

PHOTOGRAPH THIS SHEET

INVENTORY

AD-A953 769

DTIC ACCESSION NUMBER

LEVEL

WAL 710/250

DOCUMENT IDENTIFICATION

26 JAN 1938

This document has been approved for public release and sale its distribution is unlimited.

122

DISTRIBUTION STATEMENT

ACCESSION FOR	
NTIS	GRA&I <input checked="" type="checkbox"/>
DTIC	TAB <input type="checkbox"/>
UNANNOUNCED	<input type="checkbox"/>
JUSTIFICATION	
BY	
DISTRIBUTION /	
AVAILABILITY CODES	
DIST	AVAIL AND/OR SPECIAL
A-1	



DTIC ELECTED

S OCT 20 1984 D

E

DATE ACCESSIONED

DISTRIBUTION STAMP

UNANNOUNCED

DATE RETURNED

84 10 27 023

DATE RECEIVED IN DTIC

REGISTERED OR CERTIFIED

PHOTOGRAPH THIS SHEET AND RETURN TO DTIC-DDAC

DOCUMENT PROCESSING SHEET

PREVIOUS EDITION MAY BE OUT OF STOCK IS EXHAUSTED.

UNCLASSIFIED

LABORATORY

INDEXED



REPORT NO. 10/260

AD-A953 769

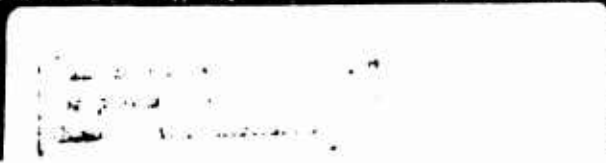
FOR OFFICIAL USE ONLY

CORRELATION OF BALLISTIC PROPERTIES OF LIGHT ARMOR PLATE

FOR OFFICIAL USE ONLY  
INFORMATION CONTAINED IN THIS REPORT  
IS UNCLASSIFIED WITHOUT PRIOR  
APPROVAL OF ISSUING OFFICER.  
WASHINGTON, WASHINGTON 20535

E. L. Reed  
Research Metallurgist

E. L. Kruegel  
Jr. Science Aide



DISTRIBUTION OF REPORTS

FOR CITIZEN USE ONLY

REPORT NO \_\_\_\_\_ TITLE \_\_\_\_\_  
 DATE DISTRIBUTED 2/1/58 \_\_\_\_\_

	Lo- cal	Other Ord. Work	Army	Navy	Private
Author	1	1	1	1	1
Lab File	1 ✓	1	1	1	1
Main Office File	1 ✓	1	1	1	1
Chief of Ordnance	- ✓	-	2	2	-
Technical Staff	-	-	1	1	-
Springfield Armory	-	-	1	1	-
Watervliet Arsenal	-	-	1	1	-
Rock Island Arsenal	- ✓	-	1	1	-
Frankford Arsenal	-	-	1	1	-
Picatinny Arsenal	-	-	1	1	-
Aberdeen Proving Ground	- ✓	-	1	1	-
Chief, Bureau Ordnance	-	-	-	1	-
Naval Gun Factory	-	-	-	1	-
Chief, Bureau C & R	-	-	-	1	-
				welding and as directed	
Local Circulation	1	1	1	1	as directed
Available for special circulation.	2	2	3	3	1
Other establishments requesting work.	-	2	-	-	-
Private Parties paying for work	-	-	-	-	2

as directed in each case

FOR CITIZEN USE ONLY

UNCLASSIFIED

~~RESTRICTED~~

FOR OFFICIAL USE ONLY

Report No. 710/250  
Watertown Arsenal

January 26, 1938

CORRELATION OF BALLISTIC PROPERTIES OF LIGHT ARMOR PLATE

Purpose

The purpose of this investigation is to correlate existing ballistic properties of light armor plate in reply to a request from the Ordnance Office, as of O.O. 400.114/16794 Misc., dated May 14, 1937.

Introduction

A copy of the specific requests in the above letter is given below:

- (a) Should we continue to use face hardened plate in all thicknesses?
- (b) Should the ballistic limit for face hardened plate be raised, and if so, how much?
- (c) Should we continue to offer a bonus for face hardened plate?
- (d) (1). Should the ductility test be made more severe, for example, by requiring the testing of all plates with 37 M. shot as is now done for heavier plates?  
(2). Considering difficulties of manufacture, relative cost, and greater facility of war procurement, would it not be desirable to obtain homogeneous plate. If so, should this be done for all thicknesses of plate or only for plates above a certain thickness? (This question

~~RESTRICTED~~

predicated on the results obtained at Aberdeen, indicating that as the thickness of plate increases, homogeneous plate approaches the face hardened plate in resistance and then exceeds it.)

- (e) If homogeneous plate be used, could it be fastened by welding at the seams? If so, what reduction in protection at the seams could be expected?

### Conclusions

Results are based upon the correlation of ballistic data taken from,

- (a) Aberdeen Partial Reports on Test of Thin Armor Plate, Ordnance Program No. 4334 T.S.T.P. No. 1922-107, dated 1922 to date.
- (b) Aberdeen letter reports on tests of experimental plate submitted by various manufacturers, dated December 9, 1936 to date.

A. Face hardened plate (carburized) can be continued in all thicknesses. Reference - Figs. 2 to 8, incl. and Tables No. 1 and No. 2.

B. The ballistic limit of carburized plate can be raised in excess of Tentative Specifications AXS-54K, dated April 19, 1937, as follows (see also Fig. 1):

Proposed Specification

Thickness (Inches)		Bullet	Impact Velocities Required Minimum f.s. ± 15 f.s.
1/4"	.250	Cal. .30 A.P. M1922	1900
5/16"	.312	"	2050
3/8"	.375	"	2200
7/16"	.437	"	2350
1/2"	.500	"	2500
9/16"	.562	Cal. .50 A.P. M1	2025
5/8"	.625	"	2125
11/16"	.687	"	2200
3/4"	.75	"	2300
7/8"	.875	"	2475
1"	1.00	"	2650
1 1/8"	1.125	"	2825
1 1/4"	1.25	"	2900

Shock tests (machine gun and 37 MM. impact) to remain same as AXS-54K.

C. No bonus should be offered for high quality carburized plate since high quality carburized plate is more easily obtained than homogeneous plate. In the last five years, only 26% of the homogeneous plate tested passed

specifications, whereas 74% of carburized and 77% of the nitrided plate passed specified limits (Tables No. 1 and 2).

D.(1) On the basis of the results in Aberdeen Report No. 102, no plate 5/8" thick or less can withstand an impact by a 37 M. shot (see Table No. 3).

(2) In view of the varying ability of different manufacturers to produce good homogeneous plate, no statement can be made as to its rapid procurement during emergency (see Tables No. 4a, b, and c). However, when obtained from those manufacturers who can readily produce homogeneous plate, it can be used to as much advantage as face hardened plate for thicknesses 5/8" and greater (see Fig. 3).

It should be noted that Fig. 7 repeats the results found at Aberdeen, i.e. "as the thickness of plate increases, homogeneous plate approaches the face hardened plate in resistance and then exceeds it". However, Fig. 7 includes data only from 1922 to 1932. More recent data, Figs. 3 and 5, do not follow this trend.

E. The opinion of this Arsenal on the question of welding has been given in Watertown Arsenal letter, 400.114/5062 as of May 28, 1937, as noted:

"It can be stated at this time that, if the design will allow a projection of the order of one inch on the rear face of the plate at the seam, a joint can be made in homogeneous plate that will give the same or greater protection than the base plate. This joint design contemplates welding a strip of soft plate to the armor plate in the annealed condition and making the weld in the soft plate after the hardening operation. While we are working on the process of trying to develop a suitable weld material for welding the heat treated plate, it is very doubtful that we will succeed in securing an effective protection of the joint greater than 25% of that of the unwelded plate."

#### Procedure

The armor plate recorded in the Aberdeen reports was separated into homogeneous, carburized, and nitrided groups.

Each group was tabulated (Tables No. 5a, b, c) according to manufacturer, chemical composition, thickness, ammunition, specification, ballistic limit, Brinell hardness, and remarks describing spalling characteristics.

(a) Manufacturer. Tabulations were made on plates manufactured by Carnegie Steel Co., Crucible Steel Co., Diebold Safe and Lock Co., Henry Disston & Sons, Inc.,

Eddystone Steel Co., Halcomb Steel Co., Ludlum Steel Co.,  
and Watertown Arsenal Experimental.

(b) Chemical Analysis. Wherever this was furnished by the manufacturer, his plates were segregated according to their chemical composition.

(c) Thickness. These were subdivided according to thickness as follows:

1/8"	-	.125	included thicknesses from	.094	-	.156
3/16"	-	.188	"	"	"	.157 - .219
1/4"	-	.25	"	"	"	.220 - .281
5/16"	-	.313	"	"	"	.282 - .343
3/8"	-	.375	"	"	"	.344 - .406
7/16"	-	.438	"	"	"	.407 - .469
1/2"	-	.500	"	"	"	.470 - .532
9/16"	-	.563	"	"	"	.533 - .592
5/8"	-	.625	"	"	"	.593 - .687
3/4"	-	.75	"	"	"	.688 - .813
7/8"	-	.875	"	"	"	.814 - .938
1"	-	1.00	"	"	"	.939 - 1.094
1 1/8"	-	1.125	"	"	"	1.095 - 1.188
1 1/4"	-	1.25	"	"	"	1.189 - 1.313

(d) Ammunition. These thicknesses were subdivided according to the caliber of shot:-

(1) Caliber .30 A.P. M1922

(2) Caliber .50 A.P. M1

A special table (No. 3) was made covering the impact by 37 M. A.P. solid shot, M .39, weight 1.45 pounds.

(e) Specifications. These were redivided according to the specification under which the ballistic limit was determined.

(1) 150 ft. range - used from Aug. 10, 1922 to Jan. 29, 1932.

(2) Spec. No. 31 - " " Jan. 29, 1932 to July 25, 1933.

(3) AXS-54 Rev. 1 - " " July 25, 1933 to Dec. 17, 1934.

(4) AXS-54 Rev. 2 - " " Dec. 17, 1934 to June 1, 1936.

(5) AXS-54 Rev. F, H, K, - used from June 1, 1936 to date.

(f) Ballistic Limit. The ballistic limit was tabulated in foot-seconds.

(g) Brinell Hardness. The Brinell hardness was also recorded.

(h) Remarks. Spalling characteristics of the plates were determined by a careful study of the photographs in the Aberdeen Reports whenever these were furnished.

The data so obtained were treated in the following manner:

Arithmetic averages of the ballistic limits and Brinell hardnesses for each grouping of each manufacturer were taken. (Table 6a, b, c).

From these arithmetic means, an optimum average was determined by arbitrarily eliminating all plate (up to 50% of the total number of plates) whose ballistic limits fell more than 100-foot seconds below the arithmetic mean (Tables 6a, b, c).

From this optimum average, the specification averages of Cal. .30 and Cal. .50 impacts were determined by the additional elimination of all brittle plate. However, in the case of 37 MM. plot (Fig. 8), ballistic limits of brittle plate were used to determine the curve since all plate attacked by 37 MM. shot showed evidence of brittleness.

In this case, the deviations of the mean and the weight of the average were determined by the usual statistical methods. (Tables 6a, b, c).

In addition, the percentage of the total number of individual plates which passed the specifications applying to that plate was calculated as well as the per cent brittleness. (Tables 6a, b, c).

For the purpose of plotting graphs Nos. 2 to 8, a weighted mean of the specification averages of the ballistic limits including all manufacturers and all chemical composition for each thickness and each specification, found in Tables 6a, b, c, was determined and is listed in Tables 7a, b, c.

These graphs (Figs. 2 to 8) were used in rating the ballistic efficiency of carburized, homogeneous and

nitrided plates, as well as in the determination of the proposed specification. (Graphs 1, 2, 3).

Tables of ballistic efficiencies of the plate of each manufacturer and of each composition and thickness were drawn up (Tables 3a, b, c). These data were taken from Tables 6a, b, c.

From these tables, brief summaries were made, showing the performance of homogeneous, face hardened, and nitrided plate for different periods of time (Table 2); for various thickness (Table 1); and for various manufacturers (Table 4a, b, c).

Table 9 was taken directly from the Aberdeen Reports and plotted in Graphs 9 and 10.

Table 10a, b, c, were taken from Aberdeen Report No. 12 and plotted in Fig. No. 11a, b, c.

Table No. 11 shows the chemical compositions furnished by various manufacturers and is a resume of information contained in Table 5.

#### Results of Investigation

A comparison of ballistic efficiency of homogeneous, carburized, and nitrided plate for the last five years is given in Table 1.

Graphical representation of the proposed specification

and the Specification AXS-54-K, K-1, is shown in Fig. 1.

Figs. 2, 3, 4, 5, 6, 7, and 8 represent ballistic limits of homogeneous and nitrided plates under various specifications, 1922 - 1936.

Table 3 shows the ballistic results of 37 LM. solid shot impact.

Table 4 shows a summary of ballistic efficiency of homogeneous carburized and nitrided plate for various periods of time.

Summaries of ballistic efficiencies of homogeneous, carburized, and nitrided plates for various manufacturers and periods are shown in Tables 4a, b, c.

The performance of each manufacturer's carburized plate for the last five years shows that Diebold plate passes specifications 100%. However, this plate is only experimental and not produced commercially.

The Disston carburized plate passes 76% and Carnegie passes only 42%.

Within the last year, Diebold and Disston plate, carburized, passed specifications 100%, but it is noted that plates of these companies were experimental.

In regard to the homogeneous plate, Disston is the only company who has supplied such plate. In the last five years, only 25% of Disston homogeneous plate has passed, but in the last year, 75% of experimental plate passed.

**TABLE 1**

**Comparison of Ballistic Efficiency of Homogeneous, Carburized and Nitrided Plate for the Last Five Years**

Thickness	% Pass		% Brittle	
	Homogeneous	Carburized Nitrided	Homogeneous	Carburized Nitrided
3/16" .188	0	-	0	-
1/4" .25	0	77	54	17
5/16" .312	-	100	-	0
3/8" .375	0	54	63	27
7/16" .438	-	100	-	8
1/2" .500	29	82	29	0
9/16" .563	-	100	-	0
5/8" .625	50	100	25	0
3/4" .75	0	50	100	50
7/8" .875	100	-	0	-
1" 1.00	0	100	100	0

**Note:** That the % of homogeneous plate that passes increases with increasing thickness.

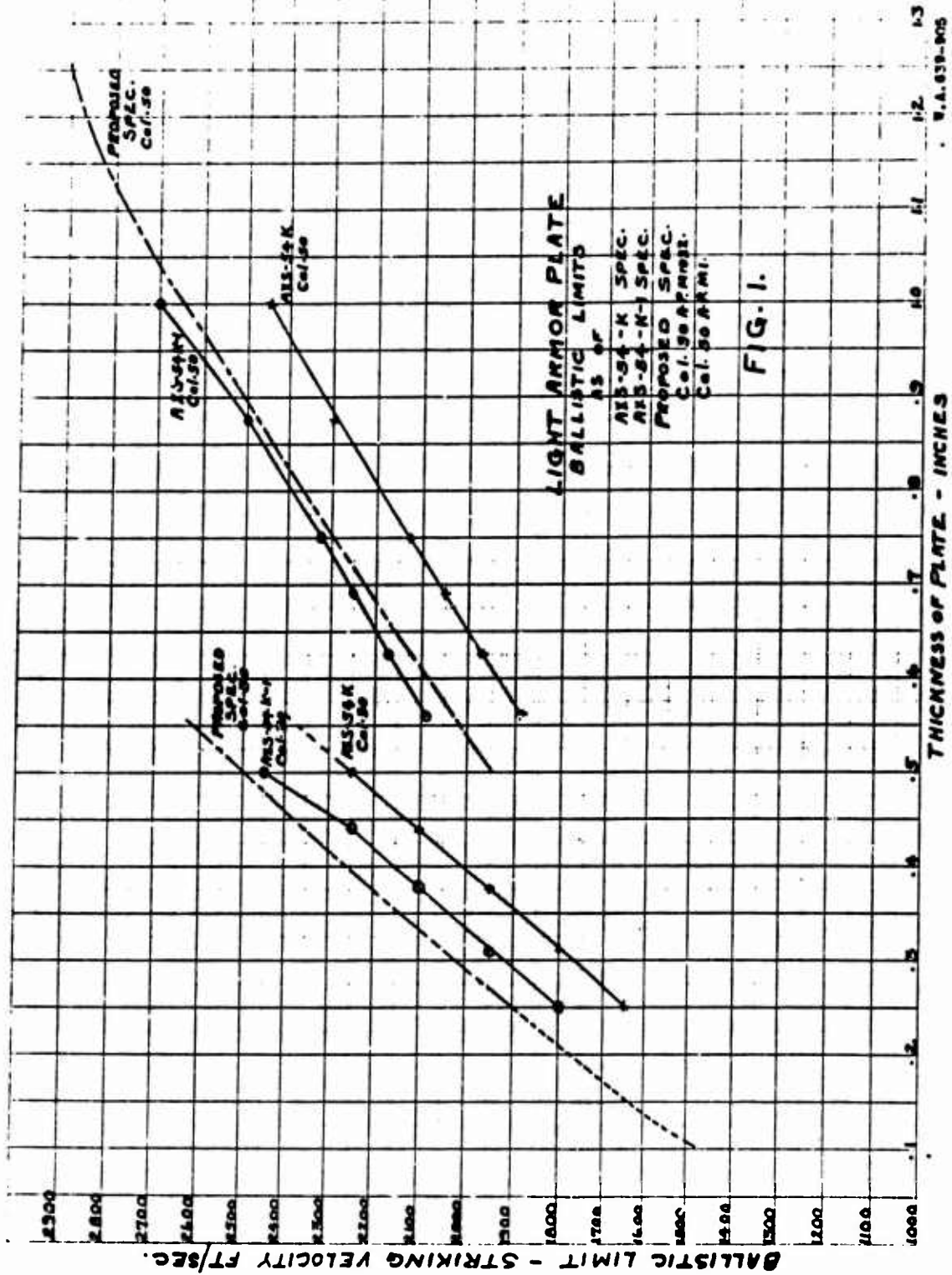
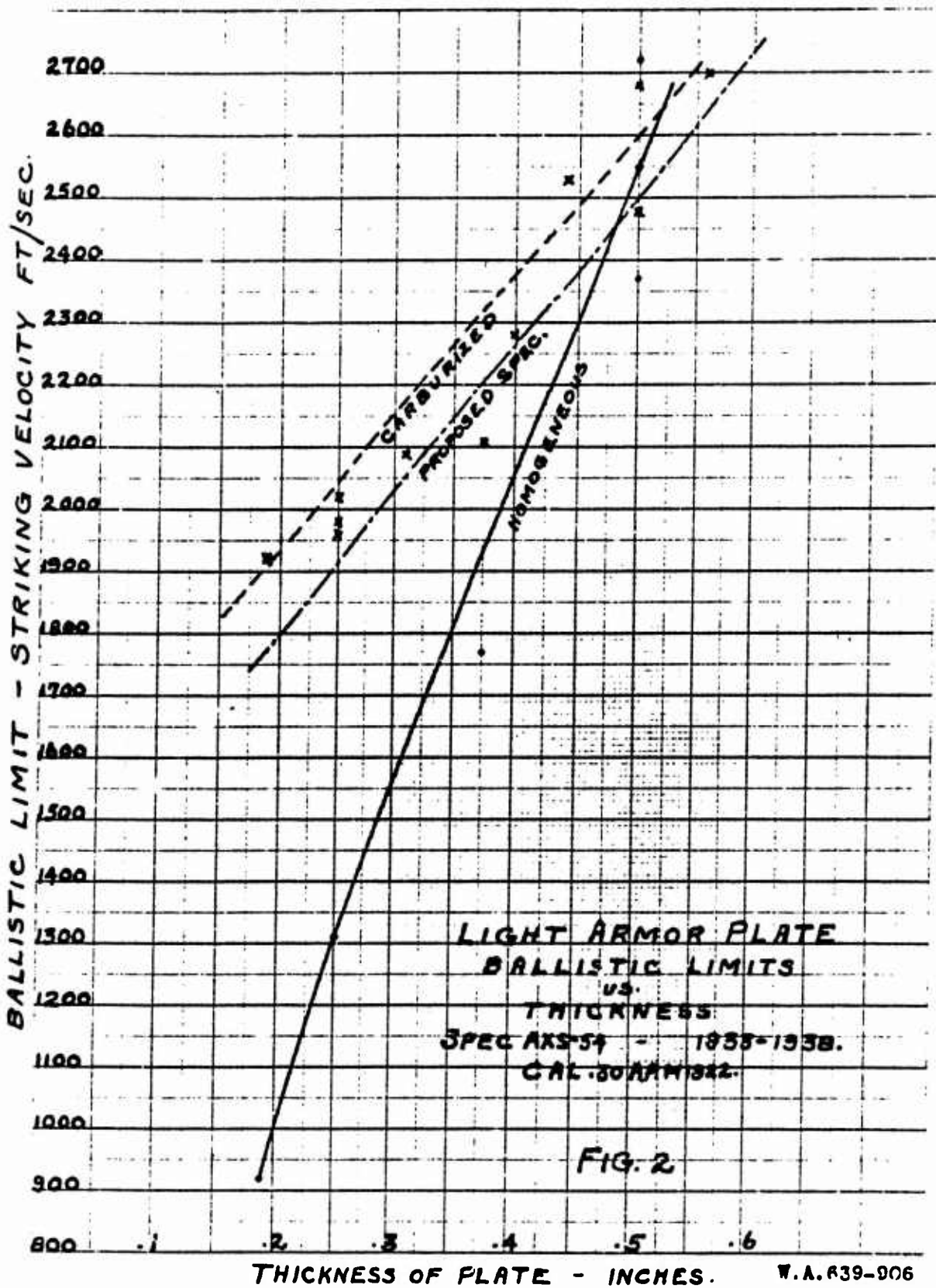
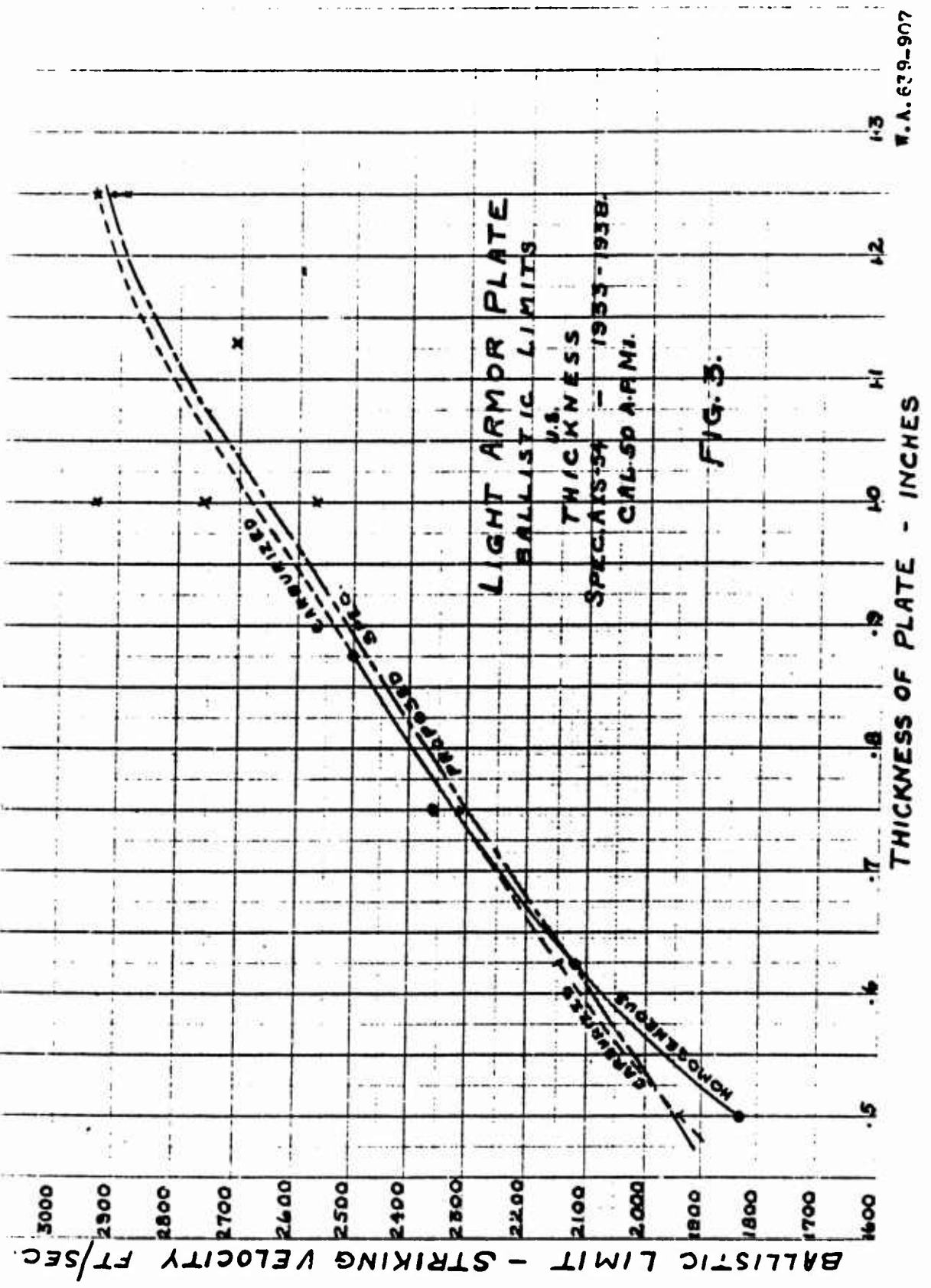
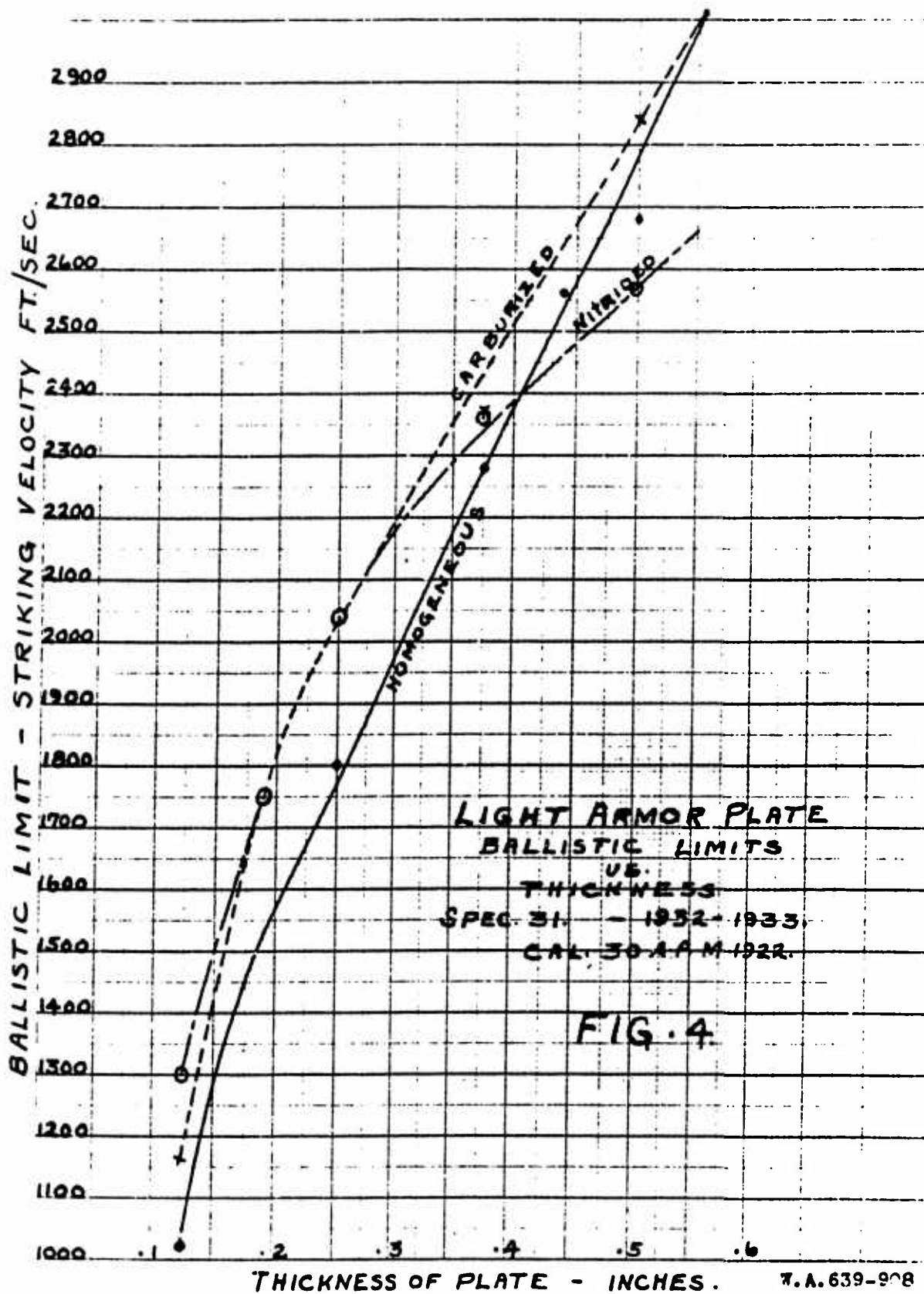


FIG. 1.

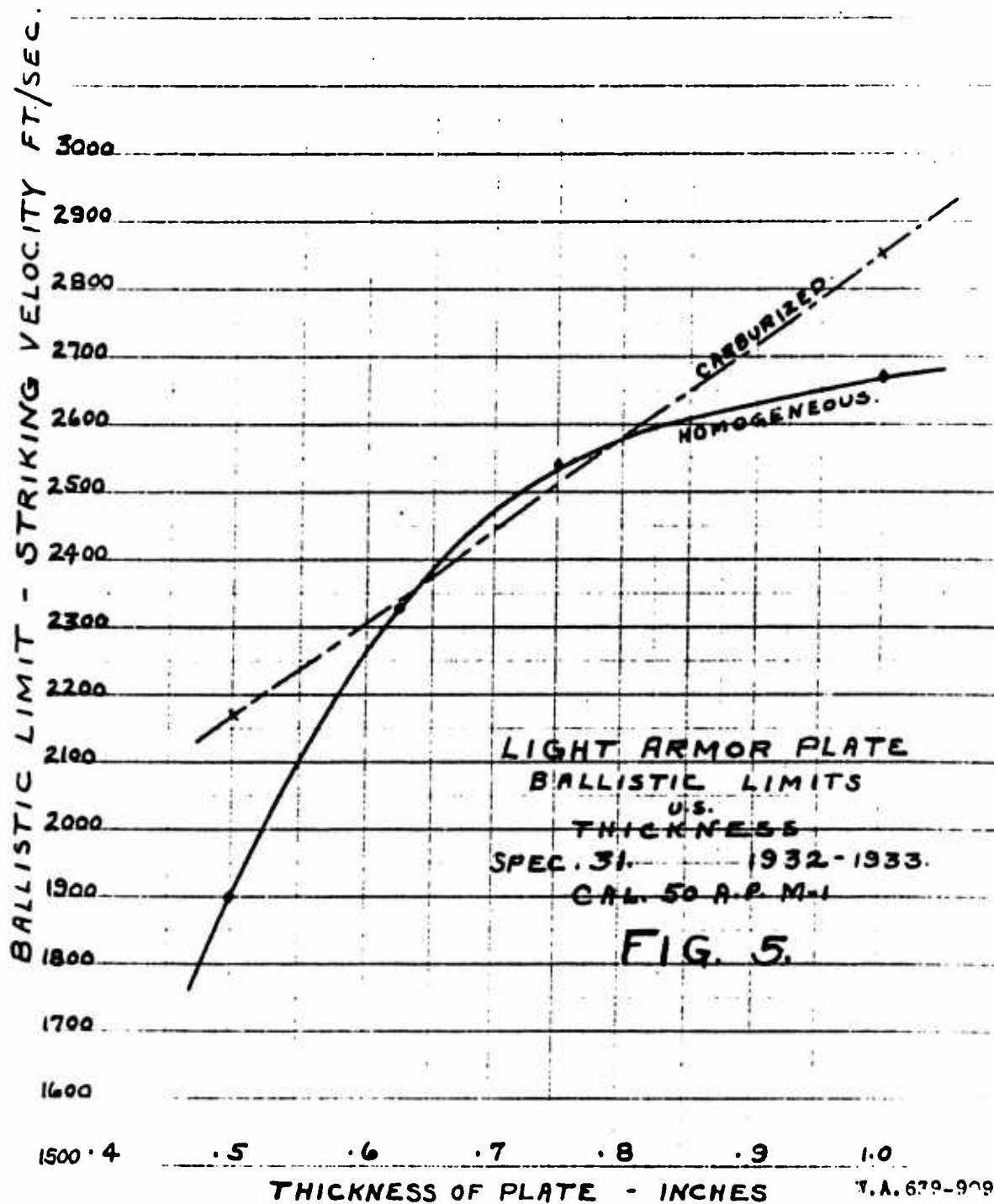




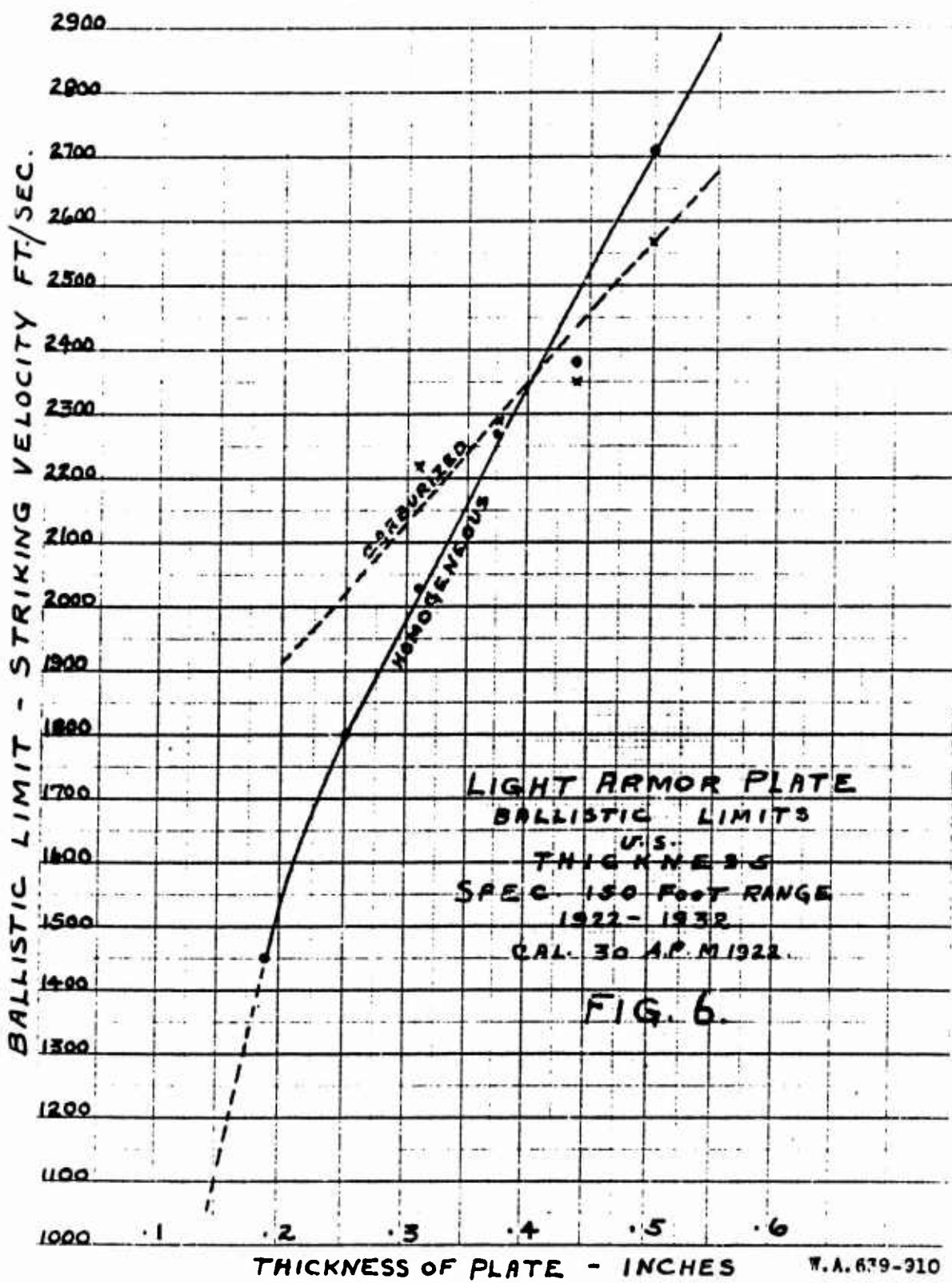
Approved for Release by NSA on 05-08-2014 pursuant to E.O. 13526



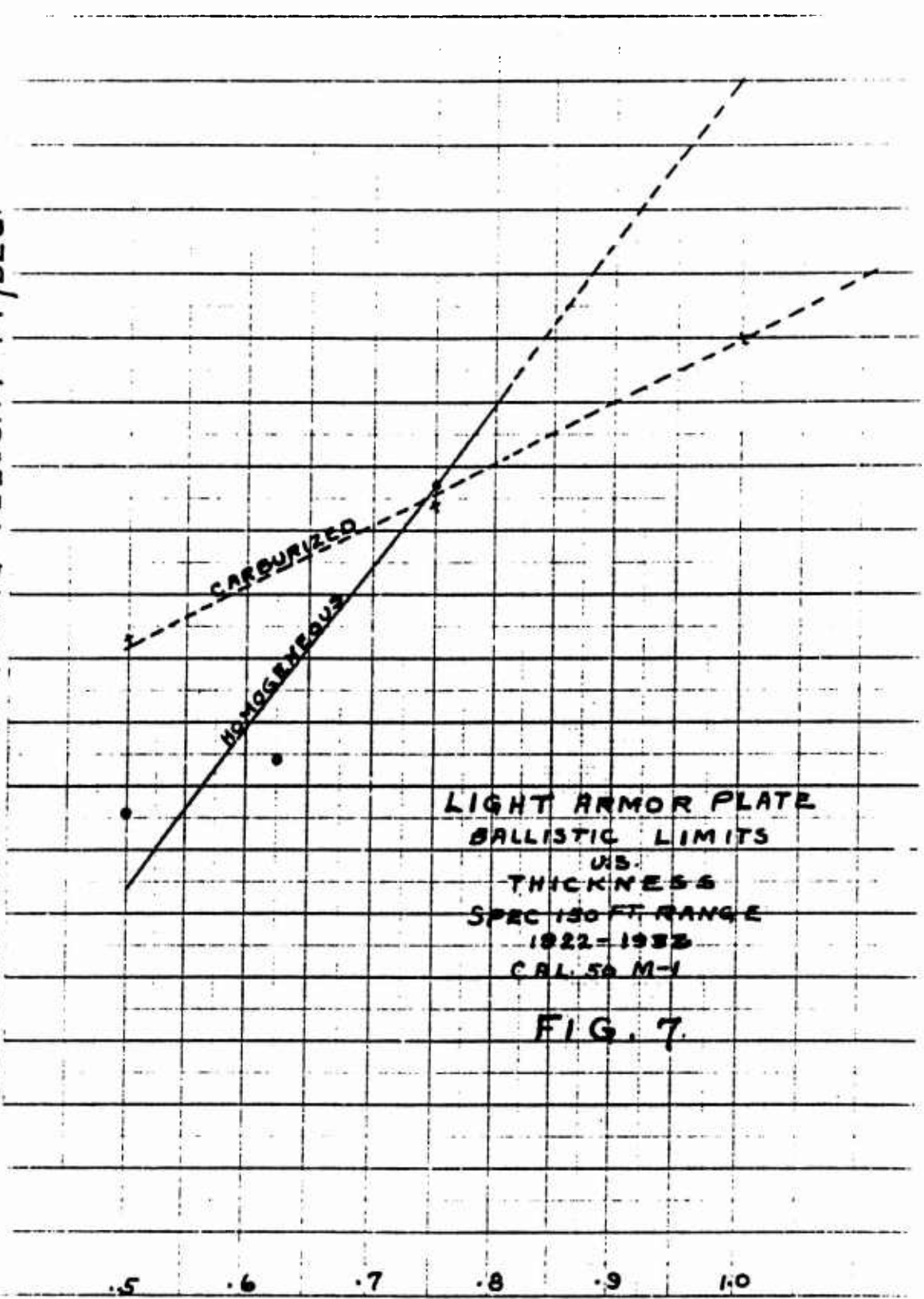
7.A. 639-908



T.A. 679-909



BALLISTIC LIMIT - STRIKING VELOCITY FT/SEC.



LIGHT ARMOR PLATE  
BALLISTIC LIMITS  
U.S.  
THICKNESS  
SPEC 130 FT RANGE  
1922-1933  
CAL. 50 M-1

FIG. 7.

THICKNESS OF PLATE - INCHES

W.A. 639-911

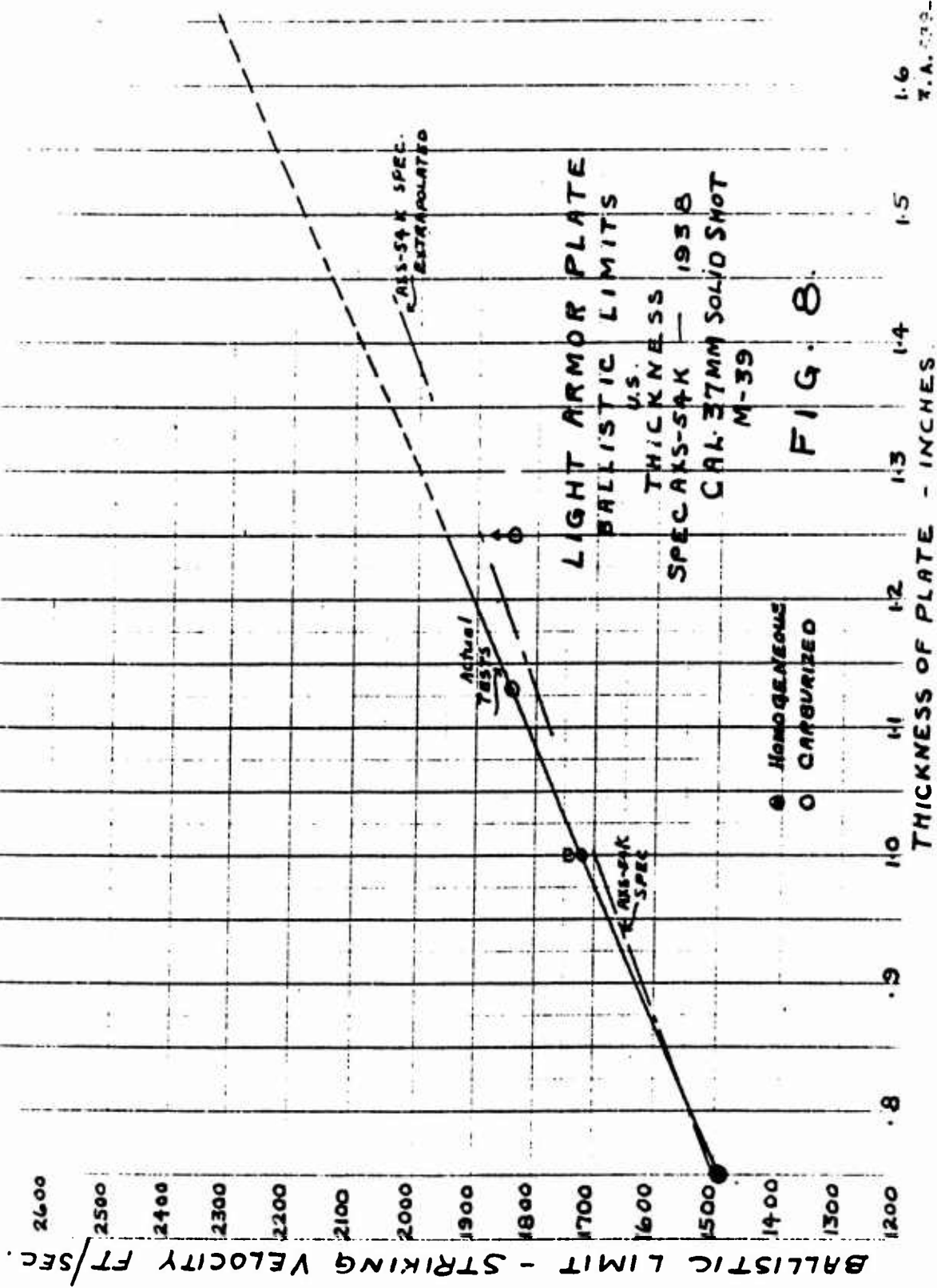


FIG. 8.

TABLE 2

Summary of Ballistic Efficiency of Homogeneous, Carburized and Nitrided Plate for Various Periods of Time

	<u>% Pass</u>		<u>% Brittle</u>	
	<u>Homogeneous</u>	<u>Carburized</u>	<u>Homogeneous</u>	<u>Carburized</u>
		<u>Nitrided</u>	<u>Nitrided</u>	<u>Nitrided</u>
Last 16 yrs.	38	57	61	30
			37	17
Last 5 yrs.	26	74	45	13
			4	4
Last year	75	100	13	0
			-	-

TABLE 3

37 Mm. Shell - M39    1.45 lb.

<u>Manufacturer</u>	<u>Thickness</u>	<u>Spec.</u>	<u>Ballistic</u>	<u>Remarks</u>
<u>DIEBOLD</u> (Face Hardened)	1" 1.00	AXS-54 -F	1715	
	1 1/8" 1.13	AXS-54 -F	1844	Complete <u>near</u> previous penetrations.
<u>DISSTON</u> (Homogeneous)	3/4" .75	AXS-54 -K	1485	Slight spall.
			1495	" "
			1490	Average
(Face Hardened)	1/4" .25			Cracked both faces front hole 4.3" rear hole 2.2"
	1/2" 5.00			Large circular cracks front hole 5.5" rear hole 1.6"
	5/8" .625			Section broke off front when fired at on the rear. Circular cracks on front. Long star cracks on rear. Front hole 6.1"
	1" 1.00	AXS-54 -H	1722	4" button
			1723	
			1723	Average
		AXS-54 -2	1737	6" button
	1 1/4" 1.25		1840	Partial buttons and cracks.

TABLE 4 (a)

Summary of Ballistic Efficiency of Homogeneous Plate  
for Various Manufacturers and Periods

<u>Manufacturer</u>	<u>% Pass</u>	<u>% Brittle</u>	<u>Years</u>	<u>Spec.</u>
Crucible	29	48	'22 - '32	150
	0	100	'32 - '33	31
Disston	81	10	'22 - '32	150
	83	11	'32 - '33	31
	1	40	'33 - '34	Rev. 1
	1	83	'34 - '36	Rev. 2
	75	13	'36	Rev. F, H, K
Eddystone	0	0	'22 - '32	150
	76	24	'32 - '33	31

TABLE 4 (b)

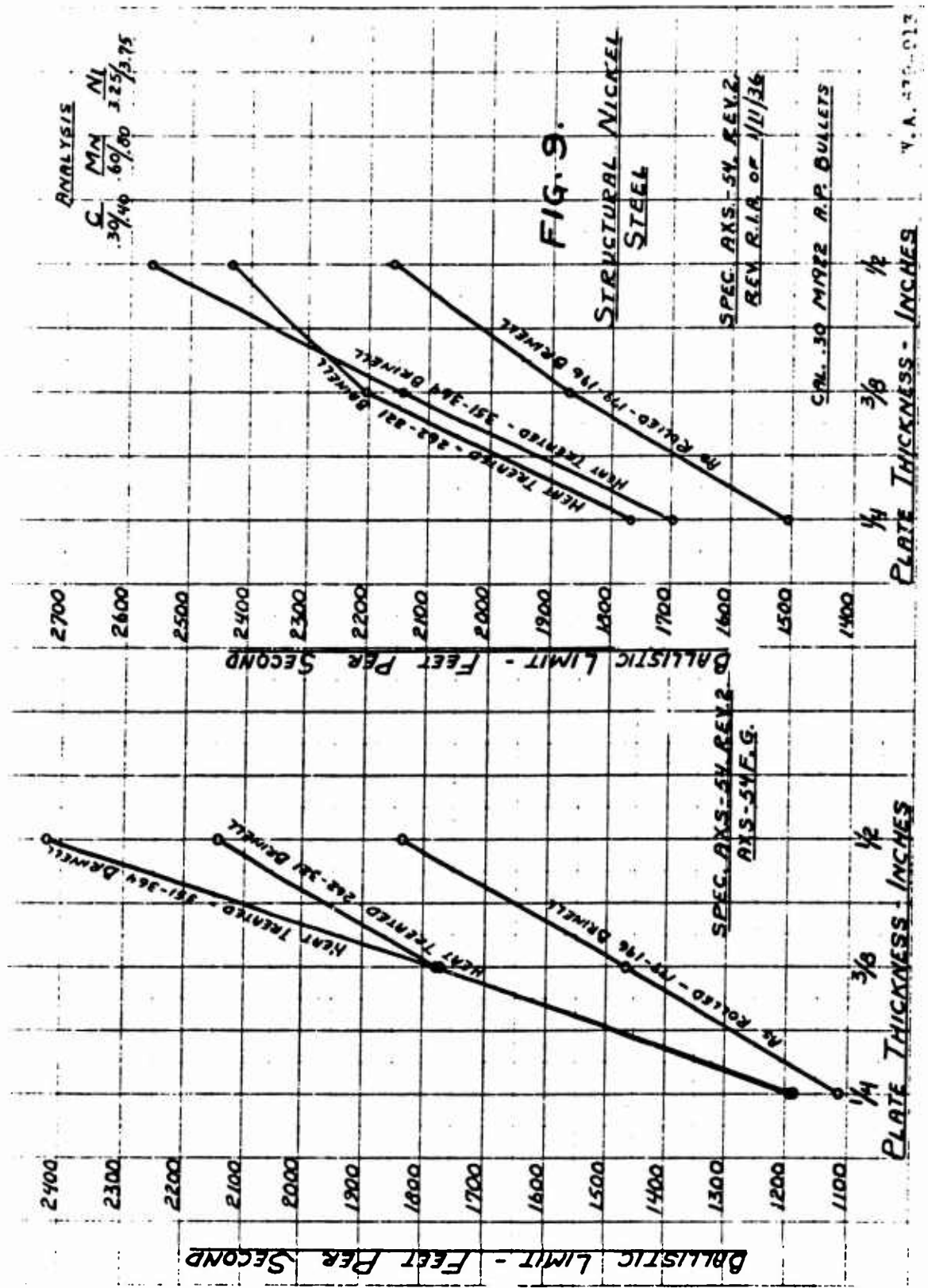
Summary of Ballistic Efficiency of Carburized Plate  
for Various Manufacturers and Periods

<u>Manufacturer</u>	<u>% Pass</u>	<u>% Brittle</u>	<u>Years</u>	<u>Spec.</u>
Carnegie	44	33	'22 - '32	150
	42	58	'32 - '33	31
	42	58	'33 - '34	Rev. 1
Crucible	35	60	'22 - '32	150
Diebold	100	0	'36	Rev. F, H, K
Disston	12	88	'22 - '32	150
	50	18	'32 - '33	31
	27	7	'33 - '34	31
	100	0	'34 - '36	Rev. 2
	100	0	'36	Rev. F, H, K
Helcomb	80	4	'22 - '32	150

TABLE 4 (c)

Summary of Ballistic Efficiency of Nitrided Plate  
for Various Manufacturers and Periods

<u>Manufacturer</u>	<u>% Pass</u>	<u>% Brittle</u>	<u>Years</u>	<u>Spec.</u>
Ludlum	67	0	'22 - '32	150
Eddystone	38	48	'32 - '33	31
Watertown Arsenal	77	4	'34 - '36	Rev. 2



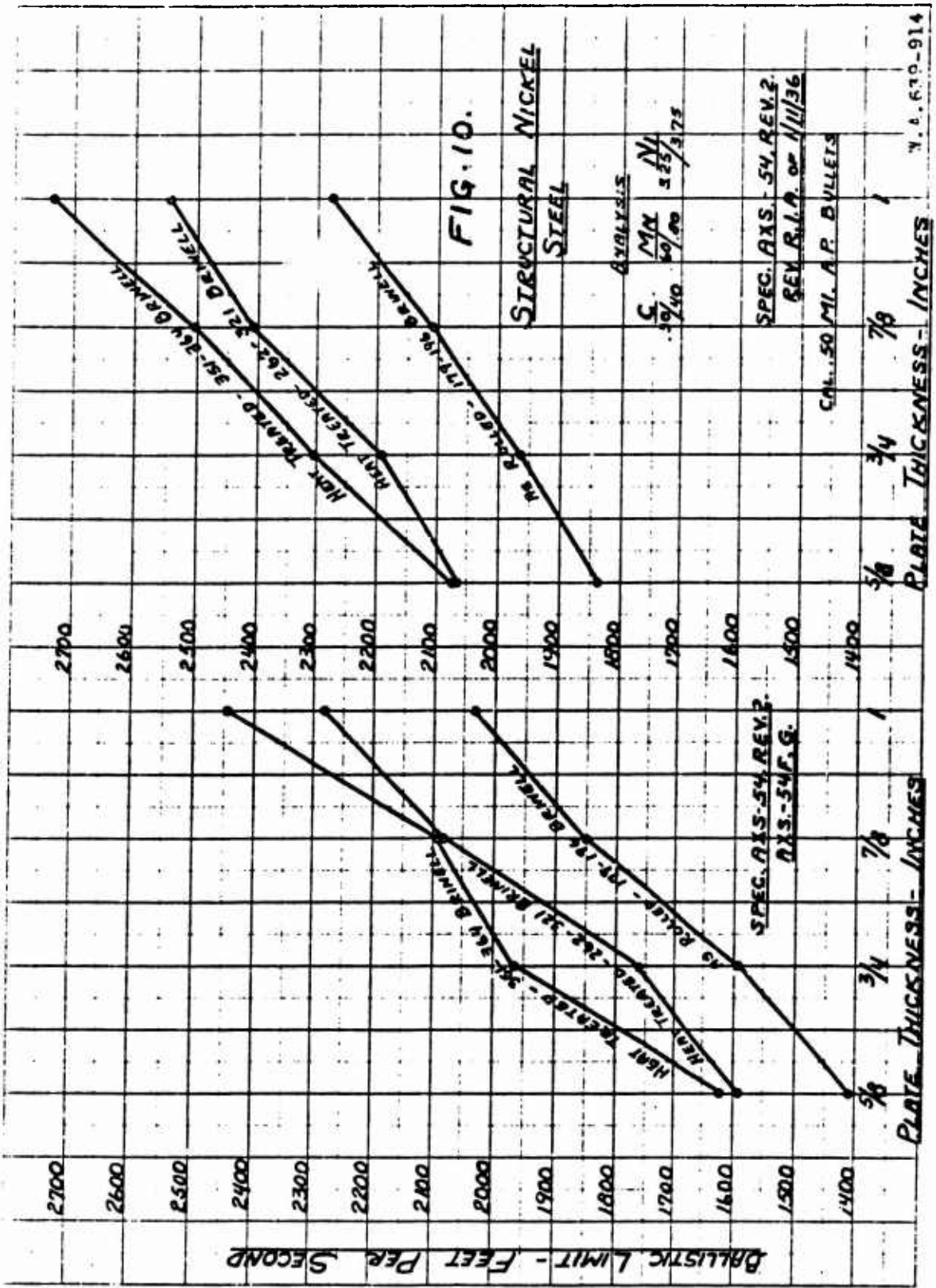


FIG 11a.

HOMOGENEOUS ARMOR PLATE

H. DISSTON INC SONS CO.

1/4 INCH THICKNESS

CHEMICAL COMPOSITION

DRAW TEMPERATURE

VS.

BALLISTIC LIMIT

TYPE OF STEEL	HEATED TO	QUENCH IN
CARBON	1450 °F.	H <sub>2</sub> O
Ni. Mo.	1500 °F.	OIL
Ni. Vn.	1500 °F.	OIL
Ni. Cr.	1500 °F.	OIL
Ni. Si.	1475 °F.	OIL

DATA TAKEN FROM 18th PARTIAL REPORT.

CAL. 30 A.P. - 150 GR. BULLETS  
73 GR. CORE.  
150 FOOT RANGE

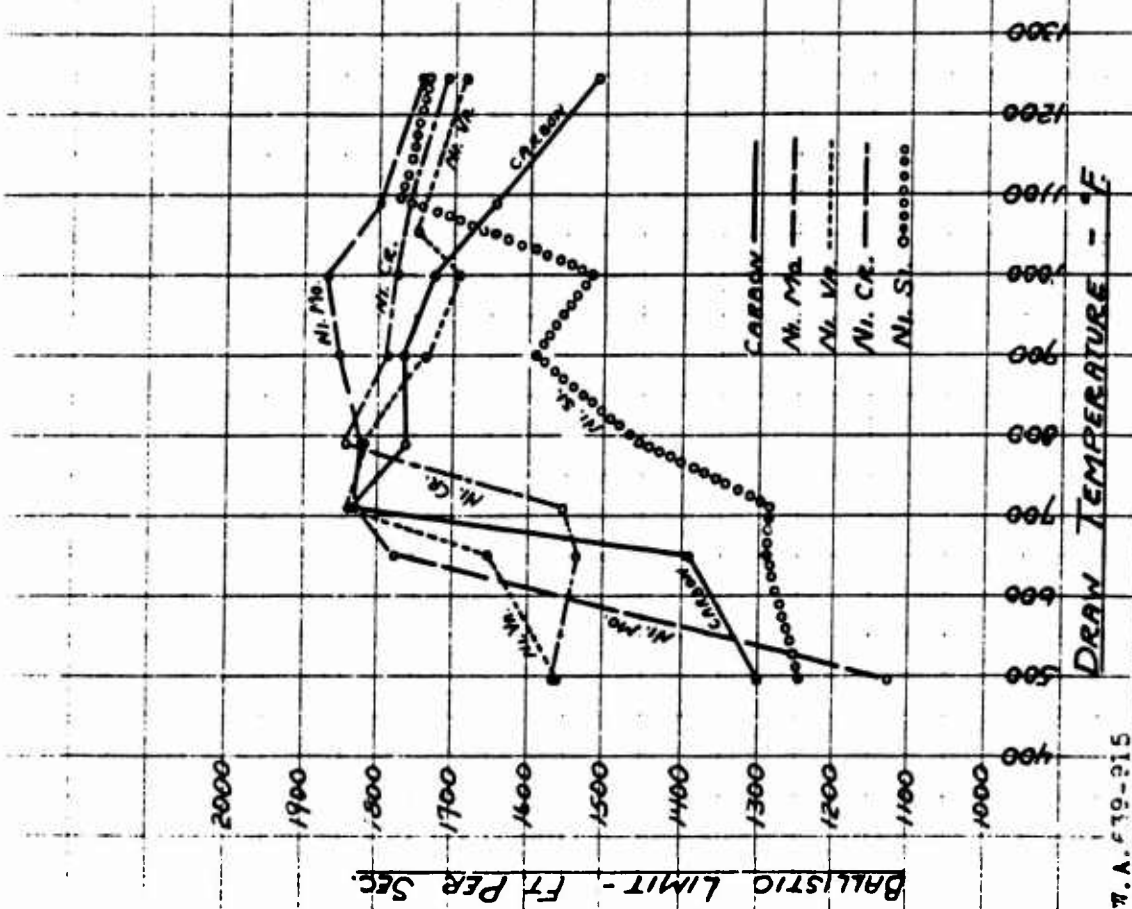


FIG. 11b.

HOMOGENEOUS ARMOR PLATE

H. DISSTON AND SONS CO.

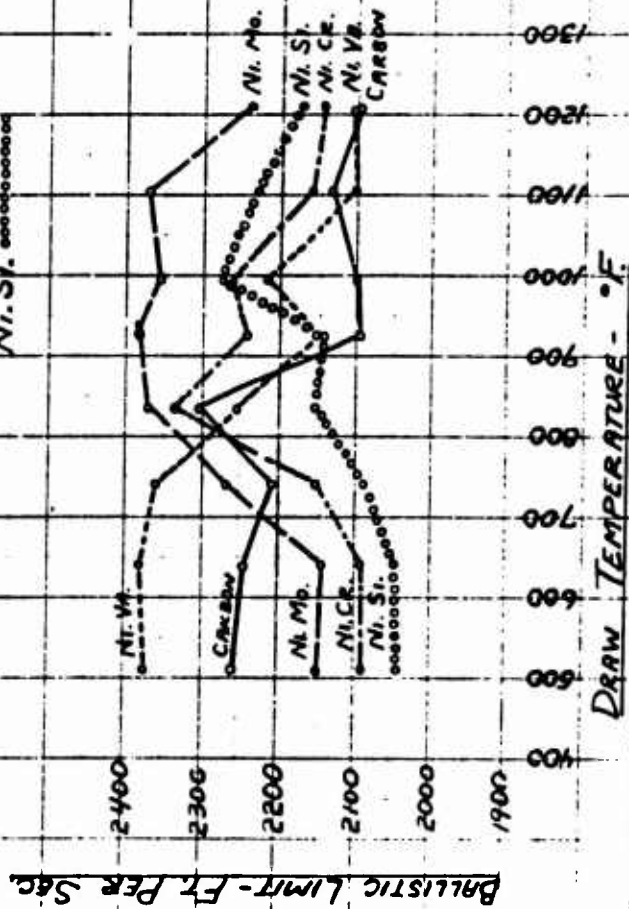
3/8 INCH THICKNESS

CHEMICAL COMPOSITION  
AND

DRAW TEMPERATURE

VS.

BALLISTIC LIMIT



TYPE OF STEEL	HEATED TO	QUENCH IN
CARBON	1455 °F.	H <sub>2</sub> O
Ni. Mo.	1505 °F.	OIL
Ni. Vn.	1505 °F.	OIL
Ni. Cr.	1510 °F.	OIL
Ni. Si.	1480 °F.	OIL

DATA TAKEN FROM 12 LB PRACTICE REPORT

CAL. 30 A.P. - 150 GR. BULLETS  
73 GR. CORE  
150 FOOT RANGE

FIG. 11C.

HOMOGENEOUS ARMOR PLATE

H. DISSION AND SONS CO.

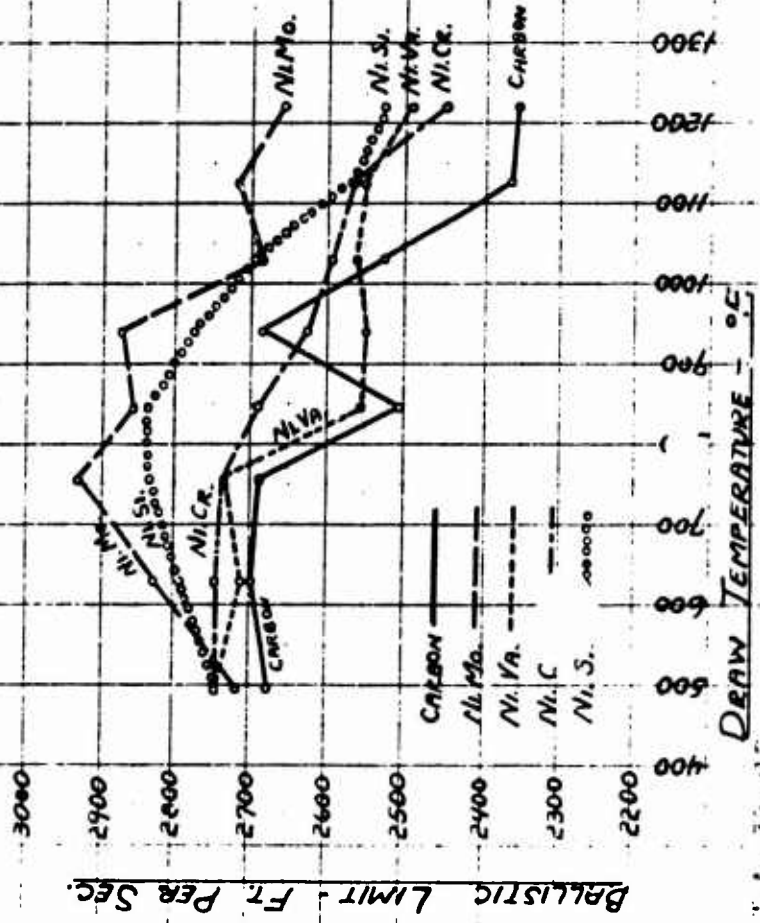
1/2 INCH THICKNESS

CHEMICAL COMPOSITION  
AND

DRAW TEMPERATURE

VS.

BALLISTIC LIMIT



TYPE OF STEEL HEATED TO		QUENCH IN
CARBON	1160 °F	H <sub>2</sub> O
Ni. Mo.	1510 °F	OIL
Ni. Va.	1515 °F	OIL
Ni. Cr.	1505 °F	OIL
Ni. Si.	1485 °F	OIL

DATA TAKEN FROM 12<sup>TH</sup> PERIAL REPORT

CAL. 30 AR - 150 GR. BULLETS.  
73 GR CORE  
150 FOOT RANGE

Watertown Arsenal experimental nitrided plate passed specifications 77%.

This information was based on Tables 4a, b, c.

The ballistic properties of rolled and heat treated structural nickel steel are given in Figs. 9 and 10.

Fig. 11 illustrates the ballistic properties of various compositions drawn at various temperatures.

#### Discussion

The results of this investigation are based entirely on the correlation of ballistic data taken from the Aberdeen reports. It is believed, however, that more reliable conclusions can be obtained if a correlative study of microstructure with ballistic properties is made, reference W.A. Report 710/242.

Due to difficulty in obtaining cooperation from armor plate manufacturers, in recent years very few test samples have been available for such study. On the basis of examinations made at this Arsenal, we are convinced that a definite correlation between microstructure and ballistic properties can be established. However, we have been hampered by the fact that all our investigations have necessarily been confined to samples which the manufacturers were willing to supply about ten years ago.

It is interesting to note that while carburized plate has been steadily improving over the years, the same improvement is not evident for homogeneous plate. We believe, however, that with sufficient cooperation between this Arsenal and the manufacturers, coupled with more complete investigation of heat treatment and microstructure, a much superior homogeneous plate could be developed. In view of the fact of greater rapidity of manufacture during emergency, we believe this program to be feasible.

During the period 1922-1932, the face hardened plate, subjected to Cal. .30 ammunition, shows an advantage up to a thickness of  $3/8$ ", beyond which the homogeneous plate is superior. However, subjected to Cal. .50 ammunition, the face hardened plate shows itself superior up to a thickness of  $3/4$ ", whereupon the homogeneous plate regains its advantage (Figs. 6 and 7).

A study of the more recent performances shows that the trend seems to be for face hardened plate to continuously increase its advantage. Thus, during 1932-1933 (Figs. 4 and 5), we note that carburized plate subjected to Cal. .30 impact now retains its superiority up to a thickness of  $9/16$ ", while under Cal. .50 impact the results are very ambiguous.

While from 1933 to date (Figs. 2 and 3), the curves indicate that now under Cal. .30 shot, carburized plate is superior to homogeneous plate to a point beyond the thickness recommended for Cal. .30 ammunition test, i.e. .525". Under Cal. .50 impact, the face hardened plate exceeds the homogeneous plate up to 5/8" plate thickness, where the curves meet and continue to show identical results up to 7/8", beyond which thickness no acceptable homogeneous plate has been submitted by manufacturers.

The line for the proposed specification was drawn in approximately 100 foot-seconds less than and parallel to the curve of the average performance of the high quality carburized plate on the Cal. .30 graph. On the Cal. .50 graph, the proposed line was drawn about 50 foot-seconds below the line representing the carburized line.

It was noted that the AXS-54 K-1 Specifications were too lenient in requirements for light plate - up to .5", beyond this thickness, however, they are too high. (See Fig. 1).

Fig. 8 represents ballistic limits of 37 MI. impact on heavy plate. The curve is extrapolated to show what performance might be expected for even heavier plate than tested to date.

The ballistic values plotted in Fig. 8 represent

four face hardened plates and only one homogeneous plate. All these plates showed various degrees of buttoning and spalling.

In reviewing the behavior of other homogeneous plates, mentioned in the Aberdeen Reports, to 37 MM. attack, it was noted that heat treated homogeneous structural nickel steel (1/2" - 1" thick) shows evidence of brittleness when subjected to such an impact.

In Table 3 is demonstrated the possibility of testing light gage plate, 1/4 - 5/8" thick, with 37 MM. solid shot for a ductility test.

Such plate was shattered to a marked degree under high velocity impact.

On the basis of recent investigations at Watertown Arsenal, under Cal. .30 impact, the advantages of nitrided plate disappears in plate thicknesses in excess of 3/8".

Nitrided chrome-moly-vanadium steels have superior ballistic properties when compared with other steels containing aluminum, as shown by the de Marre Coefficients (Table 11c).

The variation in chemical composition does not appear to cause as marked a difference in ballistic limit as does the variation heat treatment in the cases studied. (See Figs. 11a, b, c).



The advantage of nitrided plate disappears in plate thickness of  $3/8$ ".

4. With the exception of the 37 H. graph, all graphs were plotted from data obtained from good quality plate showing no evidence of brittleness. All heavy plate subjected to 37 H. impact showed evidence of brittleness.

5. No conclusions could be drawn in regard to the relationship of ballistic limit and Brinell hardness values.

Investigations at Watertown Arsenal have shown that although high and low ballistic armor plate may occasionally have the same Brinell hardness, the cause of failure in the poor plate was due to nonuniformity of microstructure, such as presence of carbides at grain boundaries, ferrite segregations or laminations.

6. Research at Watertown Arsenal has shown that there is a definite relationship between microstructure and ballistic properties of armor plate. Correct heat treatment applied to plate, thus producing the correct structure, is of more importance in obtaining high ballistic properties than normal variation in chemical composition.

Acknowledgment

Mr. A. Hurlich classified all armor plate recorded in the Aberdeen Reports into homogeneous and face hardened plate, according to manufacturer, composition, and thickness, and plotted Figs. 9, 10, 11a, b, c.

Respectfully submitted,

*E. L. Reed.*

E. L. Reed,  
Research Metallurgist.

*S. L. Kruegel*

S. L. Kruegel,  
Jr. Science Aide.

TABLE 5 (a) - Tabulation of Data from Aberdeen Reports

HOMOGENEOUS

<u>Manufacturer</u>	<u>Thickness</u>	<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Scinell</u>	<u>Remarks</u>
<u>CRUCIBLE</u>	1/4"	.25	30	150	1784	444 Buttons
Cr-Lo					1642	444 "
					1594	402 "
C = .50					1633	402 Slivers
Cr = .90					1600	364
Mo = .28					1639	351
				31	1664	370 Slivers
				AXS-54 -1	1153	370 Slivers plate dished
	5/16"	.313	30	150	1820	444 Buttons
					1823	444 "
					1883	402
					1846	389
					1852	351
					1880	351
	3/8"	.375	30	150	2012	512 Cracks
					1976	444 Buttons
					2143	444 "
					2246	444 "
					2100	402

TABLE 5 (a) - Cont'd

HOMOGENEOUS

<u>Manufacturer</u>	<u>Thickness</u>	<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>	<u>Remarks</u>
<u>CRUCIBLE</u>	3/8" .375 (Cont'd)	30	150	2192	402	
				2260	402	
				2235	402	
				2118	351	
				2133	351	
				2277	351	
				2184	351	
				2137	444	
				1346	387	
		50	150	1389	351	
			120 ft.range	1934	512	Buttons
7/16"	.438	30	150	2224	444	Buttons
				2025	512	Cracks
				2039	512	Buttons
1/2"	.500	30	150	2662	477	
				2670	444	
				2657	444	
				2452	402	
				2654	402	
				2548	364	
				2563	364	

TABLE 5 (a) - Cont'd

HOMOGENEOUS

<u>Manufacturer</u>	<u>Thickness</u>	<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>	<u>Remarks</u>
<u>CRUCIBLE</u>	1/2" .500 (Cont'd)	50	150	1391	444	Buttons
	3/4" .75	50	150	2246	495	Cracked
				2273	495	"
				2225	444	Buttons
				2270	412	
				2261	364	

TABLE 5 (a) - Cont'd

HOMOGENEOUS

<u>Manufacturer</u>	<u>Thickness</u>	<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>	<u>Remarks</u>
<u>DISSTON</u>	1/4"	.25	30	150	1748	418
					1788	418
					Straight Carbon	
					1751	418
					1783	387
					C = .495-.47	
					1772	387
					Mn = .74-.63	
					1790	418
					Si = .16	
				1781	418	
				1691	477	Cracked
				1628	387	Slivers
<hr/>						
	5/16"	.313	30	150	1921	321
					1926	332
<hr/>						
	3/8"	.375	30	150	2113	302
					2106	302
					2165	364
					2164	351
					2196	364
					2119	255
					2243	351
					2303	351
<hr/>						
	7/16"	.438	30	150	2293	332
					2296	332

TABLE 5 (a) - Cont'd

HOMOGENEOUS

<u>Manufacturer</u>	<u>Thickness</u>	<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>	<u>Remarks</u>
<u>DISSTON</u>	1/2" .500	30	150	2553	324	
				2590	293	
				2506	321	
				2453	302	
				2412	302	
				2442	302	
				2529	448	
				2459	340	
				2406	418	
		50	150	1532	430	Buttons

TABLE 5 (a) - Cont'd

HOMOGENEOUS

<u>Manufacturer</u>	<u>Thickness</u>	<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>	<u>Remarks</u>
<u>DISSTON</u>	1/4"	.25	30	150	1826	387
					1831	402
Ni-Cr					1821	402
					1839	387
C = .41-.40					1795	375
Ni=3.39-3.37					1851	387
Cr=1.35-1.30					1795	387
					1831	387
<hr/>						
	5/16"	.313	30	150	2067	375
					2084	375
<hr/>						
	3/8"	.375	30	150	2270	387
					2318	387
					2288	375
					2279	375
					2292	375
					2296	364
					2301	375
					2277	375
<hr/>						
			50	150	1216	375
					1357	332
<hr/>						

TABLE 5 (a) - Cont'd

HOMOGENEOUS

<u>Manufacturer</u>	<u>Thickness</u>	<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>	<u>Remarks</u>
<u>DISSTON</u>	7/16"	.438	3C	150	2499	430
					2485	460
<hr/>						
	1/2"	.500	30	150	2710	512
					2845	532
					2796	532
					2845	512
					2847	512
					2845	512
					2837	402
					2831	512
				2508	512	
<hr/>						
			50	150	1588	512
<hr/>						

*[Handwritten notes and signatures at the bottom of the page]*

TABLE 5 (a) - Cont'd

HOMOGENEOUS

<u>Manufacturer</u>	<u>Thickness</u>	<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>	<u>Remarks</u>		
<u>DISSTON</u>	1/4"	.25	30	150	1830	387		
					1833	387		
					1828	387		
					1638	387		
					1835	387		
					1831	387		
					1851	387		
					1842	387		
					50	150	1099	387
					5/16"	.313	30	150
				2134	418			
3/8"	.375	30	150	2315	375			
				2330	387			
				2325	387			
				2361	418			
				2337	387			
				2328	375			
				2339	387			
				2337	387			
7/16"	.438	30	150	2535	387			
				2550	387			

C = .485-.37  
 Ni=4.55-4.35  
 Mo=1.28-.36

TABLE 5 (a) - Cont'd

HOMOGENEOUS

<u>Manufacturer</u>	<u>Thickness</u>	<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>	<u>Remarks</u>
<u>DISSTON</u>	1/2" .500	30	150	2535	387	
				2858	430	
				2674	357	
				2674	387	
				2724	418	
				2742	387	
				2719	375	
				2713	387	
				2739	387	
				2706	375	
						50
				1625	387	

TABLE 5 (a) - Cont'd

HETEROGENEOUS

<u>Manufacturer</u>	<u>Thickness</u>	<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>	<u>Remarks</u>					
<u>DISSTON</u>	1/4"	.25	30	150	1756	340	Brittle & cracked				
					1716	364		"			
					1734	364	"				
					1756	364	"				
					1728	364	"				
					1542	387	"				
					1714	364	"				
					1710	364	"				
					<hr/>						
						5/16"	.313	30	150	2071	364
					2084	375					
<hr/>											
	3/8"	.375	30	150	2325	364					
					2299	364					
					2253	375					
					2327	375					
					2322	351					
					2356	364					
					2362	375					
					2347	375					
			50	150	1394	387					
<hr/>											
	7/16"	.438	30	150	2478	418					
					2498	402					

C = .52-.38  
 Ni=3.09-2.97  
 Si=1.95-1.76

TABLE 5 (a) - Cont'd

HOMOGENEOUS

<u>Manufacturer</u>	<u>Thickness</u>	<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>	<u>Remarks</u>
<u>DISSTON</u>	1/2"	.500	30	150	2793	444
					2732	387
					2752	364
					2868	375
					2778	375
					2819	430
					2769	375
					2837	430
			50	150	1649	387

TABLE 5 (a) - Cont'd

HOMOGENEOUS

<u>Manufacturer</u>	<u>Thickness</u>	<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>	<u>Remarks</u>
<u>DISSTON</u>	1/4"	.25	30	150	1761	340
					1804	387
					1800	302
					1829	387
					1883	418
					1837	387
					1857	387
					1821	302
					2142	387
					2112	387
	5/16"	.313	30	150	2343	387
					2346	387
					2291	375
					2371	418
					2350	387
					2364	418
					2359	418
					2350	387
					2192	387
						7/16"
2410	364					

N1-Va

C = .36-.30  
 Ni=3.20-3.11  
 Va=1.04-.23

TABLE 5 (a) - Cont'd

HOMOGENEOUS

<u>Manufacturer</u>	<u>Thickness</u>	<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>	<u>Remarks</u>
<u>DISSTON</u>	1/2" .500	30	150	2743	418	
				2666	364	
				2835	444	
				2737	418	
				2856	418	
				2791	418	
				2778	405	
				2712	375	
		50	150	1651	302	

TABLE 5 (a) - Cont'd

HOMOGENEOUS

<u>Manufacturer</u>	<u>Thickness</u>	<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>	<u>Remarks</u>
<u>DISSTON</u>	3/8" .375	30	150	1986	387	
Ln-Ni-Va		50	150	1322	387	
C = .35-.30				1309	444	
Ln= 1.0						
Ni=3.2-3.1						
Va=.25						
<u>DISSTON</u>	3/8" .375	50	150	1361	387	
Ni						
C = .40						
Ni= 4.60						
<u>DISSTON</u>	3/8" .375	50	150	1309	444	
Mn-Ni						
C = .36						
Mn= 1.02						
Ni= 3.17						
<u>DISSTON</u>	3/8" .375	50	150	1395	364	
Mn-Ni-Si						
C = .33-.43						
Mn=1.10-1.02	1/2" .500	50	150	1650	387	
Ni=3.09-3.04						
Si=1.63-2.05						
<u>DISSTON</u>	1/2" .500	50	150	1651	302	
Mn-Mo-Ni						
C = .39						
Mn= 1.02						
Mo= .23						
Ni= 3.24						

TABLE 5 (a) - Cont'd

HOMOGENEOUS

<u>Manufacturer</u>	<u>Thickness</u>	<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>	<u>Remarks</u>	
<u>DISSTON</u>	1/8"	.125	30	31	1003	402	Cracked
Cr-Mo-Va					1029	418	
					1048	364	
C = .55-.38					986	387	
Cr=1.35-1.00							
Mo=.86-.56							
Va=.3 - .2							
	3/16"	.188	30	31	1522	418	
					1382	-	
					1486	418	
					1539	418	
					1531	418	
					1543	418	
					1498	418	
					1526	430	
					1560	444	
					1237	401	
					AXS-54	895	-
					-1	949	401
	1/4"	.281	30	31	1541	418	
					1755	444	
					1758	401	
					1698	418	
					1543	-	
					1631	410	Slivers

TABLE 5 (a) - Cont'd

HOMOGENEOUS

<u>Manufacturer</u>	<u>Thickness</u>	<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>	<u>Remarks</u>	
<u>DISSTON</u>	1/4" .281	30	31	1545	424	Buttons	
Cr-Mo-Va	(Cont'd)		(Cont.)	1874	418		
				1815	418		
				1716	418		
				1827	418		
				1656	418	Slivers	
				1748	364		
				1809	395		
				1889	387		
				1772	403		
				1738	410		
				1640	439		
				1841	431		
				1715	431		
				1861	418		
				1710	418		
				1787	387		
				AXS-54	1233	418	Slivers
				-1	1228	364	
					1262	395	
					1258	387	
					1340	403	
					1279	410	

TABLE 5 (a) - Cont'd

HOMOGENEOUS

<u>Manufacturer</u>	<u>Thickness</u>	<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>	<u>Remarks</u>
<u>DISSTON</u>	1/4" .25	30	AXS-54	1456	449	
	(Cont'd)		-1			
Cr-Mo-Va			(Cont.)	1324	431	
				1441	431	
				1195	403	
				1183	403	
				1215	401	
			AXS-54	1247	420	Slivers
			-2	1229	424	Spall
5/16"	.313	30	31	2128	418	
3/8"	.375	30	31	2304	418	
				2173	418	
				2229	418	
				2128	444	
				2224	418	
				2239	431	
				2227	418	
				2209	418	
				2304	431	
				2276	431	
				2200	382	
				2264	426	
				2311	430	
				2117	430	

TABLE 5 (a) - Cont'd

HOMOGENEOUS

<u>Manufacturer</u>	<u>Thickness</u>	<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>	<u>Remarks</u>
<u>DISSTON</u>	3/8" .357	30	31	2297	430	
	(Cont'd)		(Cont.)			
Cr-Mo-Va				2095	461	Buttons
				2234	437	Spalled
				2178	424	"
				2192	387	
				2270	-	
				2128	444	
				2234	437	
				2178	424	
				AXS-54	1738	382
				-1	1811	403
					1762	418
					1800	461 Buttons
				AXS-54	1877	437 Spalled
				-2	1854	424 "
	7/16" .438	30	31	2545	418	
				2576	418	

TABLE 5 (a) - Cont'd

HOMOGENEOUS

<u>Manufacturer</u>	<u>Thickness</u>	<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>	<u>Remarks</u>
<u>DISSTON</u>	1/2" .500	30	150	2603	418	
Cr-Mo-Va				2630	418	
C = .53-.58			31	2526	352	
Cr=1.21-1.12				2527	370	
Mo=.86-.86				2643	387	
Va=.30-.25				2687	395	
				2700	410	
				2651	439	
				2739	418	
				2726	444	
				2744	418	Slivers
				2561	387	
				2519	364	
				2594	395	
				2462	431	
				2685	437	Spall
				2678	444	"
				2654	444	"
				2703	418	
				2707	430	Spall
				2606	364	
				2721	444	

TABLE 5 (a) - Cont'd

HOMOGENEOUS

<u>Manufacturer</u>	<u>Thickness</u>	<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>	<u>Remarks</u>
<u>DISSTON</u>	1/2" .500 (Cont'd)	30	AXS-54 -1	2470	430	Spall
Cr-Mo-Va				2242	364	
				2159	352	
				2221	370	
				2345	387	
				2390	395	
				2380	410	
				2366	499	
				2518	418	
				2431	444	
				2242	395	
				2296	410	
				2304	410	
				2326	450	
			AXS-54 -2	2451	437	Spalled
				2445	444	"
				2720	444	
				2718	444	
			AXS-54 -H	2497		Experimental
			AXS-54 -K	2609		Experimental

TABLE 5 (a) - Cont'd

HOMOGENEOUS

<u>Manufacturer</u>	<u>Thickness</u>	<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>	<u>Remarks</u>
<u>DISSTON</u>	1/2" .500 (Cont'd)	50	150	1725	500	Cracks
Cr-Mo-Va				1860	418	
				1823	418	
			31	1956	418	
				1812	418	
				1932	418	
			AXS-54	1826	470	
			-1			

TABLE 5 (a) - Cont'd

HOMOGENEOUS

<u>Manufacturer</u>	<u>Thickness</u>	<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>	<u>Remarks</u>
<u>DISSTON</u>	5/8" .625	50	150	1895	477	Buttons
Cr-Mo-Va				1795	512	Spalled
				1826	512	Spalled
C = .51-.5				1742	512	Spalled
Cr = 1.12-1.05				1807	418	
Mo = .76-.65				1862	418	
Va = .25				1419	500	Cracked
<hr/>						
		50	31	2325	430	
<hr/>						
				AXS-54	1723	Exp. Buttons
				-H	1763	
<hr/>						
				AXS-54	2122	Exp.
				-K	2117	

TABLE 5 (a) - Cont'd

HOMOGENEOUS

<u>Manufacturer</u>	<u>Thickness</u>	<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>	<u>Remarks</u>	
<u>DISSTON</u>	3/4"	.75	50	31	2245	358	Cracked
Cr-No-Va					2539	437	
C = .5-.29							
Cr= 1.36-1.12							
No= .71-.65							
Va= .25							
				AXS-54	1873	358	Cracked
				-1			
				-K	2361		Exp.
					2351		"
	7/8"	.875	50	AXS-54	2500		Exp.
				-H			
	1"	1.00	50	31	2568	418	
					2769	358	
				AXS-54	2445	358	
				-1			

TABLE 5 (A) - Cont'd

HOMOGENEOUS

<u>Manufacturer</u>	<u>Thickness</u>	<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>	<u>Remarks</u>
<u>EDDYSTONE</u>	3/16"	.188	30	31	1568	387
Cr-Ls-Va	1/4"	.25	30	31	1793	430 Slivers
C = .50					1769	418 Buttons
Cr = 1.10					1797	418
Lo = .60					1818	418
Va = .25					1821	418
	3/8"	.375	30	31	2368	418
					2283	418 Slivers
					2285	418 "
					2296	444
					2325	444
					2296	444
					2346	444 Slivers
					2245	444 Spalled
					2264	444 "
	1/2"	.500	30	31	2752	418
<u>EDDYSTONE</u>	3/16"	.188	30	150	1450	387
Cr-Va					1457	387
C = 0.45	1/2"	.500	50	150	1556	387 Buttons
Cr = 1.10						
Va = 0.25						

TABLE 5 (b) - Tabulation of Data from Aberdeen Reports

<u>Manufacturer</u>	<u>Thickness</u>	<u>CAREURIZED</u>			<u>Limit</u>	<u>Brinell</u>		<u>Remarks</u>	
		<u>Cal.</u>	<u>Spec.</u>	<u>Front</u>		<u>Back</u>			
<u>CARNEGIE</u>	1/4"	.25	30	31	2036	555	555		
					2044	555	555		
					1964	512	512	Spalled	
	AXS-54 -1					2027	555	555	
						2004	555	555	
						1964	512	512	Spalled
3/8"	.375	30	150		2481	600	444		
					31	2188	555	555	Buttons
						2170	555	555	"
					AXS-54 -1	2174	555	555	Buttons
						2170	555	555	"
						50	150	1572	652
1/2"	.500	50	150		2200	600	512	Buttons	
					31	2158	555	555	Spalled
						2146	555	532	"
					AXS-54 -1	2158	555	555	Spalled
						2146	555	532	"

TABLE 5 (b) - Cont'd

<u>Manufacturer</u>	<u>Thickness</u>	<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>		<u>Remarks</u>	
					<u>Front</u>	<u>Back</u>		
<u>CARNEGIE</u>	3/4"	.75	50	31	2119	555	555	Spalled
					2109	532	532	"
					2188	512	512	"
AXS-54 -1					1981	555	555	Spalled
					2109	532	532	"
					2057	512	512	"
7/8"	.875	50	150		2548	600	280	Spalled
					2589	600	280	"
1"	1.00	50	150		2489	600	280	
					2501	-	-	
					2494	-	-	
					31	2854	532	532
						2839	532	477
AXS-54 -1					2854	532	532	
					2661	532	477	

TABLE 5 (b) - Cont'd

Manufacturer	Thickness	CARBURIZED			Brinell		Remarks
		Cal.	Spec.	Limit	Front	Back	
CRUCIBLE Cr-Mo-Ni-Si	3/8" .375	30	150	2330	555	555	Buttons
				2449	555	555	"
				2333	600	600	"
		50	150	2089	600	600	Cracked
Cr-Mo-Ni-Si- Va-W	3/8" .375	30	150	2211	555	555	
Co-Cr-Mo-Si- Va-W	3/8" .375	30	150	2155	600	600	Buttons
				2040	555	555	"
				50	150	2318	555
Cr-Mo	3/4" .75	50	150	2360	447	-	
C = .50				2137	512	269	
Cr = .90				2216	418	-	
Mo = .28				2191	418	-	
				2104	555	-	
				2116	460	286	
				2306	683	269	
				2298	652	286	
				2115	418	255	
				2141	512	269	
				2201	512	293	
				2133	495	262	

TABLE 5 (b) - Cont'd

CARBURIZED

<u>Manufacturer</u>	<u>Thickness</u>	<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>		<u>Remarks</u>
					<u>Front</u>	<u>Back</u>	
<u>CRUCIBLE</u>	3/4" .75 (Cont'd)	50	150	2258	713	255	
Cr-Mo			(Cont.)	2042	418	362	
				2241	683	293	
				2247	600	311	
				2340	532	286	
				2388	652	277	
				2120	495	277	
				2293	627	277	
				2264	578	248	
				2221	430	293	

TABLE 6 (b) - Cont'd

CARBONIZED

<u>Manufacturer</u>	<u>Thickness</u>	<u>Gr.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Remarks</u>
<u>DYEROLD</u>	1/4"	30	AXS-54 -F	1947	Experimental
				2027	"
				2092	"
	5/16"	30	AXS-54 -F	2085	Experimental
	3/8"	30	AXS-54 -F	2320 2212	Experimental
	7/16"	30	AXS-54 -F	2249 2556 2528 2490	Punch began Experimental " "
	1/2"	30	AXS-54 -F	2693	Experimental
	9/16"	30	AXS-54 -F	2687 2713	Experimental
	5/8"	50	AXS-54 -F	2154 2142	Experimental "
	3/4"	50	AXS-54 -F	2310	Experimental

TABLE 5 (b) - Cont'd

CARBURIZED

<u>Manufacturer</u>	<u>Thickness</u>	<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Remarks</u>
<u>DIEROLD</u>	1" 1.00	50	AXS-54 -F	2609	Experimental
	1 1/8" 1.13	50	AXS-54 -F	2708	Experimental
	1 1/4" 1.25	50	AXS-54 -F	Partial at 2897+	Experimental

TABLE 8 (b) - Cont'd

<u>Manufacturer</u>	<u>Thickness</u>	<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>		<u>Remarks</u>	
					<u>Front</u>	<u>Back</u>		
<u>DISSTON</u>	1/8"	.125	30	31	1006	321	340	
					1022	340	340	
Cr-Mo-Va					1123	387	340	
C = .26-.25					1240	461	410	
Cr=1.36-1.00					1262	512	403	Slivers
Mo= .26-.56					1443	403	387	Spall
Va= .30-.20					1113	555	444	"
					1087	555	447	
					1120	403	364	
					1095	444	418	Button
					1111	444	418	
					1162	387	387	
					1046	387	387	
					1273	418	418	
					1125	418	364	Crack
	3/16"	.188	30	AXS-54 -H	1921	-	-	Experimental
	1/4	.25	30	31	2034	486	402	
					1789	469	387	
					1905	444	354	
					1920	477	364	
					1916	444	351	
					1792	430	340	

TABLE 5 (b) - Cont'd

<u>Manufacturer</u>	<u>Thickness</u>	<u>CARBURIZED</u>			<u>Brinell</u>		<u>Remarks</u>
		<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Front</u>	<u>Back</u>	
<u>DISSTON</u>	1/4" .05 (Cont'd)	30	31 (Cont.)	2024	512	431	
Cr-Lb-Va				2177	534	418	
				2227	555	432	
				2084	512	418	
				2006	512	403	
				1990	495	403	
				2100	600	544	Cracked
				1836	486	437	
				2290	600	477	Cracked
				2162	600	444	
				1645	444	302	
				1576	444	364	
				1729	477	418	
				1661	477	418	
				1686	495	413	Slivers
				1586	512	403	
				1698	477	413	
				1714	477	403	Slivers
				1697	477	418	
				1625	486	418	
				1642	488	418	Slivers
				1699	477	413	
				1485	343	212	
				1462	343	248	

TABLE 5 (b) - Cont'd

<u>Manufacturer</u>	<u>Thickness</u>	<u>CARBURIZED</u>			<u>Brinell</u>		<u>Remarks</u>
		<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Front</u>	<u>Back</u>	
<u>DISSTON</u>	1/4" .25 (Cont'd)	30	51 (Cont.)	1472	311	129	
Cr-No-Va				1400	504	418	
			AXS-54	2034	486	402	
			-1	1789	469	387	
				1905	444	354	
				1920	477	364	
				1916	444	351	
				1792	430	340	
				1645	444	302	
				1576	444	364	
				1729	477	418	
				1625	477	418	
				1686	495	418	Slivers
				1586	512	403	
				1698	477	403	
				1708	477	403	Slivers
				1697	477	418	
				1572	486	418	
				1586	488	418	Slivers
				1699	477	418	
				1028	343	212	
				1138	343	248	
				1059	311	129	
				1255	504	418	

TABLE 5 (b) - Cont'd

Manufacturer	Thickness	C&I.	Spec.	Limit	Brinell		Remarks
					Front	Back	
DISSTON Cr-No-Ve	1/4" .25 (Cont'd)	30	AXS-54 -2	1991			
				1983			
			-H	2018			Experi- mental
		50	31	1183	555	437	Spall
				1141	512	418	
				1209	486	437	
	3/8" .375	30	31	2279	495	364	
				2224	495	340	
				2262	312	340	
				2320	555	376	
				2200	555	444	
				2405	578	381	
				2573	614	495	
				2317	495	369	
				2250	504	418	
				2482	600	444	
				2215	512	418	
				2250	444	302	
				2355	430	364	
				2172	495	403	
				2227	486	431	
				2228	477	410	

TABLE 5 (b) - Cont'd

CARBURIZED

Manufacturer	Thickness	Cal.	Spec.	Limit	Brinell		Remarks
					Front	Back	
DISSTON Cr-Mo-Va	3/8" .375 (Cont'd)	50	31 (Cont.)	2256	477	431	Slivers
				2205	512	444	
				2130	477	418	
				2543	534	410	
<hr/>							
AXS-54 -1				2253	495	364	
				2123	495	340	
				2004	312	340	
				1954	444	302	
				1847	430	364	
				1794	495	403	
				1836	486	431	
				1858	477	410	
				1851	477	431	Slivers
				1817	512	444	
				1900	477	418	
				2543	534	418	
				<hr/>			
			AXS-54 -H	2471			Experi- mental
<hr/>							
		50	31	1766	614	495	Crack
				1920	555	361	"
				1833	555	444	{ Large hole Crack
				1863	495	369	

TABLE 5 (b) - Cont'd

<u>Manufacturer</u>	<u>Thickness</u>	<u>CARBURIZED</u>		<u>Limit</u>	<u>Brinell</u>		<u>Remarks</u>	
		<u>Cr.</u>	<u>Spec.</u>		<u>Front</u>	<u>Back</u>		
<u>DISSTON</u>	1/2" .500	30	150	2655	512	477	Buttons	
Cr-Mo-V8				2622	555	512	"	
				2714	600	512	"	
				2641	578	555	"	
				2638	555	555	"	
				2628	512	477	"	
				3090	555	512	"	
				2650	555	477		
				31	2788	444	418	
					2603			
					2530			
					2669	492	321	
					2625	495	321	
					2663	387	340	
					2649	512	364	
					2897	566	330	
					2738	543	397	
					2714	533	350	
					2929	589	298	Buttons
					3007	532	398	
					2947	500	341	
					3175	614	461	Spall
					3008	600	402	"

TABLE 5 (b) - Cont'd

CARBURIZED

<u>Manufacturer</u>	<u>Thickness</u>	<u>Col.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>		<u>Remarks</u>
					<u>Front</u>	<u>Back</u>	
<u>DISSTON</u>	1/2" .500	30	31	2817	469	461	Spall
Cr-Mo-V8	(Cont'd)		(Cont.)	3158	600	431	"
				2821	600	418	
				3076	555	418	
				2581	418	269	
				2643	418	387	
				2161	476	295	
				2205	495	172	
				2756	554	395	
				2779	495	387	
				2831	512	418	
<hr/>							
				AXS-54	2675	444	418
				-1	2744	460	418
					2353	492	321
					2366	495	321
					2472	387	340
					2440	512	364
					2273	418	269
					2323	418	387
					2434	554	395
					1846	478	295
					1899	495	172
<hr/>							
				AXS-54	2683		
				-2			
<hr/>							

TABLE 5 (b) - Cont'd

CARBURIZED

<u>Manufacturer</u>	<u>Thickness</u>	<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>		<u>Remarks</u>
					<u>Front</u>	<u>Back</u>	
<u>DISSTON</u>	1/2" .500	50	150	2187	600	512	Buttons
	(Cont'd)						
Cr-Mo-Va				2260	555	555	Cracks
				1592	555	512	Buttons
				2136	555	417	"
			31	1860	-	-	
				1823	-	-	
				2251	600	431	Buttons
				1920	512	302	S livers
				2140	512	286	
				1704	418	418	Buttons
				2195	512	418	"
				2283	555	364	
				1894	460	418	
				2291	600	402	Spall
				2122	566	330	
				2115	544	397	
				1891	495	387	
			AXS-54	1826	460	418	
			-1	2056			
1"	1.00	50	AXS-54	2669			Experi-
			-H	2465			mental
							"
1 1/4"	1.25	50	AXS-54	2941			
			-2				

TABLE 5 (b) - Cont'd

CARBURIZED

<u>Manufacturer</u>	<u>Thickness</u>	<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>	<u>Remarks</u>
<u>HALCO B</u>	1/4"	.25	30	150	1887	430
Ni-Cr					1598	430
					1745	400
C = .14					1856	440
Ni = 4.15					1868	444
Cr = 1.43					1874	444
					1572	430
					1544	430
					1830	460
					1763	444
					1869	444
					1817	460
					1871	460
					1822	460
					1876	460
					1944	444
					1897	477
					1724	477
					1892	555
					1955	555
					1925	555
					1931	555
					2003	555
					2064	555

TABLE 5 (b) - Cont'd

CARBURIZED

<u>Manufacturer</u>	<u>Thickness</u>	<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>	<u>Remarks</u>
<u>HALCOMB</u>	1/4" .25 (Cont'd)	30	150 (Cont.)	2243	590	
M1-Cr				2177	590	
				2235	590	
				2203	590	
	5/16" .313	30	150	2147	590	
				2224	"	
				2229	"	
				2254	"	
				2238	"	
				2204	"	
				2211	"	
				2196	"	
				2226	"	
				2240	"	
				2188	"	
				2193	"	
				2210	"	
				2234	"	
				2181	"	
				2191	"	
				2179	"	

TABLE 5 (b) - Cont'd

CARBURIZED

<u>Manufacturer</u>	<u>Thickness</u>	<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>	<u>Remarks</u>
<u>HALCOLE</u>	3/8" .375	30	150	2054	444	
Ni-Cr				1968	444	
				2015	460	
				2008	445	
				1970	360	
				2032	460	
				2240	512	
				2250	512	
				1931	477	
				2112	512	
				2146	578	
				2164	578	
				2276	578	
				2266	555	
				2333	600	
				2260	578	
				2007	477	
				2097	477	
				2181	522	
				2445	555	
				2188	555	
				2321	555	
				2320	578	
				2290	578	

TABLE 5 (b) - Cont'd

CARBURIZED

<u>Manufacturer</u>	<u>Thickness</u>	<u>Col.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>	<u>Remarks</u>
<u>HALCOMB</u>	3/8" .375	30	150	2302	590	
Ni-Cr	(Cont'd)		(Cont.)	2311	590	
				2335	590	
				2353	590	
				2310	590	
	7/16" .438	30	150	2367	590	
				2379	"	
				2333	"	
				2323	"	
				2343	"	
				2344	"	
				2328	"	
				2384	"	
				2354	"	
				2388	"	
				2330	"	
				2315	"	
				2348	"	Buttons
	1/2" .500	30	150	2572	590	
				2606	"	
				2531	"	
				2496	"	
				2531	"	

TABLE 5 (b) - Cont'd

CARBON STEEL

<u>Manufacturer</u>	<u>Thickness</u>	<u>Coil</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>	<u>Remarks</u>
<u>HALCO LB</u>	<u>1/8" .500</u>	<u>50</u>	<u>150</u>	<u>300</u>	<u>300</u>	
<u>MI-Cr</u>	<u>(Cont'd)</u>		<u>(Cont.)</u>	<u>2036</u>	"	<u>Buttons</u>
				<u>2573</u>	"	
				<u>2545</u>	"	
				<u>2597</u>	"	
				<u>2581</u>	"	
				<u>2586</u>	"	
		<u>50</u>	<u>150</u>	<u>1375</u>	<u>590</u>	
				<u>2023</u>	"	
				<u>2067</u>	"	<u>Cracked</u>
				<u>2043</u>	"	
				<u>2008</u>	"	
				<u>2023</u>	"	
				<u>2067</u>	"	<u>Cracked</u>
				<u>2080</u>	"	
				<u>2041</u>	"	
				<u>1996</u>	"	
				<u>2024</u>	"	
				<u>2037</u>	"	
	<u>3/4" .75</u>	<u>50</u>	<u>150</u>	<u>2148</u>	<u>444</u>	
				<u>2109</u>	<u>444</u>	
				<u>2070</u>	<u>444</u>	
				<u>2035</u>	<u>460</u>	
				<u>2108</u>	<u>460</u>	

TABLE 5 (b) - Cont'd

CARBON STEEL

<u>Manufacturer</u>	<u>Thickness</u>	<u>Col.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>	<u>Remarks</u>
<u>HALCO B</u>	3/4" .75 (Cont'd)	50	150 (Cont.)	2104	444	
<u>Ni-Cr</u>				2076	444	
				2042	444	
				2115	495	
				2147	477	
				2242	532	
				2156	532	
				2318	555	
				2222	555	
				2193	555	
				2260	578	
				2167	444	
				2119	444	
				2374	600	
				2248	600	
				2303	600	
				2317	600	
				2353	600	
				2210	600	
				2253	590	Slivers
				2195	"	
				2243	"	
				2243	"	
				2214	"	

TABLE 5 (b) - Cont'd

CARBUREND

<u>Manufacturer</u>	<u>Thickness</u>	<u>Gal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Princil</u>	<u>Remarks</u>
<u>HALCON</u>	5/4" .75	50	150	2076	590	
	(Cont'd)		(Cont.)			
Hi-Cr				2232	"	
				2284	"	
				2273	"	
				2211	"	Slivers
				2105	"	
				2149	555	

---

TABLE 3 (c) - Tabulation of Data from Aberdeen Reports

NITRIDED

<u>Manufacturer</u>	<u>Thickness</u>	<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>	<u>Remarks</u>
<u>EDDYSTONE</u>	1/8" .125	30	31	1296*	418	
				1362*	477	
				1236*	477	
Cr-Va						
C = .6 Cr = 1.20 Va = .28	3/16" .182	30	31	1824*	477	
				1856*	477	
				1571	477	
				1531	461	Cracked
				1457	444	"
				1518	461	"
1/4" .25	30	31	1905	444		
			2014	461		
			2014	495		
			1964	444		
			2053*	477		
			2148*	477		
3/8" .375	30	31	2296*	477		
			2432*	477		
			2454	444	Cracked	

\* No Composition

TABLE 5 (c) - Cont'd

NITRIDED

<u>Manufacturer</u>	<u>Thickness</u>	<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>	<u>Remarks</u>	
<u>EDDYSTONE</u>	1/2"	.500	30	31	2699*	477	
Cr-Va					2605*	477	
					2499	444	
					2470	444	
			50	31	1783	444	
					1782	444	
					2144*	477	Broke plate
	5/8"	.625	50	31	2357*	444	Spalled
					2357*	444	"
	3/4"	.75	50	31	2631	477	Spalled
					2437	444	"
	1"	1.00	50	31	2651	444	Plate broke
					2696	466	"

\*No composition.

TABLE 5 (c) - Cont'd

HYBRIDED

<u>Manufacturer</u>	<u>Thickness</u>	<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>ball</u>		<u>Remarks</u>
					<u>Front</u>	<u>Back</u>	
<u>LUDLUM</u>	1/4"	.25	30	150	1852	477	387
Cr-Mo-Al					2000	444	387
					1807	477	228
<hr/>							
C = .36							
Cr = 1.49	7/16"	.438	30	150	2370	477	280
Mo = .18							
Al = 1.23					2448	444	387
					2476	444	286

TABLE 5 (c) - Cont'd

<u>Manufacturer</u>	<u>Thickness</u>	<u>Cal.</u>	<u>Spec.</u>	<u>Limit</u>	<u>Brinell</u>		<u>Remarks</u>	
					<u>Front</u>	<u>Back</u>		
WATERTOWN ARSENAL EXPERIMENTAL	1/4"	.25	30	AXS-54 -2	2150	-	-	
					2050			
					1950			Shat- tered
					1850			
					2150			
				2050				
	3/8"	.375	30	AXS-54 -2	1975			
					1850			
	7/16"	.438	30	AXS-54 -2	2275			
	1/2"	.500	30	AXS-54 -2	2350			
					2550			
					2150			
					2275			

**TABLE 6 (a)**  
**HOMOGENEOUS - Spec. 150; Calibre .30**

Thickness	Manufacturer	Chemical Composition	Arithmetic Means		Optimum Averages		Specification Averages		% of plates Passing Spec.	% of Brittle Plate
			Ballistic Limits	Brinelle	Ballistic Limits	Brinelle	Ballistic Limits	Brinelle		
3/16"	.188 Eddystone	Cr-Va	1454	387	1454 $\pm$ 4	337	1454 $\pm$ 4	337	None	0
1/4"	.25 Crucible	Cr-Mo	1649	401	1620 $\pm$ 20	358	1620 $\pm$ 20	358	0	67
		Straight C	1737	414	1773 $\pm$ 14	409	1773 $\pm$ 14	409	78	22
		"	1821	389	1821 $\pm$ 13	389	1821 $\pm$ 13	389	100	0
		"	1836	387	1836 $\pm$ 6	387	1836 $\pm$ 6	387	100	0
		"	1707	364	1731	361	-	-	0	100
5/16"	.313 Crucible	Cr-Mo	1851	397	1824 $\pm$ 28	364	1824 $\pm$ 28	364	100	0
		Straight C	1924	327	1865 $\pm$ 16	373	1865 $\pm$ 16	373	0	33
		"	2076	375	1924 $\pm$ 3	327	1924 $\pm$ 3	327	100	0
		"	2131	403	2076 $\pm$ 9	375	2076 $\pm$ 9	375	100	0
		"	2078	370	2131 $\pm$ 4	403	2131 $\pm$ 4	403	100	0
5/16"	.313 Crucible	Cr-Mo	2127	387	2078 $\pm$ 7	370	2078 $\pm$ 7	370	100	0
		Straight C	2127	387	2127 $\pm$ 15	387	2127 $\pm$ 15	387	100	0

TABLE 6 (a) Cont'd

HOMOGENEOUS - Spec. .150; Calibre .30

Thickness	Manufacturer	Chemical Composition	Arithmetic Means		Optimum Averages		Specification Averages		Weight	% of Plates Passing Spec.	% of Brittle Plate
			Ballistic Limits	Brinells	Ballistic Limits	Brinells	Ballistic Limits	Brinells			
3/8"	.375	Crucible	2133	406	2184	395	2182±53	384	53	64	29
		Disston	2176	330			2176±53	330	50	100	0
		"	2290	377			2290±12	377	200	100	0
		"	2334	388			2334±10	388	250	100	0
		"	2324	368			2324±24	368	111	100	0
		"	2330	396	2347	397	2347±15	397	167	100	0
		"	1986	387			-	-	0	0	0
7/16"	.438	Crucible	2096	489			-	-	0	0	100
		Disston	2295	332			2295±2	332	500	0	0
		"	2492	445			2492±7	445	143	100	0
		"	2543	387			2543±8	387	125	100	0
		"	2488	410			2488±10	410	100	100	0
		"	2407	376			2407±4	376	250	100	0

TABLE 6 (a) Cont'd

HOMOGENEOUS - Spec. .150; Calibre .30

Thickness	Manufacturer	Crucible	Chemical Composition	Arithmetic Means		Optimum Averages		Specification Averages		% of Plates Passing Spec.	% of Brittle Plate	
				Ballistic Limits	Brinells	Ballistic Limits	Brinells	Ballistic Limits	Brinells			Weight
1/2"	.500	Crucible	-	2601	414	2626	416	2626 $\pm$ 47	416	48	100	0
		Disston	Straight C	2483	339			2483 $\pm$ 54	339	53	67	0
		"	N1-Cr	2785	504	2835	502	2835 $\pm$ 12	502	200	100	0
		"	N1-Mo	2708	392	2728	393	2728 $\pm$ 35	393	83	100	0
		"	N1-S1	2792	398			2793 $\pm$ 37	398	71	100	0
		"	N1-Va	2765	408			2765 $\pm$ 50	408	53	100	0
		"	Cr-Mo-Va	2617	418			2617 $\pm$ 14	418	71	100	0

TABLE 6 (a) Cont'd

HOMOGENEOUS - Spec. 150; Calibre .50

Thickness	Manufacturer	Chemical Composition	Arithmetic Means		Optimum Averages		Specification Averages		Weight	% of Plates Passing Spec.	% of Brittle Plate
			Ballistic Limits	Brinells	Ballistic Limits	Prinells	Ballistic Limits	Brinells			
3/8" .375	Disston	Mn-Ni-Va	1316	416	1316	416	1316	416	140	0	0
	"	Ni	1361	387	1361	387	1361	387	1	0	0
	"	Mn-Ni	1309	444	1309	444	1309	444	1	0	0
	"	Mn-Ni-Si	1395	364	1395	364	1395	364	1	0	0
1/2" .500	Crucible	-	1391	444	-	-	-	-	1	No spec. for this thickness.	100
	Disston	Straight C	1532	430	-	-	-	-	1	No spec. for this thickness.	100
	"	Ni-Cr	1588	512	1588	512	1588	512	1	0	0
	"	Ni-Mo	1582	387	1582+44	387	1582+44	387	23	0	0
	"	Ni-Si	1649	387	1649	387	1649	387	1	0	0
	"	Ni-Va	1651	302	1651	302	1651	302	1	0	0
	"	Mn-Ni-Si	1650	387	1650	387	1650	387	1	0	0
	"	Mn-Mo-Ni	1651	302	1651	302	1651	302	1	0	0
	"	Cr-Mo-Va	1803	445	1842+19	418	1842+19	418	53	33	33
	"	Eddystone	Cr-Va	1556	387	-	-	-	-	1	No spec. for this thickness.
5/8" .625	Disston	Cr-Mo-Va	1764	478	1821	475	1835+28	418	77	14	71
	Crucible	-	2255	442	2266+5	388	2266+5	388	200	40	60

TABLE 6 (a) Cont'd

HOMOGENEOUS - Spec. 31; Calibre .30

Thickness	Manufacturer	Chemical Composition	Arithmetic Means		Optimum Averages		Specification Averages		% of Plates Passing Spec.		% of Brittle Plate
			Ballistic Limits	Brinells	Ballistic Limits	Brinells	Ballistic Limits	Brinells	No Spec.	Spec.	
1/8" .125	Disston	Cr-Mo-Va	1017	393	-	-	1021+23	390	63	25	
3/16" .188	Disston	Cr-Mo-Va	1482	420	1526	423	1526+18	423	143	60	0
	Eddystone	"	1568	387	-	-	1558	387	1	100	0
1/4" .25	Crucible	Cr-Mo-	1664	370	-	-	-	-	1	0	100
	Disston	Cr-Mo-Va	1746	413	1786	411	1786+52	411	83	71	13
	Eddystone	Cr-Mo-Va	1800	420	-	-	1812+10	418	143	60	40
5/16" .313	Disston	Cr-Mo-Va	2128	418	-	-	2128	418	1	100	0
3/8" .375	Disston	Cr-Mo-Va	2218	444	2239	421	2237+37	420	111	87	13
	Eddystone	"	2301	435	-	-	2321+25	438	56	44	56
7/16" .433	Disston	Cr-Mo-Va	2561	418	-	-	2561+16	418	63	100	0
1/2" .500	Disston	Cr-Mo-Va	2642	413	2682	423	2677+43	417	71	75	25
	Eddystone	"	2752	412	-	-	2752	418	1	100	0

TABLE 6 (a) Cont'd

HOLOGENOUS - Spec. 31; Calibre .50

Thickness	Manufacturer	Chemical Composition	Arithmetic Means		Optimum Averages		Specification Averages		% of Plates Passing Spec.	% of Brittle plate
			Ballistic Limits	Brinells	Ballistic Limits	Brinells	Ballistic Limits	Brinells		
1/2" .500	Dasston	Cr-Mo-Va	1900	418			1900±59	418	24	0
5/8" .625	Dasston	Cr-Mo-Va	2325	430			2325	430	1	0
3/4" .75	Dasston	Cr-Mo-Va	2392	398			2339	437	1	50
1" 1.00	Dasston	Cr-Mo-Va	2669	388			2669±100	338	10	0

TABLE 5 (a) Cont'd

HOMOGENEOUS		Spec. AIS-54-1		Specification		1 of Plates Passing Spec.	1 of Brittl Plates			
Thickness	Manufacturer	Chemical Composition	Arithmetic Means	Optimum Averages	Averages			Weight		
			Ballistic Limits	Ballistic Limits	Ballistic Limits					
			Brinells	Brinells	Brinells					
			CALIBRE .30							
3/16"	.138	Disston	Cr-Mo-Va	922	401	922±27	401	37	0	0
1/4"	.25	Crucible	Cr-Mo	1153	370	-	-	1	0	100
		Disston	Cr-Mo-Va	1290	408	1311±65	403	45	0	8
3/8"	.375	Disston	Cr-Mo-Va	1773	416	1770±27	401	59	0	25
1/2"	.500	Disston	Cr-Mo-Va	2335	410	2383	425	56	7	7
		Disston	Cr-Mo-Va	1826	470	1826	470	1	No Spec.	100
3/4"	.75	Disston	Cr-Mo-Va	1873	358	-	-	1	0	100
1"	1.00	Disston	Cr-Mo-Va	2445	358	-	-	1	0	100
						CALIBRE .50				

HOMOGENEOUS - Spec. AIS-54-2; Calibre .30

1/4"	.25	Disston	Cr-Mo-Va	1245	422	-	-	0	0	100
3/8"	.375	Disston	Cr-Mo-Va	1866	431	-	-	0	0	100
1/2"	.500	Disston	Cr-Mo-Va	2584	443	2719	444	1000	50	50

TABLE 6 (a) Cont'd

HOMOGENEOUS - Miscellaneous (AXS-54, Revs. F, H, K, etc.) Calibre .30

Thickness	Manufacturer	Chemical Composition	Rev.	Arithmetic Means		Optimum Averages		Specification Averages		Weight	% of Plates Passing Britl Spec.	
				Ballistic Limits	Brinells	Ballistic Limits	Brinells	Ballistic Limits	Brinells			
1/2" .500	Disston	Cr-Mo-Va	H	2497	-	2497	-	2497	-	1	100	0
"	"	"	K	2609	-	2609	-	2609	-	1	100	0

Calibre .50

5/8" .625	Disston	Cr-Mo-Va	H	1743	-	1763	-	1763	-	1	0	50
"	"	"	K	2120	-	2120+3	-	2120+3	-	333	100	0
3/4" .75	Disston	Cr-Mo-Va	K	2356	-	2356+5	-	2356+5	-	200	100	0
7/8" .875	Disston	Cr-Mo-Va	H	2500	-	2500	-	2500	-	1	100	0

TABLE 6 (b)

CARBURIZED - Spec. 150; - Calibre .30

Thickness	Manufacturer	Chemical Composition	Arithmetic Means		Optimum Averages		Specification Averages		Weight	% of Plates Passing Spec.	% c Brit Pla
			Ballistic Front Back Limits	Ballistic Back Back Limits	Ballistic Front Back Limits	Ballistic Front Back Limits	Ballistic Front Back Limits	Ballistic Front Back Limits			
1/4"	Halcomb	Ni-Cr	1892	490	-	2017	536	-	30	89	c
5/16"	Halcomb	Ni-Cr	2209	590	-	-	590	-	167	100	c
3/8"	Carnegie	-	2481	600	444	-	600	444	1	100	c
	Crucible	Cr-Mo-Ni-Si	2371	570	570	-	-	-	0	0	100
	"	Cr-Mo-Ni-Si-Va-W	2211	555	555	-	555	555	1	100	c
	"	Co-Cr-Mo-Si-Ta-W	2155	600	600	-	-	-	0	0	100
7/16"	Halcomb	Co-Cr-Mo-Si-Va-W	2040	555	555	-	-	-	0	0	100
	Halcomb	Ni-Cr	2188	529	-	2293	566	-	83	52	c
1/2"	Halcomb	Ni-Cr	2347	590	-	-	590	-	167	92	8
1/2"	Disston	Cr-Mo-Va	2706	553	510	-	555	477	1	12	88
	Halcomb	Ni-Cr	2573	590	-	-	590	-	100	92	8

TABLE 6 (b) Cont'd

CARBURIZED - Spec. 150; - Calibre .50

Thickness	Manufacturer	Chemical Composition	Arithmetic Means		Optimum Averages		Specification Averages		Weight	% of Plates Passing Spec.	% of Brittle Plate			
			Ballistic Limits	Front Back	Ballistic Limits	Front Back	Ballistic Limits	Front Back						
3/8"	Carnegie	-	1572	652	477				0	100				
	Crucible	Cr-Mo-Ni-Si	2089	600	600				0	100				
	"	Co-Cr-Mo-Si	2318	555	555				0	100				
1/2"	Carnegie	-	2200	600	512				0	100				
	Disston	Cr-Mo-Va	2044	566	499	2194	570	495	0	100				
	Halcomb	Ni-Cr	2032	590	-	-	-	2025±20	590	143	17			
3/4"	Crucible	Cr-Mo	2215	537	283	2249	557	278	2249±60	557	278	67	77	0
	Halcomb	Ni-Cr	2192	537	-	2239	563	-	2239±52	563	-	91	53	6
7/8"	Carnegie	-	2569	600	280					0				100
1"	Carnegie	-	2495	-	-				2495±4	-	-	333	33	0

No sections for these thicknesses.

TABLE 5 (b) Cont'd  
CARBURIZED - Spec. 31; Calibre .30

Thickness	Manufacturer	Chemical Composition	Arithmetic Means		Optimum Averages		Specification Averages		Weight	% of Plates Passing Bri Spec.
			Ballistic Limits	Brinells Front Back	Ballistic Limits	Brinells Front Back	Ballistic Limits	Brinells Front Back		
1/8"	Disston	Cr-Mo-Va	1148	429 391	1180	447 400	1159±56	436 398	45	0
1/4"	Carnegie	-	2015	541 541	-	-	2040±4	555 555	250	67
	Disston	Cr-Mo-Va	1815	481 389	2020	510 413	1994±116	497 399	31	41
3/8"	Carnegie	-	2179	555 555	-	-	-	-	0	0
	Disston	Cr-Mo-Va	2295	502 400	2371	511 395	2371±104	511 395	28	85
1/2"	Disston	Cr-Mo-Va	2765	517 366	2890	535 392	2836±97	518 384	34	73

Spec. 31; Calibre .50

1/4"	Disston	Cr-Mo-Va	1178	518 431	-	-	1175±34	499 428	29	3
3/8"	Disston	Cr-Mo-Va	1846	555 417	-	-	-	-	0	10
1/2"	Carnegie	-	2152	555 544	-	-	-	-	0	10
	Disston	Cr-Mo-Va	2038	525 378	2200	556 375	2165±59	544 344	29	31
3/4"	Carnegie	-	2139	533 533	-	-	-	-	0	10
1"	Carnegie	-	2847	532 505	-	-	2847±8	532 505	125	100

TABLE 6 (b) Cont'd

CARBURIZED - Spec. AXS-54-1; Calibre .30

Thickness	Manufacturer	Chemical Composition	Arithmetic Means		Optimum Averages		Specification Averages		Weight	% of Plates Passing Spec.	% of Brit Pla
			Ballistic Limits	Brinells Front Back	Ballistic Limits	Brinells Front Back	Ballistic Limits	Brinells Front Back			
1/4" .25	Carnegie	-	1998	541 541	2016	555 555	2016±12	555 555	83	67	33
	Disston	Cr-Mo-Va	1626	454 364	1808	467 387	1818±101	466 386	29	18	14
3/8" .375	Carnegie	-	2172	555 555	-	-	-	-	0	0	100
	Disston	Cr-Mo-Va	1974	470 389	2114	465 382	2114±194	465 382	11	17	8
1/2" .500	Disston	Cr-Mo-Va	2348	468 336	2476	470 371	2476±117	470 371	23	45	0
<u>Spec. AXS-54-1; Calibre .50</u>											
1/2" .500	Carnegie	-	2152	555 544	-	-	-	-	0	No	100
	Disston	Cr-Mo-Va	1941	-	-	-	1941±115	-	9	Spec.	0
3/4" .75	Carnegie	-	2049	533 533	-	-	-	-	0	0	100
1" 1.00	Carnegie	-	2758	532 505	-	-	2758±97	532 505	10	100	0
<u>Spec. AXS-54-2; Calibre .30</u>											
1/4" .25	Disston	Cr-Mo-Va	1987	-	-	-	1987±4	-	250	100	0
1/2" .500	Disston	Cr-Mo-Va	2683	-	-	-	2683	-	1	100	0
1" 1.00	Disston	Cr-Mo-Va	2936	-	-	-	2936	-	1	100	0
<u>Spec. AXS-54-2; Calibre .50</u>											

TABLE 6 (b) Cont'd

CARBURIZED - Spec. AXS-54- (F,H,K,etc.); Calibre .30

Thickness	Manufacturer	Chemical Composition	Rev.	Arithmetic Means		Optimum Averages		Specification		Weight	% of Plates Passing Spec.	Plates Passing Brit Spec.	% of Plates Passing Brit Spec.
				Ballistic Brinells	Front Back	Ballistic Brinells	Front Back	Ballistic Brinells	Front Back				
3/16"	Disston	Cr-Mo-Va	H	1921				1921		1	No Spec.		
1/4"	Diebold	-	F	2022				2022+50		22	100		
	Disston	Cr-Mo-Va	H	2018				2018		1	100		
5/16"	Diebold	-	F	2085				2085		1	100		
3/8"	Diebold	-	F	2266				2266+54		19	100		
	Disston	-	H	2471				2471		1	100		
7/16"	Diebold	-	F	2456				2525+23		68	100		
1/2"	Diebold	-	F	2693				2693		1	100		
9/16"	Diebold	-	F	2700				2700+13		77	No Spec.		
<u>Spec. AXS-54- (F,H,K,etc.); Calibre .50</u>													
5/8"	Diebold	-	F	2148				2148+6		167	100		
3/4"	Diebold	-	F	2310				2310		1	100		
1"	Diebold	-	F	2609				2609		1	100		
	Disston	Cr-Mo-Va	H	2567				2567+102		10	100		

TABLE 6 (c)

NITRIDED - Spec. 150; - Calibre .30

Thickness	Manufacturer	Chemical Composition	Arithmetic Means		Optimum Averages		Specification		% of Plates Passing Spec.	% of Brittl Plate
			Ballistic Limits	Front Back	Ballistic Limits	Front Back	Ballistic Limits	Front Back		
1/4"	Ludlum	Cr-Mo-Al	1886	466 334			1886±76	466 334	33	0
7/16"	Ludlum	Cr-Mo-Al	2431	455 318			2431±41	455 318	100	0

Spec. 31 - Calibre .30

1/8"	Eddystone	Cr-Ve	1298	457			1298±43	457	0	0
3/16"	"	"	1626	466	1696	473	1750±120	477	33	50
1/4"	"	"	2016	466	2039	471	2039±50	471	100	0
3/8"	"	"	2394	466			2364±68	477	67	33
1/2"	"	"	2566	461			2566±86	461	100	0
1/2"	"	"	1903	455			1783±1	444	No Spec.	33
5/8"	"	"	2357	444			-	-	0	100
3/4"	"	"	2534	461			-	-	0	100
1"	"	"	2674	455			-	-	0	100

Spec. 31 - Calibre .50

1/4"	W.A.Exp.	-	2033		2100		2100±50		83	17
3/8"	"	-	1913		-		1913±53		50	0
7/16"	"	-	2275		-		2275	1	100	100
1/2"	"	-	2331		2450		2450±100	10	75	0

Spec. AXS-54-2, Calibre .30

TABLE 7 (a) - WEIGHTED MEANS OF SPECIFICATION AVERAGES

HOMOGENEOUS

<u>Thickness</u>	<u>Weighted Mean of Ballistic Limit</u>	<u>Weight</u>
<u>Spec. 150 - Calibre .30</u>		
3/16" - .138	1454	5
1/4" - .25	1801 $\pm$ 12	11
5/16" - .315	2031 $\pm$ 7	10
3/8" - .375	2235 $\pm$ 29	18
7/16" - .438	2384 $\pm$ 4	11
1/2" - .500	2710 $\pm$ 33	8
<u>Spec. 150 - Calibre .50</u>		
1/2" - .500	1756 $\pm$ 25	1
5/8" - .625	1835 $\pm$ 28	1
3/4" - .75	2266 $\pm$ 5	2
<u>Spec. 31 - Calibre .30</u>		
1/8" - .125	1021 $\pm$ 23	1
3/16" - .188	1526 $\pm$ 18	1
1/4" - .25	1799 $\pm$ 31	2
5/16" - .313	2128	0
3/8" - .375	2279 $\pm$ 31	2
7/16" - .438	2561 $\pm$ 16	1
1/2" - .500	2677 $\pm$ 43	1
<u>Spec. 31 - Calibre .50</u>		
1/2" - .500	1900 $\pm$ 59	.3
5/8" - .625	2325	0
3/4" - .75	2539	0
1" - 1.00	2669 $\pm$ 100	.1
<u>Spec. AXS54-Rev. 1 - Calibre .30</u>		
3/16" - .188	922 $\pm$ 27	0
1/4" - .25	1311 $\pm$ 65	1
3/8" - .375	1770 $\pm$ 27	1
1/2" - .500	2373 $\pm$ 51	1
<u>Spec. AXS54-Rev. 1 - Calibre .50</u>		
1/2" - .500	1826	0
<u>Spec. AXS54-Rev. 2 - Calibre .30</u>		
1/2" - .500	2719 $\pm$ 1	10

TABLE 7 (a) Cont'd

HOMOGENEOUS

<u>Thickness</u>	<u>Weighted Mean of Ballistic Limit</u>	<u>Weight</u>
<u>Spec. AXS54- Revs. F, H, K, etc. - Calibre .30</u>		
1/2" - .500	2553	.2
<u>Spec. AXS54- Revs. F, H, K, etc. - Calibre .50</u>		
5/8" - .625	2100±3	3
3/4" - .75	<del>2356±6</del>	2
7/8" - .875	2500	.1

2356 ←

TABLE 7 (b) - WEIGHTED MEANS OF SPECIFICATION AVERAGES

CAREPRIZED

<u>Thickness</u>	<u>Weighted Mean of Ballistic Limit</u>	<u>Weight</u>
<u>Spec. 150 - Calibre .30</u>		
1/4" - .25	2017+170	0
5/16" - .313	2219+22	2
3/8" - .375	2294+45	1
7/16" - .438	2347+21	2
1/2" - .500	2533+30	1
<u>Spec. 150 - Calibre .50</u>		
1/2" - .500	2025+20	1
3/4" - .75	2244+56	2
1" - 1.00	2495+4	3
<u>Spec. 31 - Calibre .30</u>		
1/8" - .125	1159+56	1
1/4" - .25	2035+16	3
3/8" - .375	2371+104	0.2
1/2" - .500	2536+37	0.3
<u>Spec. 31 - Calibre .50</u>		
1/4" - .25	1175+34	0.2
1/2" - .500	2165+59	0.2
1" - 1.00	2847+3	1
<u>Spec. AXS54-Rev. 1 - Calibre .30</u>		
1/4" - .25	1962+36	1
3/8" - .375	2114+194	0.1
1/2" - .500	2476+117	0.2
<u>Spec. AXS54-Rev. 1 - Calibre .50</u>		
1/2" - .500	1941+15	0.1
1" - 1.00	2752+97	0.1
<u>Spec. AXS54-Rev. 2 - Calibre .30</u>		
1/4" - .25	1927+4	3
1/2" - .500	2683	0
<u>Spec. AXS54-Rev. 2 - Calibre .50</u>		
1" - 1.00	2936	0
1 1/4" - 1.25	2941	0

TABLE 2 (b) cont'd

UNRECORDED

<u>Thickness</u>	<u>Weighted Mean of Ballistic Limit</u>	<u>Weight</u>
<u>Spec. A1584-Revs. F, H, K - Calibre .02</u>		
5/16" - .188	1901	0
1/4" - .25	2082 $\pm$ 50	0
5/16" - .312	2083	0
3/8" - .375	2278 $\pm$ 54	0
7/16" - .438	2533 $\pm$ 23	1
1/2" - .500	2693	0
3/8" - .563	2700 $\pm$ 15	1
<u>Spec. A1584-Revs. F, H, K - Calibre .50</u>		
5/8" - .625	2143 $\pm$ 6	2
3/4" - .75	2310	0
1" - 1.00	2571 $\pm$ 102	0
1 1/8" - 1.13	2703	0
1 1/4" - 1.25	2887	0

TABLE 7 (c) - WEIGHTED MEANS OF SPECIFICATION AVERAGES  
MIRRID

<u>Thickness</u>	<u>Weighted Mean of</u> <u>Ballistic Limit</u>	<u>Weight</u>
<u>Spec. 150 - Calibre .30</u>		
1/4" - .25	1998±76	2
7/16" - .438	1481±91	3
<u>Spec. 31 - Calibre .30</u>		
1/4" - .25	1693±48	3
3/16" - .188	1750±100	1
1/2" - .50	2039±50	4
3/8" - .375	2364±62	2
1/2" - .500	2566±26	2
<u>Spec. 31 - Calibre .50</u>		
1/2" - .500	1783±1	100
<u>Spec. AX554-Rev. 2 - Calibre .30</u>		
1/4" - .25	2100±50	3
3/8" - .375	1913±63	2
7/16" - .438	2275±	0
1/2" - .500	2450±100	1

(Too meager and erratic to plot  
successfully)

TABLE 6 (a) - BALLISTIC EFFICIENCY OF HOMOGENEOUS PLATE

HOMOGENEOUS

CRUCIBLE

<u>Thickness</u>	<u>Chemical Composition</u>	<u>Passed</u>	<u>Brittle</u>
<u>Spec. 150 - Calibre .30</u>			
1/4" .25	Cr-Mo	0	67
5/16" .3125	Cr-Mo	0	33
3/8" .375	Cr-Mo	64	29
7/16" .4375	-	0	100
1/2" .500	-	100	0
<u>Spec. 150 - Calibre .50</u>			
3/4" .75	-	40	60
Grand Average		34	48
<u>Spec. 31 - Calibre .30</u>			
1/4" .25	Cr-Mo	0	100
<u>Spec. AXS54-Rev. 1 - Cal. .30</u>			
1/4" .25	Cr-Mo	0	100
Grand Average		0	100

TABLE 1 (a) Cont'd

DISTON

HOMOGENEOUS - Spec. 150

<u>Thickness</u>	<u>Chemical Composition</u>	<u>1/2 Passed</u>	<u>1/2 Brittle</u>
	<u>Calibre .30</u>		
1/4" .25	Straight C	78	22
	Ni-Cr	100	0
	Ni-Mo	100	0
	Ni-Si	0	100
	Ni-Va	0	100
5/16" .313	Straight C	100	0
	Ni-Cr	100	0
	Ni-Mo	100	0
	Ni-Si	100	0
	Ni-Va	100	0
3/8" .375	Straight C	100	0
	Ni-Cr	100	0
	Ni-Mo	100	0
	Ni-Si	100	0
	Ni-Va	100	0
	In-Ni-Va	0	0
7/16" .438	Straight C	0	0
	Ni-Cr	100	0
	Ni-Mo	100	0
	Ni-Si	100	0
	Ni-Va	100	0
1/2" .500	Straight C	67	0
	Ni-Cr	100	0
	Ni-Mo	100	0
	Ni-Si	100	0
	Ni-Va	100	0
	Cr-Mo-Va	100	0
	<u>Calibre .50</u>		
5/8" .625	Cr-Mo-Va	14	71
	Grand Average	81	10

TABLE 6 (a) Cont'd

<u>DISTON</u>		<u>HOMOGENEOUS</u>	
<u>Thickness</u>	<u>Chemical Composition</u>	<u>% Passed</u>	<u>% Brittle</u>
<u>Spec. 31 - Calibre .50</u>			
3/16"	Cr-Mo-Va	00	0
1/4"	"	71	13
5/16"	"	100	0
3/8"	"	27	13
7/16"	"	100	0
1/2"	"	75	25
<u>Spec. 31 - Calibre .50</u>			
5/8"	Cr-Mo-Va	100	0
3/4"	"	50	50
1"	"	100	0
<u>Grand Average</u>		<u>83</u>	<u>11</u>
<u>Spec. AXS54-Rev. 1 - Calibre .50</u>			
3/16"	Cr-Mo-Va	0	0
1/4"	"	0	8
3/8"	"	0	25
1/2"	"	7	7
<u>Spec. AXS54-Rev. 1 - Calibre .50</u>			
3/4"	Cr-Mo-Va	0	100
1"	"	0	100
<u>Grand Average</u>		<u>1</u>	<u>40</u>
<u>Spec. AXS54-Rev. 2 - Calibre .50</u>			
1/4"	Cr-Mo-Va	0	100
3/8"	"	0	100
1/2"	"	50	50
<u>Grand Average</u>		<u>17</u>	<u>83</u>
<u>Spec. AXS54-Revs. H &amp; K - Calibre .50</u>			
5/8"	Cr-Mo-Va	0	50
		100	0
3/4"	"	100	0
7/8"	"	100	0
<u>Grand Average</u>		<u>75</u>	<u>13</u>

TABLE 6 (a) Cont'd

EDDYSTONE

HOMOGENEOUS

<u>Thickness</u>	<u>Chemical Composit'on</u>	<u>% Passed</u>	<u>% Brittle</u>
<u>Spec. 150 - Calibre .30</u>			
3/16" .183	Cr-Ve	0	0
<u>Spec. 31 - Calibre .30</u>			
3/16" .188	Cr-Mo-Ve	100	0
1/4" .25	"	60	40
3/8" .375	"	44	56
1/2" .500	"	100	0
Grand Average		76	24

TABLE 6 (b) - BALLISTIC EFFICIENCY OF CARBURIZED PLATE

CARNEGIE

<u>Thickness</u>	<u>Chemical Composition</u>	<u>% Passed</u>	<u>% Brittle</u>
<u>Spec. 150 - Calibre .50</u>			
3/8" .375	-	100	0
<u>Spec. 150 - Calibre .30</u>			
7/8" .375	-	0	100
1" 1.00	-	33	0
GRAND AVERAGE		44	33
<u>Spec. 31 - Calibre .30</u>			
1/4" .25	-	67	33
3/8" .375	-	0	100
<u>Spec. 31 - Calibre .50</u>			
3/4" .75	-	0	100
1" 1.00	-	100	0
GRAND AVERAGE		42	58
<u>Spec. AXS54-Rev. 1 - Calibre .30</u>			
1/4" .25	-	67	33
3/8" .375	-	0	100
<u>Spec. AXS54-Rev. 1 - Calibre .50</u>			
3/4" .75	-	0	100
1" 1.00	-	100	0
GRAND AVERAGE		42	58

TABLE 8 (b) Cont'd

CRUCIBLE

CARBURIZED - Spec. 150

<u>Thickness</u>	<u>Chemical Composition</u>	<u>% Passed</u>	<u>% Brittle</u>
<u>Calibre .30</u>			
3/8" .375	Cr-Mo-Ni-Si	0	100
	Ni-Si-Cr-Mo-W	100	0
	Co-Cr-Mo-Si-Va-W	0	100
	Co-Cr-Mo-Si	0	100
<u>Calibre .50</u>			
3/4" .75	Cr-Mo	77	0
<u>Grand Average</u>		<u>35</u>	<u>60</u>

TABLE 2 (b) Cont'd

DIEBOLD

CARBURIZED

Spec. AXS54-Revs. F, H, & K

<u>Thickness</u>	<u>Chemical Composition</u>	<u>% Passed</u>	<u>% Brittle</u>
<u>Calibre .30</u>			
1/4" .25	-	100	0
5/16" .313	-	100	0
3/8" .375	-	100	0
7/16" .438	-	100	0
1/2" .500	-	100	0
<u>Calibre .50</u>			
9/16" .563	-	100	0
5/8" .625	-	100	0
3/4" .75	-	100	0
1" 1.00	-	100	0
<b>GRAND AVERAGE</b>		<b>100</b>	<b>0</b>

TABLE 2 (b) Cont'd

DISSTON

CARBURIZED

<u>Thickness</u>	<u>Chemical Composition</u>	<u>% Passed</u>	<u>% Brittle</u>
1/2" .500	<u>Spec. 150 - Calibre .30</u> Cr-Mo-Va	12	88
<hr/>			
1/3" .125	<u>Spec. 31 - Calibre .30</u> Cr-Mo-Va	0	33
1/4" .25	"	41	16
3/8" .375	"	85	5
1/2" .500	"	73	19
<hr/>			
Grand Average		50	18
<hr/>			
1/4" .25	<u>Spec. AXS54-Rev. 1 - Calibre .30</u> Cr-Mo-Va	18	14
3/8" .375	"	17	8
1/2" .500	"	45	0
<hr/>			
Grand Average		27	7
<hr/>			
1/4" .25	<u>Spec. AXS54-Rev. 2 - Calibre .30</u> Cr-Mo-Va	100	0
1/2" .500	"	100	0
<hr/>			
1" 1.00	<u>Spec. AXS54-Rev. 2 - Calibre .50</u> Cr-Mo-Va	100	0
<hr/>			
Grand Average		100	0
<hr/>			
1/4" .25	<u>Spec. AXS54-Revs. F, H, &amp; K, Cal. .30</u> Cr-Mo-Va	100	0
3/8" .375	"	100	0
<hr/>			
1" 1.00	<u>Spec. AXS54-Revs. F, H, &amp; K, Cal. .50</u> Cr-Mo-Va	100	0
<hr/>			
Grand Average		100	0

TABLE 2 (b) Cont'd

HALCOMBCARBURIZED - Spec. 150

<u>Thickness</u>	<u>Chemical Composition</u>	<u>% Passed</u>	<u>% Brittle</u>
	<u>Calibre .30</u>		
1/4" .25	Ni-Cr	69	0
5/16" .313	"	100	0
3/8" .375	"	52	0
7/16" .438	"	92	3
1/2" .500	"	92	8
	<u>Calibre .50</u>		
3/4" .75	Ni-Cr	55	6
	<u>Grand Average</u>	<u>80</u>	<u>4</u>

TABLE 6 (c) - BALLISTIC EFFICIENCY OF NITRIDED PLATE

<u>Thickness</u>	<u>Chemical Composition</u>	<u>% Passed</u>	<u>% Brittle</u>
<u>LUDLUM - Spec. 150 - Calibre .50</u>			
1/4" .25	Cr-Mo-Al	33	0
7/16" .438	"	100	0
Grand Average		67	0
<u>EDDYSTONE - Spec. 31 - Calibre .50</u>			
1/8" .125	Cr-Va	0	0
3/16" .188	Cr-Va	33	50
1/4" .25	"	100	0
3/8" .375	"	67	33
1/2" .500	"	100	0
<u>EDDYSTONE - Spec. 31 - Calibre .50</u>			
5/8" .625	Cr-Va	0	100
3/4" .75	"	0	100
1" 1.00	"	0	100
Grand Average		38	48
<u>WATERTOWN ARSENAL EXPERIMENTAL</u>			
<u>Spec. AXS54-Rev. 2 - Calibre .30</u>			
1/4" .25		83	17
3/8" .375		50	0
7/16" .438		100	0
1/2" .500		75	0
Grand Average		77	4

TABLE 9

HOMOGENEOUS ARMCO  
STRUCTURAL NICKEL STEEL

I      II      III  
.33/.40    .30/.30    3.25/3.75

Thickness	Spec. AXS-54, Rev. 2 AXS-54F, G				Spec. AXS-54, Rev. 3, Rev. R.I.A., 1/11/36			
	As Rolled		Heat Treated		As Rolled		Heat Treated	
	Hard.	B. L.	Hard.	B. L.	Hard.	B. L.	Hard.	B. L.
1/8" .075	187	1431	321	1720	187	1833	321	2130
1/4" .25	196	1113	302	1193	196	1508	302	1765
3/8" .375	178	1497	286	1837	183	1914	286	2274
1/2" .500	179	1837	269	2144	179	2157	269	2433
5/8" .625	187	1408	269	1590	187	1839	269	2067
3/4" .75	179	1592	262	1762	179	1965	262	2190
7/8" .875	187	1851	311	2061	187	2110	311	2407
1" 1.00	196	2032	286	2281	196	2276	286	2546
1/4" .25			351	1186			351	1698
3/8" .375			351	1769			351	2145
1/2" .500			364	2424			364	2567
5/8" .625			351	1622			351	2072
3/4" .75			351	1965			351	2304
7/8" .875			351	2093			351	2502
1" 1.00			364	2446			364	2737
<u>Calibre .30 M1922 - A.P.</u>								
1/4" .25		1113		1193		1508		1765
3/8" .375		1431		1720		1833		2130
1/2" .500		1497		1837		1914		2274
		1837		2144		2157		2433
<u>Calibre .50 M1 - A.P.</u>								
5/8" .625		1408		1590		1839		2067
3/4" .75		1592		1762		1965		2190
7/8" .875		1851		2081		2110		2407
1" 1.00		2032		2281		2276		2546

TABLE 10 (a)

CHEMICAL COMPOSITION AND DRAW TEMPERATURE  
VS  
DRAW TEMPERATURE

FOR DISSTON HOMOGENEOUS 1/4" PLATE

Spec. 150 - Calibre .30 - 150 grain bullet, 73 grain core.

<u>Chemical Composition</u>	<u>Heat Treatment</u>			<u>Ballistic Limit f. s.</u>
	<u>Quench °F</u>	<u>In</u>	<u>Draw °F</u>	
Carbon	1450	H <sub>2</sub> O	495	1300
"	"	"	650	1391
"	"	"	710	1837
"	"	"	790	1760
"	"	"	900	1764
"	"	"	1000	1726
"	"	"	1090	1644
"	"	"	1245	1510
Ni-Ko	1500	Oil	495	1125
"	"	"	650	1774
"	"	"	710	1831
"	"	"	790	1824
"	"	"	900	1855
"	"	"	1000	1871
"	"	"	1090	1798
"	"	"	1245	1741
Ni-Va	1500	Oil	495	1560
"	"	"	650	1651
"	"	"	710	1842
"	"	"	790	1818
"	"	"	900	1735
"	"	"	1000	1691
"	"	"	1055	1748
"	"	"	1245	1686
Ni-Cr	1500	Oil	495	1565
"	"	"	650	1534
"	"	"	710	1555
"	"	"	790	1844
"	"	"	900	1787
"	"	"	1000	1772
"	"	"	1095	1756
"	"	"	1245	1705

TABLE 10 (a) Cont'd

FOR DISSTON HOMOGENEOUS 1/4" PLATE

<u>Chemical Composition</u>	<u>Heat Treatment</u>			<u>Ballistic Limit f. s.</u>
	<u>Quench °F</u>	<u>In</u>	<u>Draw °F</u>	
Ni-Si	1475	Oil	495	1248
"	"	"	650	1288
"	"	"	710	1286
"	"	"	790	1451
"	"	"	900	1595
"	"	"	1000	1519
"	"	"	1095	1771
"	"	"	1245	1736

CHEMICAL COMPOSITION AND DRAW TEMPERATURE  
VS  
DRAW TEMPERATURE

FOR DISSTON HOMOGENEOUS 3/4" PLATE

Spec. 150 - Calibre .50 - 150 Grain bullet, 73 Grain core.

Chemical Composition	Heat Treatment			Ballistic Limit P. S.
	Quench °F	In	Draw °F	
Carbon	1455	H <sub>2</sub> O	510	2253
"	"	"	640	2243
"	"	"	740	2207
"	"	"	835	2304
"	"	"	925	2194
"	"	"	995	2100
"	"	"	1105	2134
"	"	"	1210	2097
Ni-Lo	1505	Oil	510	2151
"	"	"	640	2146
"	"	"	740	2267
"	"	"	835	2371
"	"	"	925	2381
"	"	"	995	2355
"	"	"	1105	2370
"	"	"	1210	2236
Ni-Va	1505	Oil	510	2372
"	"	"	640	2379
"	"	"	740	2360
"	"	"	835	2252
"	"	"	925	2157
"	"	"	995	2216
"	"	"	1105	2102
"	"	"	1210	2104
Ni-Cr	1510	Oil	510	2088
"	"	"	640	2091
"	"	"	740	2154
"	"	"	835	2337
"	"	"	925	2240
"	"	"	995	2260
"	"	"	1105	2162
"	"	"	1210	2144
Ni-Si	1480	Oil	510	2042
"	"	"	640	2047
"	"	"	740	2078
"	"	"	835	2156
"	"	"	925	2143
"	"	"	995	2272
"	"	"	1105	2228
"	"	"	1210	2174

TABLE 10 (c)  
 CHEMICAL COMPOSITION AND DRAW TEMPERATURE  
 VS  
 DRAW TEMPERATURE

FOR DISTON HOMOGENEOUS 1/2" PLATE

Spec. 150 - Calibre .50 - 150 grain bullet, 73 grain core.

Chemical Composition	Heat Treatment			Ballistic Limit f. s.
	Quench °F	In	Draw °F	
Carbon	1460	H <sub>2</sub> O	495	2675
"	"	"	630	2697
"	"	"	755	2688
"	"	"	845	2504
"	"	"	940	2684
"	"	"	1030	2526
"	"	"	1125	2364
"	"	"	1220	2357
Ni-Mo	1510	Oil	495	2717
"	"	"	630	2827
"	"	"	755	2931
"	"	"	845	2858
"	"	"	940	2873
"	"	"	1030	2684
"	"	"	1125	2717
"	"	"	1220	2657
Ni-Va	1515	Oil	495	2746
"	"	"	630	2709
"	"	"	755	2737
"	"	"	845	2557
"	"	"	940	2549
"	"	"	1030	2561
"	"	"	1125	2550
"	"	"	1220	2491
Ni-Cr	1510	Oil	495	2744
"	"	"	630	2744
"	"	"	755	2734
"	"	"	845	2690
"	"	"	940	2625
"	"	"	1030	2593
"	"	"	1125	2564
"	"	"	1220	2449
Ni-Si	1485	Oil	495	2742
"	"	"	630	2791
"	"	"	755	2833
"	"	"	845	2837
"	"	"	940	2774
"	"	"	1030	2696
"	"	"	1125	2569
"	"	"	1220	2528

TABLE 11 (a)

CHEMICAL COMPOSITIONS OF VARIOUS MANUFACTURERS  
OF HOMOGENEOUS PLATE

Manufacturer	Type	Chemical Analysis (General Limits)												
		C	Mn	Si	Ni	Cr	Mo	Va	W	Co				
Crucible	Cr-Mo	.50	-	-	-	.90	.28	-	-	-	-	-	-	-
Disston	Straight, Carbon	.495/.470	.74/.63	.16	-	-	-	-	-	-	-	-	-	-
	Ni-Cr	.41/.40	-	-	-	1.35/1.30	-	-	-	-	-	-	-	-
	Ni-Mo	.485/.370	-	-	3.39/3.37	-	-	-	-	-	-	-	-	-
	Ni-Si	.52/.38	-	-	4.55/4.35	-	1.28/.36	-	-	-	-	-	-	-
	Ni-Va	.36/.30	1.93/1.76	-	3.09/2.97	-	-	-	-	-	-	-	-	-
	Mn-Ni-Va	.35/.30	-	-	3.20/3.11	-	-	1.04/.23	-	-	-	-	-	-
	Ni	.40	1.0	-	3.2/3.1	-	-	.25	-	-	-	-	-	-
	Ni-Mn	.36	-	-	4.60	-	-	-	-	-	-	-	-	-
	Mn-Ni-Si	.43/.33	1.02	-	3.17	-	-	-	-	-	-	-	-	-
	Mn-Mo-Ni	.39	1.10/1.02	2.05/1.63	3.09/3.04	-	-	-	-	-	-	-	-	-
Cr-Mo-Va	.55/.29	-	-	3.24	-	-	.23	-	-	-	-	-	-	
Eddystone	Cr-Mo-Va	.50	-	-	-	1.36/1.00	.86/.56	.30/.20	-	-	-	-	-	-
	Cr-Va	.45	-	-	-	1.10	.60	.25	-	-	-	-	-	-

TABLE 11 (b)

CHEMICAL COMPOSITIONS OF VARIOUS MANUFACTURERS  
OF CARBURIZED PLATE

Manufacturer	Type	Chemical Analysis (General Limits)						
		C	Mn	Si	Ni	Cr	P	S
Carnegie	No analysis furnished.							
Grucible	Cr-Mo-Ni-Si	.36/.35	-	1.60	3.62/3.25	.71/.60	.32/.37	-
	Cr-Mo-Ni-Si-Va-W	.60/.50	-	2.00/1.75	3.25/3.00	.70/.60	.50/.50	.30/.20
	Co-Cr-Mo-Si-Va-W	.55/.45	-	1.75/1.50	-	.70/.60	.40/.30	.30/.20
	Cr-Mo	.50	-	-	-	.90	.28	-
Diebold	No analysis furnished.							
Disston	Cr-Mo-Va	.26/.23	-	-	-	1.36/1.00	.86/.55	.30/.20
Halcomb	Ni-Cr	.14	-	-	4.15	1.43	-	-

TABLE 11 (c)

CHEMICAL COMPOSITIONS OF VARIOUS MANUFACTURERS  
OF NITRIDED PLATE

Manufacturer	Grade	DeMarre Coefficient	Chemical Analysis (General Limits)							
			C	Mn	Si	Ni	Cr	Mo	Va	Al
Eddystone	Cr-Va	1.771	.6	-	-	-	1.20	-	.28	-
Ludlum	Cr-Mo-Al	1.643	.36	-	-	-	1.49	.18	-	1.23
F. A. Experimental	Cr-Mo-Va-Al-Ni	1.513	.450/.445	-	-	3.31/3.23	1.20	.51/.60	.27/.255	1.00/.55
	Cr-Mo-Va-Ni	1.286	.525	-	-	3.09	1.24	.72	.24	-
	Cr-Mo-Va-Al	1.451	.56/.39	-	-	-	3.50/1.26	.76/.53	.255/.21	1.19/.11
	Cr-Mo-Va	2.042	.50	-	-	-	1.09	.72	.27	-