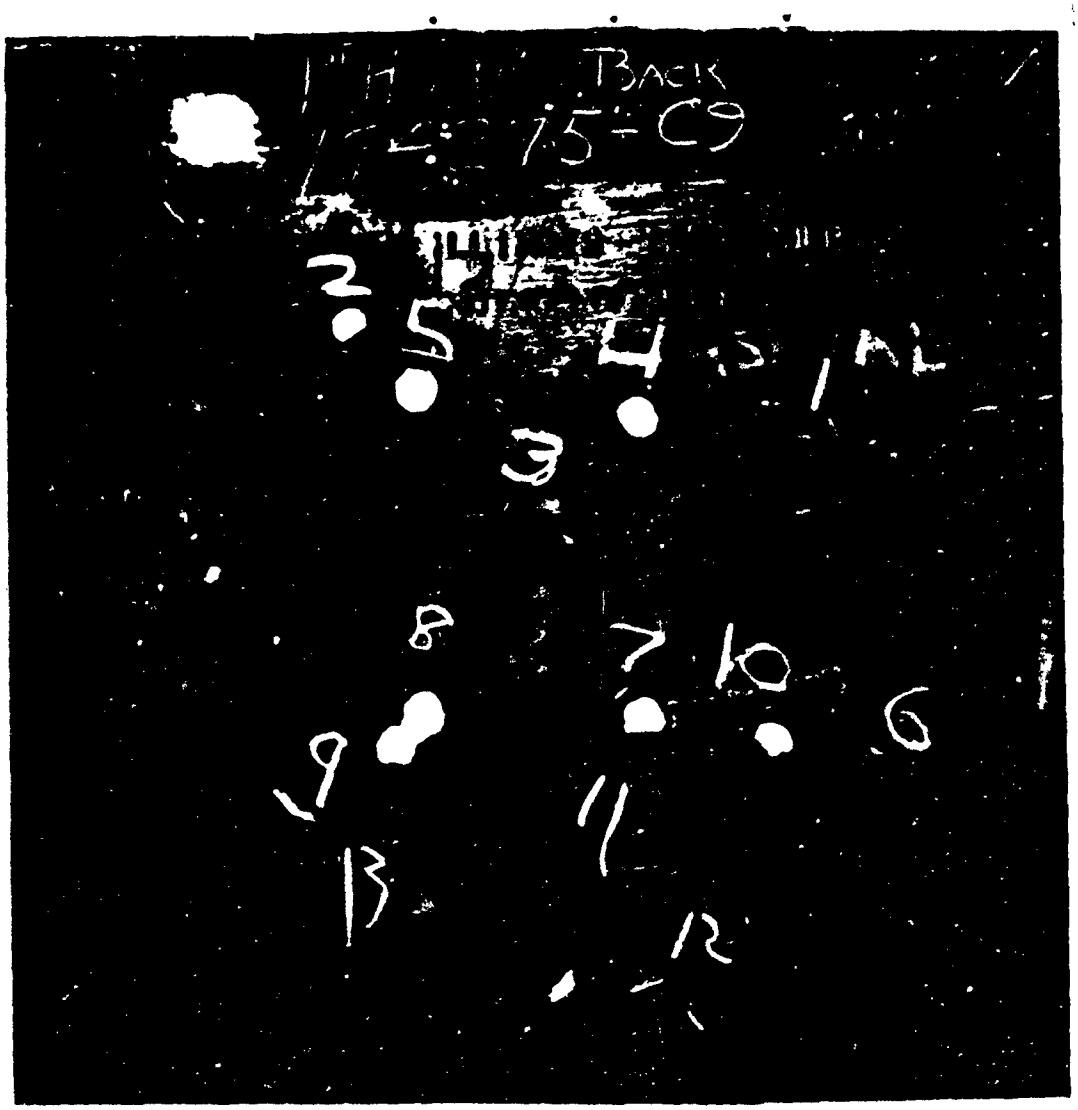
WATERTOWN ARSENAL

HEAT 1848, PLATE 10. 3/4" F.H.; NI-MO. BRINELL FACE 503-601
REAR 415-455. BACK MAY 16 1942 W.A.710-1823



WATERTOWN ARSENAL

PLATE 194275-C9. 1" HOMO. NI-CR. T.S. 120,000; BRINELL 244
TESTED AT 0° AND 30° OBLIQUITIES WITH 37 MM M51 A.P.C.
MAY 16 1942 FRONT W.A.710-1842



WATERTOWN ARSENAL

PLATE 154275-C9. 1" HOMO. NI-CR. T.S. 120,000; BRINELL 244
MAY 16 1942 BACK W.A.710-1843

Ballistic Data Sheet No. 30

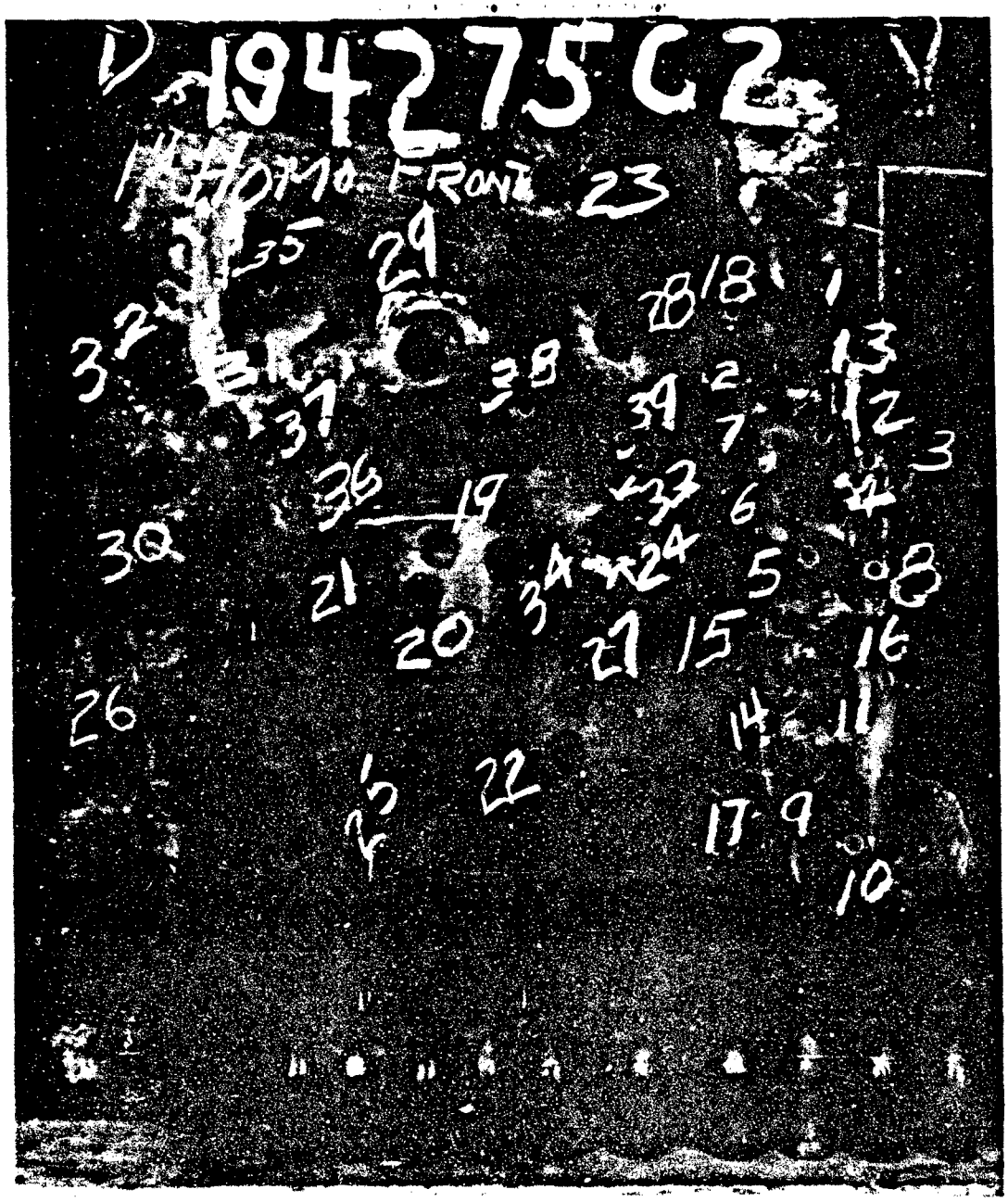
Carnegie-Illinois Plate 194275C2 - 1"x36"x36" Ni-Cr Homogeneous
BHN 263 - T.S. 127,500 - Photographs W.A. 710-1737, W.A. 710-1738

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
0°	1	190.0	2514	CP - PTP
0°	2	190.0	2499	CP - PTP
0°	3	185.0	2432	CP - FPTP
0°	4	180.0	2412	CP - CIP
0°	5	170.0	2241	CP - FPTP
0°	6	167.0	2261	CP - FPTP
0°	7	165.0	2191	Hit Rd. #2 - Disregard
0°	8	167.0	lost	PP - MB
0°	9	167.0	2181	PP - MB
0°	10	168.5	2228[a]	CP - FPTP
0°	11	167.5	2188[a]	PP - MB
0°	12	190.0	lost	CP - PTP
0°	13	190.0	2501	CP - PTP
0°	14	188.0	2513	CP - PTP
0°	15	187.0	2485	CP - PTP
0°	16	186.0	2478[n]	CP - PTP
0°	17	185.0	2490	CP - PTP
0°	18	184.0	2464[n]	CP - CIP
[a]Army limit at 0° - 2208 f/s; [n]Navy limit at 0° - 2471 f/s				
10°	35	165.0	2274	CP - FPTP
10°	36	170.0	2272[a]	CP - FPTP
10°	37	165.0	2239[a]	PP - MB
10°	38	187.0	2515[n]	CP - PTP
10°	39	180.0	2495[n]	CP - CIP
[a]Army limit at 10° - 2256 f/s; [n]Navy limit at 10° - 2505 f/s				
37 MM AP M51 Firings:				
0°	19	1.65oz.	1247[a]	CP - CL
0°	20	1.55oz.	1198[a]	PP - LB
0°	21	1.95oz.	1335	CP - FPTP 1.7"x1.5" Punching
0°	22	1.85oz.	1311	CP - FPTP 1.5"x1.6" Punching
0°	23	2.00oz.	1392	Hit in area backed by support - Disregard
0°	24	1.98oz.	1362	CP - CIP
0°	25	2.00oz.	1368[n]	CP - CIP
0°	26	2.01oz.	1373	Hit in area backed by support - Disregard
0°	27	2.02oz.	1400[n]	CP - PTP 1.83"x1.90" punching
[a]Army limit at 0° - 1223 f/s; [n]Navy limit at 0° - 1384 f/s				
20°	28	3.00oz.	1784[n]	CP - FPTP
20°	29	3.20oz.	1831[n]	CP - PTP
20°	30	2.00oz.	1402	CP - CIP
20°	31	1.80oz.	1309	CP - FPTP 1/2"x1-1/2" FP
20°	32	1.70oz.	1267[a]	CP - FPTP
20°	33	1.60oz.	1216	Hit Rd. #24 - Disregard
20°	34	1.60oz.	1219[a]	PP - LB
[a]Army limit at 20° - 1243 f/s; [n]Navy limit at 20° - 1808 f/s				

Ballistic Data Sheet No. 31

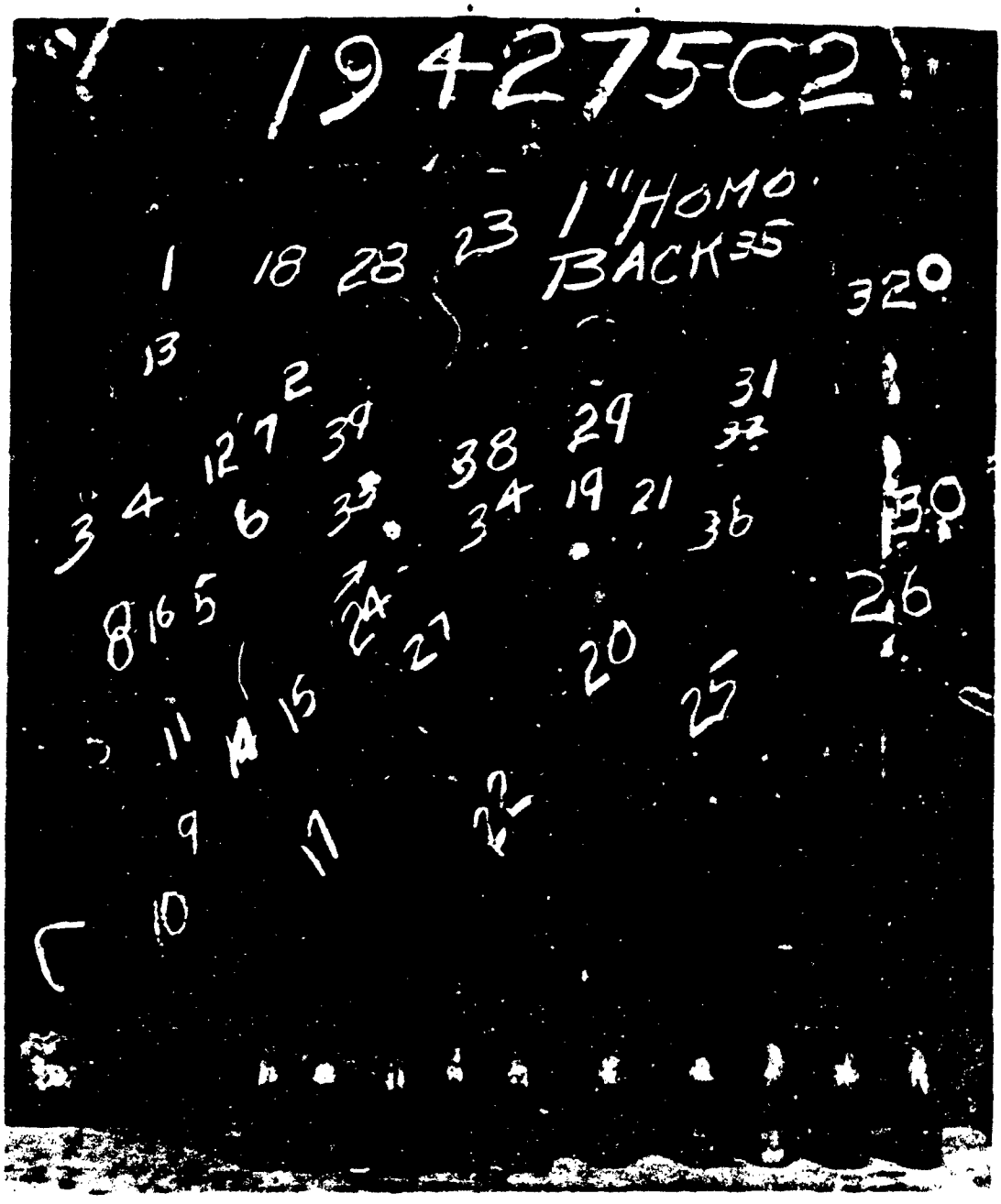
Carnegie-Illinois Plate 19427501 - 1"x36"x36" Ni-Cr Homogeneous
BHN 272 - T.S. 131,500 - Photographs W.A. 710-1735, W.A. 710-1736

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
0°	1	170.0	2266	CP - FPTP
0°	2	165.0	2211[a]	CP - FPTP
0°	3	164.0	2135	PP - SB
0°	4	165.0	2199[a]	PP - MB
0°	5	185.0	2445	CP - CIP
0°	6	190.0	2488[a]	CP - PTP
0°	7	185.0	2462[a]	CP - CIP
[a]Army limit at 0° - 2205 f/s; [b]Navy limit at 0° - 2475 f/s				
10°	8	170.0	lost	CP - FPTP
10°	9	170.0	2246	Hit edge of plate - Disregard
10°	10	170.0	2254	PP - LB
10°	11	170.0	2234	PP - MB
10°	12	172.0	2256	PP - LB
10°	13	175.0	2328	CP - FPTP
10°	14	173.0	2258[a]	PP - LB
10°	15	174.0	2272[a]	CP - FPTP
10°	16	190.0	2494	CP - CIP
10°	17	195.0	2553	CP - CIP
10°	18	200.0	2624	CP - CIP
10°	19	205.0	2715[a]	CP - CIP
10°	20	210.0	2763	CP - PTP
10°	21	208.0	2752[a]	CP - PTP
[a]Army limit at 10° - 2265 f/s; [b]Navy limit at 10° - 2734 f/s				
20°	26	175.0	2446	CP - FPTP
20°	27	165.0	2371[a]	CP - FPTP
20°	28	160.0	2267	PP - MB
20°	29	163.0	2265	PP - MB
20°	30	164.0	2310	PP - MB
20°	31	165.0	2299	PP - LB
20°	32	165.0	2324	PP - LB
20°	33	166.0	2333[a]	PP - LB
20°	34	190.0	2569	CP - CIP
20°	35	195.0	2660[a]	CP - PTP
20°	36	192.5	2634[a]	CP - FPTP
[a]Army limit at 20° - 2354 f/s; [b]Navy limit at 20° - 2647 f/s				
Plate Reversed:				
0°	22	185.0	2520	CP - CIP
0°	23	187.0	2555[a]	CP - PTP
0°	24	186.0	lost	CP - CIP
0°	25	186.0	2525[a]	CP - CIP
[b]Navy limit at 0° - (plate reversed) 2540f/s; Army limit not determined.				
37 MM TP M51 Firing:				
0°	37	4.10oz.	2122	PP - LB



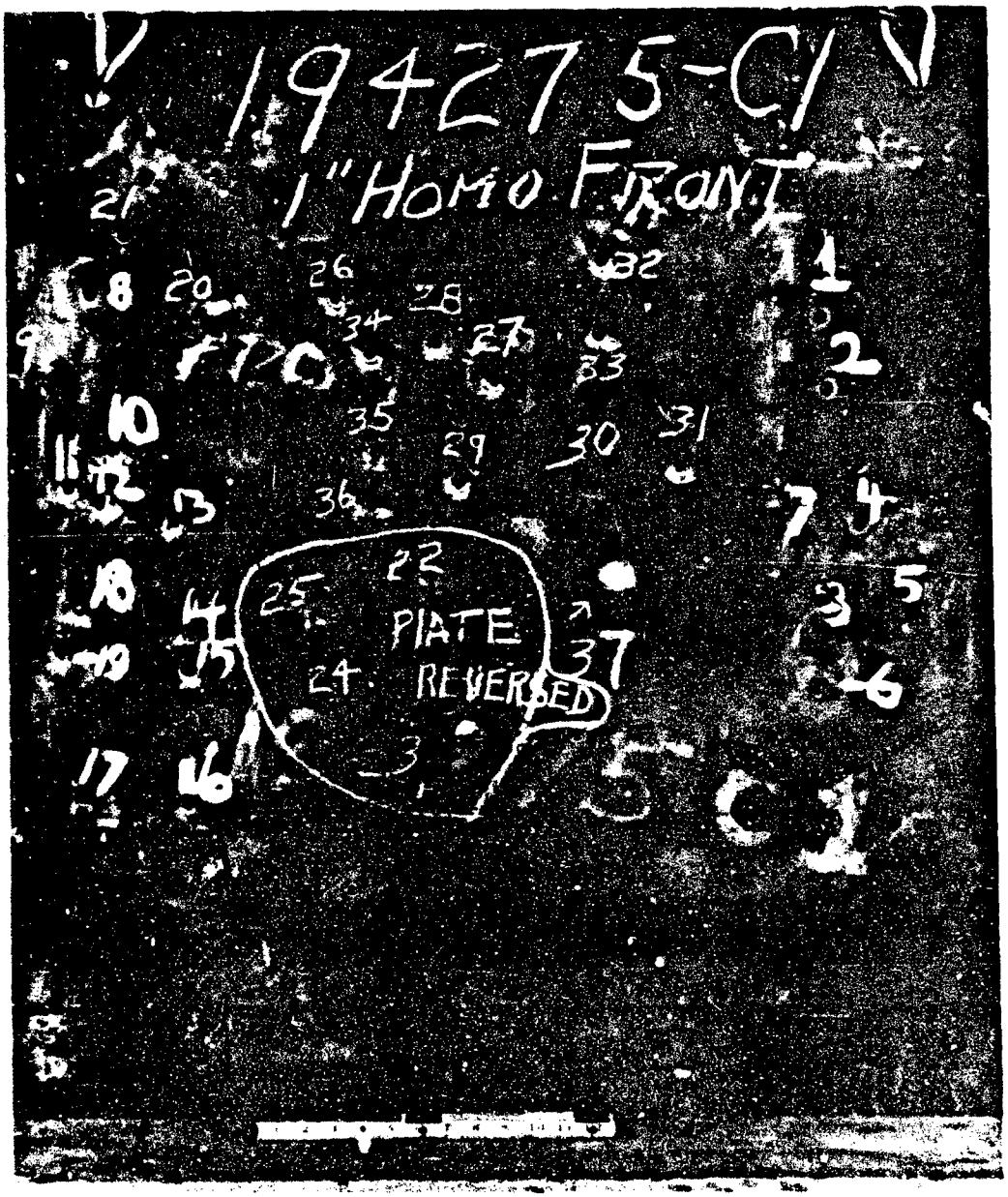
WATERTOWN ARSENAL

PLATE C-2, 1" HOMOGENEOUS, BRINELL 263, T.S. 127,500; 127,500
TESTED AT NORMAL AND 10°, CAL. .50 A.P. M2, TESTED AT NORMAL,
20° 37 MM M51 A.P. (FRONT) JAN. 30 1942 W.A.710-1737



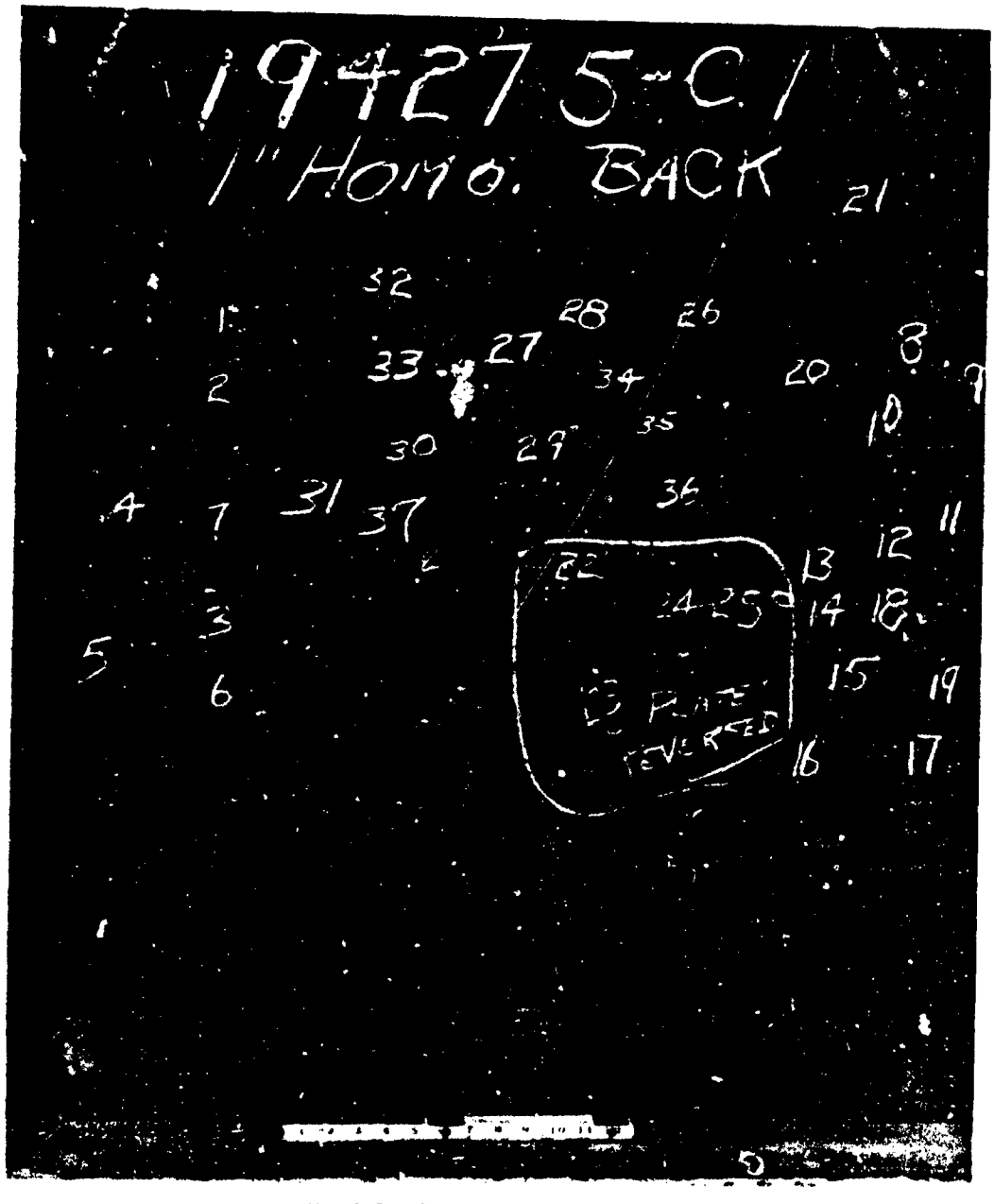
WATERTOWN ARSENAL

PLATE C-8, 1" HOMOGENEOUS, BRINELL 263, T.S. 127,500; 127,500
TESTED AT NORMAL AND 10°, CAL. .50 A.P. M2. TESTED AT NORMAL,
20° 37 MM M51 A.P. (BACK) JAN. 30 1942 W.A.710-1738



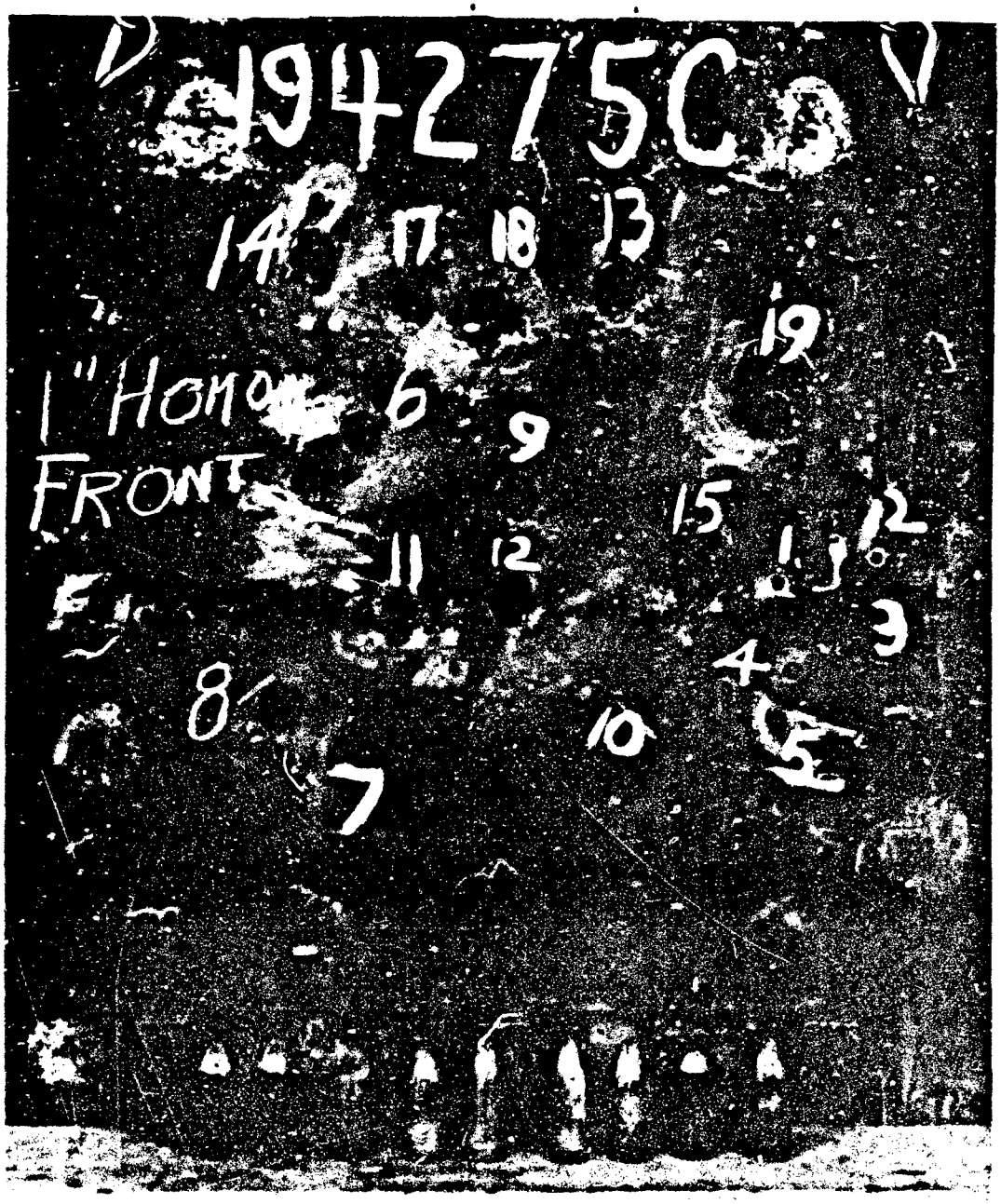
WATERTOWN ARSENAL

PLATE C-1, 1" HOMOGENEOUS, BRINELL 272, T.S. 131,500; 132,000
TESTED NORMAL, 10°, 20° WITH CAL. .50 A.P. M2 SHOCK TESTED (FRONT)
WITH 37 MM M51 T.P. AT 2122 F/S S.V.
JANUARY 30 1942 W.A.710-1735



WATERTOWN ARSENAL

PLATE C-1, 1" HOMOGENEOUS, BRINELL 272, T.S. 131,500; 132,000
TESTED NORMAL, 10°, 20° WITH CAL. .50 A.P. M2 SHOCK TESTED (BACK)
WITH 37 MM M51 T.P. AT 2122 F/S S.V.
JANUARY 30 1942 W.A.710-1736



WATERTOWN ARSENAL

PLATE C, 1" HOMOGENEOUS, BRINELL 279, T.S. 131,500; 131,500
TESTED NORMAL CAL. .50 A.P. M2, AT 20°, 30° WITH 37 MM M51 A.P.
JANUARY 30 1942 (FRONT) W.A.710-1733

Ballistic Data Sheet No. 32

Carnegie-Illinois Plate 194275C - 1"x36"x36" Ni-Cr Homogeneous
BHN 279 - T.S. 131,500 - Photographs W.A. 710-1733, W.A. 710-1734

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
0°	1	160.0	2158[a]	PP - SB
0°	2	165.0	2187[a]	CP - FPTP
0°	3	185.0	2419	CP - CIP
0°	4	185.0	2439[n]	CP - CIP
0°	5	186.0	24[illegible]3[n]	CP - PTP

[a]Army limit at 0° - 2173 f/s; [n]Navy limit at 0° - 2444 f/s

37 MM AP M51 Firings:				
20°	6	1.80oz.	1297[a]	CP - FPTP
20°	7	1.70oz.	1259[a]	PP - LR Cracking on back
20°	8	3.00oz.	1775	CP - PTP
20°	9	2.00oz.	1411	CP - FPTP Two 1" radial cracks
20°	10	2.25oz.	1493[n]	CP - FPTP
20°	11	2.50oz.	1579	CP - PTP
20°	12	2.35oz.	1542[n]	CP - PTP

[a]Army limit at 20° - 1278 f/s; [n]Navy limit at 20° - 1518 f/s

30°	13	2.75oz.	1665	CP - PTP
30°	14	2.50oz.	1573	CP - PTP
30°	15	2.25oz.	1491	CP - FPTP 1/2" back crack
30°	16	2.42oz.	1556[n]	CP - PTP
30°	17	2.00oz.	1401[a]	CP - FPTP
30°	18	1.92oz.	1356[a]	PP - MB
30°	19	2.34oz.	1524[n]	CP - CIP

[a]Army limit at 30° - 1379 f/s; [n]Navy limit at 30° - 1540 f/s

Ballistic Data Sheet No. 33

Carnegie-Illinois Plate 1342753 - 1"x36"x36" Ni-Cr Homogeneous
BHN 304 - T.S. 145,000 - Photographs W.A. 710-1739, W.A. 710-1740

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
0°	1	170.0	2229	PP - SB
0°	2	180.0	2402	CP - FPTP
0°	3	175.0	2336	CP - FPTP
0°	4	172.5	2264[a]	PP
0°	5	173.0	2274[a]	CP - FPTP
0°	6	190.0	2514	Backed by support - Disregard
0°	7	190.0	2534[n]	CP - CIP
0°	8	195.0	2555	CP - FPTP Hit within 2 cals. of RD.#7 - Disregard
0°	9	195.0	2562[n]	CP - PTP
[a]Army limit at 0° - 2269 f/s; [n]Navy limit at 0° - 2548 f/s				
10°	25	180.0	2366	CP - FPTP
10°	26	200.0	2619[n]	CP - FPTP
10°	27	210.0	2765	CP - PTP
10°	28	175.0	2333	CP - FPTP
10°	29	170.0	2286[a]	PP - LB
10°	30	205.0	2689	CP - PTP
10°	31	202.5	2663	CP - PTP
10°	32	172.5	2259	PP - MB
10°	33	173.5	2348	CP - FPTP
10°	34	173.0	2288[a]	CP - FPTP
10°	35	201.0	2622	Hit tangent to Rd.#28 - Disregard
10°	36	202.0	2621[n]	CP - PTP
[a]Army limit at 10° - 2287 f/s; [n]Navy limit at 10° - 2620 f/s				
20°	37	175.0	2431	PP - MB .6"x.2" FP
20°	38	185.0	2555	PP - LB
20°	39	187.0	2558	PP - LB
20°	40	188.5	2604	PP - LB
20°	41	195.0	lost	CP - FPTP
20°	42	193.0	2611	PP - LB
20°	43	195.0	2597	PP - LB
20°	44	197.0	2663	CP - FPTP
20°	45	196.0	2650[a]	CP - FPTP
20°	46	195.5	2662	CP - FPTP
20°	47	195.0	2643[a]	PP - CIP
20°	48	200.0	2717	CP - CIP BD
20°	49	205.0	2768[n]	CP - PTP
20°	50	203.0	2745[n]	CP - CIP
[a]Army limit at 20° - 2647 f/s; [n]Navy limit at 20° - 2756 f/s				

Ballistic Data Sheet No. 33 (Cont'd)

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
37 MM AP M51 Firings:				
0°	10	1.42oz.	1135[a]	PP - LB
0°	11	1.49oz.	1158[a]	CP - FPTP
0°	12	1.86oz.	1316	CP - FPTP
0°	13	1.97oz.	1369	Backed by support - Disregard
0°	14	1.97oz.	1358	CP - FPTP - Excessive yaw - Disregard
0°	15	1.97oz.	1363	CP - FPTP - Excessive yaw - Disregard
0°	16	1.97oz.	1367[a]	CP - FPTP 1.5"x1.3" EP
0°	17	2.02oz.	1397[a]	CP - PTP .4"x.7" EP
[a]Army limit at 0° - 1142 f/s; [b]Navy limit at 0° - 1382 f/s				
20°	18	2.00oz.	1392	CP - FPTP
20°	19	1.75oz.	1269	Hit within 1 caliber of Rd. #17 - Disregard
20°	20	1.87oz.	1316[a]	PP - LB Cracking started
20°	21	1.95oz.	1349[a]	CP - FPTP
20°	22	2.08oz.	1423	CP - FPTP Pun 8; 2-1/2" back crack
20°	23	2.10oz.	1424[a]	CP - CIP
20°	24	2.20oz.	1470[a]	CP - PTP
[a]Army limit at 20° - 1334 f/s; [b]Navy limit at 20° - 1457 f/s				
37 MM TP M51 Firing:				
0°	51	4.10oz.	2133	PP - LB Face impression 2.1"x2.2"

Ballistic Data Sheet No. 34

Carnegie-Illinois Plate 19427505 - 1"x36"x36" Ni-Cr Homogeneous
BHN 361 - T.S. 179,500 - Photographs W.A. 710-1743, W.A. 710-1744

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
0°	1	180.0	2392	PP - MB
0°	2	185.0	2461	PP - MB
0°	3	190.0	2486[a]	PP - MB
0°	4	195.0	2555	Hit on Rd.#1 - Disregard
0°	5	195.0	2551	CP - FPTP
0°	6	192.5	2531[a]	CP - FPTP
0°	7	205.0	2681[n]	CP - CIP .35"x.50" FP
0°	8	210.0	2759	CP - PTP .35"x.50" FP; .35"x.50" BP
0°	9	207.5	2729[n]	CP - PTP
[a]Army limit at 0° - 2509 f/s; [n]Navy limit at 0° - 2705 f/s				
10°	22	195.0	2531	Backed by support - Disregard
10°	23	195.0	2559	CP - FPTP
10°	24	190.0	2508	CP - FPTP
10°	25	190.0	2524	CP - FPTP
10°	26	185.0	2443[a]	PP - LB
10°	27	187.5	2461	Hit tangent to Rd.#26 - Disregard
10°	28	187.5	2525	CP - FPTP
10°	29	187.5	2487[a]	CP - FPTP
10°	30	210.0	2761[n]	CP - PTP
10°	31	205.0	2701	CP - FPTP
10°	32	200.0	2654	CP - FPTP
10°	33	205.0	2682	CP - CIP
10°	34	205.0	2695	CP - CIP
10°	35	207.0	2710	Glanced off rest - Disregard
10°	36	207.0	2724[n]	CP - CIP
[a]Army limit at 10° - 2465 f/s; [n]Navy limit at 10° - 2742 f/s				
20°	37	215.0	2927	PP - BIP - LB - BD
20°	38	220.0	lost	CP - PTP
20°	39	220.0	2969[n]	CP - PTP
20°	40	218.0	2942[n]	CP - CIP BD
20°	41	212.0	2884[a]	CP - FPTP BD
20°	42	211.0	2852[a]	PP - LB Pun S BD
[a]Army limit at 20° - 2865 f/s; [n]Navy limit at 20° - 2956 f/s				
37 MM AP M51 Firings:				
0°	10	1.7oz.	1264[n]	CP - CIP 2"x2.3" BS
0°	11	1.85oz.	1313[n]	CP - PIP 2"x2.2" BS
0°	12	1.35oz.	1125	CP - FPTP 3.25"x2.40" BS
0°	13	1.28oz.	1078[a]	CP - FPTP
0°	14	1.22oz.	1064[a]	PP - LB
[a]Army limit at 0° - 1071 f/s; [n]Navy limit at 0° - 1259 f/s				

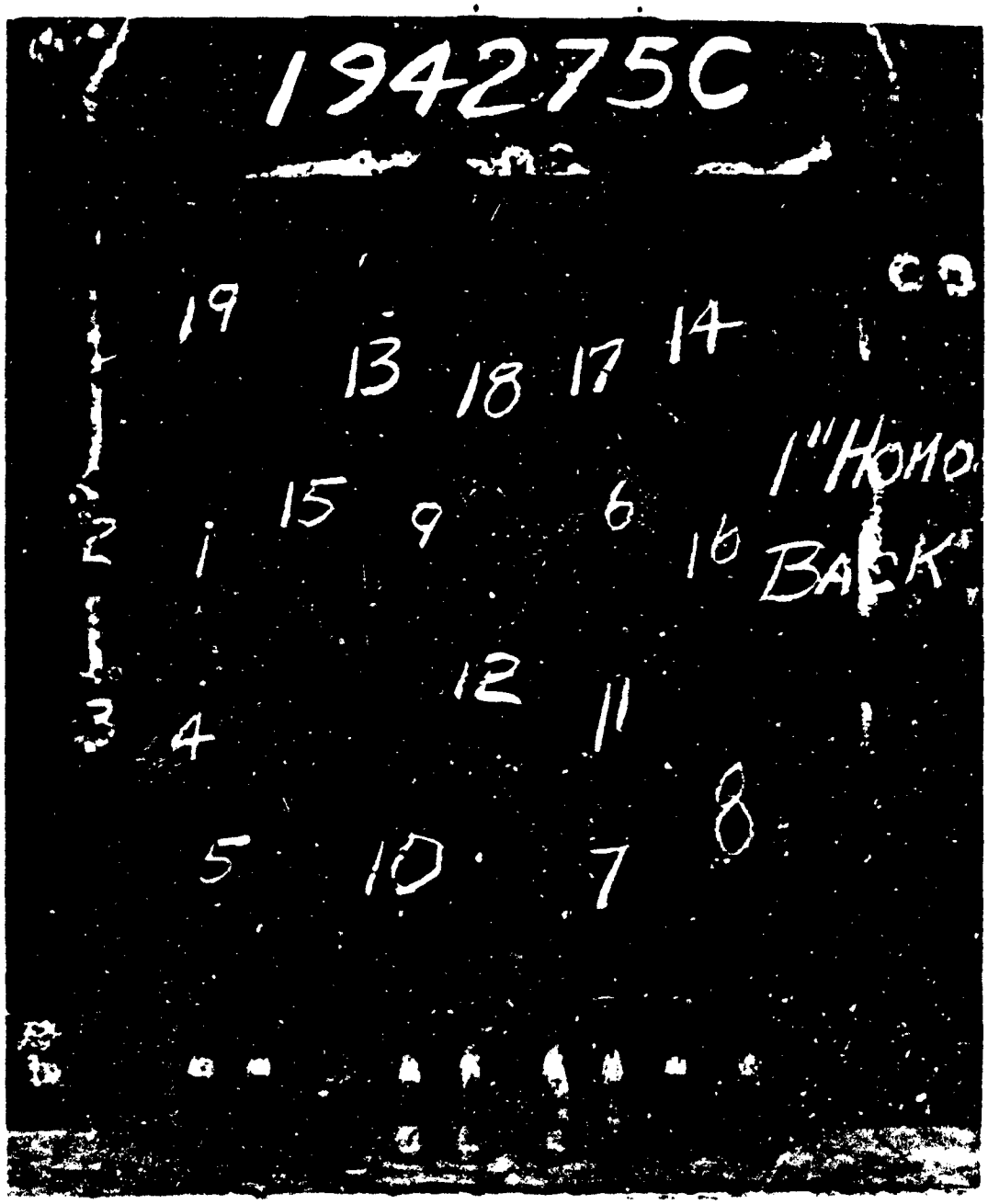
Ballistic Data Sheet No. 34 (Cont'd)

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
37 MM AP M51 Firings:				
20°	15	1.75oz.	1267[a]	CP - FPTP
20°	16	1.70oz.	1240[a]	FP - LB Pun 8
20°	17	2.25oz.	1490	CP - PTP 2.6"x2.2" BS
20°	18	2.15oz.	1448	CP - PTP 2.6"x2.2" BS
20°	19	2.05oz.	1416	CP - PTP 2.2"x2.1" BS
20°	20	1.95oz.	1368[a]	CP - PTP 2.1"x3.0" BS
20°	21	1.85oz.	1320[a]	CP - FPTP Pun 8 4.25" Back crack
[a]Army limit at 20° - 1254 f/s; [a]Navy limit at 20° - 1344 f/s				
37 MM TP M51 Firings:				
20°	43	4.10oz.	2120	CP - PTP 1.8"x2.8" BS Hit on Rd. #7

Ballistic Data Sheet No. 35

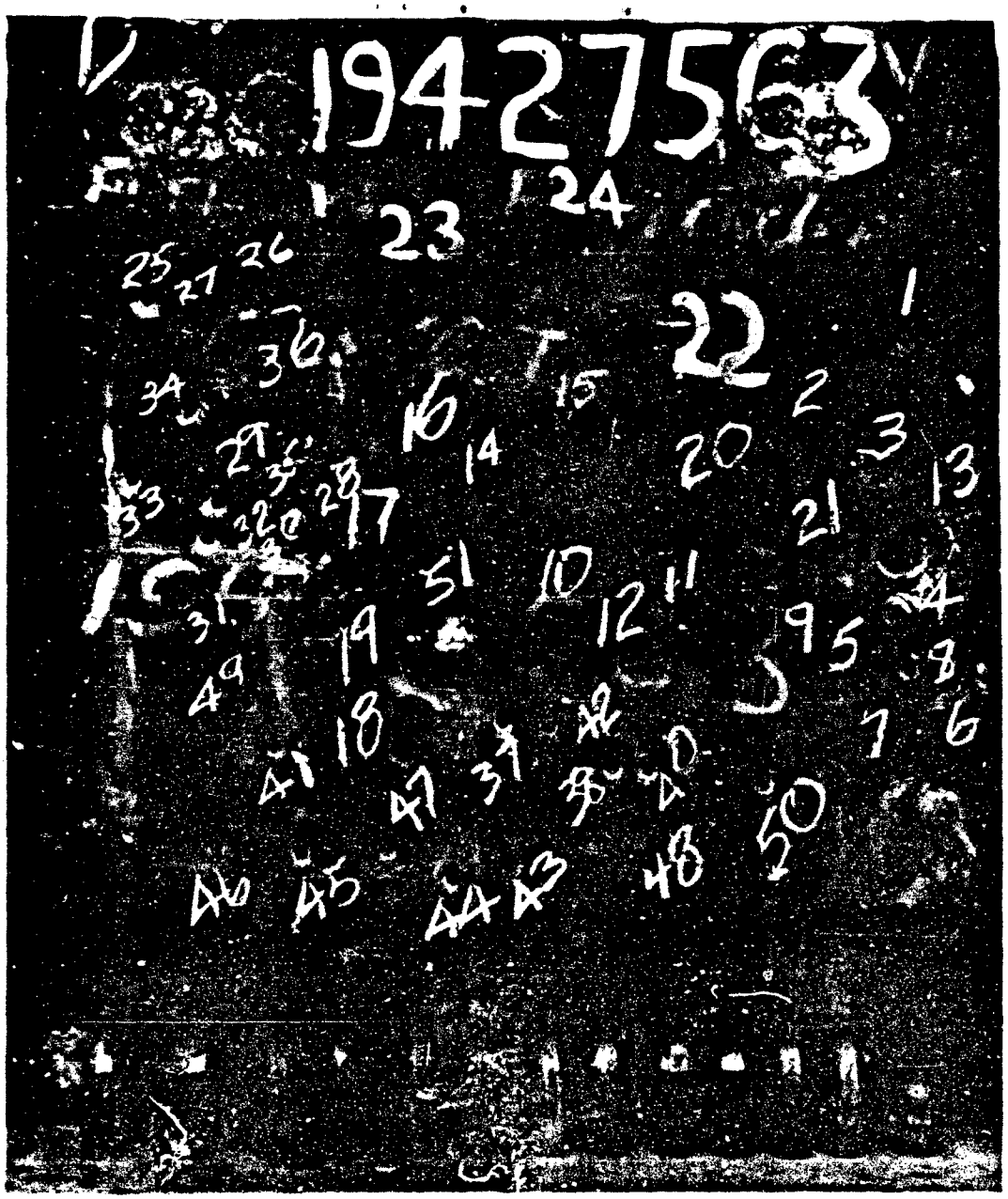
Carnegie-Illinois Plate 19427508 - 1"x36"x36" Ni-Cr Homogeneous
BHN 363 - T.S. 174,000 - Photographs W.A. 710-1840, W.A. 710-1841

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
0°	11	170.0	2407	PP - LB Cracking started
0°	12	175.0	2431[a]	PP - LB Cracking started
0°	13	177.0	2451[a]	CP - FPTP
0°	14	195.0	2653	CP - CIP
0°	15	190.0	2663	CP - CIP
0°	16	200.0	2690	CP - PTP
0°	17	200.0	2710	CP - PTP
0°	18	193.0	2695	Backed by support - Disregard
0°	19	192.0	2685	CP - CIP
[a]Army limit at 0° - 2441 f/s; [n]Navy limit at 0° - 2698 f/s				
10°	1	190.0	2612	CP - FPTP 1/2"x7/8" FP
10°	2	180.0	2466	PP - LB
10°	3	185.0	2515[a]	CP - FPTP
10°	4	183.0	2584	CP - FPTP
10°	5	180.0	2495[a]	PP - LB Cracking started
10°	6	200.0	2701[n]	CP - PTP
10°	7	195.0	2662	CP - CIP
10°	8	198.0	2750	CP - FPTP
10°	9	188.0	2653	CP - CIP
10°	10	191.0	2691[n]	CP - FPTP
[a]Army limit at 10° - 2505 f/s; [n]Navy limit at 10° - 2696 f/s				
20°	20	190.0	2633	PP - SB
20°	21	200.0	2740	CP - CIP BD ND
20°	22	195.0	2691[a]	PP - LB Pun S
20°	23	198.0	2715[a]	CP - CIP BD
20°	24	210.0	2879	CP - PTP 5/8"x1/2" Inc. BP
20°	25	205.0	2809[n]	CP - FPTP
20°	26	208.0	2849[n]	CP - PTP
[a]Army limit at 20° - 2703 f/s; [n]Navy limit at 20° - 2829 f/s				
37 MM TP M51 Firings:				
0°	27	4.0oz.	2028	PP - MB



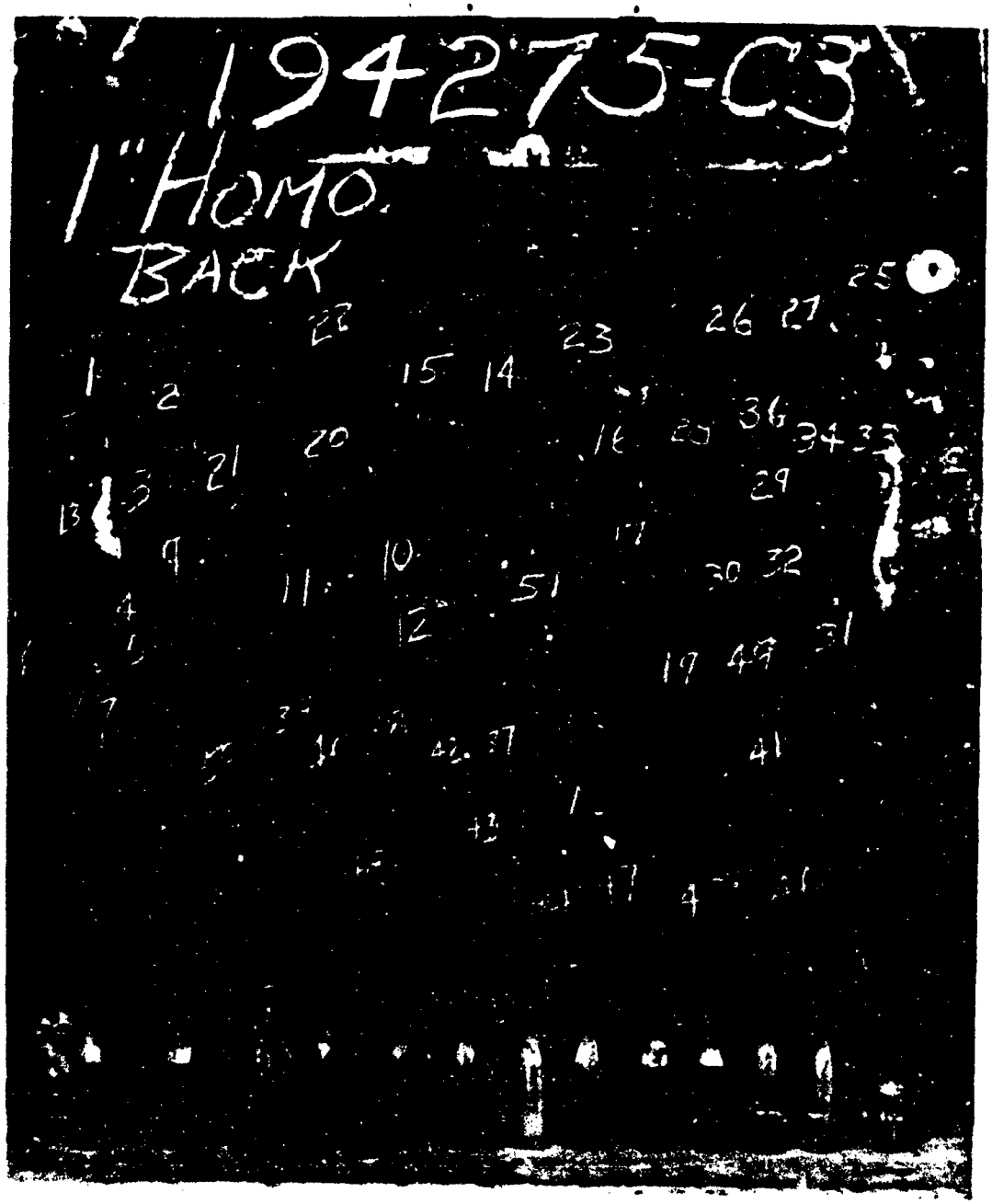
WATERTOWN ARSENAL

PLATE C, 1" HOMOGENEOUS, BRINELL 270, T.S. 131,500; 131,500
TESTED NORMAL CAL. .50 A.P. M2, AT 20°, 30° WITH 37 MM M51 A.P.
JANUARY 30 1942 (BACK) W.A.710-1734



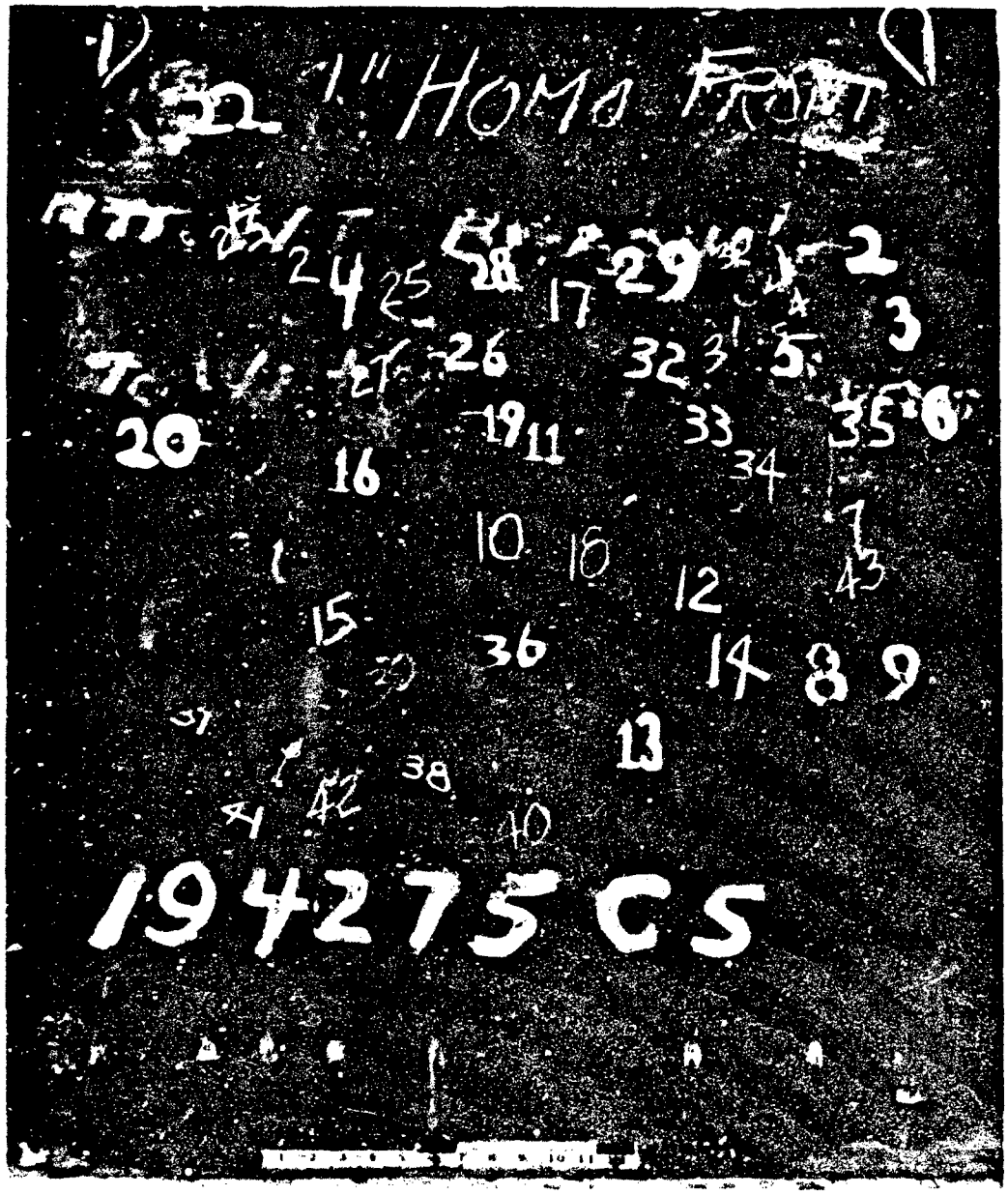
WATERTOWN ARSENAL

PLATE C-3, 1" HOMOGENEOUS, BRINELL 304, T.S. 143,500; 145,000
TESTED AT NORMAL, 10°, 20° CAL. .30 A.P. M2. TESTED AT NORMAL,
20° WITH 37 MM M51 A.P. SHOCK TESTED AT NORMAL WITH 37 MM M51
T.P. AT 2133 F/S S.V. (FRONT) JAN 30 1942 W.A.710-1739



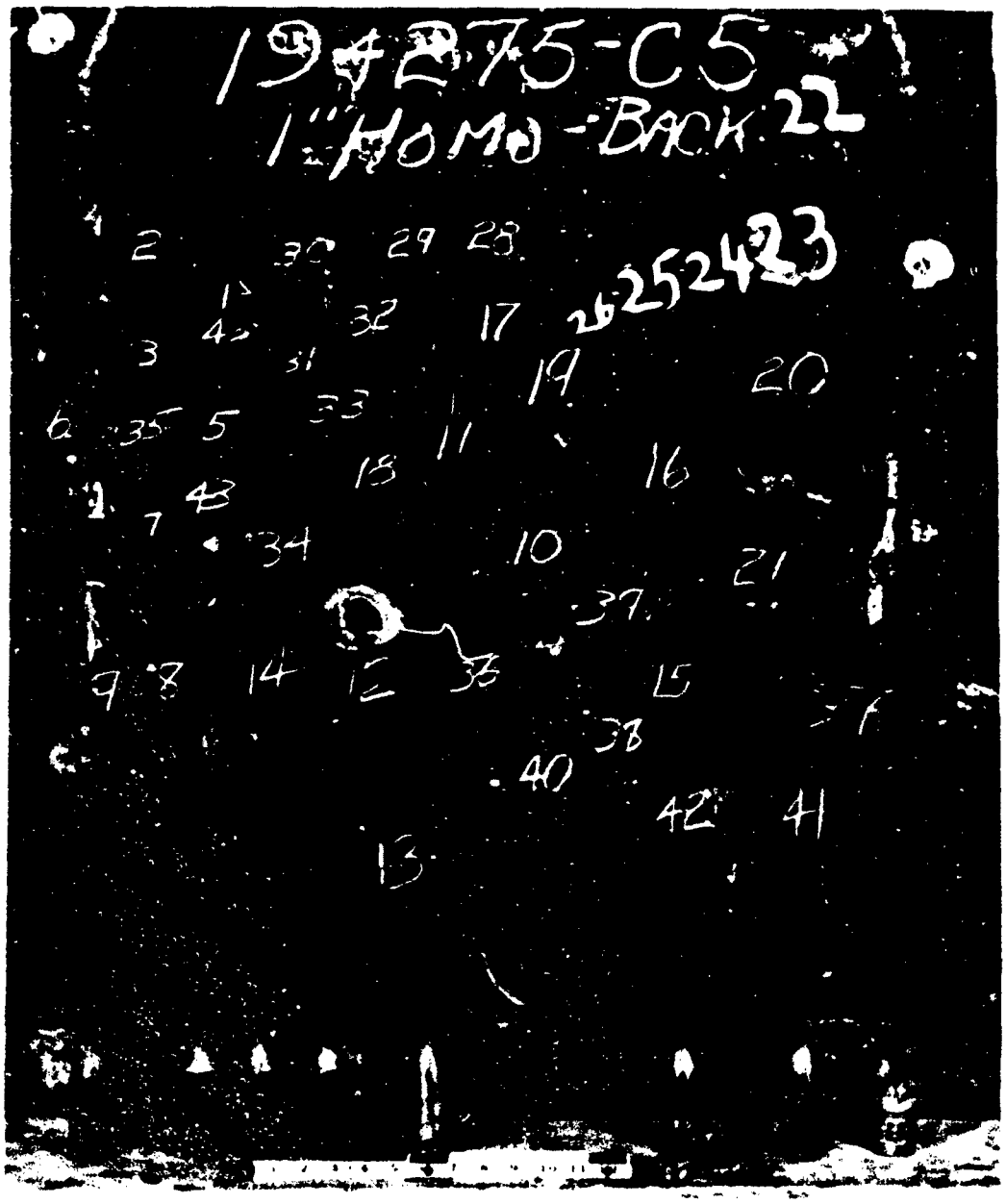
WATERTOWN ARSENAL

PLATE C-3, 1" HOMOGENEOUS, BRINELL 304, T.S. 143,500; 145,000
TESTED AT NORMAL, 10°, 20° CAL. .50 A.P. M2. TESTED AT NORMAL,
20° WITH 37 MM M51 A.P. SHOCK TESTED AT NORMAL WITH 37 MM M51
T.P. AT 2133 F/S S.V. (BACK) JAN 30 1942 W.A.710-1740



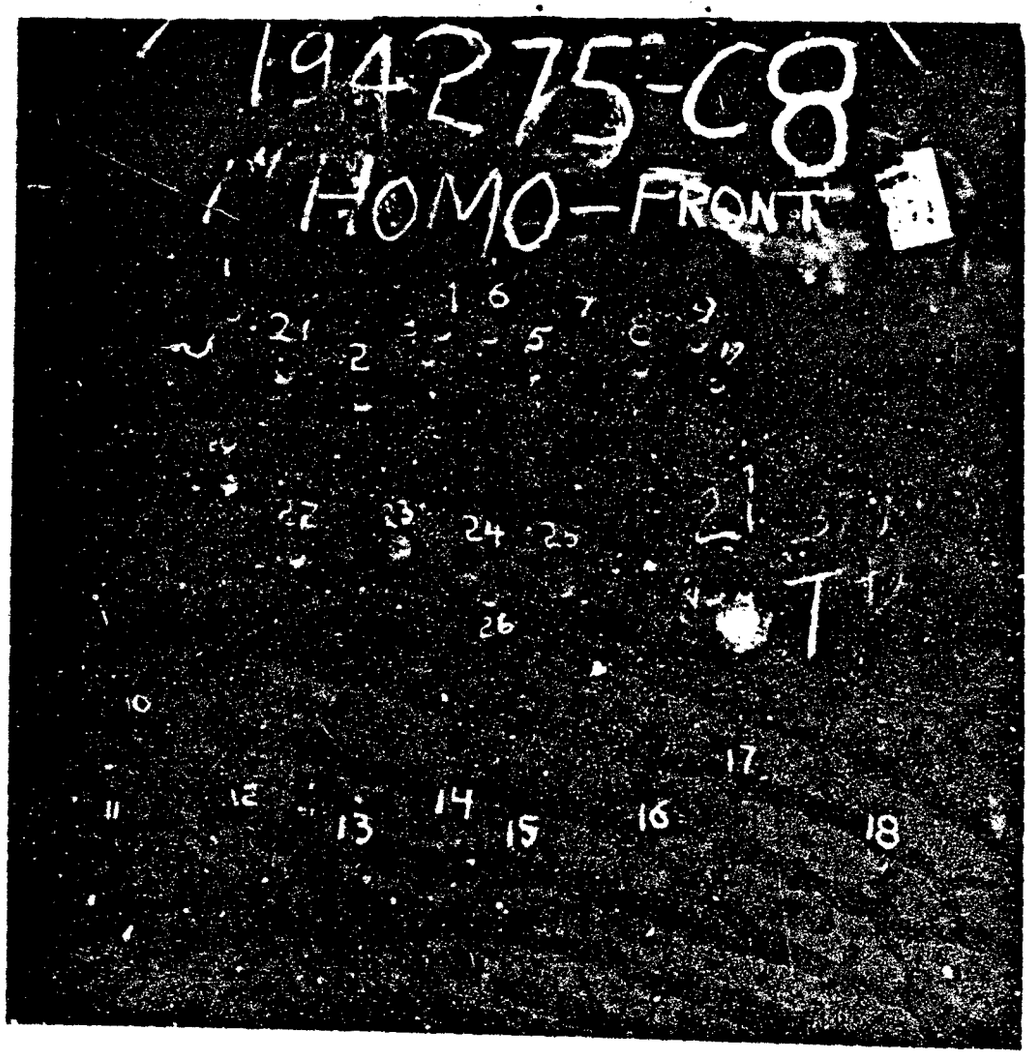
WATERTOWN ARSENAL

PLATE C-5, 1" HOMOGENEOUS, BRINELL 361, T.S. 173,500; 179,500
TESTED AT NORMAL, 10°, 20° CAL. .50 A.P. M2. TESTED AT NORMAL,
20° WITH 37 MM M51 A.P., SHOCK TESTED AT NORMAL 37 MM M51 T.P.
2120 F/S S.V. (FRONT) JAN 30 1942 W.A.710-1743



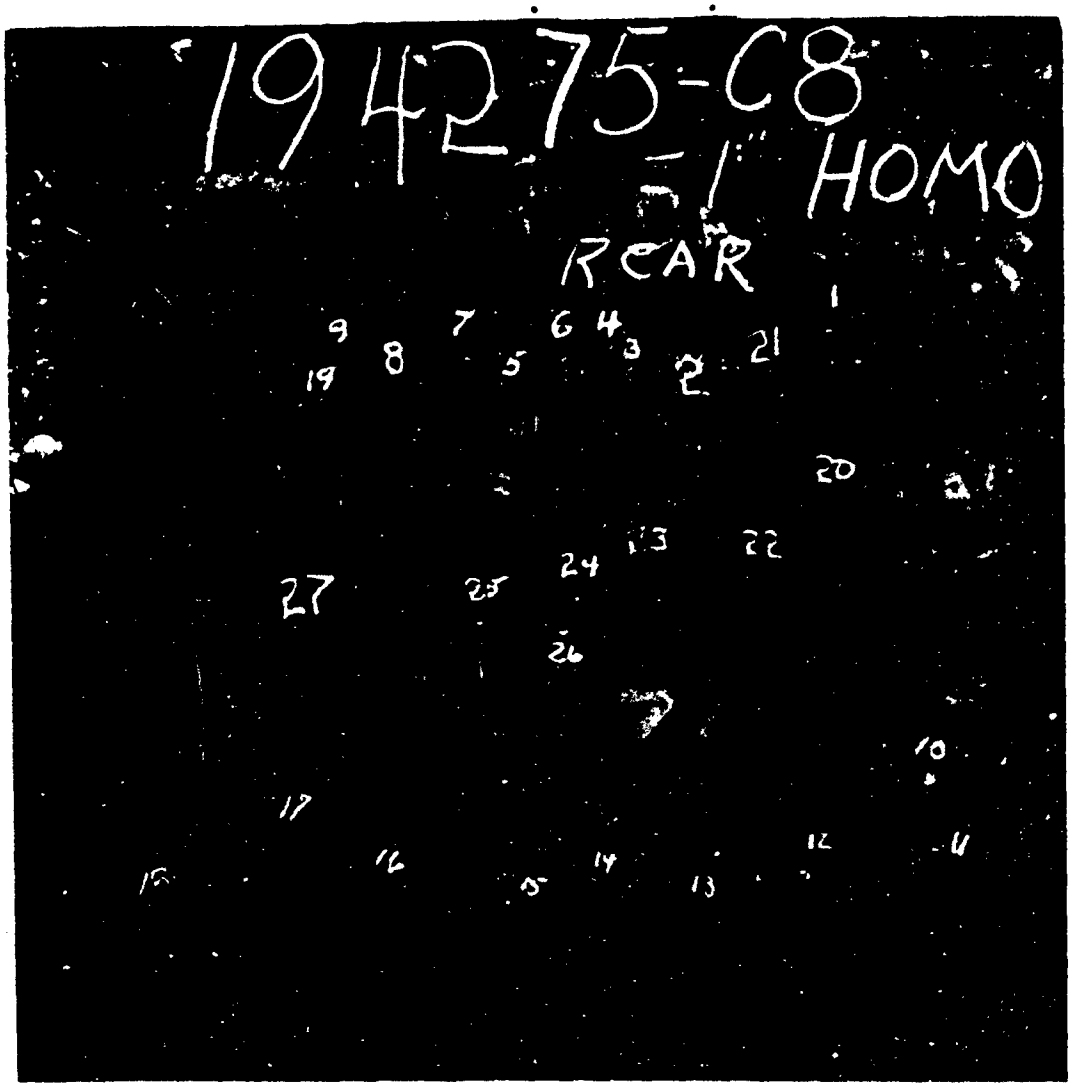
WATERTOWN ARSENAL

PLATE C-5, 1" HOMOGENEOUS, BRINELL 361, T.S. 173,500; 173,500
TESTED AT NORMAL, 10°, 20° CAL. .50 A.P. M2. TESTED AT NORMAL,
20° WITH 37 MM M51 A.P. SHOCK TESTED AT NORMAL 37 MM M51 T.P.
2120 F/S S.V. (BACK) JAN 30 1942 W.A.710-1744



WATERTOWN ARSENAL

PLATE 194275-C8. 1" HOMO. NI-CR. T.S. 174,000; BRINELL 363. TESTED AT 0°, 10°, AND 20° OBLIQUITIES WITH CAL .50 AP M2. SHOCK TESTED WITH 37 MM M51 TP. FRONT MAY 16 1942 W.A.710-1840



WATERTOWN ARSENAL

PLATE 194275-C8. 1" HOMO. NI-CR. T.I. 174,000; BRINELL 363
MAY 16 1942 REAR W.A.710-1841

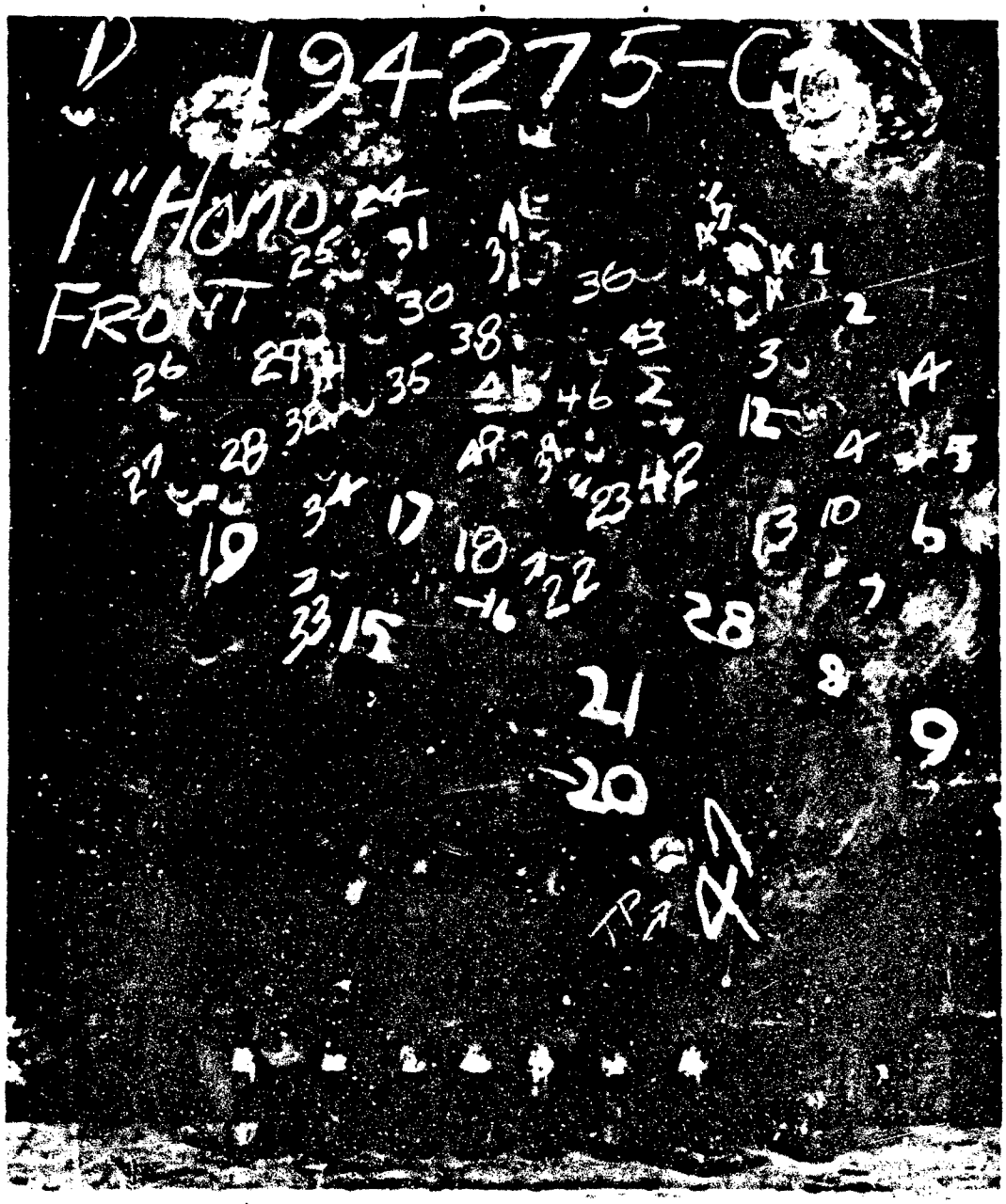
Ballistic Data Sheet No. 36

Carnegie-Illinois Plate 194275C6 - 1"x36"x36" Ni-Cr Homogeneous
BHN 368 - T.S. 17400 - Photographs W.A. 710-1745, W.A. 710-1746

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
0°	1	180.0	2408	PP-SB .5"x.3" FP
0°	2	185.0	2426	PP-MB-SC
0°	3	190.0	2474[a]	CP-FPTP .5"x.35" FP
0°	4	187.5	2496	CP-FPTP .5"x.3" FP
0°	5	186.0	2443	PP-MB
0°	6	186.5	2466[a]	PP-MB .3"x.35" FP
0°	7	205.0	2625	CP-CIP
0°	8	205.0	2696[n]	CP-FPTP
0°	9	205.0	2694	CP-CIP
0°	10	206.0	2687	CP-CIP
0°	11	207.0	2726	CP-FPTP Excessive yaw - Disregard
0°	12	207.0	lost	CP-CIP BD
0°	13	208.0	2765	CP-PTP
0°	14	207.0	2729[n]	CP-PTP
[a]Army limit at 0° - 2480 f/s; [n]Navy limit at 0° - 2713 f/s				
10°	24	187.0	2545	CP-FPTP
10°	25	185.0	lost	CP-FPTP
10°	26	185.0	2515	CP-FPTP
10°	27	182.5	2495[a]	CP-FPTP
10°	28	180.0	2466[a]	PP-MB
10°	29	195.0	2701	CP-FPTP-Pun S
10°	30	198.0	2711	CP-FPTP
10°	31	205.0	2760	PP-MB
10°	32	210.0	2839	CP-FPTP
10°	33	213.0	2884	CP-PTP
10°	34	211.5	2899	CP-PTP
10°	35	210.0	2884[n]	CP-PTP
10°	36	208.0	2859[n]	CP-FPTP
[a]Army limit at 10° - 2481 f/s; [n]Navy limit at 10° - 2872 f/s				
20°	37	190.0	2624	PP-SB-Excessive yaw - Disregard
20°	38	195.0	2672	PP-CIP
20°	39	210.0	2784	PP-MB
20°	40	215.0	lost	Hit rd. #39 - Disregard
20°	41	215.0	2939	CP-PTP 1.35"x1" FS
20°	42	212.0	2893[n]	CP-FPTP 3/4"x1" FS

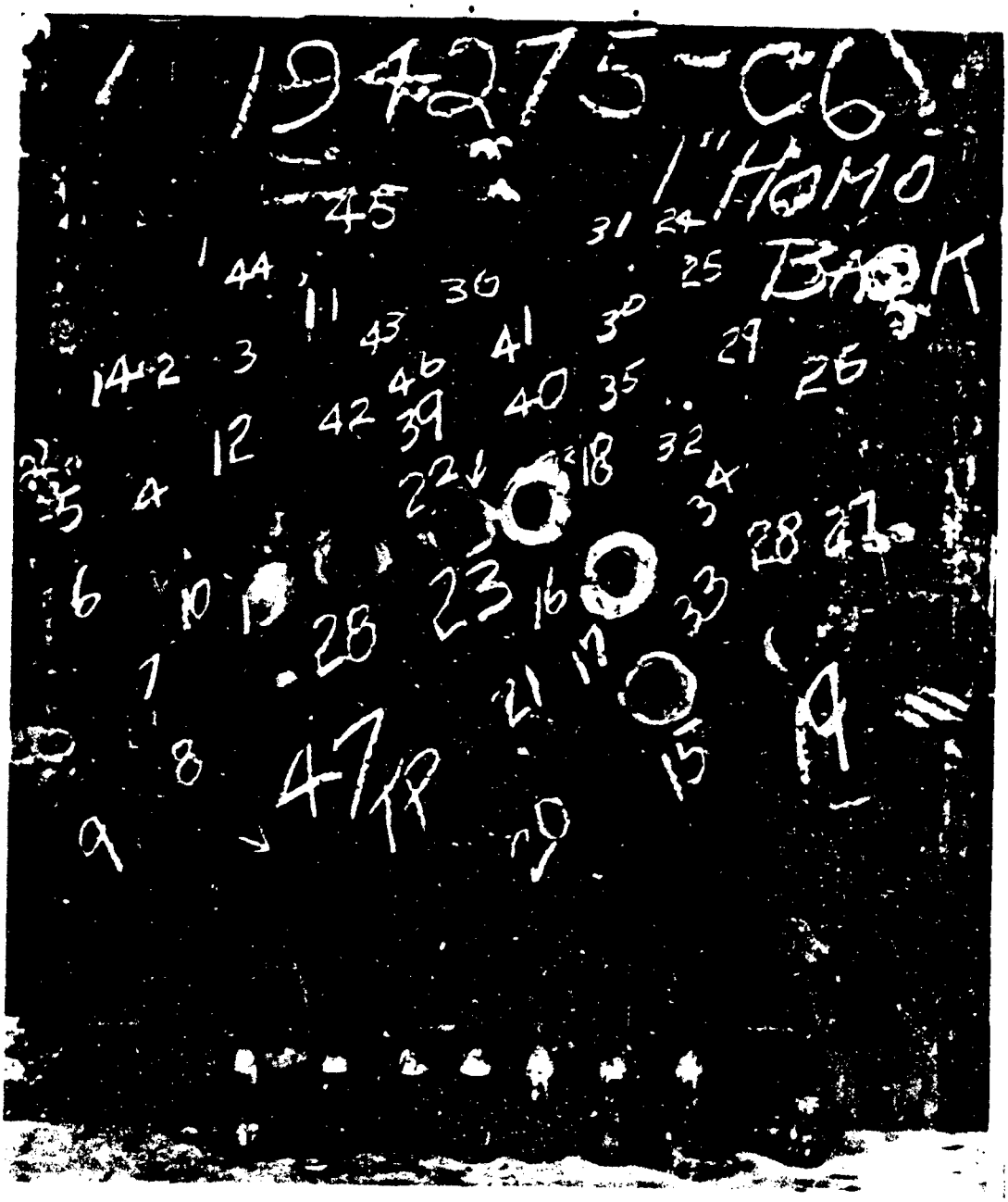
Ballistic Data Sheet No. 36 (Cont'd)

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
20°	43	213.5	2883	CP-FPTP 7/8"x5/8" BS
20°	44	213.0	2919[n]	CP-PTP .9"x1.0" BS; .25"x.55" FP
20°	45	211.0	2879[a]	CP-CIP .32"x.85" FS
20°	46	210.0	2859[a]	PP-SB .7"x1.0" FS
[a]Army limit at 20° - 2869 f/s; [n]Navy limit at 20° - 2906 f/s				
37MM AP M51 Firings:				
0°	15	1.15oz.	1032[n]	CP-PTP 2.8"x2.9" BS
0°	16	1.00oz.	932[a]	PP-MB
0°	17	1.07oz.	962[a]	CP-FPTP 3.25"x2.85" BS
0°	18	1.07oz.	984[n]	CP-FPTP 2.50"x2.45" BS
[a]Army limit at 0° - 947 f/s; [n]Navy limit at 0° - 1008 f/s				
20°	19	1.75oz.	1269	CP-FPTP 2.3"x1.9" BS
20°	20	1.50oz.	1167[a]	CP-FPTP Pun S
20°	21	1.42oz.	1119[a]	PP-MB Pun S 2.85" Crack on back
20°	22	1.65oz.	1210[n]	CP-CIP 2.7"x2.5" BS
20°	23	1.70oz.	1242[n]	CP-PTP 2.9"x2.4" BS
[a]Army limit at 20° - 1143 f/s; [n]Navy limit at 20° - 1231 f/s				
37MM TP M51 Firings:				
20°	47	4.10oz.	2130	PP-LB



WATERTOWN ARSENAL

PLATE C-6, 1" HOMOGENEOUS, BRINELL 368, T.S. 174,500; 174,000
TESTED AT NORMAL, 10°, 20° CAL. .50 A.P. M2. TESTED AT NORMAL,
20° WITH 37 MM M51 A.P. SHOCK TESTED AT NORMAL 37 MM M51 T.P.
2130 F/S S.V. (FRONT) JAN 30 1942 W.A.710-1746



WATERTOWN ARSENAL

PLATE C-6, 1" HOMOGENEOUS, BRINELL 368, T.S. 174,500; 174,000
TESTED AT NORMAL, 10°, 20° CAL. .50 A.P. M2. TESTED AT NORMAL,
20° WITH 37 MM M51 A.P. SHOCK TESTED AT NORMAL 37 MM M51 T.P.
2130 F/S S.V. (BACK) JAN 30 1942 W.A.710-1746

Ballistic Data Sheet No. 37

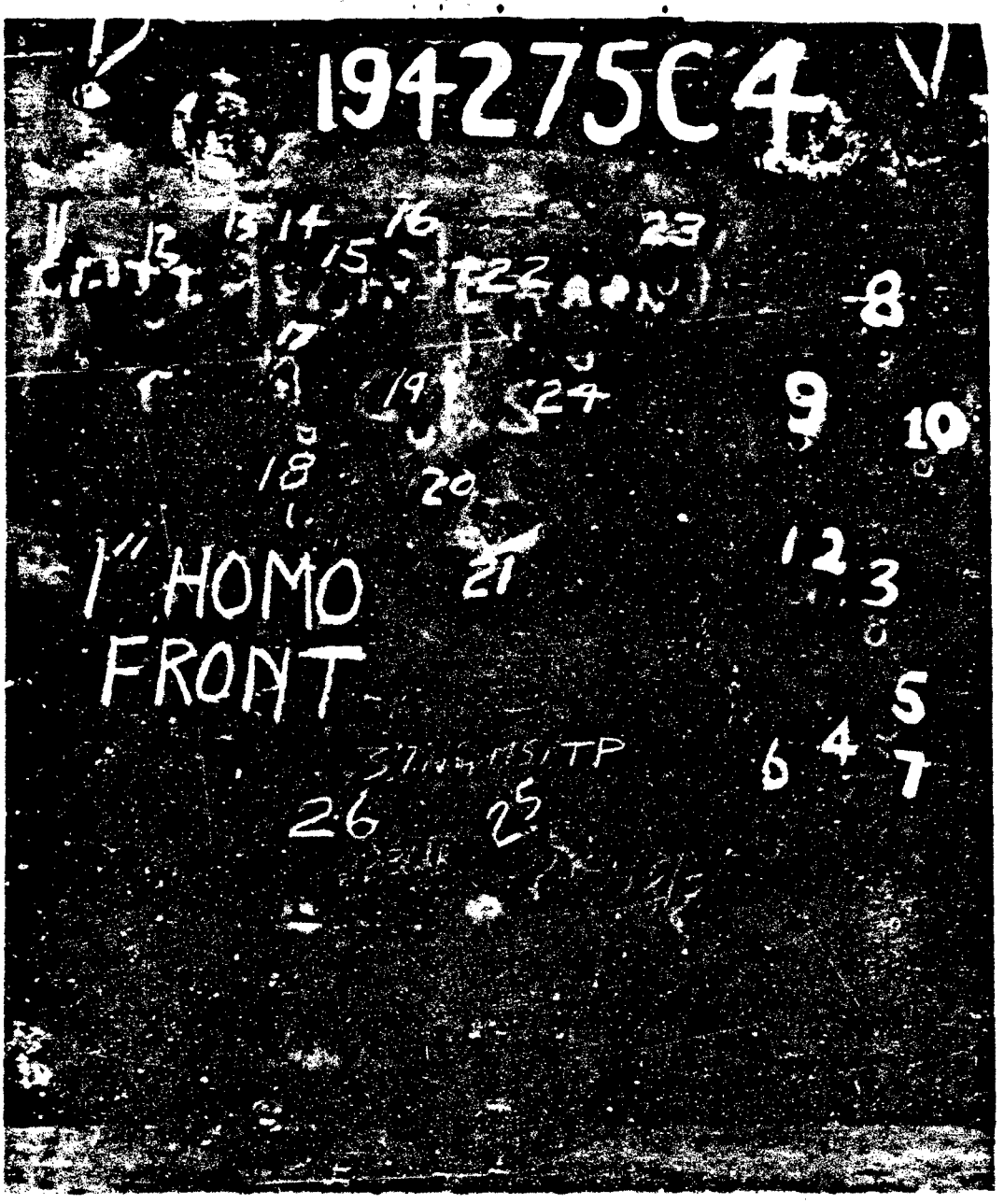
Carnegie-Illinois Plate 194275C4 - 1"x36"x36" Ni-Cr Homogeneous
BHN 370 - T.S. 184,000 - Photographs W.A. 710-1741, W.A. 710-1742

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
0°	1	175.0	2332	PP-SB
0°	2	185.0	2433	PP-MB
0°	3	192.5	2496	CP-FPTP .60"x.35" FP
0°	4	191.5	2531	CP-FPTP .70"x.40" FP
0°	5	190.5	2504	CP-FPTP .40"x.50" FP
0°	6	190.0	2488[a]	CP-FPTP
0°	7	189.5	2484[a]	PP-LB
0°	8	205.0	2686	CP-CIP
0°	9	206.0	2721[n]	CP-PTP .40"x.15" FP
0°	10	205.5	2701[n]	CP-CIP
[a]Army limit at 0° - 2486 f/s; [n]Navy limit at 0° - 2711 f/s				
10°	11	185.0	2475	PP-MB
10°	12	190.0	2574[a]	PP-LB
10°	13	200.0	2701[n]	CP-PTP 1"x.5" inc. FP; 5/8"x7/8" BP
10°	14	192.5	2579[a]	CP-FPTP 1"x7/8" FP; 1/2" DC
10°	15	193.0	2570	PP-LB
10°	16	197.5	2673[n]	CP-FPTP Pun S 3/8"x½"
[a]Army limit at 10° - 2577 f/s; [n]Navy limit at 10° - 2687 f/s				
20°	17	195.0	2684	PP-MB 1-½"x.9" FS
20°	18	205.0	2774	PP-CIP-SB 1-½"x.9" FS
20°	19	215.0	2919[n]	CP-PTP 1.45"x1.05" FS
20°	20	210.0	2843	PP-MB-Pun S 1.3"x.85" FS
20°	21	212.0	2882	Hit tangent to rd. #20 - Disregard
20°	22	212.0	2879[a]	PP-CIP-Pun S 1.45"x1" FS
20°	23	213.0	lost	CP-PTP .7"x.6" BS; 1.5"x.4" FS
20°	24	213.0	2906[a,n]	CP-PTP 1.15"x1.0 FS
[a]Army limit at 20° - 2893 f/s; [n]Navy limit at 20° - 2913 f/s				
37MM TP M51 Firings:				
20°	25	4.10oz.	2137	PP-LB
20°	26	4.50oz.	2238	CP-FPTP Pun S 5-1/4"x3-5/8" semi-circular crack.

Ballistic Data Sheet No. 38

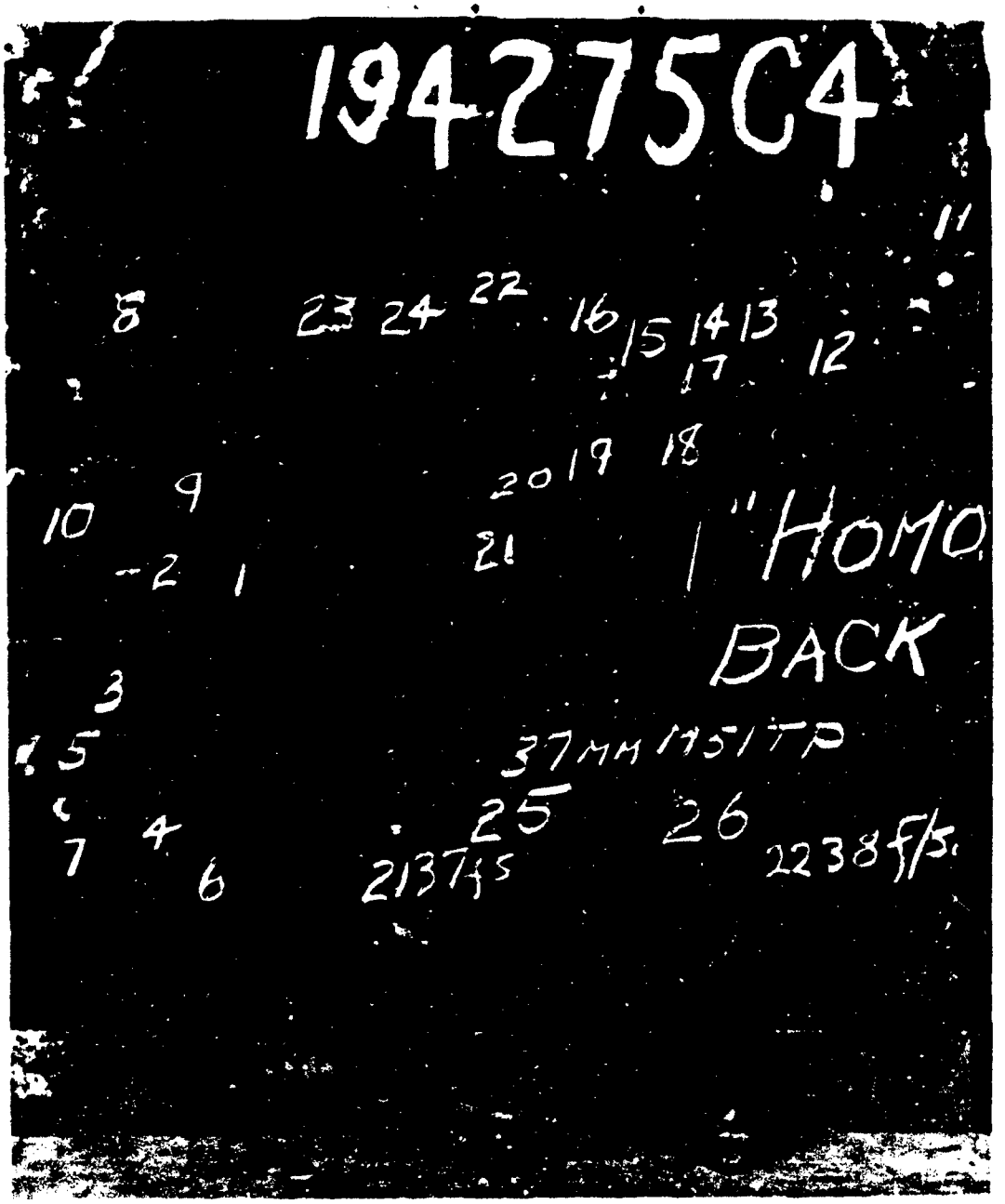
Carnegie-Illinois Plate 194275C7 - 1"x36"x36" Ni-Cr Homogeneous
BHN 387 - T.S. 190,500 - Photographs W.A. 710-1747, W.A. 710-1748

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
0°	1	195.0	2553	CP-FPTP .5"x.9" FP
0°	2	190.0	2520	CP-FPTP
0°	3	187.5	2496	CP-FPTP
0°	4	185.0	2470[a]	CP-FPTP
0°	5	182.5	2432[a]	PP-MB
0°	6	210.0	2819	CP-PTP
0°	7	205.0	2686	CP-CIP
0°	8	210.0	2744[n]	CP-PTP
0°	9	207.5	2711[n]	CP-CIP
[a]Army limit at 0° - 2451 f/s; [n]Navy limit at 0° - 2728 f/s				
10°	10	195.0	2569[a]	PP-MB
10°	11	200.0	2625	CP-FPTP
10°	12	197.5	2585[a]	CP-FPTP
10°	13	max.	2909	CP-PTP
10°	14	215.0	2819	CP-PTP
10°	15	210.0	2749[n]	CP-CIP
10°	16	212.5	2795[n]	CP-PTP
[a]Army limit at 10° - 2577 f/s; [n]Navy limit at 10° - 2772 f/s				
20°	17	206.0	2706	PP-MB
20°	18	210.0	2754	CP-FPTP - Excessive yaw - Disregard
20°	19	215.0	2814	PP-MB
20°	20	215.0	2823	PP-SB
20°	21	220.0	2908[a,n]	PP-LB
20°	22	222.0	2955[a,n]	CP-PTP 1"x1-1/8" BS
[a]Army limit at 20° - 2932 f/s; [n]Navy limit at 20° - 2932 f/s				
57MM TP M51 Firings:				
0°	23	3.5oz.	1919	PP-MB
0°	24	4.75oz.	2305	CP-PTP 3⅛"x3½" Punching



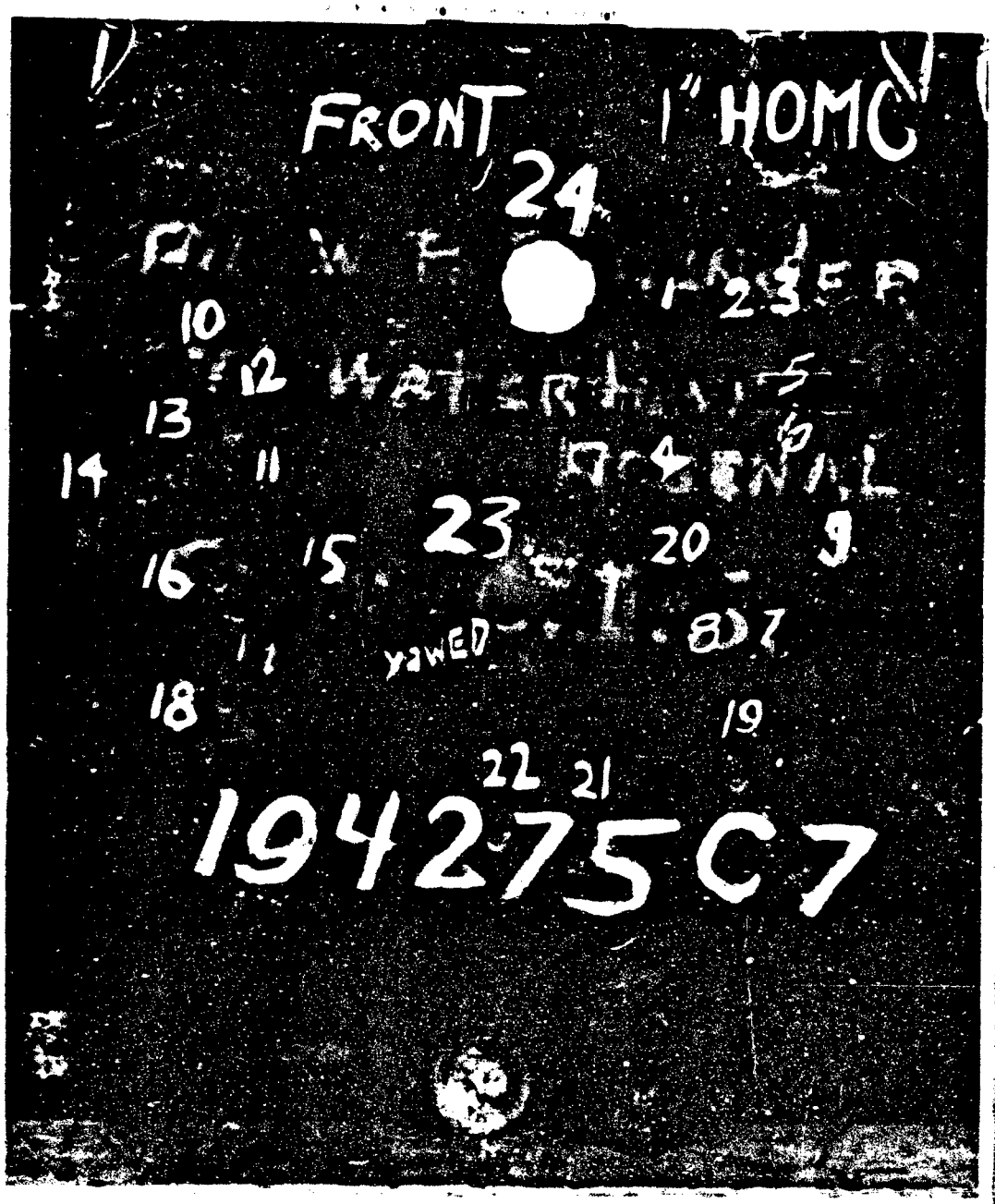
WATERTOWN ARSENAL

PLATE C-4, 1" HOMOGENEOUS, BRINELL 370, T.S. 173,500; 179,500
TESTED AT NORMAL, 10°, 20° CAL. .50 A.P. M2 SHOCK TESTED AT
NORMAL 2 ROUNDS 37 MM M51 T.P. AT 2137 AND 2238 F/S B.V.
JANUARY 30 1942 (FRONT) W.A.710-1741



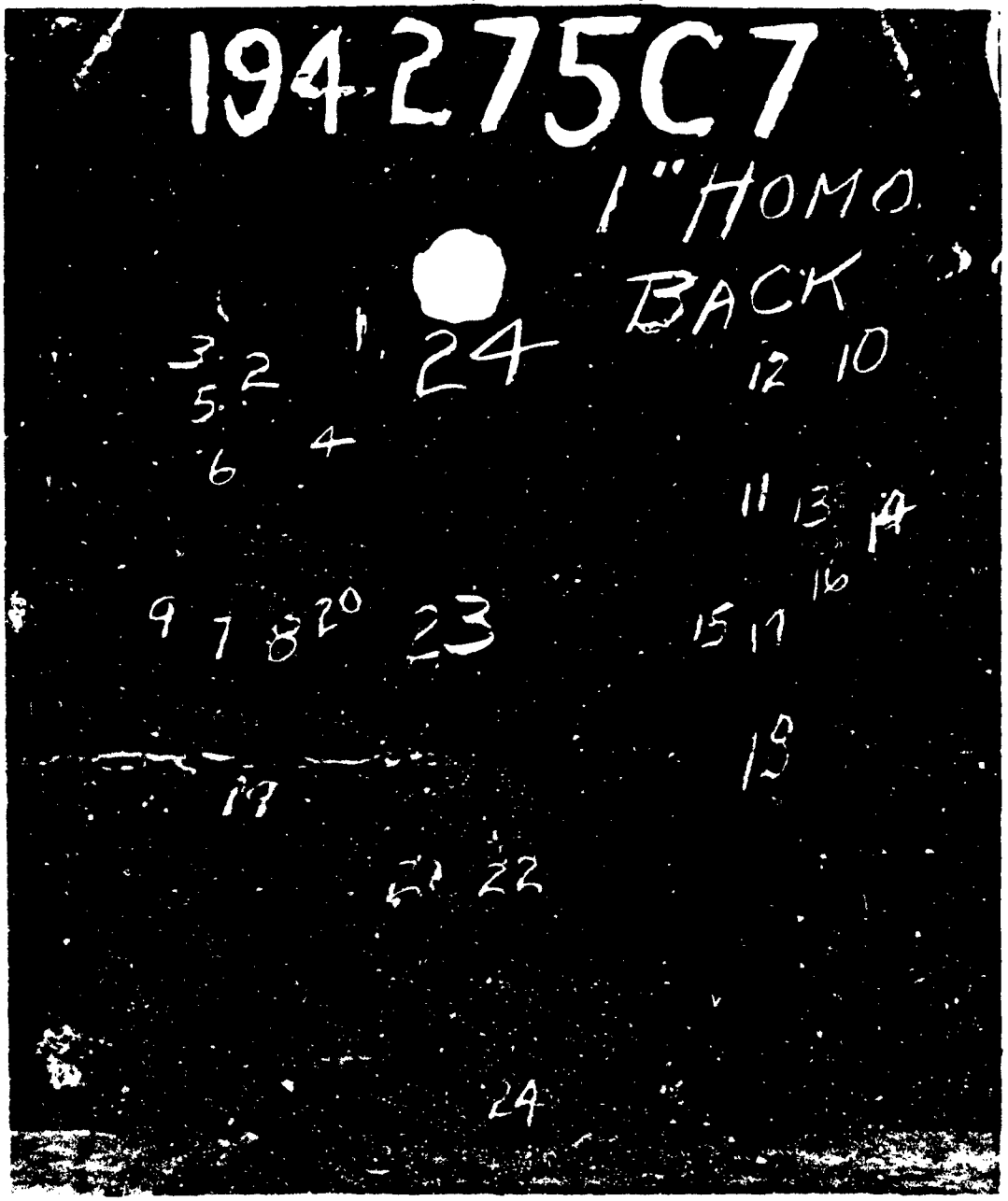
WATERTOWN ARSENAL

PLATE C-4, 1" HOMOGENEOUS, BRINELL 370, T.S. 173,500; 179,500
TESTED AT NORMAL, 10°, 20° CAL. .50 A.P. M2. SHOCK TESTED AT
NORMAL 2 ROUNDS 37 MM M51 T.P. AT 2137 AND 2238 F/S R.V.
JANUARY 30 1942 (BACK) W.A.710-1742



WATERTOWN ARSENAL

PLATE C-7, 1" HOMOGENEOUS, BRINELL 387, T.S. 192,000; 190,500
TESTED AT NORMAL, 10°, 20° CAL. .50 A.P. M2. SHOCK TESTED AT
NORMAL 2 ROUNDS 37 MM M51 T.P. AT 1919 AND 2305 F/S S.V.
JANUARY 30 1942 (FRONT) W.A.710-1747



WATERTOWN ARSENAL

PLATE C-7, 1" HOMOGENEOUS, BRINELL 387, T.S. 192,000; 190,500
TESTED AT NORMAL, 10°, 20° CAL. .50 A.P. M2. SHOCK TESTED AT
NORMAL 2 ROUNDS 37 MM M51 T.P. AT 1919 AND 2305 F/S S.V.
JANUARY 30 1942 (BACK) W.A.710-1746

Ballistic Data Sheet No. 39

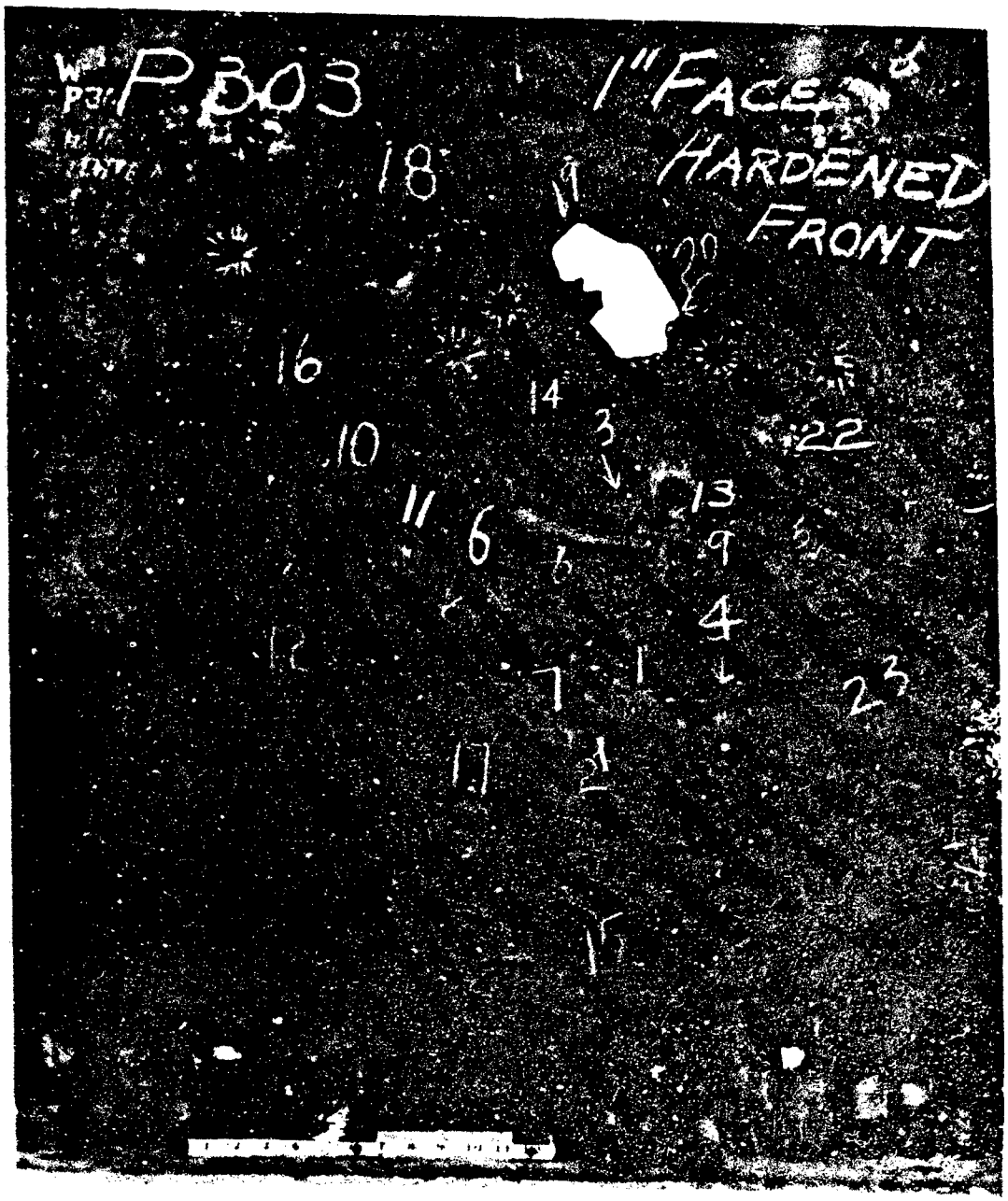
Disston Plate 7 - 1"x36"x36" Ni-Mo Face-Hardened
BHN: Face 555, Rear 384 - Photographs W.A. 710-1729, W.A. 710-1730

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
37MM AP M51 Firings:				
0°	1	1.00oz.	1007	PP-MB
0°	2	1.05oz.	920	PP-SB
0°	3	1.75oz.	1037	PP-MB
0°	4	1.50oz.	1163	PP-SB 1"x1-3/8" FS
0°	5	1.65oz.	1219[a]	PP-SB
0°	6	1.90oz.	1334	CP-CIP 2-3/8"x1-1/2" BS; 2-3/8"x3-3/8"FS
0°	7	1.75oz.	1283	CP-FPTP
0°	8	1.70oz.	1229[a]	CP-FPTP
0°	9	1.95oz.	1361[n]	CP-FPTP
0°	10	2.02oz.	1399[n]	CP-PTP 4.05"x2.90" BS; 3"x2.75" FS
[a]Army limit at 0° - 1224 f/s; [n]Navy limit at 0° - 1380 f/s				
20°	11	2.00oz.	1412[a]	PP-MB ND BD
20°	12	2.20oz.	1461[a]	CP-FPTP
20°	13	2.40oz.	1503	CP-FPTP
20°	14	2.55oz.	1583	CP-FPTP 2.85"x1.5" FS
20°	15	2.65oz.	1627	CP-FPTP
20°	16	2.75oz.	1662[n]	CP-FPTP 2.0"x2.5" FS
20°	17	2.85oz.	1710[n]	CP-PTP 2.1"x2.35" FS
[a]Army limit at 20° - 1437 f/s; [n]Navy limit at 20° - 1686 f/s				
30°	18	2.50oz.	1579	CP-FPTP
30°	19	2.75oz.	1668	CP-FPTP
30°	20	3.00oz.	1761	CP-PTP 5.1"x6-7/8" BS overlapping rd.#19
30°	21	2.25oz.	1501	CP-FPTP
30°	22	2.00oz.	1405[a]	PP-SB
30°	23	2.18oz.	1479	CP-FPTP
30°	24	2.09oz.	1432[a]	CP-FPTP
[a]Army limit at 30° - 1419 f/s; Navy limit not determined.				

Ballistic Data Sheet No. 40

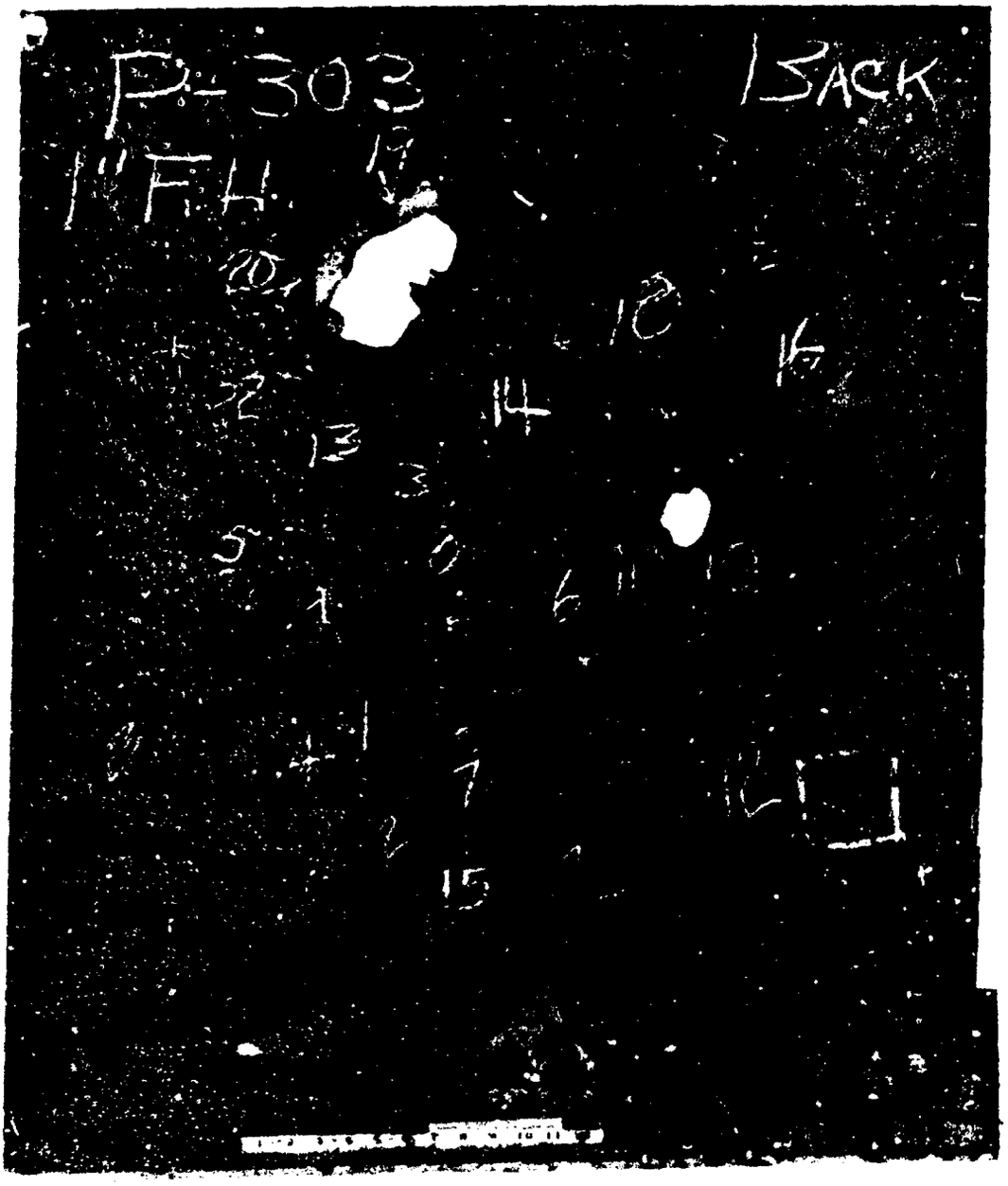
Disston Plate 295 - 1"x18"x36" Ni-Mo Face-Hardened
BHN: Face 601, Rear 363 - Photographs W.A. 710-1731, W.A. 710-1732

Plate Obliquity	Plate Rd. No.	Powder Charge	Str. Vel.	Results
Caliber .50 AP M2 Firings:				
0°	1	Preload	2753	CP - PTP 1-1/12"x1-17/60" FS 1-21/60"x1-11/30" BS 6½ Star cracking
0°	2	Preload	2585	CP - PTP 1"x6" FS 1-3/8"x1-1/2" BS 3-7/8" Star cracking
0°	3	Preload	2745	PP-SB
0°	4	205.0	2673	PP-MB Pun S
0°	5	205.0	2701	PP-IB Pun S 1.15"x1.2" FS
0°	6	210.0	2749	PP-MB 1.15"x.8" FS
0°	7	210.0	2772	PP-MB .95"x.8" FS
0°	8	215.0	2838	Hit rd. #6 - Disregard
0°	9	215.0	2811	PP-LB .95"x.8" FS
0°	10	220.0	lost	Hit edge of plate - Disregard
0°	11	220.0	lost	CP-FPTP .85"x.75" FS
0°	12	220.0	2877[a]	PP-Pun S
0°	13	220.0	2887[a]	CP-FPTP - Pun S 1.0"x.8" FS
0°	14	220.0	2877	PP-Pun S .9"x.85" FS
0°	15	225.0	2955	Hit edge of plate - Disregard
0°	16	225.0	3001[n]	CP-PTP 1.0"x.85" FS
0°	17	225.0	2939	CP-CIP .95"x.9" FS; .8"x.55" BS
0°	18	224.0	2955[n]	PP-LB
[a]Army limit at 0° - 2882 f/s; [n]Navy limit at 0° - 2978 f/s				
37MM TP M51 Firing:				
0°	19	4.10oz.	2178	CP-CIP 8-5/8"x8-5/8" piece broken out; face diameter of 7-½"x7-5/8"; difference due to back spalling. Core in piece broken out, causing punching of 2"x1.7".



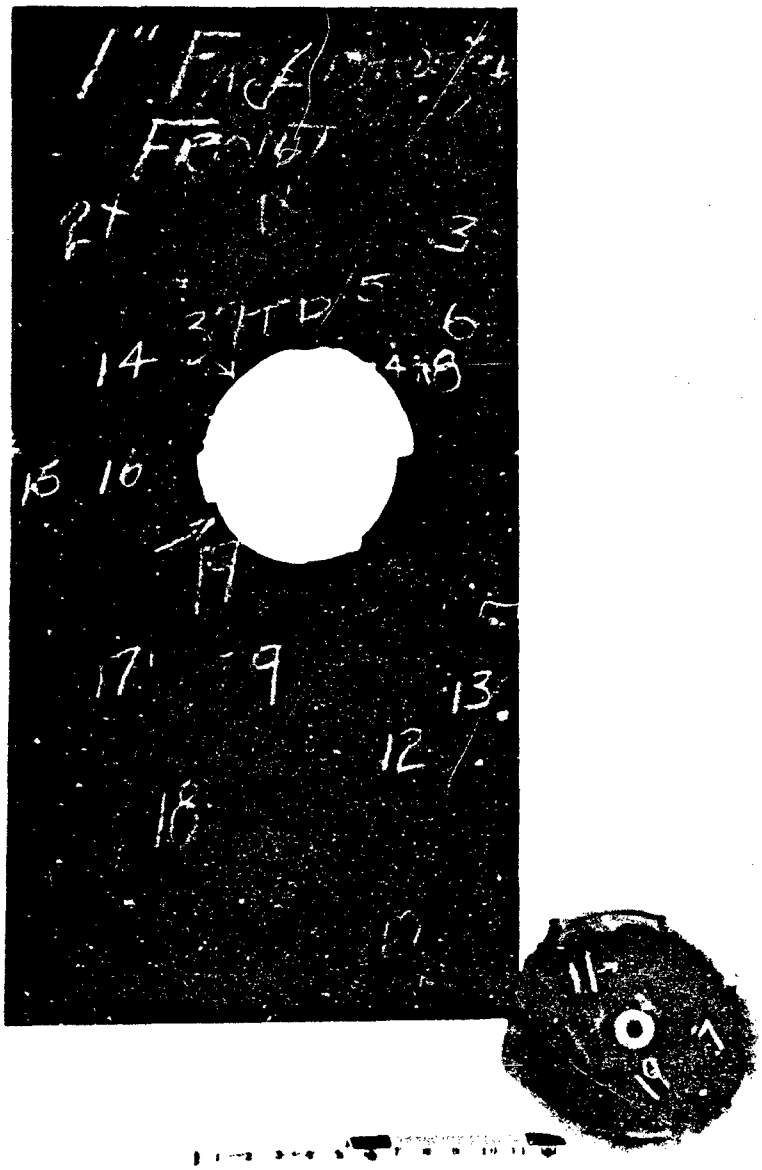
WATERTOWN ARSENAL

PLATE # P-303 1" FACE HARDENED BRINELL BHN/384
TESTED WITH 37 MM M51 A.P. AT NORMAL, 20° - 30°
JANUARY 30 1942 (FRONT) W.A. 710-1729



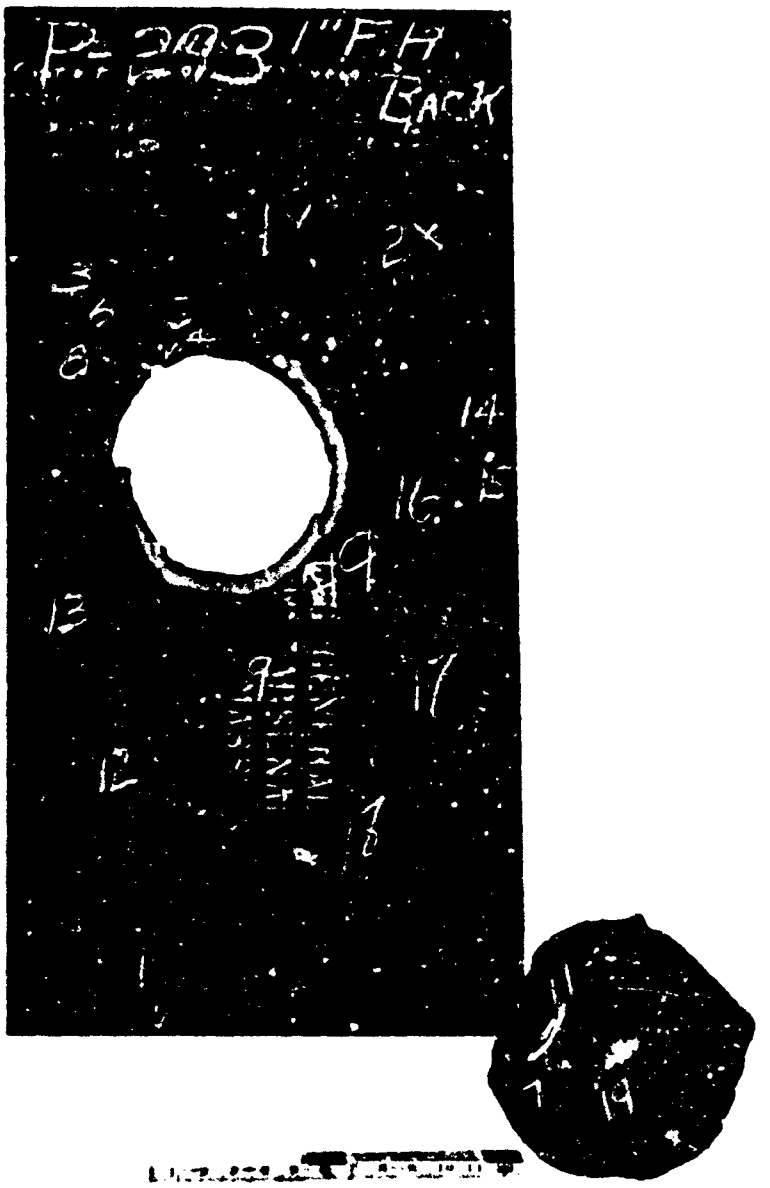
WATERTOWN ARSENAL

PLATE # P-303 1" FACE HARDENED BRINELL 388/384
TESTED WITH 37 MM M51 A.P. AT NORMAL, 20°, 30°
JANUARY 30 1942 (BACK) W.A.710-1730



WATERTOWN ARSENAL

PLATE # 283, HEAT 1846 1" FACE HARDENED, 18"X36", BRINELL 601/363
TESTED AT NORMAL CAL. .50 A.P. M2 AND SHOCK TESTED WITH 37 MM
M51 T.P. AT 2178 F/S S.V. (NOTE PUNCHING) (FRONT)
JANUARY 30 1942 W.A.710-1731



WATERTOWN ARSENAL

PLATE # 203, HEAT 1848 1" FACE HARDENED, 18"X36", BRINELL 601/363
TESTED AT NORMAL CAL. .50 A.P. M2 AND SHOCK TESTED WITH 37 MM
M5 T.P. AT 2170 F/S S.V. (NOTE PUNCHING) (BACK)
JANUARY 30 1942 W.A.710-1732