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OTTAWA April 28, 1945.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1853.

Examination of Extruded Magnesium Alloy Channel Section Assembly with Steel Locking Device.

(Copy No. 10.)

Division of Metallic Minerals
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Physical Metallurgy
Research Laboratories

DEPARTMENT
OF
MINES AND RESOURCES

Mines and Geology Branch

OTTAWA April 28, 1945.

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Origin of Material and Object of Investigation:

On April 17, 1945, Col. E. C. Thorne, of the Directorate of Engineering Development, Department of National Defence (Army), Ottawa, Ontario, submitted two extruded magnesium alloy channel section assemblies similar to those used in an assault bridge. The channels, reported to be of magnesium alloy A.S.T.M. 8X (nominal composition 6.5 per cent aluminium, 0.7 per cent zinc, 0.2 per cent manganese, balance magnesium), were joined together by a locking device of SAE 4130 steel, as shown in Figure 1.

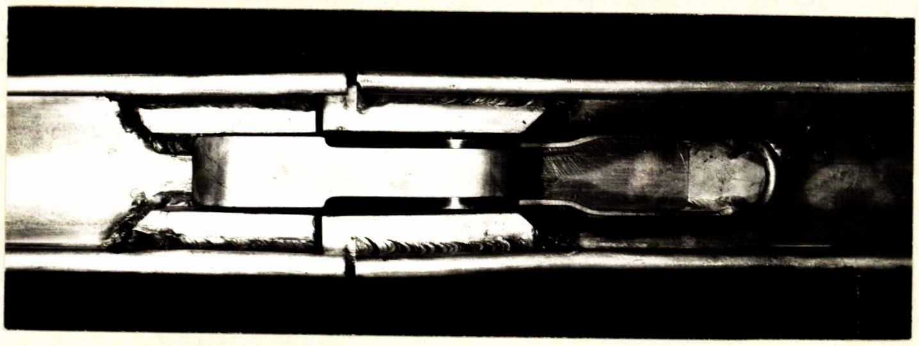
The locking device consists of a steel hook which works on two steel pins attached to the flanges of the channels. As may be seen from Figure 1, magnesium alloy blocks are welded to the channel flanges to lessen the danger of tearing the material about the steel pin when the assembly is under tension. To reduce the tendency of the

(Origin of Material and Object of Investigation, cont'd) -

magnesium alloy to corrode, the steel parts are cadmium-plated and the pins prevented from coming into contact with the magnesium alloy by aluminium alloy bushings.

The steel pins in one assembly are 5/8 inch in diameter, while those in the other are 11/16 inch in diameter. Both assemblies were to be tested in tension to determine whether the locking device would stand up to the design load of 36,000 pounds and also to decide which size of pin to use in production. Two SAE 4130 steel pins, 5/8-inch and 11/16-inch in diameter respectively, were submitted for tensile testing to determine the tensile properties of the pin material.

Figure 1.



MAGNESIUM ALLOY CHANNEL ASSEMBLY SHOWING STEEL LOCKING DEVICE.
(Approximately 1/3 actual size).

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Results of Tests on Channel Assemblies:

The channel assemblies were tested in tension in an Amsler Universal testing machine. It was necessary to cut a 3/8-inch slot in the web at each end of the channel and crimp in the flanges in order to fit them into the machine. Table I shows the load and extension on two inches measured under load up to failure of each assembly.

(Continued on next page)

(Results of Tests on Channel Assemblies, cont'd) -

TABLE I.

CHANNEL WITH 5/8-IN. DIAMETER PINS		CHANNEL WITH 11/16-IN. DIAMETER PINS	
Load, pounds	Extension in 2 inches, inches	Load, pounds	Extension in 2 inches, inches
5,000	0.02	5,000	0.00
7,500	0.02	7,500	0.00
10,000	0.02	10,000	0.00
12,500	0.04	12,500	0.03
15,000	0.04	15,000	0.03
17,500	0.05	17,500	0.03
20,000	0.06	20,000	0.03
22,500	0.08	22,500	0.03
23,500	0.08	25,000	0.06
25,000	0.09	26,000	0.06
26,000	0.10	27,000	0.07
27,000	0.10	30,000	0.11
28,000	0.11	32,500	0.15
29,000	0.12	35,350	Failure in steel hook.
30,000	0.13		
31,000	0.14		
32,000	0.15		
33,000	0.17		
34,000	0.20		
35,000	0.23		
36,750	Failure in weld.		

The assembly with 11/16-inch diameter pins was taken by the Army after tensile testing while that with 5/8-inch diameter pins was retained by these Laboratories for a

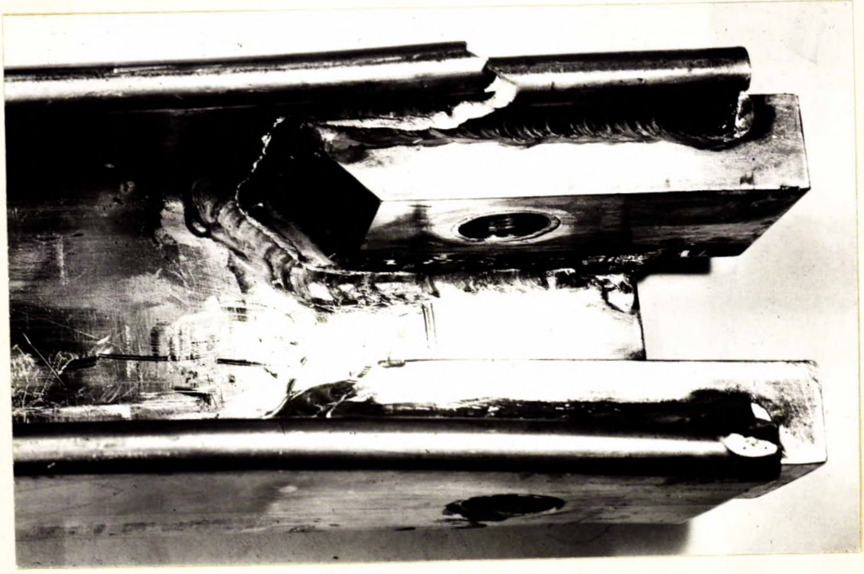
(Results of Tests on Channel Assemblies, cont'd) -

metallurgical examination.

Metallurgical Examination of Channel Assembly:

The tensile and shear properties of the material in the magnesium alloy channel had been previously determined and reported in P.M. Lab. Report No. 7629, issued on April 10, 1945. The compression yield was determined on a section of the channel three inches long by the 0.2 Per Cent Offset method and found to be 18,100 p.s.i. Figures 2 and 3 show the fracture through the weld and flange of the channel after tensile testing of the assembly. Figure 4 shows the amount of bending on the 5/8-inch diameter pin.

Figure 2.

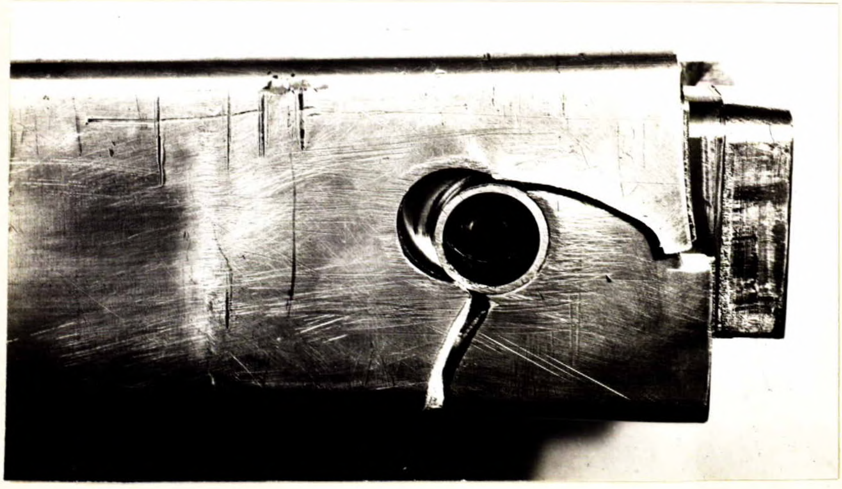


TOP VIEW OF MAGNESIUM ALLOY CHANNEL
AFTER TESTING.

Note how fracture follows weld.

(Approximately 2/3 size).

Figure 3.



SIDE VIEW OF FRACTURE IN MAGNESIUM CHANNEL.
(Approximately 2/3 size).

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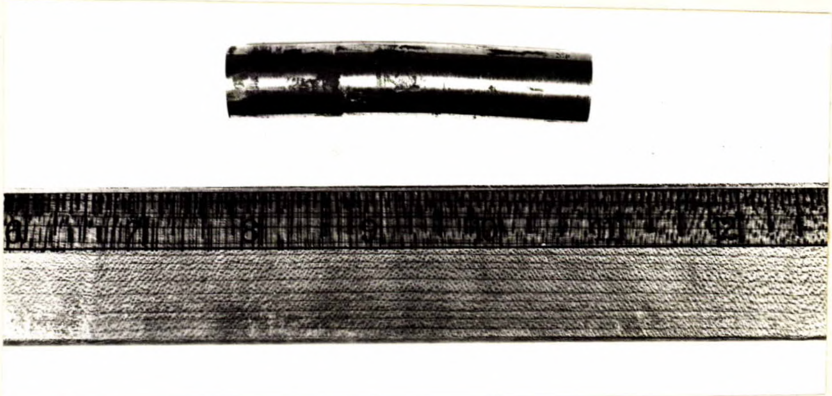
Figure 4.



5/8-INCH DIAMETER STEEL PIN AFTER TESTING.
Note slight bend in pin.

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It will be seen, from Figures 2 and 3, that the fracture followed the weld around to a point on the flange

(Metallurgical Examination of Channel Assembly, cont'd) -

near the hole for the 5/8-inch pin and its bushing and here the flange failed.

Examination of the weld fracture showed lack of penetration of the weld metal at the root of the weld. This may be seen in Figures 5 and 6. Figure 5 shows the lack of penetration at the root of the vertical weld on the flange of the channel. Figure 6, a photomicrograph at 30 magnifications, shows a cross-section of the weld at the root, showing the lack of penetration.

Figure 5.

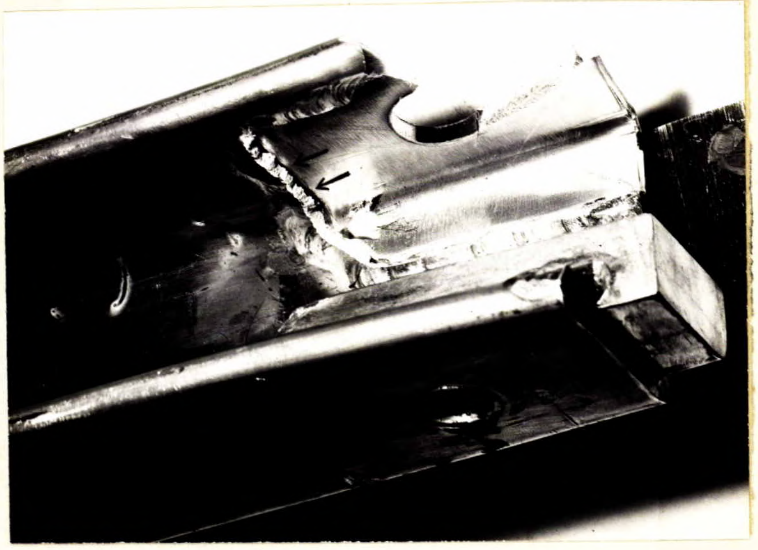

FIGURE SHOWING LACK OF PENETRATION AT ROOT OF WELD.

Dark area (arrow) at root of vertical weld indicates lack of penetration.

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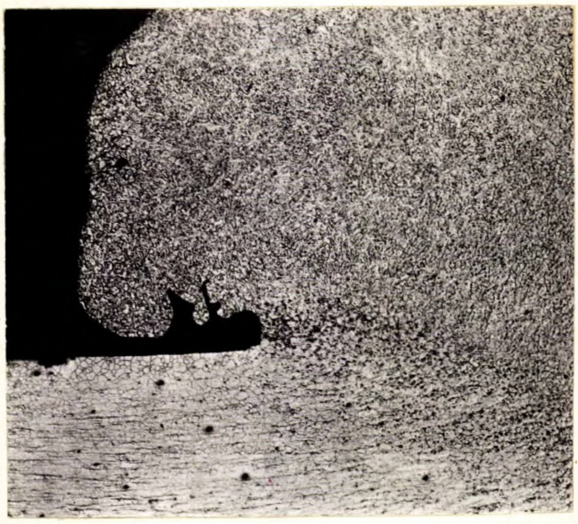
(Metallurgical Examination of Channel Assembly, cont'd) -

Figure 6.



X30, etched in 2 per cent nital.
PHOTOMICROGRAPH SHOWING LACK OF PENETRATION AT ROOT OF WELD.

The steel hook was macro-etched in 50 per cent hydrochloric acid and found to have been machined from a solid block of forged steel. Its hardness was found to be 302 Brinell. Figure 7, a photomicrograph at X500 magnification, shows its structure to consist of tempered martensite. No decarburization was observed at the surface.

Figure 7.

X500, nital etch.
STRUCTURE OF STEEL HOOK.
Tempered martensite.

(Metallurgical Examination of Channel Assembly, cont'd) -

Tensile tests on the two pins gave the following results:

Diameter of Pin, inches	0.2 per cent Yield Stress, p.s.i.	Ultimate Strength, p.s.i.	Elongation in 2 inches, per cent	Reduction in area, per cent	Rockwell 'C' Hardness
5/8	178,200	190,200	14.0	52.0	38
11/16	170,800	182,200	15.0	49.7	37

Discussion:

The channel assembly with the 5/8-inch diameter pins withstood the specified load of 36,000 pounds, failing through the weld at 36,750 pounds load. The assembly with the 11/16-inch diameter pins failed at 35,350 pounds load through the steel hook. At the time of the test it was decided to specify the 11/16-inch diameter pin for use in production and to change the design of the hook to withstand higher loads. It was felt that the larger pin would provide a greater margin of safety.

Examination of the fracture through the weld (Figures 2 and 3) showed that there was some lack of penetration at the root of the weld (see Figures 5 and 6). This should be eliminated by improving the welding technique. The stress-raising effect of the hole in the channel flange accommodating the pin may have had some part in causing the failure, but it is felt that improving the weld would increase the strength of the assembly.

The mechanical properties of the pin material as indicated by tensile tests are satisfactory. They indicate that the pins have been water-quenched from 1550-1600° F. and drawn

(Discussion, cont'd) -

at 900° F. After such a treatment the steel would be expected to have an Izod impact strength of 40 foot-pounds. It is felt that no attempt should be made to increase the properties by lowering the draw temperature, as the Izod would be decreased. Increasing the diameter of the pin is a more satisfactory way to raise the strength. The bend angle of the 5/8-inch diameter pin removed from the assembly after testing does not seem excessive (see Figure 4).

Macro-etching the steel hook showed that it had been machined from a solid rolled or forged block. Its microstructure, consisting of tempered martensite (see Figure 7), shows that its heat treatment has been satisfactory.

CONCLUSIONS:

1. The channel assembly with the 5/8-inch diameter pins withstood the specified load of 36,000 pounds without failing, while that with the 11/16-inch diameter pins did not. However, it is felt the 11/16-inch pins would provide a greater margin of safety provided the hook is redesigned to increase its strength.

2. The welding on the channel examined showed lack of penetration of the weld metal at the root of the weld.

3. The mechanical properties of the steel in the pins are satisfactory.

4. The steel hook was machined from a solid block of forged or rolled material. Its heat treatment is satisfactory.

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