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O T T A W A June 6th, 1944.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1660.

Examination of CTL-112 Guide Rod Nuts
with Projection Welded Flanges.

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(Copy No. 10.)

Bureau of Mines
Division of Metallic
Minerals

Physical Metallurgy
Research Laboratories

Department of
Mines and Resources

Mines and Geology Branch

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Origin of Material:

On May 15th, 1944, Mr. R. J. Robinson, of the Automotive Design Division, through the Director of Metallurgy, Army Engineering Design Branch, Department of Munitions and Supply, Ottawa, Ontario, submitted samples of guide rod nuts, with projection welded flanges, for examination. In the past, these flanged nuts have been machined from round stock. It is desired to replace these completely machined nuts with those assembled by projection welding. The latter are made from hexagon bar stock and 5/32-inch sheet steel. It is readily recognized that if this substitution is successful a considerable saving in machining, material and labour can be effected.

Also submitted was a report of the Engineering Department of the Ford Motor Co. of Canada, Windsor, Ontario, giving the results of a field test on similarly welded nuts. After 5,220 miles the flanges were found to be severely deformed but still firmly attached to the body of the nut. A photograph

(Origin of Material, cont'd) -

showing the condition of the nuts after field trials was attached to the report, a copy of which is incorporated in this investigation (see Figure 1).

The samples submitted were not those that had undergone field trials, but consisted of one welded assembly, one solid section of hexagon bar stock, and one flange plate ready for welding.

Object of Investigation:

(1) To examine the welding of the sample submitted.

(2) To make recommendations to improve the assembly, if this is desirable.

(3) To assess the acceptability of the welded assembly as a replacement for the machined flanged nut.

Procedure:

1. The samples submitted were subjected to a careful visual examination. Figure 2 shows the samples in the "as received" condition. Figure 3 is a close-up of the welded assembly. Note the welding areas revealed by the bluing of the steel. Figure 4 shows the weld areas on the inside of the nut. Note the complete penetration of molten metal.

2. A chemical analysis of the sample of hexagon bar stock showed considerable similarity to SAE 1113. The following table lists the analysis obtained and that of SAE 1113, for the purpose of comparison.

		Hexagon Bar Stock	Specified for SAE 1113
		- Per Cent -	
Carbon	-	0.14	0.08-0.13
Phosphorus	-	0.113	0.09-0.13
Sulphur	-	0.287	0.24-0.33
Manganese	-	1.00	0.60-0.90
Silicon	-	Trace.	-
Chrimium	-	None.	-
Nickel	-	None.	-
Molybdenum	-	Trace.	-

3. The welded assembly was sectioned through two

(Procedure, cont'd) -

welds. Figures 5 and 6 show these macro sections after polishing and etching. Note incomplete penetration of molten metal to outside of nut.

4. Both samples were subjected to a micro-examination. Figure 7 shows an area of lack of fusion towards the outside of a weld. Figure 8 shows the same area after etching. Figure 9 shows the typical fusion line between the nut and flange. Figure 10 shows the same area after etching. Figure 11 reveals the structure of the heat-affected zone of the nut material very close to the fusion line. Figures 12 and 13 show the normal structures of the nut and flange materials respectively.

5. Hardness readings, using a Vickers machine and a 10-kilogram load, were obtained on the nut, weld and flange material. The figures listed below are the averages of four readings in each case:

Area Tested		Vickers Hardness Number
Normal nut material	-	216
Normal flange material	-	135
Heat-affected zone of nut material	-	405

6. One section of the welded assembly was clamped in a vise and the flange hammered off the nut. It was found that a considerable number of blows were necessary to fracture the welds and that the flange material deformed severely before fracture took place. An examination of the welds revealed that good penetration of the embossments into the nut material had been secured and that the welded area ranged from ¼ to 5/16 inch in diameter.

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Discussion:

A visual examination of the welded assembly revealed that from the centre of the weld the molten metal had penetrated completely to the inside of the nut, whereas penetration had not been secured from the centre to the outside. This is confirmed by the macroscopic and microscopic examinations.

The chemical analysis of the hexagon bar stock indicates that the steel manufacturer was aiming at an SAE 1113 composition. The steel is slightly higher in carbon and manganese contents than the specification would allow and contains residual molybdenum. The small trace of silicon indicates the following steelmaking practice: Standard additions to the melt were used, and, due to high ore percentages or oxidized metal, insufficient silicon remained to kill the steel. Killing was probably brought about by additions of aluminium. With these conditions of manufacture the steel might have low impact resistance. Unfortunately, insufficient material was submitted to permit making impact tests.

From the standpoint of welding, steels high in phosphorus and sulphur may prove troublesome. In a severely banded or laminated steel the phosphorus and sulphur may attain high concentrat ion within bands. Should a weld area coincide with a band the result might well be a weld with a phosphide stringer along the fusion line. Such a weld would be weak. In summary, it may be stated that the steel might prove to be satisfactory, but consideration should be given to change to another analysis (such as SAE 1010) before production of large quantities of these assemblies is undertaken.

The design of the projection welding appears to be quite suitable. Although a cone-shaped embossing die has been used, the result has been a round projection. Since in this type of welding the weld grows from the centre outwards, the

(Discussion, cont'd) -

round projection is desirable to obtain uniform weld growth. Since the welding operation involves making six welds simultaneously, the tops of the projections should all be in the same plane. This means, of course, that all projections should be of the same height. Should some projections be higher than others the welding current would tend to shunt through those projections and this would result either in no welding at the lower projections or in weak welds due to lack of fusion.

The normal structures of the nut and flange materials reveal nothing unusual. The nut material shows the banded structure characteristic of hot-rolled steel and also numerous manganese sulphide inclusions which are typical of free-machining steels. The flange material is apparently a low-carbon steel. Unfortunately, insufficient material was available for chemical analysis of this part.

The presence of low-carbon martensite along the fusion line of the nut material is to be expected in this type of welding. Under very severe impact conditions this hardened zone might produce brittle cracking. However, should this occur the condition can be rectified by following the welding operation closely with several surges of current. This would retard the cooling rate and prevent the formation of martensite.

The hardness readings show nothing abnormal. The high hardness of the heat-affected zone of the nut material confirms the formation of martensite which was detected in the microscopic examination.

The fracture test indicates that the welds have considerable strength. As previously noted, the flange material deformed severely before the welds fractured. Weld penetration was good and the weld area ranged from ¼ to 5/16 inch in

(Discussion, cont'd) -

diameter. The lack of fusion towards the outside of the nut is to be expected, since the width of material is 3/8 inch at the welding zone.

CONCLUSIONS:

1. The design of the assembly is satisfactory and the strength secured is of a high order. The round type of projection used is the best for this job.

2. The nut material is of SAE 1113 composition.

3. Projection heights are not as uniform as is desirable.

4. Martensite has been formed in the heat-affected zones of nut material.

Recommendations:

1. The composition of the nut material is such that difficulties might be encountered with heavily banded or laminated steel. A change to SAE 1010 steel should be considered before large-scale production is started.

2. The die used to emboss the flange material should be checked to ensure that all projections are of the same height.

3. Should brittle weld failures be encountered they will probably be due to the formation of martensitic structures along the fusion lines. This condition may be eliminated by following the welding operation closely with several surges of current while the assembly is still in the welding machine.

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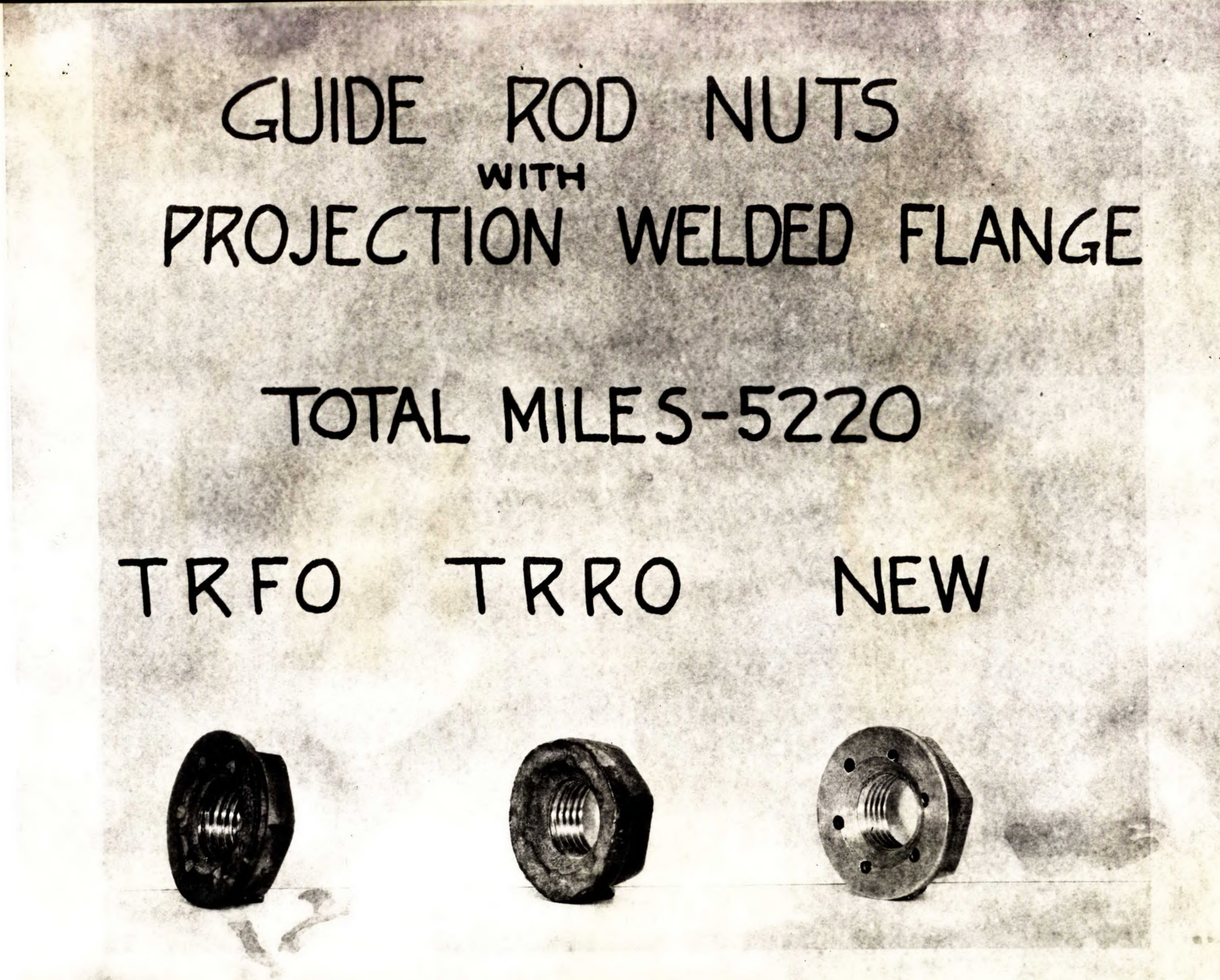
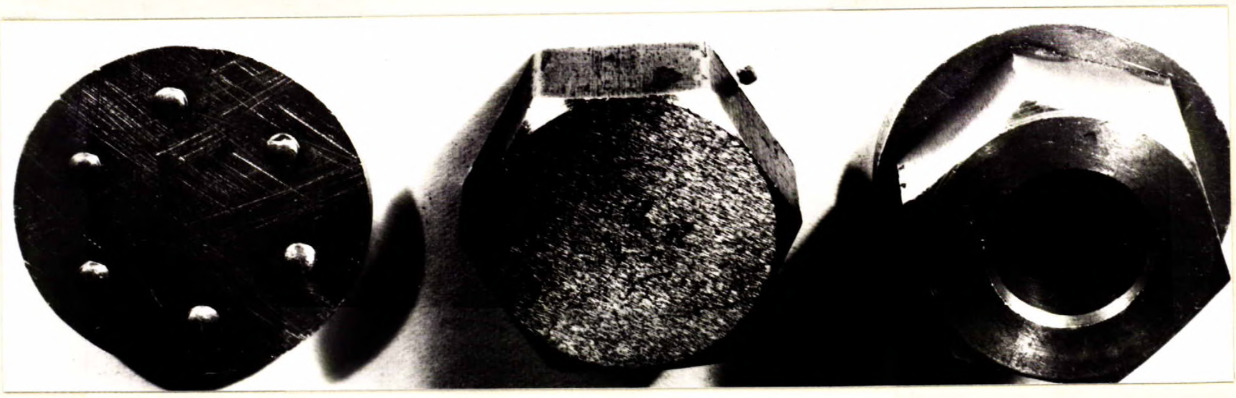

GUIDE ROD NUTS
WITH
PROJECTION WELDED FLANGE
TOTAL MILES-5220
TRFO
TRRO
NEW

Figure 1.

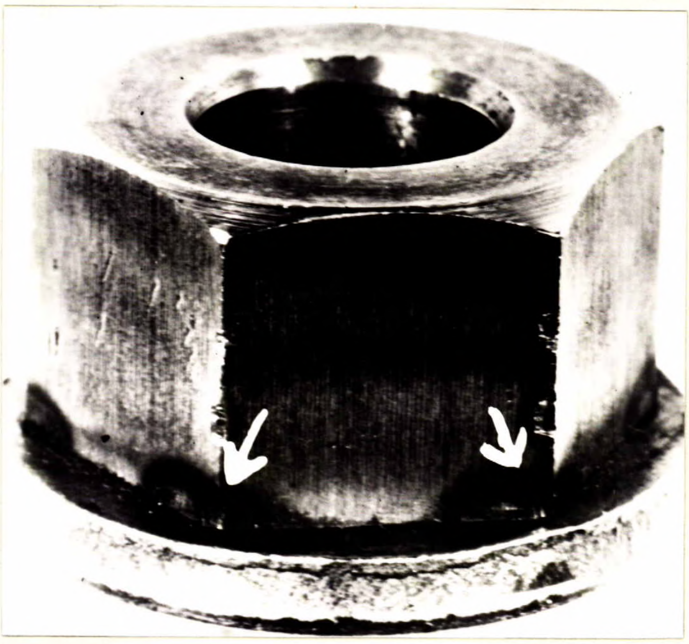
Figure 2.



SAMPLES AS RECEIVED.

From left to right: embossed flange plate, section of hexagon bar stock, and welded assembly.

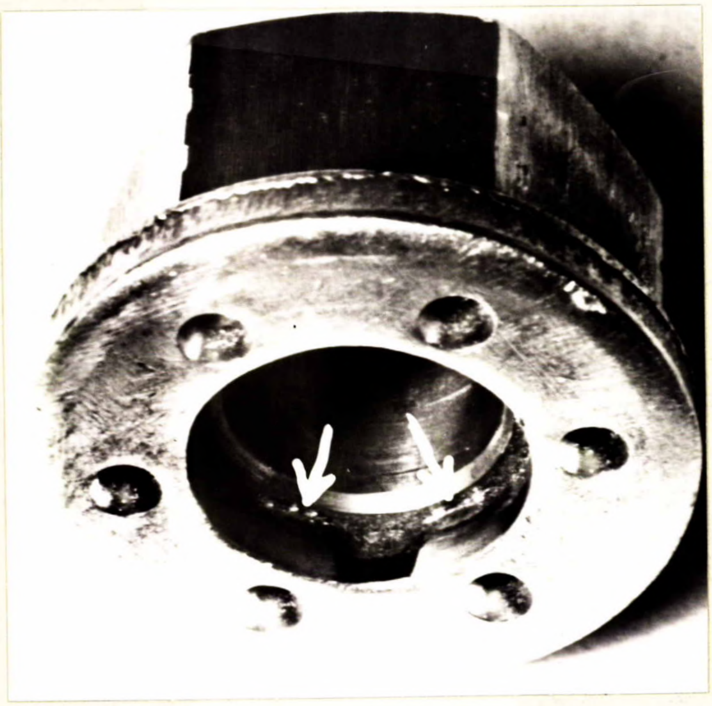
Figure 3.



WELDED ASSEMBLY AS RECEIVED.

Note weld areas at points of nut and also lack of complete penetration of weld metal.

Figure 4.



WELDED ASSEMBLY AS RECEIVED.

Note complete penetration of weld metal.

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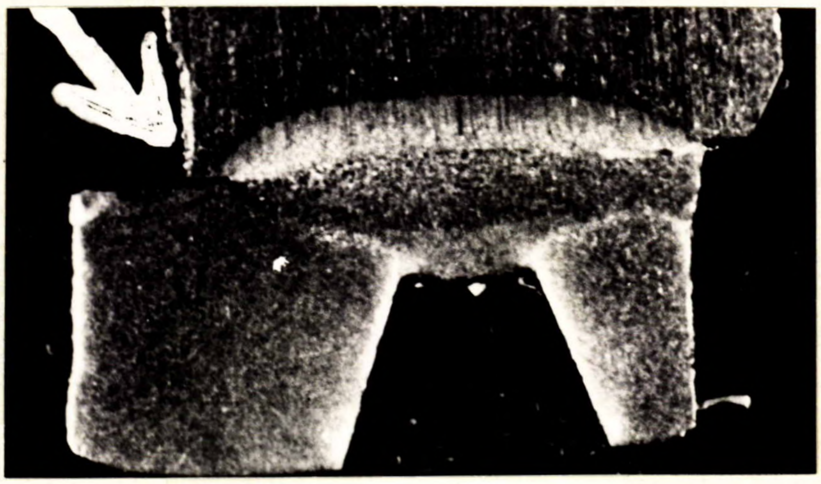
Figure 5.



POLISHED AND ETCHED MACRO SAMPLE.

Note lack of penetration to outside of nut material. Note also good penetration of projection into the nut material.

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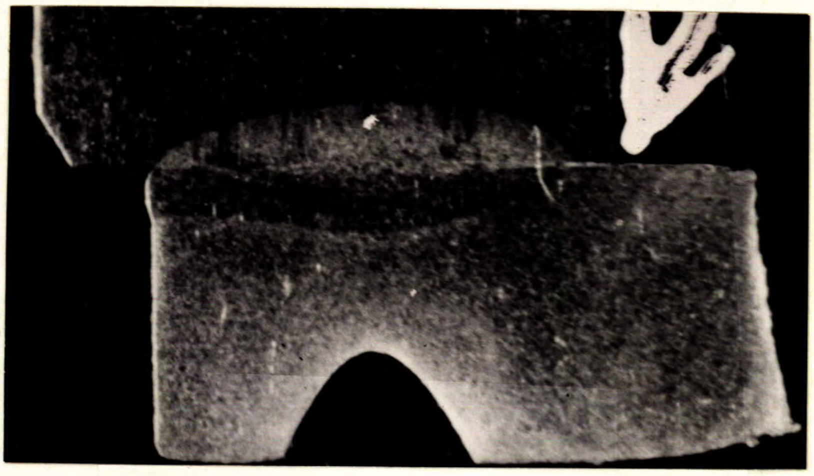
Figure 6.



POLISHED AND ETCHED MACRO SAMPLE.

Note lack of penetration to outside of nut material. Note also good penetration of projection into nut material.

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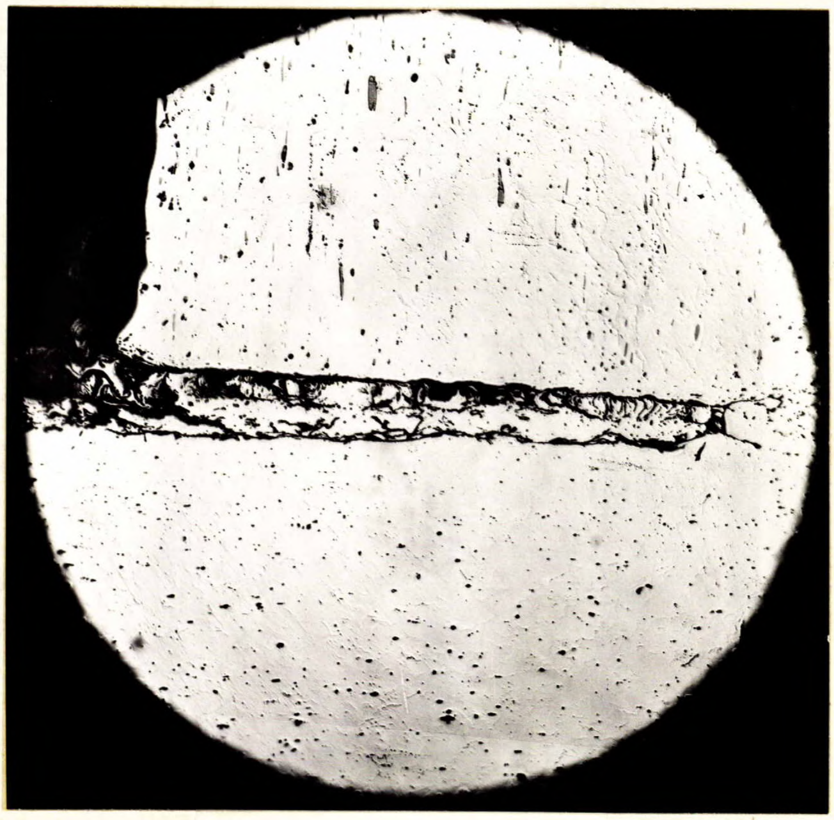
Figure 7.



X80, unetched.

AREA OF LACK OF FUSION TOWARD OUTSIDE OF NUT MATERIAL.

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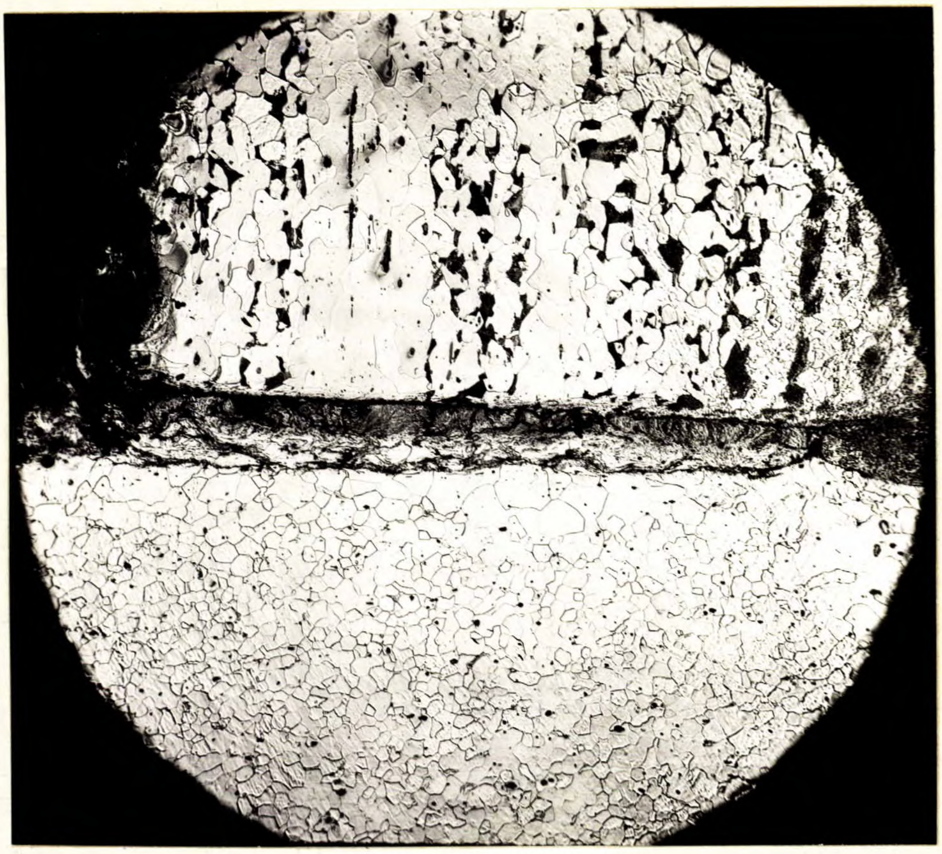
Figure 8.



X100, etched in 2 per cent nital.

SAME AREA AS FIGURE 7, AFTER ETCHING.

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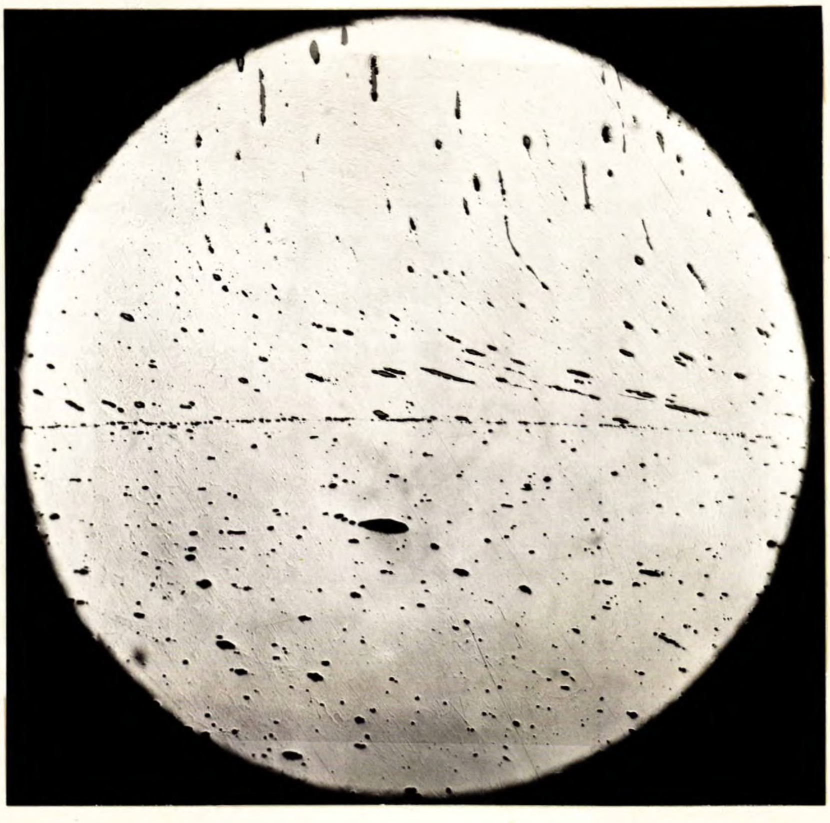
Figure 9.



X80, unetched.

TYPICAL FUSION LINE.
Note sulphide inclusions.

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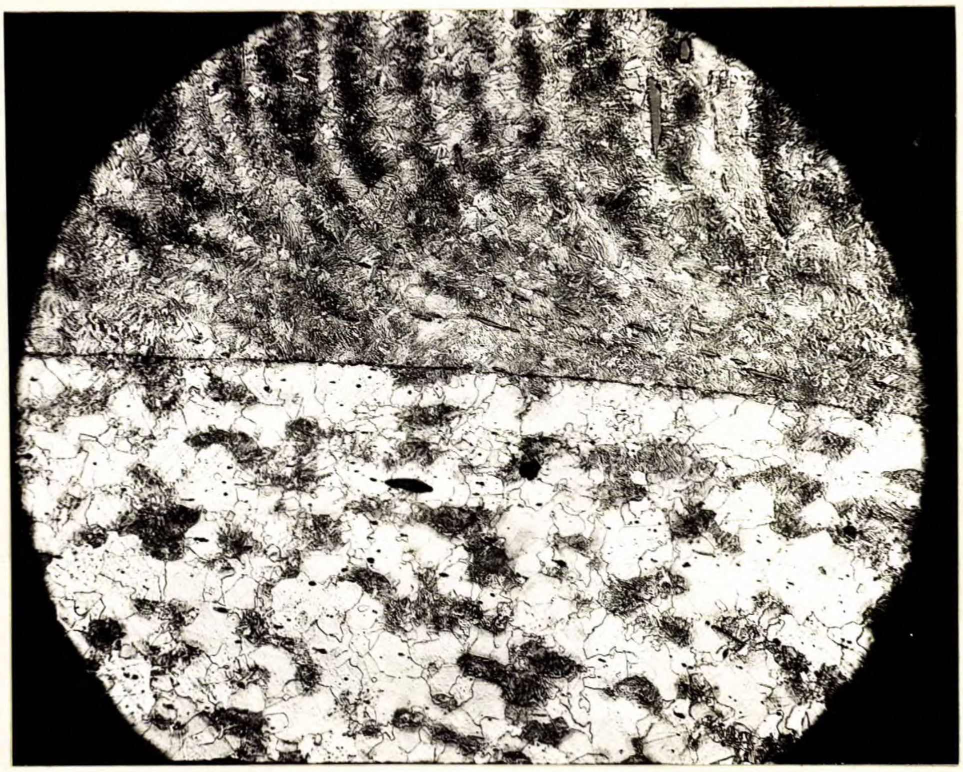
Figure 10.



X100, etched in 2 per cent nital.

SAME AREA AS FIGURE 9, AFTER ETCHING.

-

Figure 11.

X500, etched in 2 per cent nital.

MARTENSITIC STRUCTURE OF HEAT-AFFECTED ZONE OF NUT MATERIAL.

Hardness, 405 Vickers.

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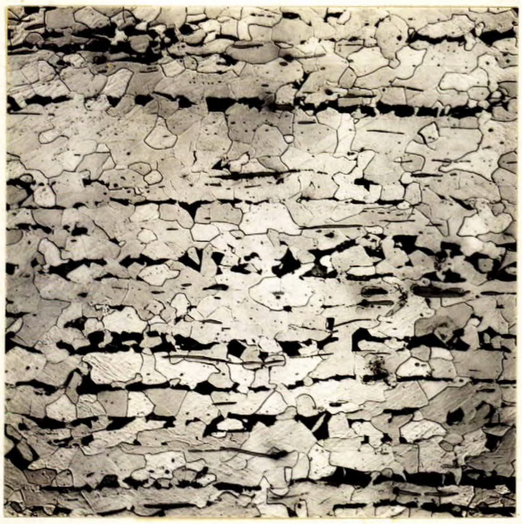
Figure 12.



X100, etched in 2 per cent nital.

BANDED STRUCTURE OF NORMAL NUT MATERIAL, TYPICAL OF HOT-ROLLED STEEL.

Note numerous manganese sulphide inclusions.

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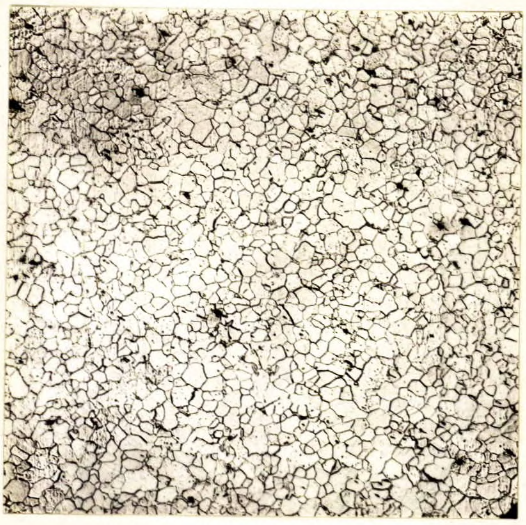
Figure 13.



X100, etched in 2 per cent nital.

STRUCTURE OF FLANGE MATERIAL, TYPICAL OF LOW-CARBON STEEL.

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