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METALLURGICAL EXAMINATION OF FAILED CAP SCREWS FROM MERCURY PUMPS

by

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SUMMARY OF RESULTS

Samples of failed cap screws from mercury pumps produced by Canadian Vickers Limited were examined. The fractures were essentially intercrystalline, having oxidized secondary cracks which resembled caustic corrosion.

Consideration of the service environment, which contains hydrogen, caustic soda and mercury, and of the rapid failure of the original cap screws, indicates that replacement screws should be manufactured from an austenitic stainless steel.

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(5 illus.)

INTRODUCTION

On May 27, 1958, a letter (reference: Contract 34587 IE/SAP/MR) was received from Mr. S. A. Purski, Chief, Machinery Division, Industrial Engineering Department, Canadian Vickers Limited, P.O. Box 550, Place d'Armes Station, Montreal, P. Q., requesting that the Mines Branch investigate the failure of certain cap screws from their mercury pumps.

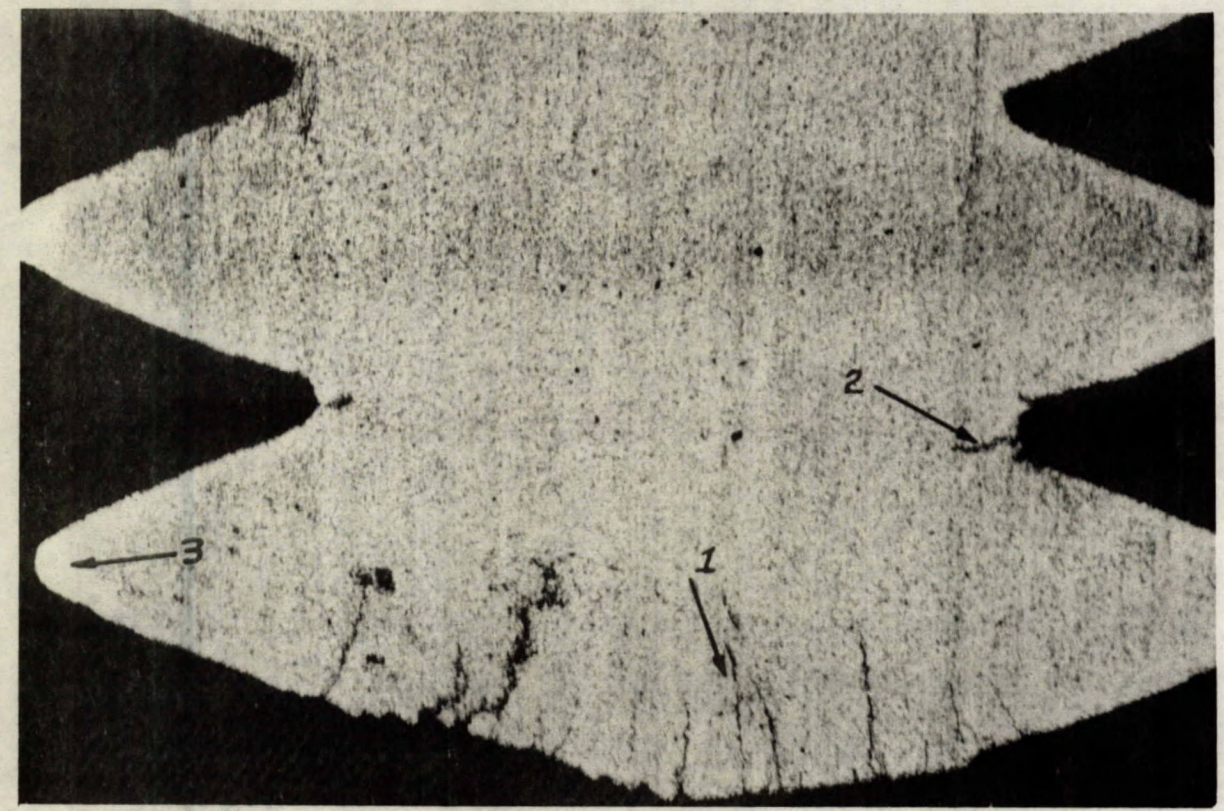
DESCRIPTION OF SAMPLES

Five broken screws were submitted with drawing No. A6, showing their position in the pump assembly. The cap screws are used to hold together the revolving part of the pump (the pump rotor) and the spider. A simple mechanical failure was not suspected as the torque required to revolve the rotor was very small, as shown on the drawing. Proper tightening of the screws should be sufficient to develop the frictional force required.

The screws are in contact with hydrogen, mercury, and caustic solution.

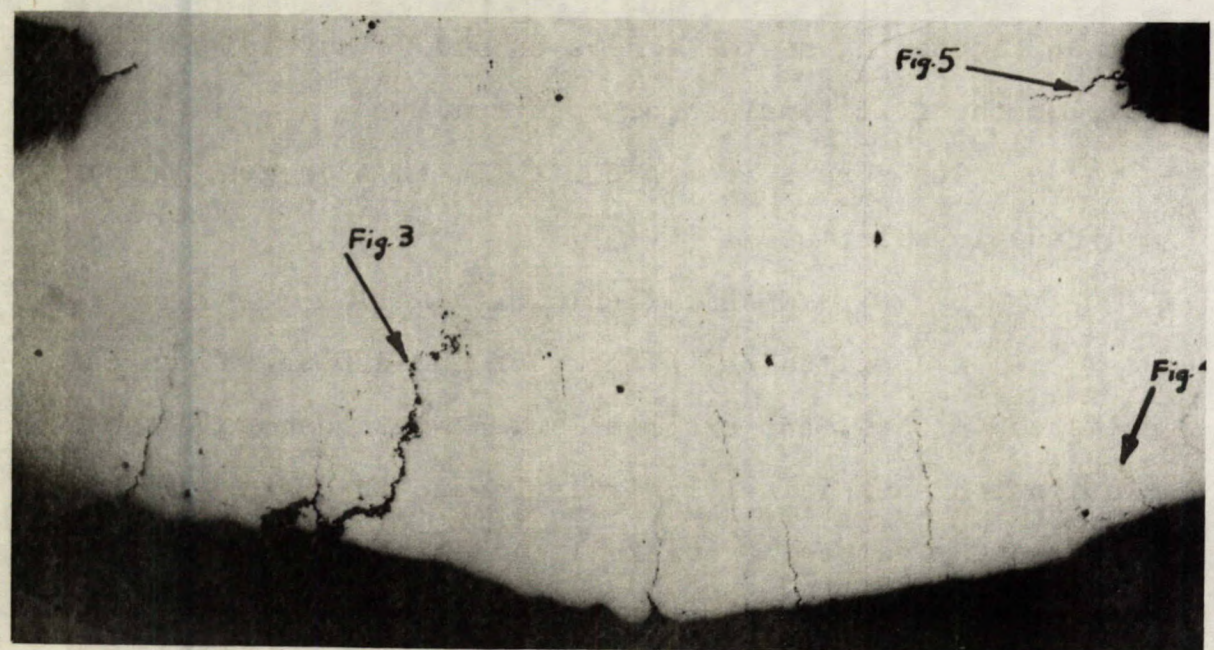
METALLOGRAPHIC EXAMINATION

A longitudinal section of one cap screw was cut, polished, etched, and examined under a microscope. The examination showed that, in addition to the main fractures, there were a number of cracks located at the base of the screw threads, as well as secondary cracks adjacent to the fractured surfaces (see Figures 1 and 2).



(X33, etched in 2% nital)

Fig. 1. - Longitudinal section through cap screw.



(X50, unetched)

Fig. 2. - Longitudinal section through cap screw.

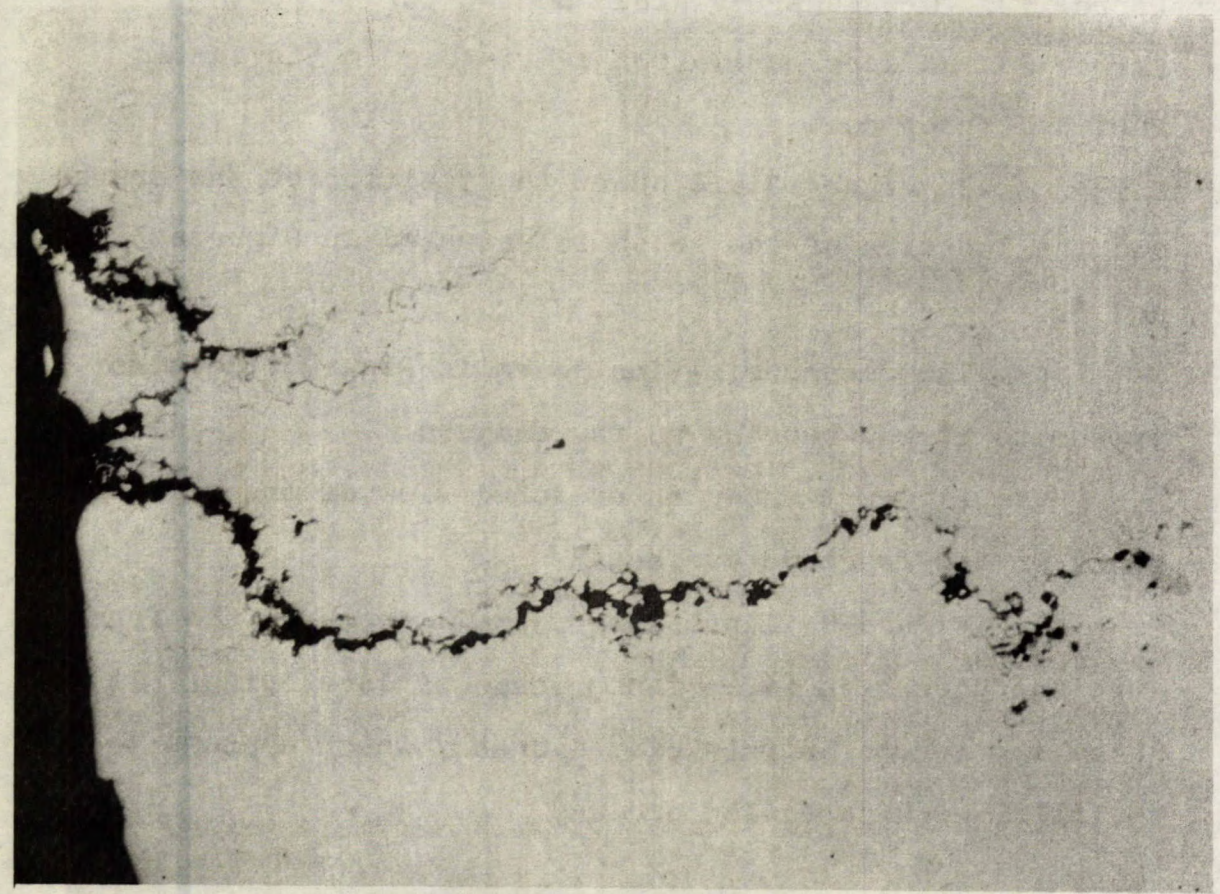
The fracture surface is shown at the bottom of the photomicrograph in Figure 1. Secondary cracks extending from the main fracture surface are visible (arrow 1). Cracks are visible at the thread roots (arrow 2) and decarburization is visible on the thread surfaces (arrow 3).

In Figure 2 are shown the position of the cracks and the location of the areas illustrated in Figures 3, 4 and 5.

The decarburization shown in Figure 1 does not appear to have a bearing on the failure.

Figure 3 shows an unetched view of the main crack on the fracture surface.

Figure 4 illustrates a small crack on the fracture surface which is in the process of developing. It shows the irregular path of the crack, which appears to be filled with corrosion product.



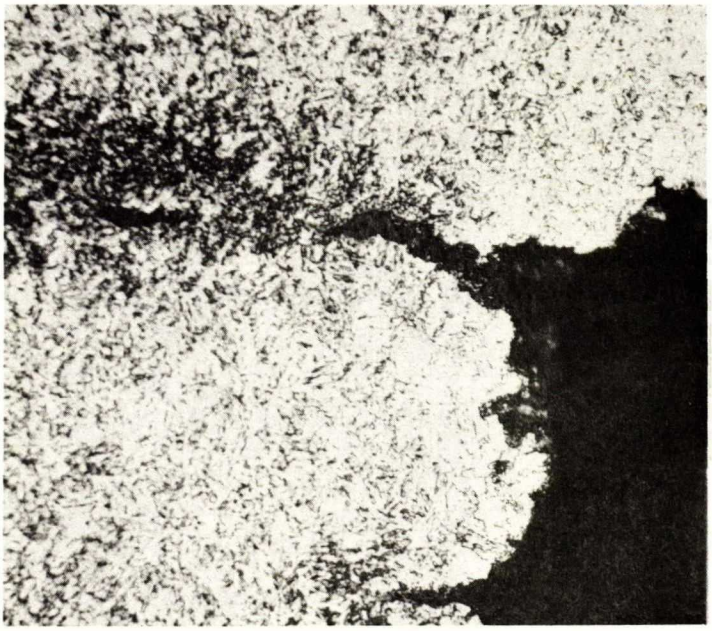
(X200, unetched)

Fig. 3.- Main secondary crack emanating from the fracture surface.

(X500, etched in 2% nital)

Fig. 4.- Small secondary crack emanating from the fracture surface.

Figure 5 illustrates a crack at the root of a thread.



(X500, etched in 2% nital)

Fig. 5 - Crack at the thread root shown in Fig. 2.

SPECTROGRAPHIC EXAMINATION

The specimen was examined by microarc spectrography for traces of mercury. There was no mercury left in the cracks and it was therefore assumed that the mercury had no effect on the corrosion.

DISCUSSION

The concentration of caustic soda in the thread roots may become very high, although the overall concentration is rather low. This concentration may be sufficient to cause initial cracking in this steel.

CONCLUSIONS

1. The failures were caused by stress corrosion similar to that found in boilers.
2. The failures were essentially brittle, and intergranular, and resembled caustic cracking.

RECOMMENDATIONS

1. It is recommended that an 18/8 stainless steel be used, instead of the mild steel, for the manufacture of these screws. The 18/8 stainless steel is resistant to embrittlement caused by hydrogen, caustic soda, or mercury.
2. Monel is not recommended, since it is not at all good in its resistance to corrosion, particularly stress corrosion, in the presence of mercury above 100°C.

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