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NOTES ON CERTAIN ELASTIC PECULIARITIES OF PHOSPHOR BRONZE WIRES.

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Introduction.—Some previous work by one of the authors with wires of an alloy of platinum-iridium, portions of which work were published in these Proceedings,[1] indicated that when the wires were used as suspensions for torsion pendulums, the relations between the period of vibration and the amplitude were exceedingly complicated. The effect of drawing these wires was dealt with in another paper.[2] In all these papers referred to, the statement was made that similar tests should be applied to some of the more common wires in the hope of finding similar, even though smaller effects. Through press of work these experiments have been deferred until the present year. This particular paper will deal with but one feature of the work, namely, the effect of drawing on the elastic nature of phosphor bronze wires. The writers are indebted to the American Electrical Works, of Phillipsdale, Rhode Island, for kindly furnishing them with specimens of the wires.

Significance of the work.—Physicists, and no doubt many others, will realize that it is highly important to know intimately the elastic nature of phosphor bronze wires on account of the fact that these wires are in such common use in the manufacture of delicate suspensions of all kinds, particularly for galvanometers. Often, especially in absolute measurements, we depend on the general law for vibrating wires that the coefficient of simple rigidity determined statically be in agreement with the same coefficient determined kinetically. This agreement is possible only where the wires follow the law that the period of vibration, in angular harmonic motion, is practically independent of the amplitude. In fact the only thing, aside from internal friction of various sorts, that can affect the period should be external air friction, and for reasonably slow periods this should not be a serious source of error.

[1]Ia. Acad. of Sci., Proc. XVII, p. 185, XVIII, p. 115, XIX, p. 189.
[2]Phys. Rev. 35, 347, 1912.

Apparatus, and Experimental Methods.—We were supplied with a series of wires of phosphor bronze, all drawn from the same original alloy. There were thirteen of these wires, representing successive drawings, and ranging in diameter from .100 mm. to .508 mm. Previous work by one of us, already referred to, indicated that platinum iridium wires showed a marked deviation from constancy of period with varying amplitude, the larger periods being associated with the larger amplitudes, and particularly it was pointed out that the variation became more

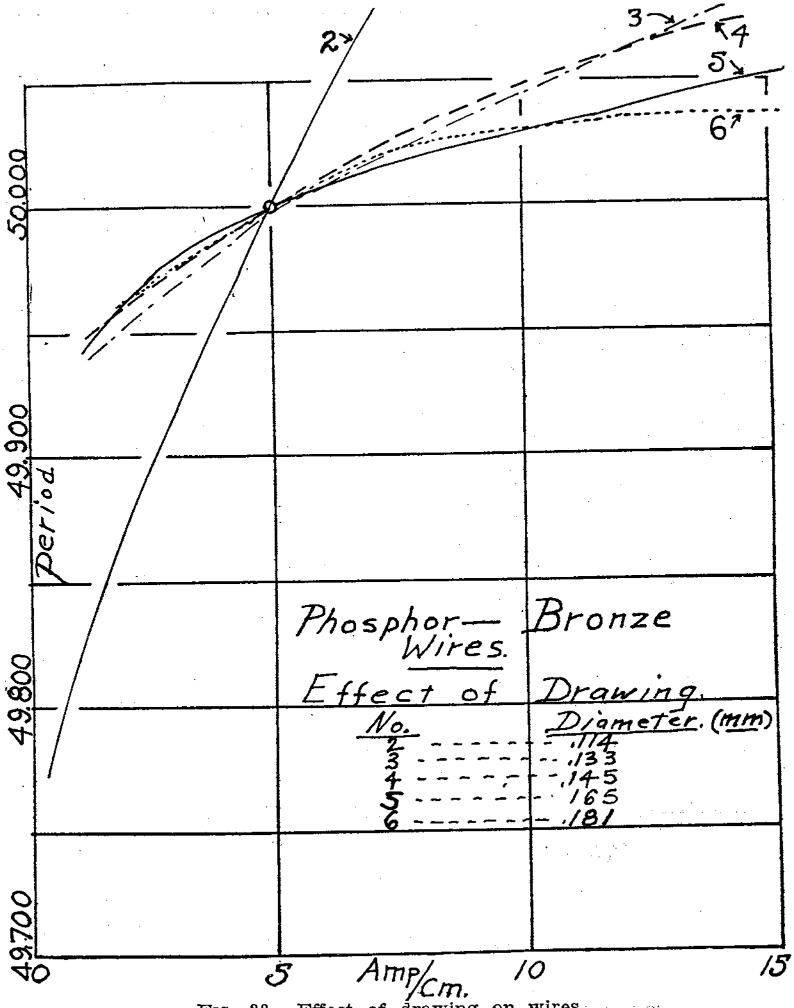

FIG. 23.—Effect of drawing on wires.

marked as the wires were successively drawn down to smaller lengths. In these present experiments similar, though smaller effects were found, and for a sample set of experiments are shown in figure 23. The curve is practically self-explanatory. The coördinates are amplitude per cm. of length of the wire experimented on, and period of one semi-vibration. The numbers on the curves from *2* to *6* indicate that we are dealing with a series of successive drawings, the succession of the drawings running inversely as the numbers. That is, number six is the largest wire experimented on, and number two the smallest. The

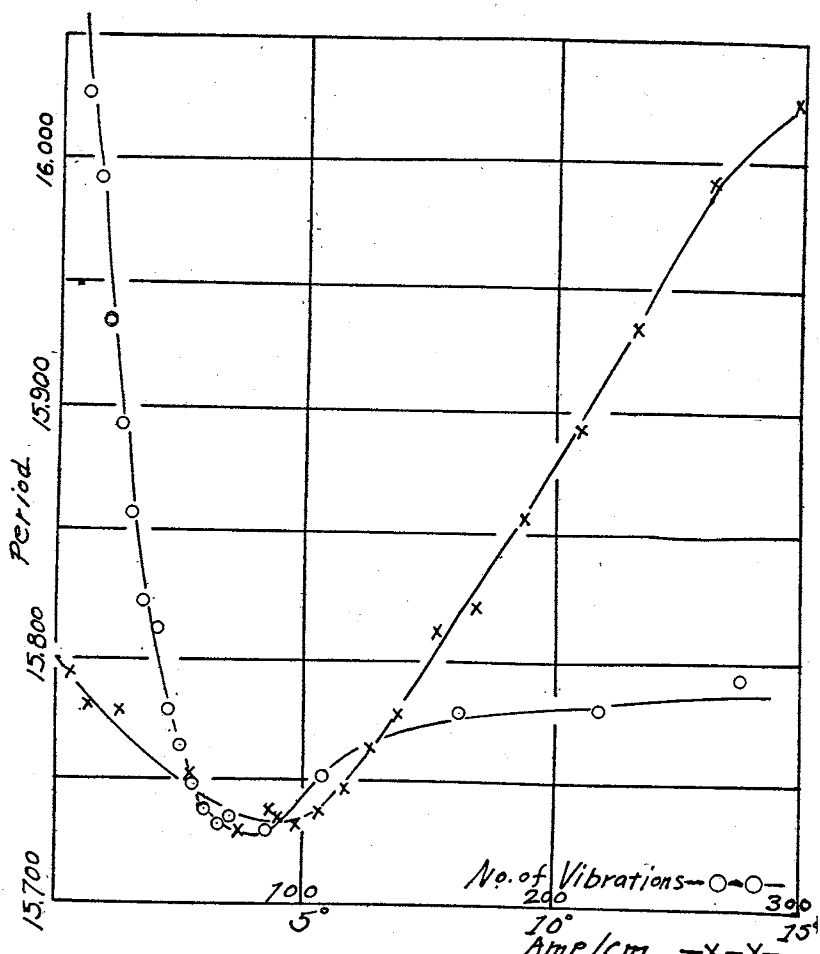

FIG. 24.—Curves showing effect on wires of heating and long continued vibrations.

effect of the drawing is clearly brought out. It is of especial interest to note that the wire that showed the greatest deviation from the assumed law of elasticity, No. 2, is of the size .114 mm., most usually employed in the manufacture of galvanometer suspensions. The apparatus employed will not be described, as both it and the method have been fully detailed in the former volumes of these Proceedings, already referred to.

A New Effect.—The curves in figure 23 represent the results that were obtained from these wires by using them just as they came from the draw plates of the makers. After numerous experiments were made on the points above discussed, it was determined to see what effects would arise from various treatment of the wires. The two treatments that were employed were heating almost to redness, and long continued vibrations. After these preliminary treatments were employed, an entirely new effect was discovered. This effect is to be noted in figure 24. Here as before the curve (marked with crosses) indicates the relation betwen period and amplitude. It will be noted that the period decreases with amplitude just as in the previous experiments, with the important exception that at an amplitude of about 4° per cm. of length, the curve takes a sudden rise, and from this amplitude downward it continues to rise. This seems to be an entirely new effect. The other curve in figure 24, represented by the circles, is for the same wire except that in this case the period is platted against vibration number. It is only another way of illustrating the same point.

To make sure that this new effect did not come about as a result of differences in the original amplitude of the displacement of the supported weight, it was determined to let the wire rest for some days, and then to start it in vibration with a small amplitude, carrying out the experiment as usual, and then increasing the initial amplitude in successive experiments. The results of these experiments are graphically shown in figure 25. The curves would be so near alike that only the observed points are represented, the curves not being drawn. It is evident that the form of curve is practically the same, regardless of the initial amplitude of the vibration, at least within the limits of our experiments. The curve is perhaps clear enough to entail no additional explanation.

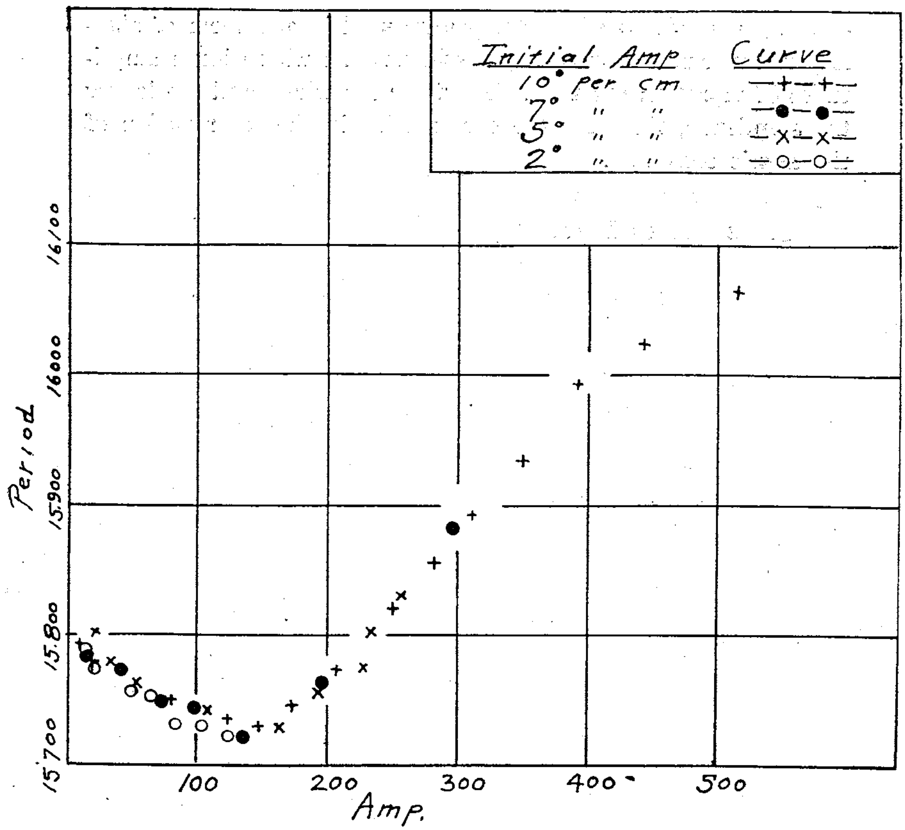

FIG. 25.—Diagram showing effect on wires of varying amplitudes.

Conclusions.—The specific results of the experiments on phosphor bronze wires that are for record in this paper are the following:

1. The effect of drawing these wires is to make the departure from ideal elastic solids increase steadily with the increased fineness of the drawn wires.

2. A new effect, which might be classed as a second order effect, superimposed on the one noted above, has been discovered. This effect is the increase in period with decreasing amplitude after a certain limiting amplitude has been reached. From the results of the above experiments it is quite evident that great care should be used by all experimenters who use such wires, and

especially is this true if the wires are used in any form of absolute measurements, or in any measurements where large amplitudes of vibration are used. The finer the wires, and the larger the amplitude, the more the care needed in the examination of the elastic constants.

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