OTTAWA August 30th, 1943.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1485.

Examination of Snowmobile Bogie Wheel Suspension Assemblies made by the Bombardier Snowmobiles, Limited, Valcourt, Quebec.

(Copy No. 10.)

Bureau of Mines
Division of Metallic
Minerals
-
Ore Dressing
and Metallurgical
Laboratories

CANADA

DEPARTMENT
OF
MINES AND RESOURCES

Mines and Geology Branch

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Origin of Material:

On August 13th, 1943, Prof. J. U. MacEwan, Consultant to the Director of Metallurgy, Army Engineering Design Branch, Department of Munitions and Supply, Ottawa, Ontario, submitted the following snowmobile materials for examination:

One shaft ring, broken in field tests.

Four complete bogie wheel suspension assemblies, numbered 1, 2, 4 and 5.

Assemblies Nos. 1 and 2 (see Figure 5) are of the type in which the shaft ring is attached to the pipe frame by means of a fillet weld around the end of the pipe frame. Assembly No. 4 (see Figure 9) is of the type in which the shaft ring is attached to the pipe frame by means

(Origin of Material, cont'd) -

of a complete strap fillet welded to the shaft ring and pipe frame. Assembly No. 5 (see Figure 8) is of the type in which the shaft ring is attached to the pipe frame by means of a split strap fillet welded to the ring and pipe frame.

It is understood that these assemblies are fabricated from SAE 1020 steel and welded with Stelco No. 604 (A.W.S. E 6012) electrode, 5/32-inch diameter.

Object of Investigation:

1. To determine the cause of failure of the shaft ring broken in service.

2. To examine the welding of the submitted assemblies with a view to detecting defects and making recommendations designed to eliminate them.

3. To advise on the suitability of the material and the welding electrode used.

4. To determine the effect of stress relief on distortion of the assembly.

5. To recommend welding techniques and assembly methods.

Procedure:

(1). The broken shaft ring and assemblies were given a complete visual examination.

(2). The welds joining the shaft rings to the frame were subjected to an X-ray examination at the National Research Council, Ottawa. Figures 1 to 4 are prints of the exographs of some of the welds and illustrate the defects found. In examining these prints it should be borne in mind that there is an inevitable loss of sensitivity in the reproduction process and that the colours are the reverse of the exograph itself.

(3). Figure 5 shows the general shape of the assembly as received (Assembly No. 1). Figure 6 is a photograph of the

(Procedure, cont'd) -

shaft rings of Assembly No. 2 showing the fillet weld joining the pipe frame and the shaft rings. Note the width and irregularity of the weld and also undercutting as indicated by the arrow. Figure 7 is a close-up photograph of the opposite side of Assembly No. 2. Note the excessive width of the weld. Figures 8 and 9 show the split strap and complete strap methods, respectively, of attaching the shaft ring to the pipe frame. Figure 10 is a photograph of a fillet weld joining a strap to a shaft ring. Note the severe undercutting typical of all of these welds.

(4). The broken shaft ring was sectioned and examined under the microscope. Figures 11 and 12 are structures adjacent to, and ½ inch from, the fracture respectively. Hardness readings were taken in the same areas, using a Vickers machine and a 10-kilogram load. In both areas the hardness was 151 Vickers pyramid hardness.

(5). Assembly No. 2 was sectioned through the welds joining the shaft ring to the pipe frame in areas in which defects were shown in the X-ray examination. Figure 13 shows two typical sections (numbered 9 and 10). The remainder of the assembly was sectioned at random to secure typical samples of all welded joints in the assembly. Figures 14 and 15 show these samples (numbered 1 to 8).

(6). A chemical analysis of the shaft ring of Assembly No. 2 produced the following results:

		Per cent
Carbon	-	0.12
Manganese	-	0.48
Silicon	-	0.06
Sulphur	-	0.027
Phosphorus	-	0.009
Chromium	-	0.06
Nickel	-	None
Molybdenum	-	0.03
Vanadium	-	None

(Procedure, cont'd) -

(7). Assemblies Nos. 1 and 5 were stress-relieved by the following treatment: The assemblies were charged into a cold furnace and brought to a temperature of 1200° F. in four hours, soaked at this temperature for 1 hour, and cooled to room temperature in the furnace. Rough measurements before and after the treatment indicated that no gross distortion had taken place.

Discussion:

Visual and microscopic examinations, together with hardness tests, fail to reveal any metallurgical reason for failure of the broken shaft ring. It was noted that the thickness of this broken ring was 3/16 inch whereas the same part in the test assemblies was 3/8 inch in thickness, indicating that the broken part was too thin to stand the stresses of service and that this had been recognized and corrected in the test assemblies. In the absence of any conclusive proof as to cause of failure, it is only possible to offer for consideration the possibility of overstressing in test.

The chemical analysis of the shaft ring of Assembly No. 2 indicates that this part has been made from an SAE 1010 or 1015 steel with some alloy residuals, and not from SAE 1020 as specified. It is our opinion that SAE 1020 should be satisfactory for this part and has the advantage (as has SAE 1015) of being insensitive to the thermal cycle of welding.

The lack of distortion after stress relief indicates either low, locked-up stresses or well-balanced higher stresses. In either case, stress relief may or may not be necessary. This can only be established by field tests on assemblies in the 'as welded' and 'stress-relieved' conditions and a comparison

(Discussion, cont'd) -

of the results obtained.

The electrode used conforms to the A.W.S. E 6012 specification and is sometimes referred to as the "poor fit-up" electrode. This is due to the ability of the electrode to bridge over wide gaps in the roots of members to be welded. This characteristic is accompanied by reduced penetration and increased danger of trapping slag in the root of the weld. Properly handled, however, it should produce satisfactory results.

The discovered defects and their probable causes are listed below:

(1) Lack of penetration - partly due to electrode characteristics and partly to too low welding current.

(2) Slag inclusions - partly due to electrode characteristics and partly to too low welding currents.

(3) Undercutting - due to either or both of too high currents or too long an arc.

(4) Incomplete fusion - due to welding steel surfaces not being thoroughly cleaned of scale and slag.

(5) High piled-up welds - due to effort to mask welding defects or to erroneous belief that the weld strength is thereby increased.

(6) Poor fit-up - due to improper or inaccurate measurements of parts to be fitted together.

Of all these defects the first three were by far the most prevalent. Fortunately their cause is very easy to eliminate. In all cases the welding currents specified by the electrode manufacturer should be used and arc length kept to a minimum. These simple precautions should eliminate the most serious of the above defects. In the event that trouble is still encountered, a change to a Stelco No. 804 electrode (A.W.S. E 6030) would be beneficial.

All of the above defects act as stress raisers due

(Discussion, cont'd) -

to the notch effect. Since these assemblies will be subjected to impact and fatigue stresses at low temperatures, the presence of these defects greatly increases the probability of failure. In our opinion the design is satisfactory for welding with a technique which would eliminate the defects and reduce locked-up stresses to a minimum.

CONCLUSIONS:

1. No metallurgical reason was found for the failure of the shaft ring broken in service.

2. The shaft rings in the test assemblies have been made from SAE 1010 or 1015 steel, and not SAE 1020 as specified. SAE 1020 should prove satisfactory for this part.

3. The necessity of stress relief of the assemblies can only be established by field tests of assemblies in the 'as-welded' and 'stress-relieved' conditions and a comparison of the results obtained.

4. The electrode used, properly handled, should be satisfactory. Should the defects persist, a change to Stelco No. 804 (A.W.S. E 6030) would be beneficial

5. The following welding defects were found: Lack of penetration, slag inclusions, undercutting, incomplete fusion, high piled-up welds, and poor fit-up. All of these defects act as stress raisers and would prove serious in low-temperature service.

RECOMMENDATIONS:

1. Residual stresses may be reduced to a minimum by liberal use of tack welds and also by welding long seams from the centre towards the ends.

2. Distortion should be controlled by rigid jigging and by permitting the assembly to cool to low temperatures before removing from the jig.

3. Welding electrodes should be used within the welding current ranges specified by the manufacturer.

4. Arc length should be kept to a minimum at all times.

5. A subassembly technique would also reduce locked-up stresses. A suggested sequence would be: pipe frame assembly, stiffeners and compression spring socket assembly, body plates to pipe frame, and then final assembly.

6. Stiffener plates should be welded from both sides, using 3/16-in. fillet welds.

7. Every effort should be made to improve joint fit-up.

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Figure 1.

Slag inclusions.

Poor penetration at pipe edges.

PRINT OF AN EXOGRAPH OF ASSEMBLY NO. 1.
WELD JOINING SHAFT RING TO PIPE FRAME.

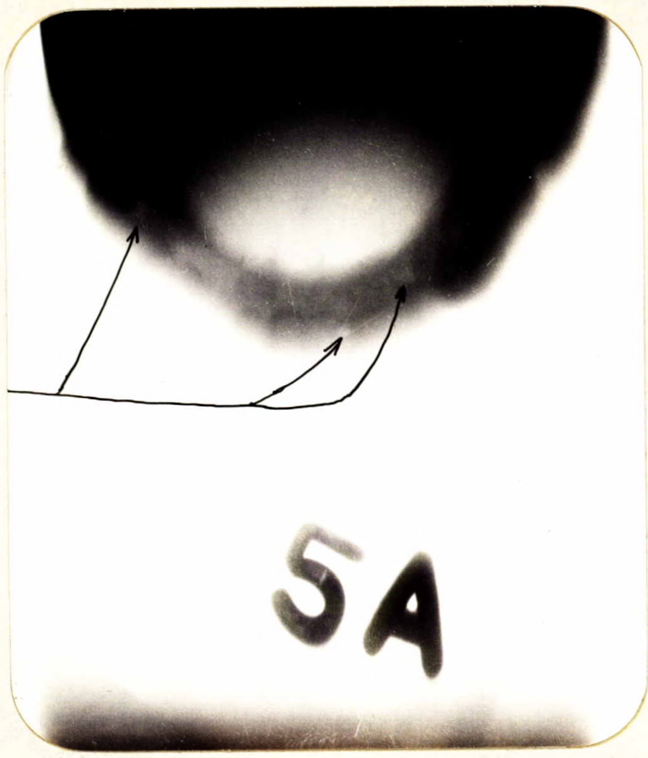
Figure 2.

Slag at root of weld.

PRINT OF AN EXOGRAPH OF ASSEMBLY NO. 5.
WELD JOINING SHAFT RING TO PIPE FRAME.

Figure 3.

Slag inclusions.



PRINT OF AN EXOGRAPH OF ASSEMBLY NO. 5.
WELD JOINING SHAFT RING TO PIPE FRAME.

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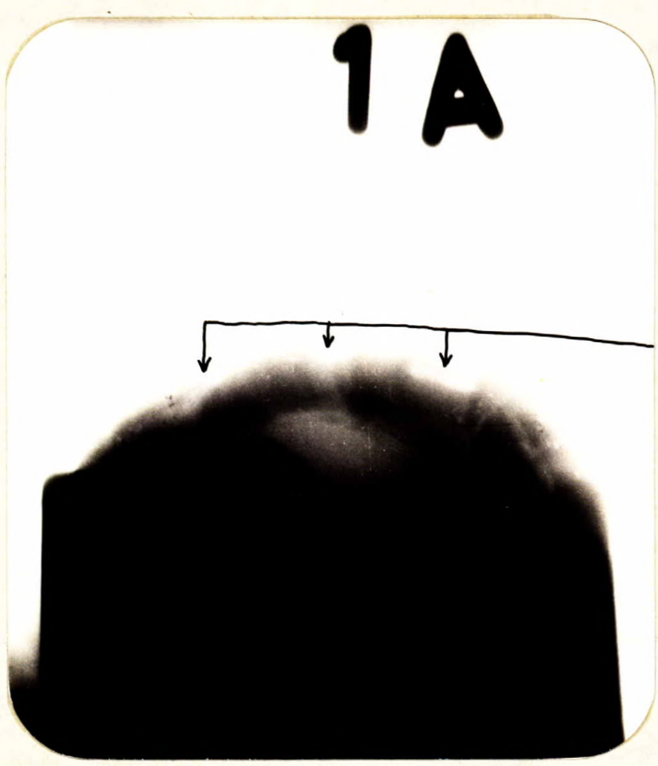
Figure 4.



Slag inclusions.

PRINT OF AN EXOGRAPH OF ASSEMBLY NO. 1.
WELD JOINING SHAFT RING TO PIPE FRAME.

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Figure 5.

GENERAL SHAPE OF BOGIE SUSPENSION ASSEMBLY AS RECEIVED. ASSEMBLY NO. 1.

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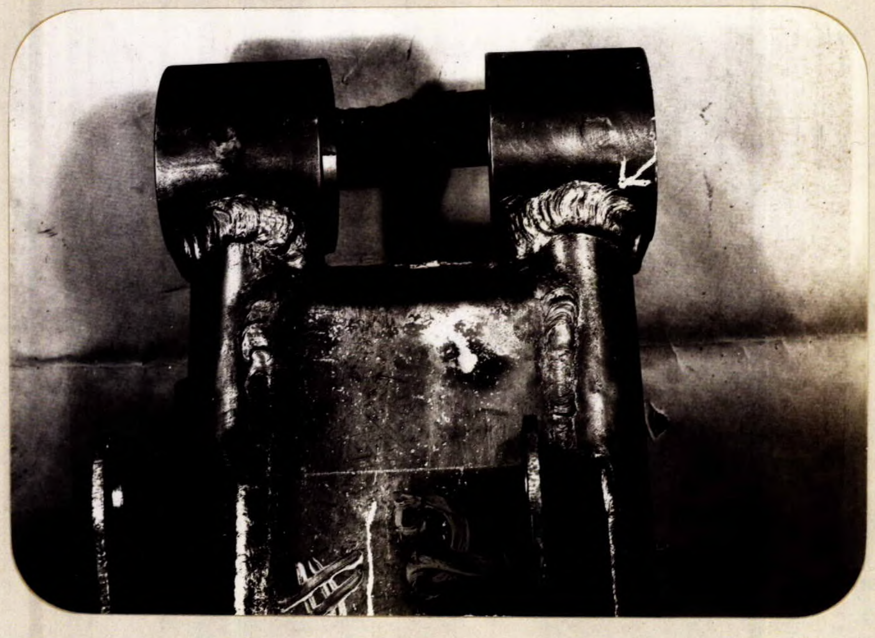
Figure 6.



ASSEMBLY NO. 2. FILLET WELD JOINING SHAFT RING TO PIPE FRAME.

Note width and irregularity of weld, and also undercutting, indicated by arrow.

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Figure 7.

ASSEMBLY NO. 2. - WELD JOINING SHAFT RING TO PIPE FRAME.

Note excessive width of weld.

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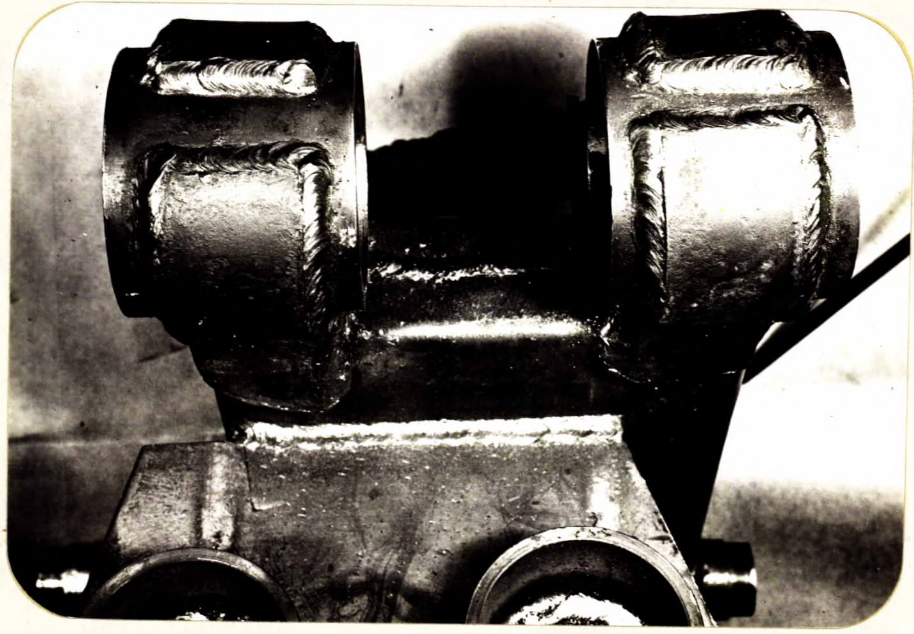
Figure 8.



ASSEMBLY NO. 5. - SPLIT STRAP METHOD OF JOINING SHAFT RING TO PIPE FRAME.

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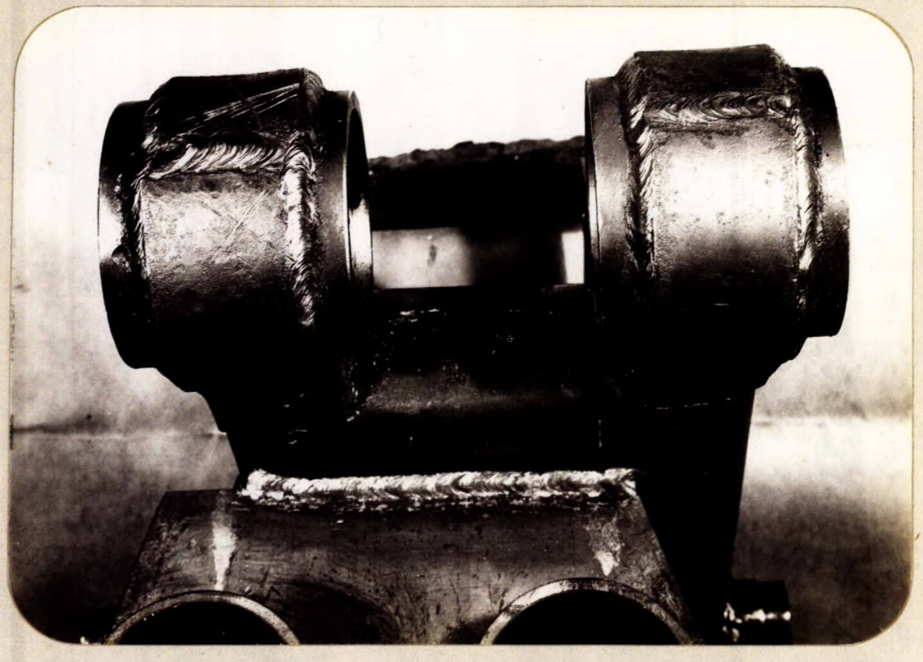
Figure 9.



ASSEMBLY NO. 4. - COMPLETE STRAP METHOD OF JOINING SHAFT RING TO PIPE FRAME.

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Figure 10.

FILLET WELD JOINING A STRAP TO A SHAFT RING.

Note severe undercutting, typical of all of these welds.

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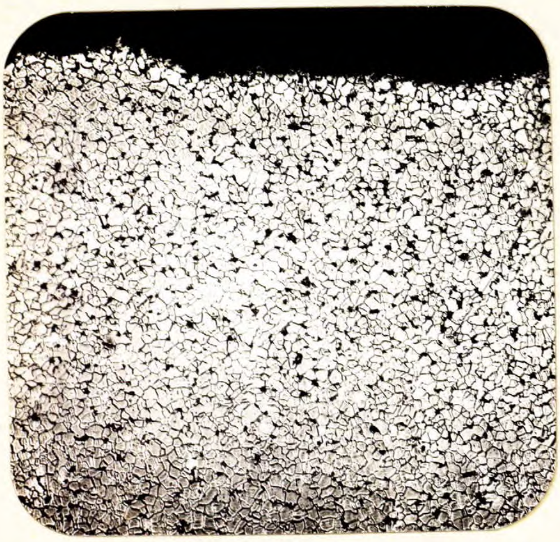
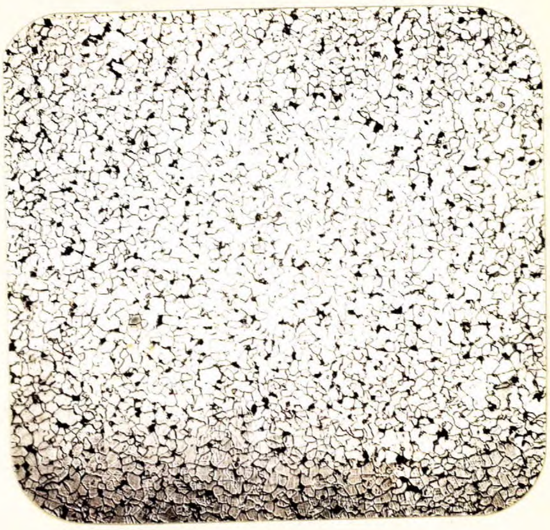
Figure 11.



X100, etched in 2 per cent nital.

STRUCTURE ADJACENT TO FRACTURE.

Figure 12.



X100, etched in 2 per cent nital.

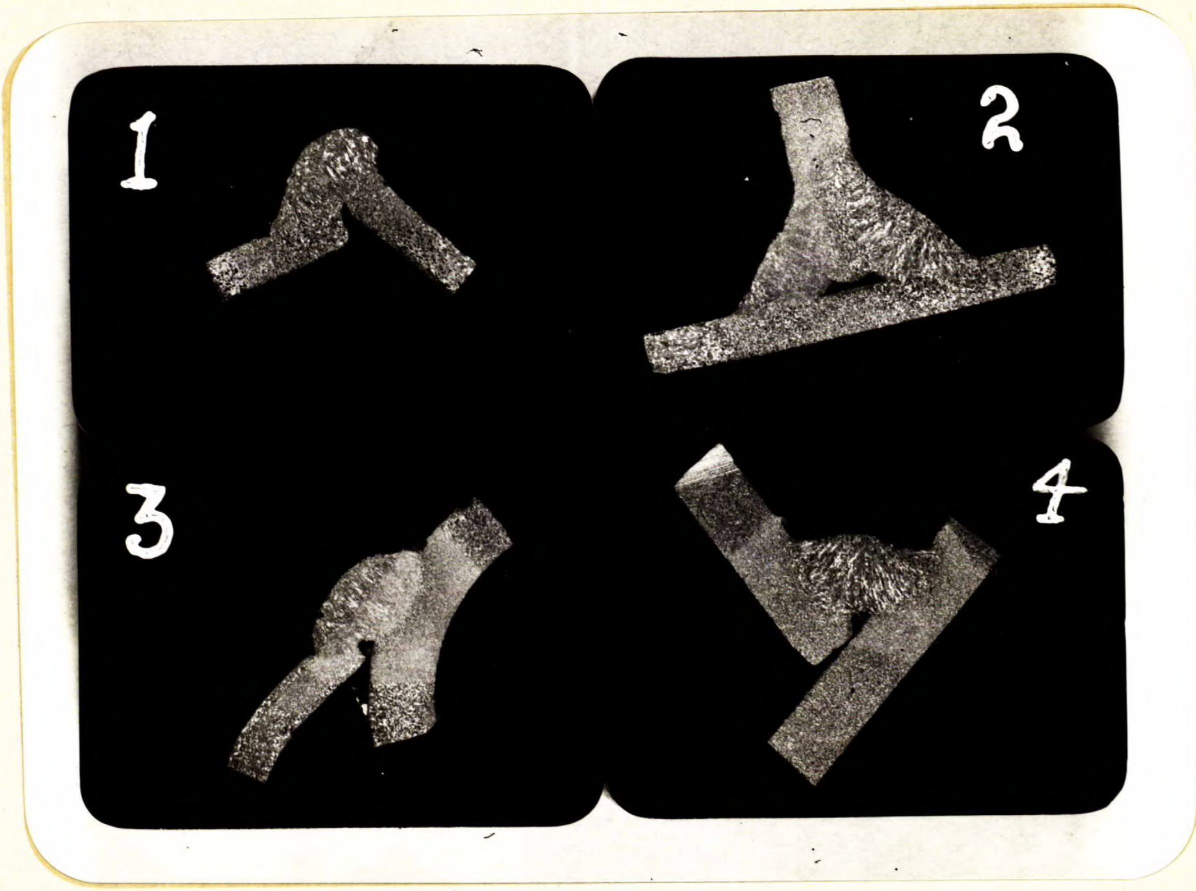
STRUCTURE ½ INCH FROM FRACTURE.

Figure 13.

ASSEMBLY NO. 2. - SECTIONS THROUGH WELD JOINING SHAFT RING TO PIPE FRAME.

Note slag inclusions at root of weld.

Figure 14.



ASSEMBLY NO. 2 - SECTIONS OF VARIOUS WELDED JOINTS.
Note poor penetration, slag inclusions, undercutting, and high, piled-up welds.

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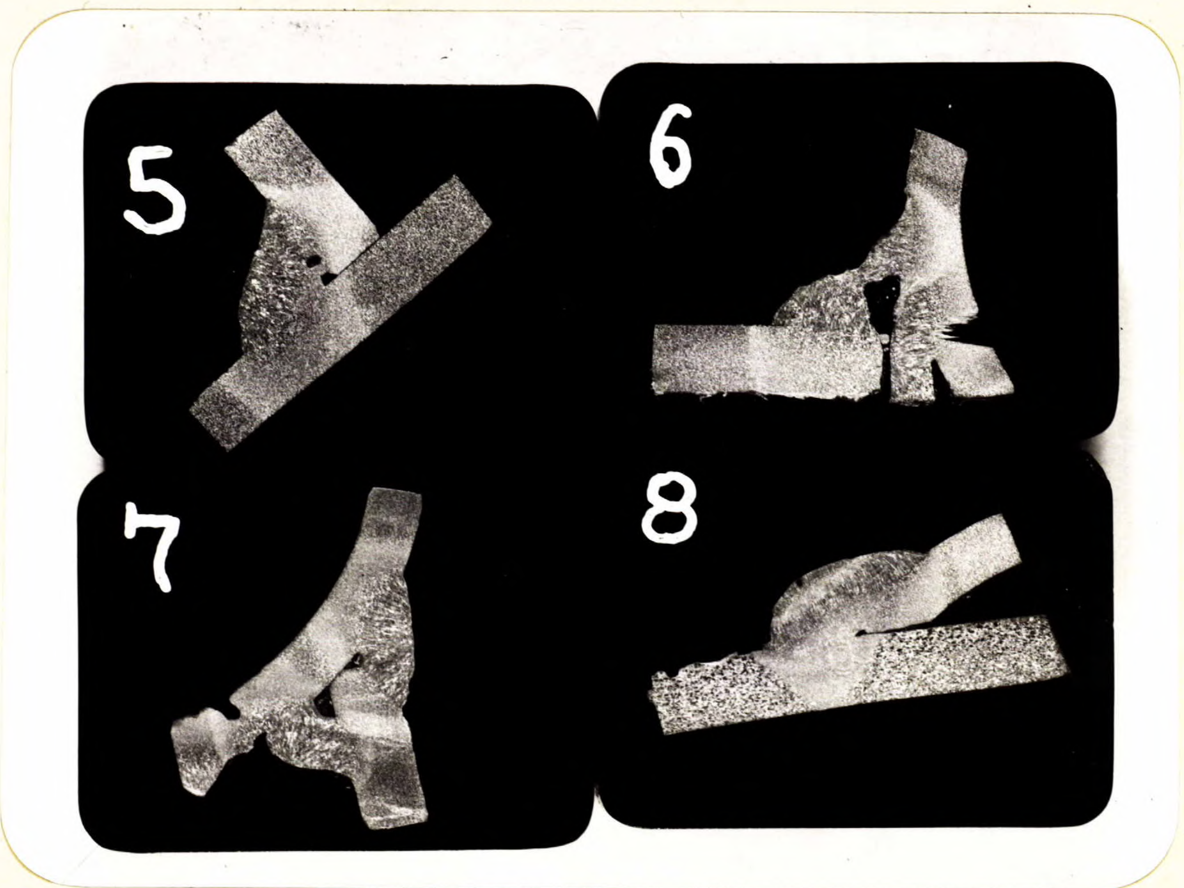
Figure 15.



ASSEMBLY NO. 2. - SECTIONS OF VARIOUS WELDED JOINTS.
Note poor penetration, slag inclusions, undercutting, and high, piled-up welds.

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