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# R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1781.

Examination of Dominion Magnesium Limited
Alloy Steel Retort No. C-951.

(Copy No. 10.)

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**Origin of Material:**

On November 15, 1944, Mr. M. Martinson, of Dominion Magnesium Limited, Haley, Ontario, submitted a section of Retort No. C-951 for examination. In his covering letter, Mr. Martinson gives the following information:

The analysis of the retort (Shawinigan) is as follows:

| Carbon | Manganese | Silicon | Nickel | Chromium | Molybdenum |
|---|---|---|---|---|---|
| | | - Per Cent - | | | |
| 0.21 | 0.52 | 0.57 | 38.48 | 17.98 | 0.20 |

Originally the retort wall thickness was 1 inch. The retort had been blown up eight times and had a total service life of 146 days. Originally the retort failed by cracking along the barrel. This crack was repaired by welding but there was insufficient metal to ensure a proper weld. It failed again at the weld after 6 days of operation. A cross-section of the metal shows it to be less than one inch thick.

**Object of Investigation:**

To determine the cause of failure of the welded repair.

Procedure:

(1) The section of retort was examined in the "as received" condition. Figure 1 shows a photograph of the retort in this condition. Figure 2 is a photograph of the inside of the section, showing the weld repair area and the crack formed in the short additional service. Figure 3 is a photograph of the outside of the retort, where ultimate failure occurred, and shows the cracking extending from the holes.

(2) The section was cut parallel to the cracks by arc gouging and a section through the weld area by means of an abrasive cut-off wheel. The sample was then etched in aqua regia to remove the closely adhering scale and then photographed. Figure 4 shows the bottom or inside of the repair area and the string-bead type of welding.

(3) A thin cross-section of the above sample was secured by means of an abrasive cut-off wheel, etched in aqua regia, and photographed. Figure 5 shows the cross-section of the weld repair and the crack causing the ultimate failure.

Discussion:

The examination of the section of the retort revealed a considerable variation in the wall thickness around the complete periphery.

An examination of the outside of the repair area produced no clue as to the cause of failure of the repair. However, on the inside of the retort the repair area was clearly visible as a depression approximately 3/16 inch in depth below the general level of the retort wall. The sharp edges, regular depth and outline of the depression precluded any possibility of this being the result of localized corrosion.

After removal of the scale from a section of the

(Discussion, cont'd) -

repair area, the bottom of the weld could be seen to be made in a series of string beads running parallel to the major length of the repair. A cross-section of the repair area revealed that the weld thickness was only two-thirds of that of the retort wall. This had left an unwelded root which was fully one-third of the wall thickness, with the result that a deep notch had been formed between the bottom of the weld and the retort wall. Failure by cracking had occurred at this deep notch and once started had progressed beyond the original repair area.

A notch of this type will inevitably produce cracking troubles. The severe stress-raising effect of the defect is such as to readily cause the formation of a crack. It is interesting to note that the crack follows the notch along the entire length of the repair area and extends into the sound metal beyond. This is a normal characteristic of metals in that cracks in highly stressed materials produce their own notch effect and thereby produce progressive failure.

The formation of a notch of the type found is the result of a defective welding procedure. From the appearance of the bottom of the weld it would seem that either a plastic back-up material such as carbon paste had been used or the retort had been positioned so that the bottom layer of the weld was deposited in the manner of horizontal fillet welds. If the plastic back-up material was used it must have projected up into the cavity to be filled with weld metal. If positioning for horizontal welding was used the operator failed to reach the bottom of the repair area. In either case the procedure is defective, in that the full thickness of the retort wall has not been welded.

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Conclusion:

Failure of the welded repair has been the result of a defective welding procedure. This prodedure has resulted in shallow weld with a deep notch at the root. The stress-raising effect of the notch has resulted in cracking.

Recommendations:

1. The welding procedure should be such as to permit welded repairs to be fully as thick as the retort wall.

2. A type of welding joint design previously recommended should be used.

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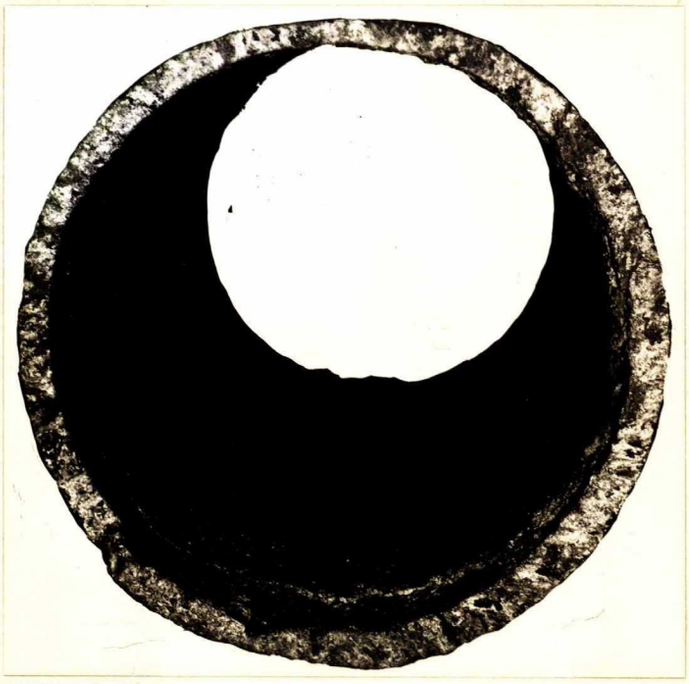
Figure 1.



END VIEW OF SECTION OF RETORT
IN "AS RECEIVED" CONDITION.

Note variations in wall thickness.

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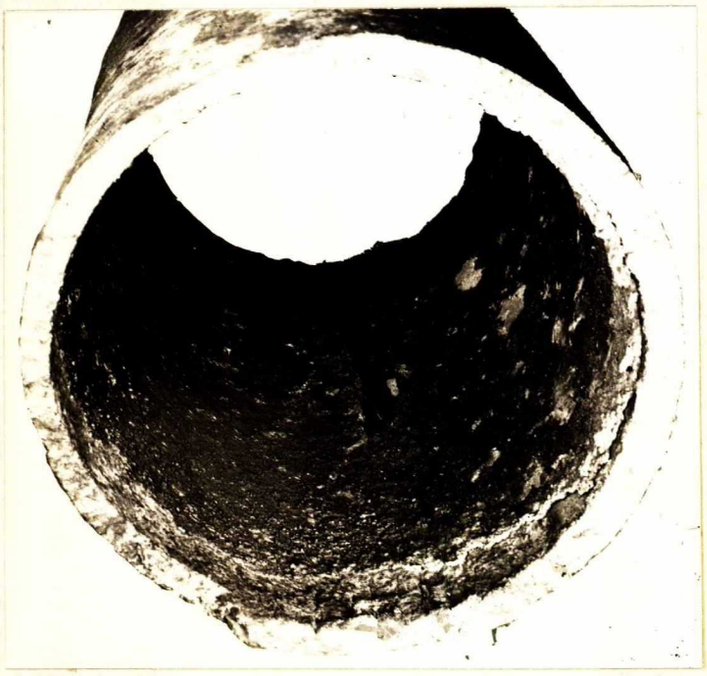
Figure 2.



INSIDE VIEW OF RETORT "AS RECEIVED".

Note depression which is the weld repair area. Note, also, crack extending from the weld repair area out into the retort wall.

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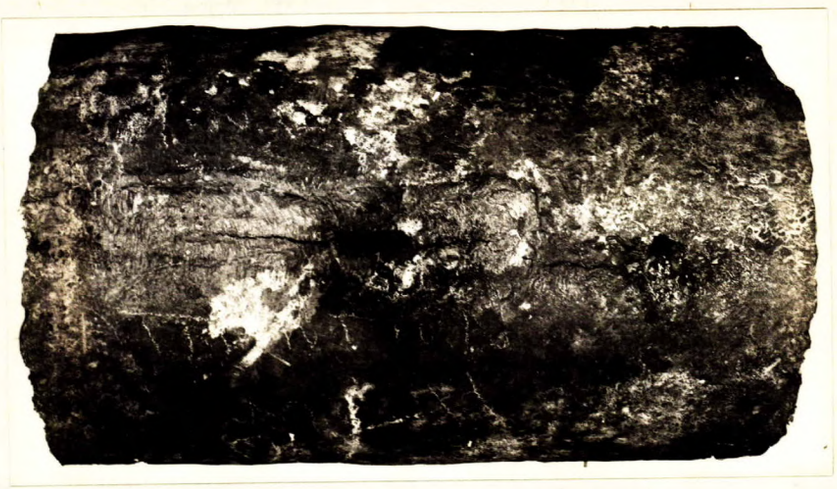
Figure 3.



OUTSIDE OF WELD REPAIR AREA.

Note the cracks in the weld, and their position.

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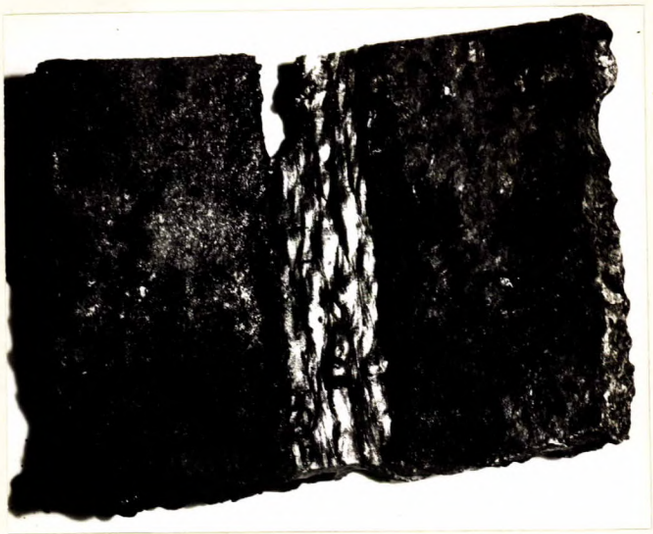
Figure 4.



BOTTOM OF A SECTION OF THE WELD REPAIR AREA AFTER SCALE REMOVAL.

Note string-bead type of weld. Note, also, sharp edges of the depression and the location of a part of one of the holes with relation to the weld.

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Figure 5.

TRANSVERSE SECTION OF WELD REPAIR AREA,
ETCHED IN AQUA REGIA.

Note that weld depth is only approximately two-thirds of retort wall thickness. Note notch at right side of root where cracking has occurred.

(Approximately 3¼ times actual size).

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