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DEVELOPMENT OF PRACTICES FOR COMMERCIAL PRODUCTION OF
TITANIUM AND TITANIUM ALLOY WIRE S

REPORT NO. 21

For Period

1 May '60 to 1 Nov. '60

for

WATERTOWN ARSENAL

Watertown, Massachusetts

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W. C. Lewis, Jr.
W. C. Lewis, Jr.
Tech Engineer

Harold McKinney
Harold D. McKinney
Vice President

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DEVELOPMENT OF PRACTICES FOR COMMERCIAL PRODUCTION OF
TITANIUM AND TITANIUM ALLOY WIRES

REPORT NO. 21

For Period 1 May '60 to 1 Nov. '60

Scope

This report covers experimental wire drawing of Titanium-13 V - 11 Cr - 3 Al Alloy (B-120 VCA). The objective was to investigate drawing of this alloy to finer sizes than before - .064" to .010". Also, vulnerability to stress-corrosion of the hard-drawn .010" wire was compared to that of .182" hard-drawn wire of the same alloy.

Summary

A quarter-pound piece of Titanium -13 V - 11 Cr - 3 Al Alloy (B-120 VCA, was drawn from 0.064" to 0.011". Plastic coating (proprietary) was tried but was unsatisfactory. Copper coating after sand-blasting, with cowles and lime, was found satisfactory, as with previous drawing of other titanium alloys.

The hard-drawn 0.011" wire was not vulnerable to stress-corrosion cracking in acid, although previously hard-drawn 0.182" wire, under stress, broke up when dipped in acid to remove copper and lime before anneal.

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I. Introduction

Previous processing of this alloy, Ti - 13 V -
11 Cr - 3 Al (B-120 VCA), covered:

1. Drawing a 12-ft. piece of 0.240" to 0.064",
using 20% reductions, -
resulted in poor surface
2. Drawing a 12-ft. piece of 0.240" to 0.064",
using 11% reductions (below 0.128" size), -
resulted in improved surface
3. Drawing a 13-lb. piece of 1/4" to 0.182",
using 18% reductions, -
wire broke up from "stress-corrosion", when
coil which was stressed by restraining band-
wire was dipped in acid to remove copper and lime.

Current processing involved drawing a quarter-
pound piece of this alloy from 0.064" (produced
in 2, above) to 0.011"

II. Procedure and Results

Processing Starting material was good-quality 0.004" wire, the finished product of earlier experiments. This was drawn to 0.011" by the schedule given in Table I. Good quality finished wire was produced.

A plastic drawing compound, which had been satisfactory in drawing other difficult alloys, was tried for the initial draft. Scratched wire resulted, despite several trials. Further drawing was with the copper coating used heretofore for other titanium alloys.

Stress-Corrosion Specimens of 0.011" finished wire, hard, were tested for stress-corrosion vulnerability. Open "overhand knots"



of various diameters from 1/4" to 2-1/2", were made of the wire, and dropped into acid (approximately 40% HCl, 10% HNO₃, hot) such as had previously broken 0.182" stressed hard wire. The knot kept the 0.011 wire stressed to simulate the stress from band wire restraining the coil of 0.182" wire. The .182" wire also broke in acid when stressed by an elastic bend of about 20" radius. The 0.11" wire did not break in any of the tests. It also showed good ductility-2 1/2% elongation (in 10") in tensile test.

Maximum ("extreme fiber") stress in a wire bent below the elastic limit may be expressed as -

$$S = \frac{d}{r} K, \text{ where } d \text{ is wire diameter and } r \text{ is radius of}$$

bend, with K lumping all other variables. Then for the 0.182" wire bent over 20" radius -

$$S = \frac{0.182}{20} K = .0091 K.$$

For the 0.011" wire bent over 1.21" radius

$$S = \frac{0.011}{1.21} K = .0091 K$$

Thus the knot diameters from 1/4" to 2-1/2" for .011" wire, included the range of stress which broke the 0.182" wire.

Photomicrographs of the 0.011" hard wire, and of the 0.182" hard wire, to which it was compared in corrosion tests, are shown in figures 1 and 2, respectively.

III. Discussion and Conclusions

Wire of this alloy, Ti - 13 V - 11 Cr - 3 Al (B-120 VCA) was satisfactorily drawn from 0.064" to 0.011" by the "standard" method of dry-drawing copper-coated material. A plastic compound drawing-coat was not satisfactory. Commercially, 0.064" wire could be drawn to 0.011" with an intermediate anneal at 0.032" only.

Results of the stress-corrosion experiment should allay fear that smaller sizes of this alloy will break up when stripping copper at the finished size. The fibered fine-grain structure of the 0.011" wire (figure 1) is one in which intergranular cracks could not propagate rapidly. The coarse-grain structure of the 0.182" wire broke promptly when stressed and acid dipped.

J Lewis
27 Jan/61



Figure 1.
0.011" size, drawn from 0.032" annealed soft
Does not break in acid when stressed.
Mag. 400 X - Mount W-35

Ti-13V-11Cr-3Al (B-120 VCA)

Figure 2.
0.182" size, drawn from 0.240" annealed soft
Broke up in acid when stressed
Mag. 400 X - Mount W-48



TABLE I.
Experimental Processing - Ti - 13V - 11Cr - 3Al (D 120 VCA)

Started: 1/2 lb. 0.0645" hard wire

1. Air annealed, 1400°F. 1Hr., air cooled
2. Pickled in acid (30% HNO₃ + 3% HF)
3. Plastic coated (Bangsterrier's #5 PCNF), dipped.
4. Drawn* to .057, 21% reduction. Wire chattered, scratched badly, broke.
5. Cecolene dipped to remove plastic coat
6. Sand blasted - - - batch style
7. Copper coated - - - " "
8. Cowles and lime coated - - - " "
9. Drawn to .0526 and .0486, 14 1/2% reductions (27% total). Broke, but did not scratch. Produced: 3 short pieces at .0526" Main piece at .0486"
10. Stripped copper by dip in HNO₃
11. Annealed in vacuum, 1385°F., 30 min., fast cooled in cooling chamber.
12. Sand blasted - - - batch style
13. Copper coated - - - " "
14. Cowles & lime coated - - - " "
15. Drawn, 3 samples (a, b, c), 1 main coil (d) -

a) .0513"	-.0485	-.045	-.0425	-.040	-.0384	-.0363
6 1/2%	10%	14%	10%	11%	8%	11%
b) .0485	-.0425	-.0384	-.0363	-.032		
16%	14%	18%	11%	22%		
c) .0485	-.0425	-.0384	-.0363	-.032	-.028	
16%	14%	18%	11%	22%		
d) .0425	-.0384	-.0363	-.032			(main coil)
14%	18%	11%	22%			
16. Stripped copper by dip in HNO₃
17. Annealed in vacuum, 1385°F 30 min; fast cooled in cooling chamber
18. Sand blasted - - - batch style
19. Copper coated - - - " "
20. Cowles & lime coated - - - " "
21. Drawn, with 21% reductions -

Sample, b)	.032	-.0284	-.0253	-.0226	-.020	-.018	-.016
	copper coating renewed, drawing continued .0142-.0125-.011						
Main coil, d)	.032	-.0284	-.0253	-.0226	-.020	-.018	
	copper coating renewed, drawing continued						
	.016	-.0142	-.0125	-.011			
	Wt. at finished size 0.15 lbs.						

*All drawing was on lab. machine, with standard (18°) dies, at approximately 80 ft. per min., with dry soap powder in the die box