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DEPARTMENT OF MINES AND RESOURCES

BUREAU OF MINES

CANADA

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Ottawa, September 20, 1946.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 2103.

Metcolizing of Hastalloy B.

(Copy No. 6.)

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DEPARTMENT
OF
MINES AND RESOURCES

Bureau of Mines

Division
of Mineral Resources

Mines and Geology Branch

O T T A W A September 20, 1946.

R E P O R T

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Investigation No. 2103.

Metcolizing of Hastalloy B.

Introduction:

On August 17, 1946, Mr. H. H. Bleakney, Mechanical Engineering Division, National Research Council, Ottawa, Ontario, requested an investigation of the possibility of improvement of the corrosion resistance of Hastalloy B by means of metal-sprayed coatings of aluminium and subsequent thermal diffusion treatments. For certain applications, Hastalloy B (70% Ni, 30% Mo) has highly desirable physical properties but inferior corrosion resistance, particularly in the range of approximately 1200° to 1400° F.

A sample of the alloy, 1" diam. x 4", was submitted for experiment.

Object:

To investigate the possibility of securing improved corrosion resistance of Hastalloy B by means of metal-sprayed aluminium coatings with subsequent heat treatments to secure diffusion of the aluminium into the base metal.

PROCEDURE:

(1) The sample submitted was sectioned into pieces ¼" thick. These sections were then shot-blasted with No. 40 angular steel shot to prepare the surface for spraying. Shortly after this preparation the samples were sprayed with aluminium, using a Metco* 2E spray gun operated at 65 pounds air pressure, 15 pounds acetylene and 18 pounds oxygen. After spraying all samples were dipped in Metcoseal (finely divided aluminium suspended in oil) and then subjected to the following heat treatments:

1 piece	heated to	1450° F.	for 10	minutes.
1 piece	"	" 1700° F.	for 1	hour.
1 piece	"	" 1700° F.	for 5	hours.
1 piece	"	" 1700° F.	for 20	"
1 piece	"	" 1700° F.	for 32	"
1 piece	"	" 1700° F.	for 48	"

(2) After these heat treatments all sections were cut in half and one half mounted, polished, and examined under the microscope. The following table lists the photomicrographs at the end of this report:

Figure No.	Comments
1	Bond at interface after 1450° F. for 10 mins.
2	" " " " 1700° F. for 1 hour.
3	" " " " 1700° F. for 5 hours.
4	" " " " 1700° F. for 20 "
5	" " " " 1700° F. for 32 "
6	" " " " 1700° F. for 48 "

DISCUSSION:

An examination of the nickel-aluminium constitution diagram(1) reveals that a composition of approximately 30 per cent aluminium, 70 per cent nickel has a melting point in excess of 1600° C. and consists of NiAl in solid solution. Compositions with greater or lesser percentages of aluminium have lower melting points.

(Continued on next page)

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* Metcolizing Engineering Co., New York.

(1) A.S.M. Handbook, 1939 Edition, p. 1621.

(Discussion, cont'd) -

This experiment has demonstrated that it is possible to introduce aluminium into the surface of the Hastalloy B alloy by means of metal-sprayed aluminium and subsequent thermal diffusion treatments. From the surface downward it is logical to expect a continual reduction in the percentage of aluminium within the Ni-Mo alloy. It is also reasonable to expect that somewhere below the surface the composition will be that of the high melting point material. If the composition with the highest melting point has good corrosion-resisting properties, this method might be applicable to high-temperature applications where improved corrosion resistance is desirable. At high temperatures some loss from the surface would be expected due to the low melting point of the aluminium-rich compositions. However, the longest thermal diffusion treatment (1700° F. for 48 hours) produced the maximum penetration of aluminium to a depth of 0.002 inch. Therefore, such a surface loss could not exceed this figure and provision could be made for such a loss.

It should be emphasized that this is a preliminary investigation designed to establish the possibility of surface aluminizing of this alloy. No practical value will result unless corrosion resistance at elevated temperatures is obtained by the treatment. For this reason, samples will be prepared for corrosion testing and if the results of these tests are promising, further investigation of spraying and thermal diffusion treatments will be undertaken.

Conclusions:

1. An intermetallic aluminium nickel alloy can be formed on the surface of Hastalloy B by means of metal spray-

(Conclusions, cont'd) -

ing and subsequent thermal diffusion treatments.

2. The first formation of the alloy was detected after treating the sprayed Hastalloy B at 1700° F. for 1 hour.

3. The maximum depth of penetration of aluminium into the Hastalloy B was 0.002 inch after treatment at 1700° F. for 48 hours.

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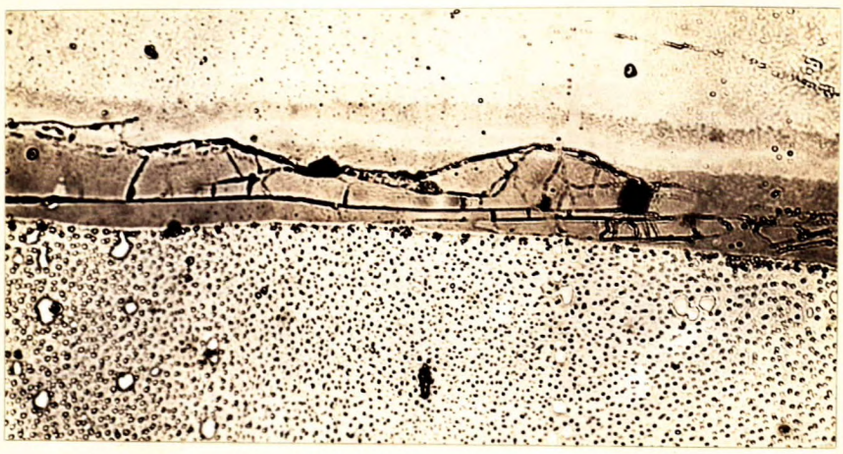
(Figures 1 to 6 follow,
on Pages 5 to 7.)

Figure 1.



X500, unetched.

BOND AT INTERFACE AFTER TREATMENT AT 1450° F. FOR 10 MINUTES. ALUMINIUM ABOVE, HASTALLOY B BELOW.

No visible intermetallic compound formed.

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Figure 2.

X500, unetched.

BOND AT INTERFACE AFTER TREATMENT AT 1700° F. FOR 1 HOUR. ALUMINIUM ABOVE, HASTALLOY B BELOW.

Note beginning of formation of intermetallic compound.

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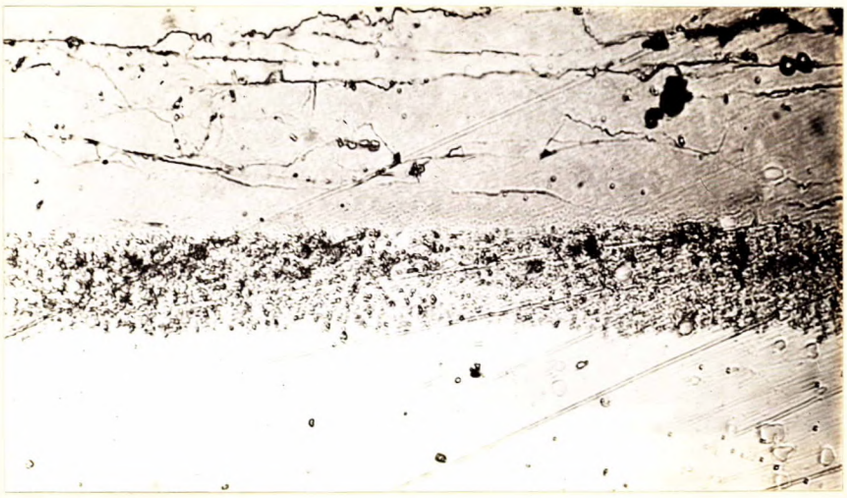
Figure 3.



X500, unetched.

BOND AT INTERFACE AFTER TREATMENT AT 1700° F. FOR 5 HOURS. ALUMINIUM ABOVE, HASTALLOY B BELOW.

Note cracks in aluminium layer. Definite formation of intermetallic compound at interface.

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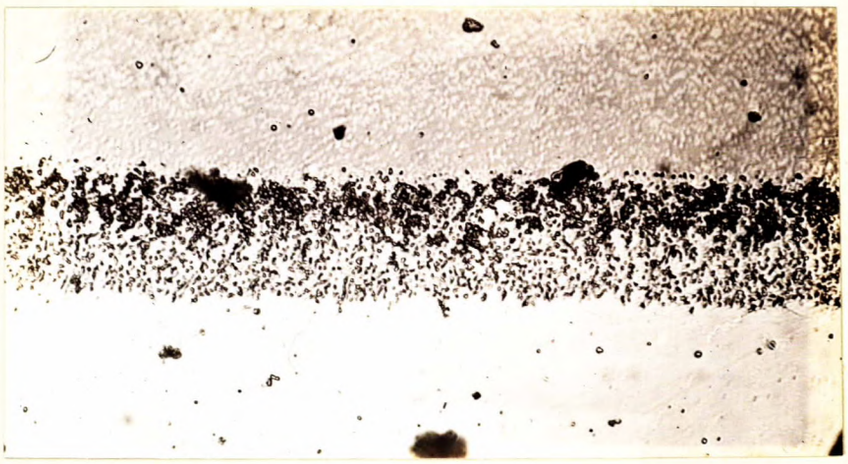
Figure 4.



X500, unetched.

BOND AT INTERFACE AFTER TREATMENT AT 1700° F. FOR 20 HOURS. ALUMINIUM ABOVE, HASTALLOY B BELOW.

Intermetallic compound increasing in depth and density.

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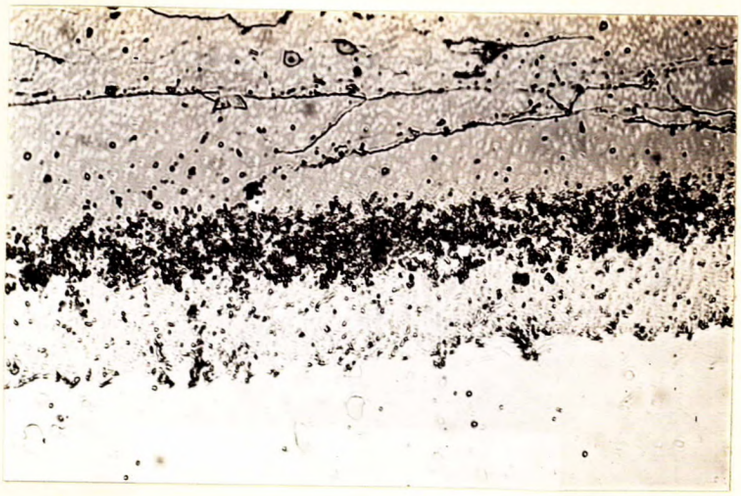
Figure 5.



X500, unetched.

BOND AT INTERFACE AFTER TREATMENT AT 1700° F. FOR 32 HOURS. ALUMINIUM ABOVE, HASTALLOY B BELOW.

Apparently two intermetallic compounds of different composition being formed. Depth of penetration increasing.

Figure 6.

X500, unetched.

BOND AT INTERFACE AFTER TREATMENT AT 1700° F. FOR 48 HOURS. ALUMINIUM ABOVE, HASTALLOY B BELOW.

Apparently two intermetallic compounds, both of increasing depth.

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