EXPERIMENTS WITH THE TUBE RESISTANCE FURNACE ON THE EFFECT OF POTENTIAL DIFFERENCE

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The form of electric furnace which has been found most effective in spectroscopic work is the tube resistance type, in which the substance to be vaporized is placed in a graphite tube heated by a current, the electrodes being applied at the ends of the tube. A column of vapor of almost uniform temperature is thus obtained in a considerable length of the tube. The temperature can be closely controlled and raised until the vaporization of the tube material becomes very violent, in the neighborhood of 3000° C. Regulated in this way, the furnace has uniformly emitted a definite spectrum of the enclosed vapor at a given temperature, and much evidence has been gathered which indicates a high degree of independence of chemical action arising from the use of various compounds or the presence of different gases in the furnace chamber, such actions appearing to affect the general intensity of a spectrum without materially modifying its character.

Since an important feature of the furnace is the excitation of the enclosed vapor by the high temperature of the tube rather than by the passage of a current as in the case of the arc, any approach to arc conditions which may result from the mass of ionized vapors being exposed to the potential difference of the ends of the tube must be carefully taken into account. It is obvious that a certain amount of such conduction may take place, in spite of the low potentials employed and the very small resistance of the graphite tube. Experiments have therefore been carried out to see whether, at least for the temperatures which usually bring out the important features of furnace spectra, a reduction or elimination of the potential difference by special means would cause any deviation from the spectrum observed at the same temperature with the regular operation of the furnace. For this purpose the tube was charged with iron, and certain lines very sensitive to change of temperature and especially strong in the arc were taken as a test spectrum. The bands given by the vaporization of the carbon tube and the lines of titanium and vanadium resulting from impurities were noted for the same purpose.

A reduction of the potential difference was obtained by two methods: first, by the use of direct current, which avoided the high momentary values of the alternating voltage usually employed; and, second, by using an insulated tube to contain the luminous vapor, inside the tube carrying the current, this inner tube furnishing an extra low-resistance path for any current not carried by the furnace tube. In each case, the test spectrum was the same at a given temperature, showing no effect of the reduced possibility of conduction by the vapor. With the first method, an extra protection of the tube from loss of heat permitted the observation of the test spectrum with a potential difference of less than 0.6 volt per centimeter length of the tube.

Two experiments in which there was no potential difference on the tube were next tried. In one, the tube was heated, the current broken, and the exposure made during an interval while the tube cooled with no current. The spectrum was found to be the same as when the furnace was operated in the regular way at the mean temperature of the no-current experiment. In the other test, a tube containing iron was heated by a high-current arc between horizontal electrodes supported beneath the tube. The vapor in the tube used as a crucible in this way emitted a spectrum in which the test lines appeared as in the resistance tube carrying a current.

The conclusion from this series of experiments is that for the temperatures required in the line classification which the writer has carried out for a number of metallic spectra, the potential difference acting on the tube is not effective in modifying the spectrum, the lines sensitive to arc conditions appearing with equal ease whether a voltage is acting on the tube or not. Higher temperatures, accompanied by increase of both ionization and potential drop, should be checked when possible as to the effect of conduction by the vapor. Lines brought out only at these higher temperatures are, however, usually so faint that they are of little importance in the furnace spectrum. For a study involving these lines, the arc would usually be employed.

AN APPLICATION OF THE PORISM OF FOUR TANGENTS OF A TWISTED CUBIC

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The problem of determining the involutions of degree n of a given discriminant has not been solved except when $n = 2,3,4$.

Special forms of discriminant occur in Jacobi's transformation of elliptic integrals and in researches on reducible integrals. Geometrically the problem is to construct a rational curve in n-space of degree n to touch $2(n - 1)$ hyperplanes of a pencil. For $n = 3$ the solution depends on a certain porism;[1] that of four tangents of a twisted cubic. There is in fact the theorem: No proper twisted cubic can be drawn to touch four lines unless they satisfy a condition in which case an infinity of cubics

[1] Dixon, A. C., on twisted cubics which fulfil certain conditions, *Quar. J. Math.*, **23**, 1889 (343–357).