

where D is the damping coefficient of the coil, d that of the frame, and a the value of A for the damping frame.

The detrimental magnetic effect is proportional to the magnetic attraction divided by the controlling force; that is, to H^2K/Q , if the shape and manner of construction of the coil do not vary. By the use of equation (1), it can then be shown to be proportional to TR/R' ; that is, zero shifts, etc., are in general less troublesome at short periods.

THE CONSTANCY OF PLATINUM THERMOELEMENTS, AND OTHER THERMOELEMENT PROBLEMS.¹

BY WALTER P. WHITE.

I.

IT has frequently been observed that thermoelements of metals of the platinum group deteriorate when exposed at 1200° or even less in a reducing atmosphere. The trouble has been variously attributed to reduced silicon or absorbed gases, but appears not to have been thoroughly investigated. It is usually removed by sufficient heating of the wires in air. At this laboratory, much trouble has been experienced from contamination of a character totally different and apparently hitherto unrecognized. It occurs at higher temperatures (1000 to 1600°), in an oxidizing atmosphere, and is much more serious.

The total thermoelectromotive force in any circuit equals $\int TdH$, where T is the temperature above that of the cold junction, and H is the thermoelectric height. In a thermoelement which is not homogeneous, therefore, the reading depends on a large number of different temperatures, namely, those at every point at which there is a change in the character of the wire. The reading of the contaminated elements, therefore, varied irregularly, according to the accidental condition of the furnace in which they were placed. It was found possible, however, to work with such elements by comparing them frequently with standards, taking great pains to make the comparison under conditions of temperature distribution in the furnace as nearly as possible the same as those prevailing when the elements were used to read temperatures. The standards were in use only a few minutes each day, and therefore deteriorated with relative slowness. At 1400° results obtained by this method generally agree within one third of a degree.

An investigation into the cause of the trouble, with a view to its prevention, began with the physical study of the contaminated wire, that is, of its thermoelectric properties.

¹ Abstract of a paper presented at the meeting of the Physical Society held April 20-21, 1906.

Several different forms of apparatus were tried. Their general principle is the following: The wire to be tested was in contact at two points, *A* and *B*, one or two centimeters apart, with two lead wires of the same material which ran off to a cold junction. *A* was heated indirectly by means of steam, while *B* was kept cool. The wire between *A* and *B* thus formed part of a thermoelement; and its thermoelectric height compared to the lead wires, and therefore the amount of its deterioration, could be easily found. Since all the wires were of the same material, the method was a differential one, and slight inequalities of temperature in the circuit, as well as small changes in the difference of temperature between *A* and *B*, did little harm. In the apparatus that was found best for general work, *A* and *B* were over and insulated from plates of copper. For one or two special investigations a sharper temperature gradient was obtained by using two baths of kerosene, each containing a stirrer, and separated by a thin wooden partition through which the wire passed.

With the testing apparatus it was possible to get not only more definite results than could be obtained by the observation of thermoelements in furnaces, but to work on pieces of wire 2 or 3 cm. long, which could easily and at slight expense be subjected to various conditions. The investigation then undertaken yielded the following results:

1. The contamination of the platinum wire causing the change in electromotive force probably represents in the worst cases two or three per cent. of added impurity.
2. The platinum-rhodium wires are altered in electromotive force about one fourth as much as the platinum, which probably indicates an equal percentage of added impurity.
3. The contamination is first noticed at about 1000° and increases with the temperature. (Of course it also increases with the time.)
4. Only a little of the contaminated material is removed by glowing, that is, heating the wires nearly to their melting points by an electric current.
5. Wires heated in carbon monoxide and illuminating gas under a wide variety of conditions showed no contamination at high temperatures, 1200° and above.
6. Wires heated to 1500° for an hour in a glazed porcelain tube showed no contamination; no contaminating substance came through the furnace, and the porcelain gave out none. There is therefore probably no danger of contamination from silicates in an oxidizing atmosphere.
7. A platinum wire in a porcelain tube with a wire containing ten per cent. of iridium showed about as much contamination as when used in the furnace. Iridium from the coils of our furnace, which contain ten per cent. of it, is therefore probably the main cause of the trouble we have experienced.

8. Chemical analysis showed iridium in substantially the expected amount.

9. A few milligrams of iron wire inserted in the tube caused contamination. The wire probably exhausted the oxygen in the tube when first put in.

10. Ferric oxide at the same temperature (1500°) produced no contamination.

11. The wires were not contaminated in front of a blast lamp, but they were in the exhaust from a Fletcher furnace. Iron in some form was found to be present in the gases from this furnace, which also probably gave at times a reducing atmosphere.

12. When a tube of commercial platinum was used to shield the test wire from the furnace atmosphere, the wire was still contaminated. When the tube itself was tested thermoelectrically, it was found to contain at least three or four per cent. of impurity. As much of this was probably iridium, its presence is believed to be the cause of the contamination obtained with this tube. Thermoelectric tests of other samples of commercial platinum show from one half of one per cent. of iridium upward. Proximity to commercial platinum is therefore a source of danger to thermoelements at high temperatures.

13. A Heraeus thermoelement from the Corning Glass Works, which had been in continuous use for five months at 1400° in gas furnaces, showed one or two per cent. contamination of the platinum wire; far less in proportion to the time than was shown by our elements. But a striking difference was found in the condition of the rhodium-alloyed wire, which was not contaminated at all. A chemical test is now in progress to see whether the contamination in this case was due to rhodium from the rhodium wire.

14. Two attempts to check the contamination of wires by the use of a nitrogen atmosphere have failed. Further work, however, will be done in this direction.

CONCLUSION.

The proximity of platinum containing iridium, etc.; that is, practically all commercial platinum, will cause deterioration of platinum thermoelements when exposed in an oxidizing atmosphere above 1000° . There is apparently no other source of danger in an oxidizing atmosphere.

II.

Ordinary wires of constantan, German silver, etc., show inhomogeneities which greatly detract from their value in thermoelectric work. By using a thermopile instead of a thermoelement, the total electromotive force was increased and at the same time it was hoped that the inhom-

geneities would tend to neutralize each other's effect. Experience seemed to show that it was better to first test the condition of the wire rather than rely on accidental corrections. A wire tester adapted to insulated wires several meters in length was made of a steam-jacketed glass tube. The wire was gradually drawn out of this tube, so that the thermoelectric height of the portion which was at the opening at any time was compared directly with another immovable portion. The result showed for No. 36 Advance wire a rise and fall of thermoelectric height with a fairly constant period of 60 cm., averaging about .25 per cent. of the electromotive height against copper, or over ten times the height of the short period variations found by Professor Hall.¹

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THE VELOCITY, AND RATIO e/m , FOR THE PRIMARY AND SECONDARY β -RAYS OF RADIUM.²

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THE work of Kaufmann has shown that the primary β -rays are composed of negatively charged particles travelling with velocities nearly equal to that of light, and that further, as the velocity of light is approached the apparent mass of the electron increases rapidly. In trying to repeat these results, using, instead of the photographic method of Kaufmann, the well-known ionization one, the author experienced at first great difficulty in getting any true deflection of the β -rays. By further investigation however this difficulty was shown to be due to the presence of secondary and tertiary rays, which to a great extent masked the action of the primary β -rays.

An investigation into the nature of these secondary and tertiary rays, more especially absorption tests, and their behavior in a magnetic field, brought forth the following facts:

1. When the β -rays strike upon solid objects, there is produced at the surface of these, secondary rays, which differ both in quantity, and penetrating power with the nature and density of the object.
2. Nearly all of the secondary rays, whether from dielectrics or metals, are deflected in a magnetic field in the same direction as the primary β -rays would be.

¹ Proc. Am. Acad., 41, 543.

² Abstract of a paper presented at the Washington Meeting of the Physical Society, April 21, '06.