

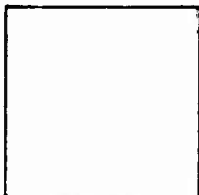
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REPORT NO. 3457

TINLESS SOLID INVESTIGATION

Supplementary Report

INDEXED

By

H. G. Carter
Associate Metallurgist

August 25, 1939

WATERTOWN ARSENAL
WATERTOWN, MASS.

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1939

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TINLESS SOLDER INVESTIGATION

Supplementary Report

Ex. O. 49-A10

This report is a continuation of the investigation reported in Experimental Report 377A and Report No. 345/6. It deals primarily with the Charpy Impact of the solders recommended in the above reports. Thin (.015") sheets were joined.

Conclusions

1. Lead-cadmium-zinc solder, containing 1-1/2% zinc added to the eutectic mixture of lead and cadmium (Pb 78.8%, Cd 19.7%, Zn 1.5%), gave the best joints when bright annealed sheets, brass sheets, tin plate, terne plate and galvanized iron sheets were soldered.
2. A similar solder containing 1% zinc is nearly as good.
3. The above solders, when used to joint bright annealed sheets, brass sheets and terne plate, gave results which were much superior to half and half lead-tin solder. When used to join tin plate and galvanized iron sheets, the results were equal to, but not much different from, solder containing half and half lead-tin.

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4. Lead-cadmium-zinc solders, containing 2 and 4% zinc added to the eutectic mixture of lead and cadmium gave superior results when used to join uncoated sheets such as bright annealed and brass sheets than did half and half lead-tin solder, but, when used to join coated plates such as terne sheet, tin plate and galvanized iron sheets, the results were either about equal to or slightly inferior (especially with terne plate) to half and half lead-tin solder.

5. Old coated sheets (tin plate, terne plate and galvanized iron) can be successfully soldered if, before soldering, they are dipped in hot zinc chloride ($ZnCl_2$) soldering flux (Hydrochloric acid "killed" with zinc) for fifteen to twenty minutes (15-20 min.). This cleaning does not remove the coatings as would scraping with a knife or emery cloth.

Procedure

The same method of soldering was used as reported in Watertown Arsenal Report No. 345/6. Old stock which had been stored several years was used in the investigation and was first cleaned as described on pages 10 and 11 of the above report.

The Charpy impact tests were made on a 220-foot pound machine, but the available energy was reduced to about

15 foot pounds by using only a 30-degree swing.

The results, averaged by the method of Least Squares, are given in Table A and plotted in Figures 1 - 7. To make the comparisons more complete, the tensile values (in shear) recorded in Watertown Arsenal Report No. 345/6, are repeated in Table B and plotted on the same figures as the impact results.

Table A

Charpy Impact .. Foot Pounds
.015" Plate Thickness

<u>Material**</u>	<u>1/2 & 1/2</u>	<u>1 1/2 Zn</u>	<u>1-1/2% Zn</u>	<u>2% Zn</u>	<u>4% Zn</u>
B.A.	3.87	6.84	6.43	6.72	5.74
T.	2.10	2.03	1.91	1.86	1.82
Tr	3.43	5.85	5.62	1.39	1.60
B	5.70	6.66	8.61	6.62	6.71
G	0.94	1.47	1.09	1.10	0.98

**B.A.=Bright Annealed Sheet:
T.=Tin Plate :
Tr =Terne Plate :

B = Brass Sheet
G = Galvanized Sheet

Table B

Tensile Strength in Shear - Pounds per Square Inch*
.015" Plate Thickness

<u>Material**</u>	<u>1/2 & 1/2</u>	<u>1% Zn</u>	<u>1-1/2% Zn</u>	<u>2% Zn</u>	<u>4% Zn</u>
B.A.	5850	6480	6600	6400	6510
T	6700	6200	6600	6400	6510
Tr	6300	6500	7250	6800	6700
B	6400	6900	6900	6700	6700
G	5100	4600	4900	5300	4900

*Above table was taken from Table IV,
Watertown Arsenal Report No. 345/6.

**B.A. = Bright Annealed Sheet: B = Brass Sheet
T = Tin Plate : G = Galvanized Sheet
Tr = Terns Plate :

Inasmuch as other arsenal work interrupted this investigation frequently, only sheets of .015" thickness were soldered. It is believed that similar results could be obtained with .035" thick sheets if certain precautions were used so that sufficient alloying of the solder and the base metals would result.

Discussion

Figure 1 shows a graph of the Charpy impact and the tensile strengths (shear) when bright annealed sheets are joined by the various solders. All the solders containing zinc gave greater Charpy impact and tensile strengths than when half and half lead-tin solder was used. There was very little choice between the solders containing 1, 1-1/2, and 2% zinc. Apparently the solder containing 4% zinc had too much zinc for the best results, but even it was superior to that given by half and half lead-tin solder.

Figure 2 shows a graph of the Charpy impact and tensile strengths (shear) when tin plate is joined by the various solders. All the solders containing zinc gave results that were approximately the same as when soldered with half and half lead-tin solder. On page 8, Watertown Arsenal Report No. 345/6, it was shown that tin-cadmium oxidized very rapidly in air when heated to fusion. The tin plate has a coating of tin and the solders studied contain cadmium. It is very probable that, during soldering, sufficient tin cadmium alloy formed and that there was insufficient soldering flux to prevent or remove the oxides which formed during the soldering. These oxides would lower the impact and tensile strengths con-

siderably. Probably, also, the longer the solder was kept molten and in contact with the tin (unless very large amounts of flux were used), the lower would be the impact and tensile strengths of the joints.

Figure 3 shows a graph of the Charpy impact and tensile strengths (shear) when terne plate is joined by the various solders. Solders containing 1 and 1-1/2% zinc gave results that were very superior to those obtained when half and half lead-tin solder was used. Solders containing 2 and 4% zinc showed results inferior to those obtained with half and half lead-tin solder.

Figure 4 shows a graph of the Charpy impact and tensile strengths (shear) when brass is joined by the various solders. All solders containing zinc were slightly stronger (tensile strength in shear) than when soldered with half and half lead-tin solder, while the Charpy impact values were considerably greater, especially the solder containing 1-1/2% zinc.

Figure 5 shows a graph of the Charpy impact and the tensile strengths (shear) when galvanized iron sheets are joined by the various solders. All solders containing zinc were only about equal to half and half lead-tin solder. Probably the zinc of the galvanizing adds to the zinc content of the solder. Too much zinc apparently impairs the lead-cadmium-zinc solders.

Figure 6 is a graph comparing the various solders and the materials soldered. The solder containing 1-1/2% zinc takes first place with the solder containing 1% zinc a close second. The solders containing 2 and 4% zinc are about equal for third place and generally are about equal to half and half lead-tin solders.

Figure 7 is a comparison of the various materials soldered and the solders. It is the same graph as Figure 6 except the solders and the materials are interchanged for the abscissas. The uncoated plates of bright annealed and brass sheets gave results that were far superior to those obtained with half and half lead-tin solder. The coated plates (terne plate excepted) were about equal to half and half lead-tin solder. Terne plate and solders containing 1 and 1-1/2% zinc gave much better results than half and half lead-tin solder, while the solders containing 2 and 4% zinc were inferior.

Summary

1. The lead-cadmium-zinc solder containing 1-1/2% zinc was especially good and was much superior to half and half lead-tin solder. The solder containing 1% zinc was a close second, while the solders containing 2 and 4% were about equal for third place, and generally equal to the half and half lead-tin solder.

2. Uncoated plates such as bright annealed and brass sheets gave results much superior to half and half lead-tin solder when joined by lead-cadmium-zinc solders containing the eutectic mixture of lead and cadmium with 1 - 4% zinc added.

3. Coated plates such as tin plate and galvanized iron gave results about equal but not much superior to half and half lead-tin solder when the above lead-cadmium-zinc solders were used.

4. Coated plates such as terne plate gave results that were much superior to half and half lead-tin solder when joined by lead-cadmium-zinc solders containing 1 - 1-1/2% zinc, but were inferior with solders containing 2 and 4% zinc.

5. The sheets used in this investigation were in storage several years and had to be cleaned by the method described in Watertown Arsenal Report No. 345/6 before successful joints could be obtained.

Respectfully submitted,


H. G. Carter,
Assoc. Metallurgist.

Chart
Tensile Strength
Pounds

8

7

6

5

4

3

2

1

0



Fig. 1

Bright Annealed

Fig. 2

Tin Plated



8
7
6
5
4
3
2
1
0

00082
SF 2
00073
SF 2
00003
SF 2
00000

Change
Feet Pounds

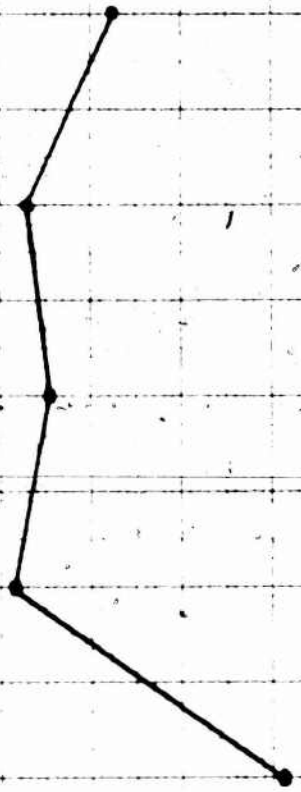


Fig. 1
Bright Annealed



Fig. 2
Tin Plate

4620
2
1 1/2
PB. Cd-Zn
1 1/2
PB. Sn
4 1/2
PB. Zn
2
1 1/2
PB. Cd-Zn
1 1/2
PB. Sn
4 1/2
PB. Zn

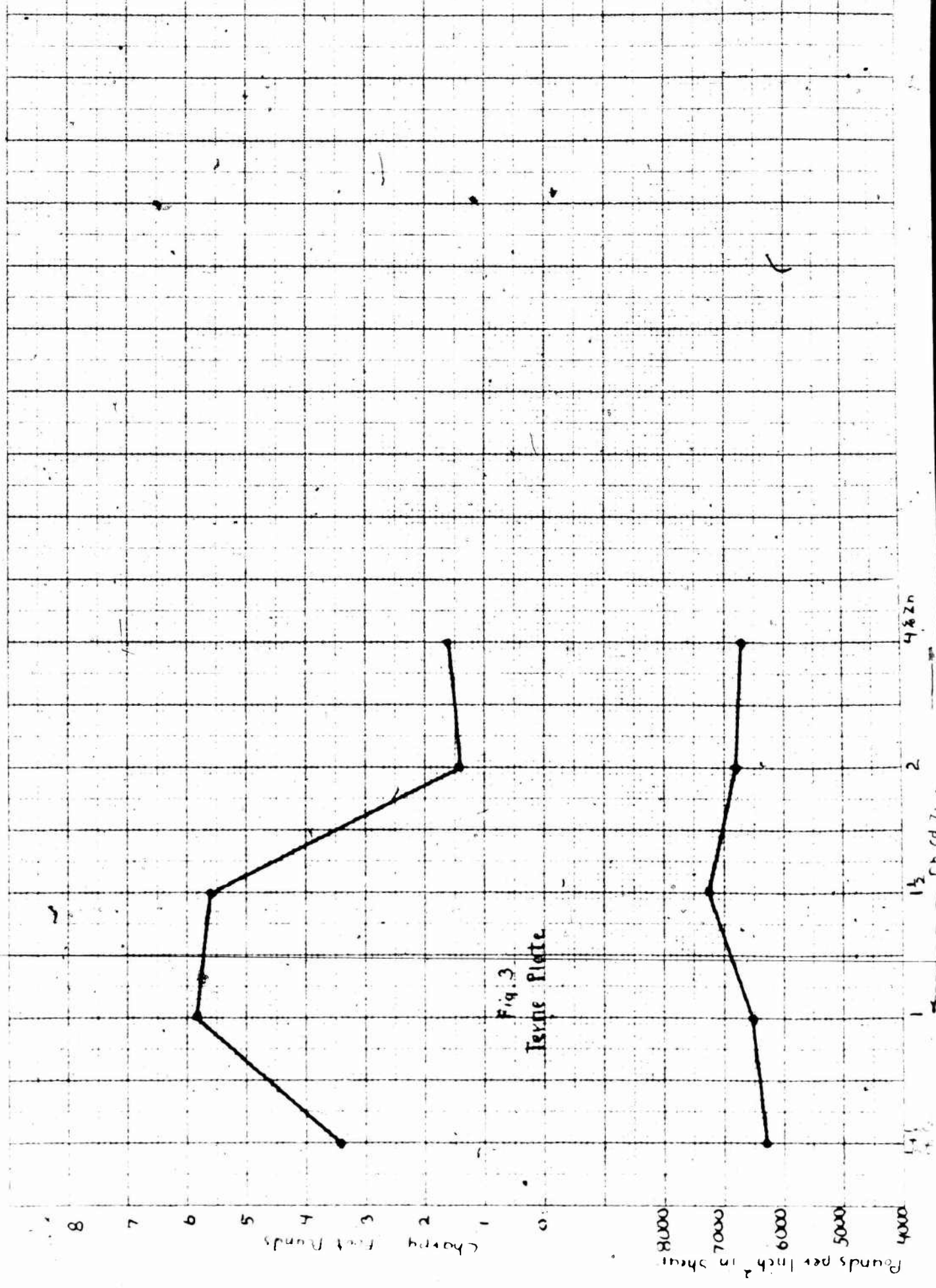
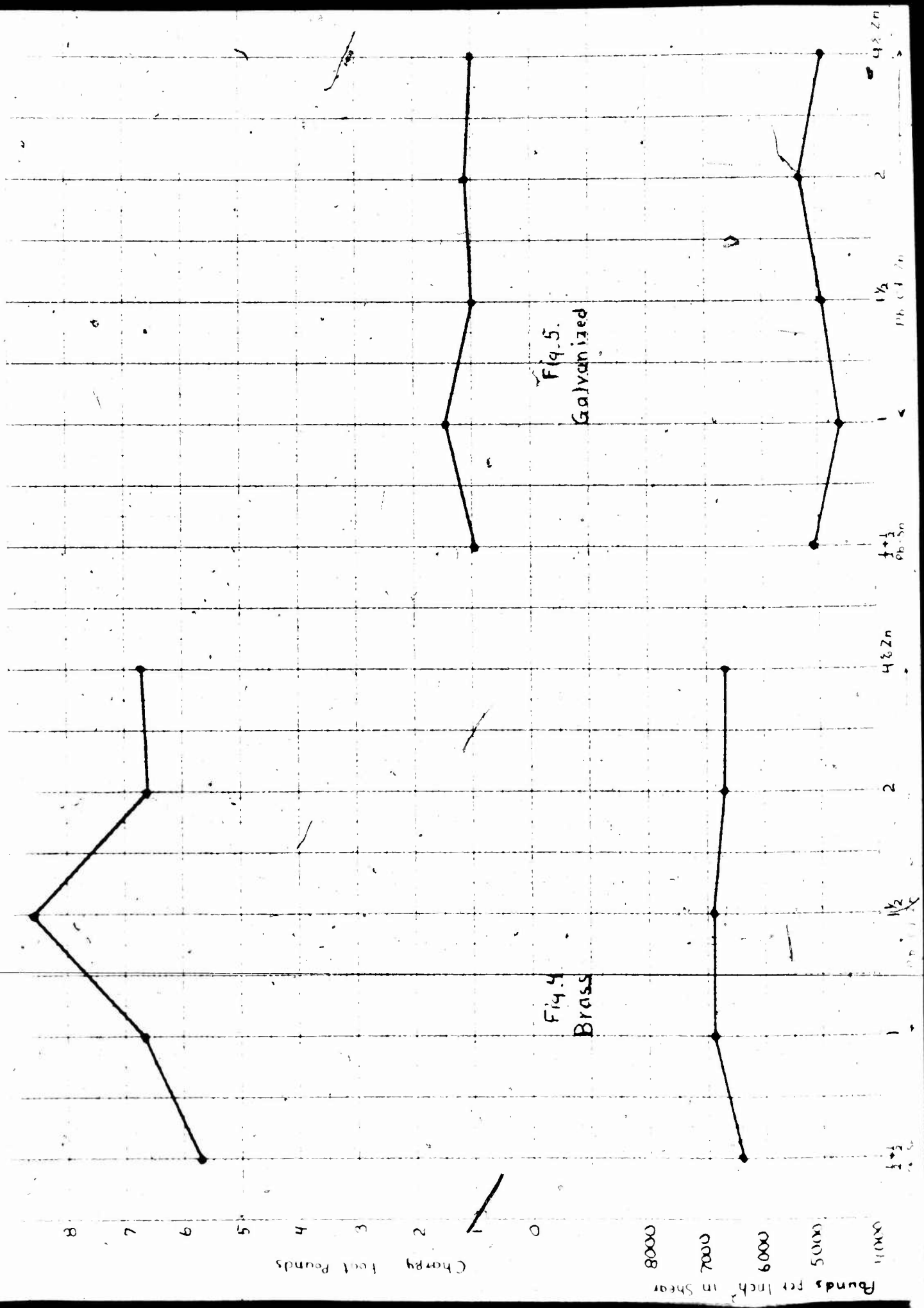


Fig. 3
Texne Plate

Chord Foot Pounds

Pounds per Inch² in Shear

1 1/2 2 4&20



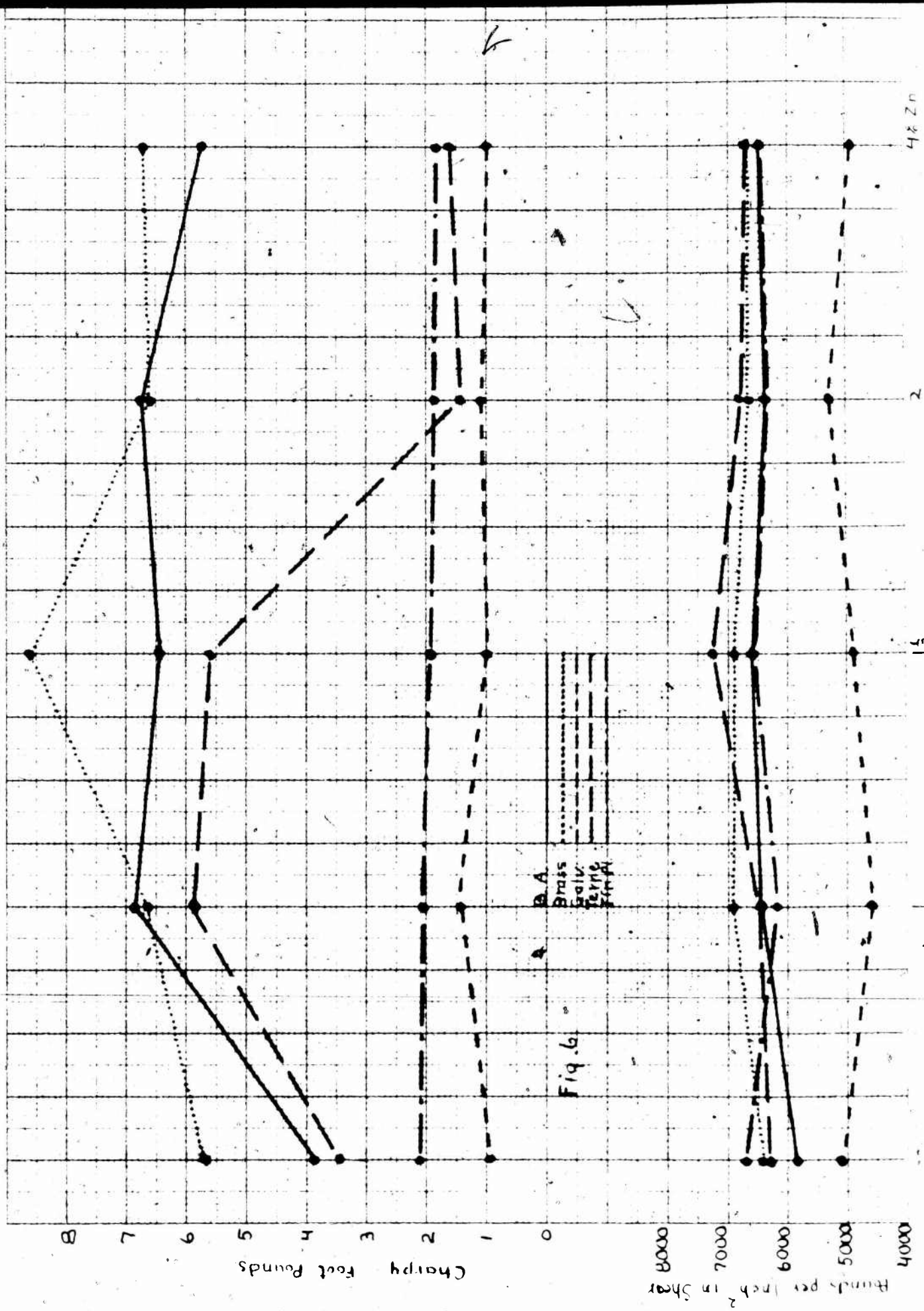
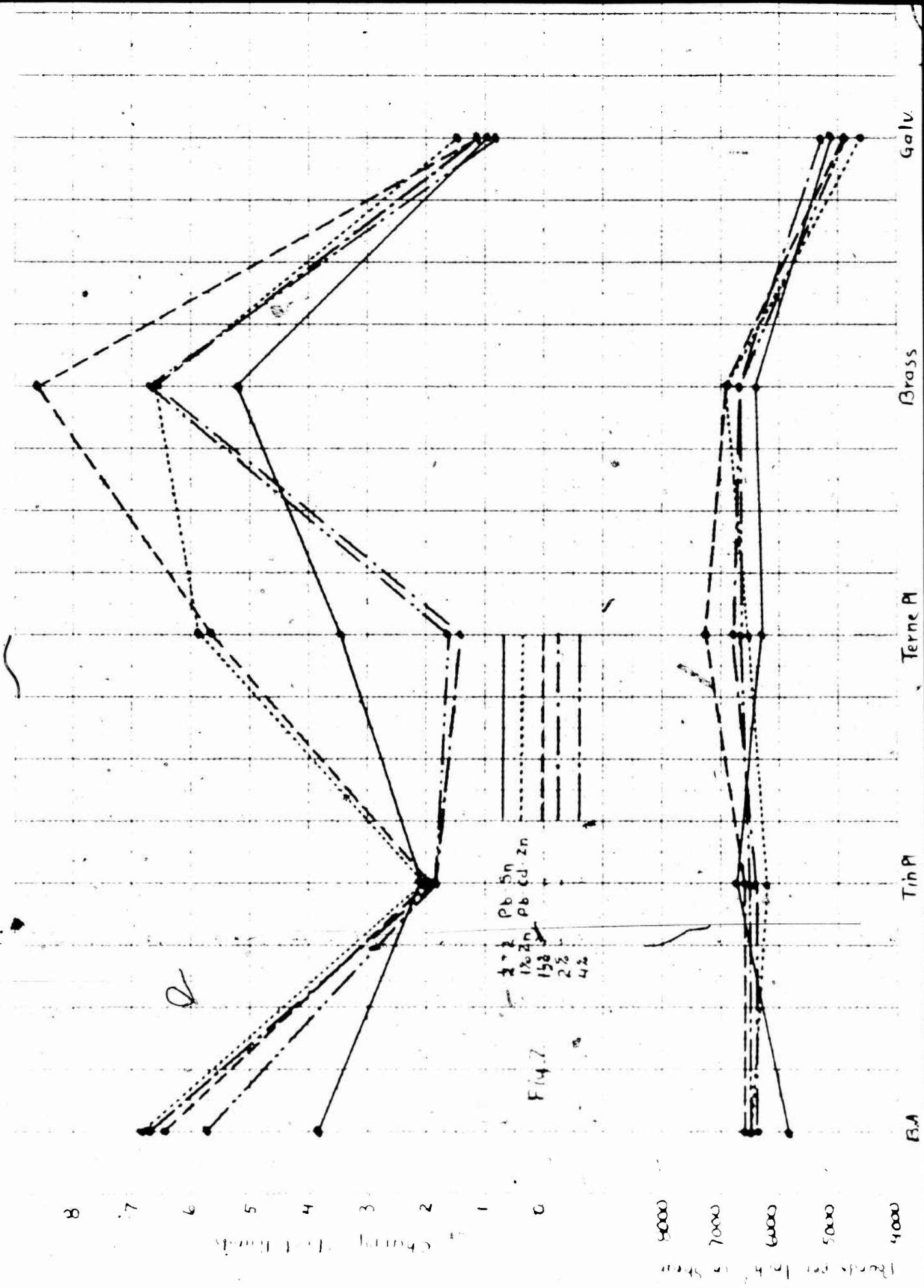


Fig. 6



8000
7000
6000
5000
4000