Proceedings of the Iowa Academy of Science

Volume 28 | Annual Issue Article 18

1921

The Effect of Drawing on the Crystal Structure of Tungsten Wires

L. P. Sieg
State University of Iowa

THE EFFECT OF DRAWING ON THE CRYSTAL STRUCTURE OF TUNGSTEN WIRES.

L. P. SIEG

The writer has in various places published results of tests on the coefficient of rigidity of drawn tungsten wires. The latest [1] results indicated clearly that in a series of wires drawn down from the same original stock the coefficient of simple rigidity progressively increased as the diameters of the wires decreased. For example, the value of "n" ranged in the case of two extremes of five such wires from 14.15×10^{11} to 15.10×10^{11} dynes per square cm., for corresponding radii of 0.0227 cm., and 0.00240 cm. The hypothesis was put forth at that time that a change in the crystal structure which was limited to the surface, and which yielded a greater rigidity for the wire would account for the results. This, because as the wires become progressively smaller the effect of the surface would become more and more pronounced.

No opportunity came for testing this suggestion until after the war. Last year the five wires were again tested for their rigidities, the results from which tests have not yet been reported. However, the tests agreed excellently with those taken two years previously, establishing incidentally that the changes were very likely permanent.

The examination involved a photomicrographic study of sections of the wires. To accomplish this short lengths of wires were embedded in two copper plates by squeezing together the plates, with the wires between them, exerting great enough pressure to mould the copper around the wires. The copper plates were then dressed down, first roughly with a file (which failed to make much impression on the tungsten), then with successively finer grades of carborundum paper. The last stage of the polishing was done with rouge. Great patience and care is required throughout all this operation, greater even than for most metals on account of the extreme hardness of the tungsten. One must have the patience not to progress to a finer grade of the abrasive until he is sure that all scratches of a size larger than the grade he is using have been obliterated. After the polishing was completed the surfaces were

1 Ia. Acad. Science, Proc. 24, p. 207, 1917.

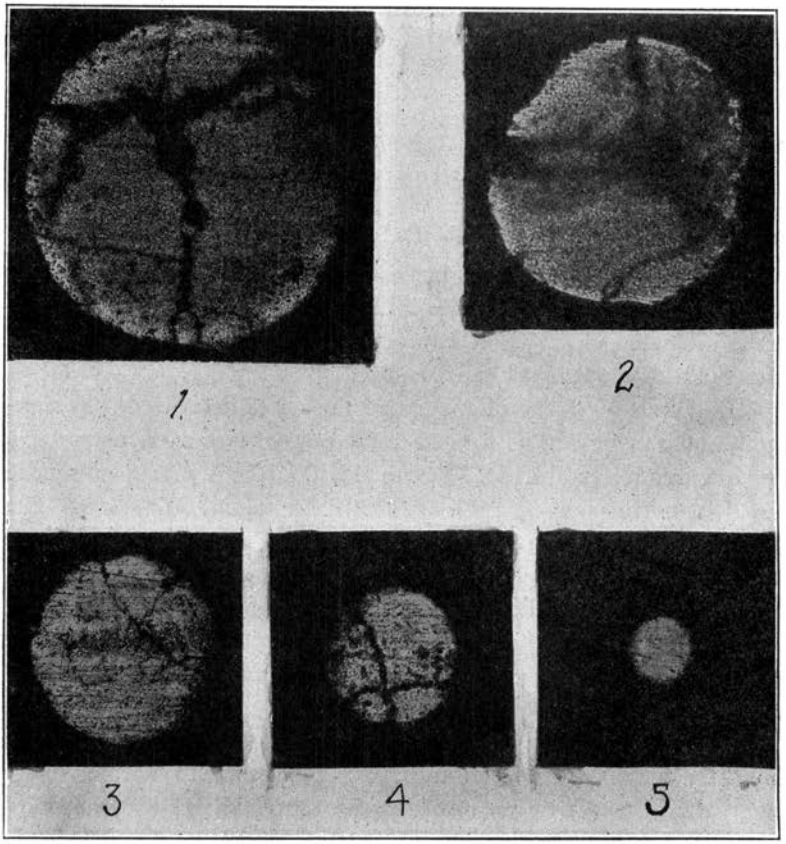

Fig. 19. Photomicrographic sections of five tungsten wires, drawn down successively from the same original wire.

complete blanks, so it was, as usual, necessary to etch the surfaces. The most successful liquid was boiling hot hydrogen dioxide. A mixture of hydrofluoric and nitric acids served nearly as well.

The accompanying photomicrographs (See Fig. 19) taken with monochromatic green light show, probably as well as any reproduction can, the effect sought. However, it must be said that even the original negatives failed to show with anywhere the clearness the structure which one could observe directly through the eyepiece. In the present half tone the magnification is 110 diameters. The actual sizes of the wires were respectively, 0.0227, 0.01762, 0.01262, 0.00784, and 0.00240 cm., and the corresponding sections are shown in numbers 1 to 5 in the accompanying figure. The cracks shown in the wires developed during the process of embedding the wires in the copper, but these do not do any damage as

far as the present tests are concerned. The photographs show that the crystal structure near the surface is distinctly different from that throughout the body of the crystal. In No. 1 the lighter-colored rim, free from crystals (or apparently so) is clearly in evidence. In No. 2 the same ring appears, and it is practically of the same depth as that in No. 1. In No. 3 the light area has penetrated much farther, the dense crystals being very much less in evidence. In No. 4 the dark crystals are to be seen only in isolated spots, while in No. 5 the dark grains are totally absent. This effect can not be attributed to variations in polishing and in etching, for throughout the wires were treated exactly alike in order to avoid that contingency.

Exactly what the difference is between the two phases of crystal structure, the writer is not in a position to state. He is of the opinion, however, that the light-colored areas represent the fact that the amorphous cement is much in excess, and that the crystals in that region are so fine as to be beyond the resolving power of the microscope. According to modern theories of such crystals, the amorphous state should exhibit the higher elasticity.

In conclusion, whatever the structures of the two crystal states may be, it has been demonstrated that drawing has an effect on the surface which is different from the effect deeper in the structure of the wires. This accounts for the progressive changes in the elastic constants of the wires.

STATE UNIVERSITY OF IOWA.