The Melting Point of Palladium.

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I. *Introduction.*

The melting point of palladium is a convenient reference point for the measurement of high temperatures. In fixing a scale of temperature the aim is, of course, to approximate as closely as possible to the thermodynamic scale. From the absolute zero up to moderately high temperatures this ideal scale is realised most directly and accurately through the medium of the gas thermometer. However, with increase of temperature beyond a certain limit, the experimental difficulties of gas thermometry multiply rapidly, so that ultimately it becomes necessary to adopt another basis for obtaining the scale. This is conveniently found in the laws governing the radiation from a black body, which have a sound theoretical foundation and permit the use of measuring instruments of precision.

The establishment of a practical scale of temperature on the lines above indicated has been the subject of considerable discussion between the national standardising laboratories of Germany, Great Britain and the United States of America. As a result, proposals for the definition of an "International Temperature Scale" were submitted to the 7th General Conference* of Weights and Measures, and approved by them. In effect, the basis of the scale up to the melting point of gold is the gas thermometer,† and beyond this temperature the Wien or Planck law‡ of radiation with an agreed value for the constant c_2. Owing to the difficulty of absolute measurements of radiation, no attempt has so far been made to place the radiation scale on an independent basis by fixing the other constant in the Wien or Planck equation. Consequently the scale is defined, for the present, relatively to a fixed point on the thermodynamic

* 'Comptes rendus des Séances, Sept. Conférence générale des poids et mesures,' Paris, 1927.

† The scale is actually defined by the assignment of certain values to the melting or boiling points of a number of pure substances, and by prescribed means of interpolation between these temperatures, the whole being based on work with the gas thermometer.

‡ The definition adopts the Wien law as confined to monochromatic visible radiation. When thus limited the two laws become practically identical.

scale, as given by the gas thermometer, namely the melting point of gold (1063° C.).

While the radiation scale of temperature is thus completely defined by the values assigned to one fixed point and the constant c_2, it is useful to place on record the values of other fixed points in terms of the scale. Determinations of this kind serve to indicate the degree of reproducibility of the scale, and, where the values are sufficiently well established, may afford secondary standards for its realisation. Of such fixed points the most important is the melting point of palladium, a determination of which is described in this paper.

II. *Description of Method.*

For the purpose of realising the radiation scale of temperature as above defined, it has been found to be convenient to work with monochromatic, or nearly monochromatic, radiation in the visible portion of the spectrum, employing a photometer designed to measure the relative intensities of such radiation from black body radiators at different temperatures. The instrument most commonly used is the Holborn-Kurlbaum type of the disappearing-filament pyrometer. This can be fitted with a spectrometer so as to deal with monochromatic radiation or with a filter transmitting as narrow a band of radiation as possible. The latter type has the advantage of simplicity, and apparently also of ease and accuracy of setting, but the wave-length to which its transmission is to be assigned, involves a somewhat troublesome calculation. The "effective wave-length"* of the filter for any two temperatures is defined as that wave-length for which the ratio of the integral luminosities, viewed through the filter, of black bodies at these temperatures is equal to the ratio of their radiation intensities. The limiting value of this wave-length when the two temperatures approach each other has been shown by Foote† to be given by

$$\lambda_L = \int_0^\infty \mathrm{TVJ}\, d\lambda \div \int_0^\infty (\mathrm{TVJ}/\lambda)\, d\lambda,$$

where for any wave-length T, V and J are respectively the percentage transmission of the glass, the visibility coefficient‡ for the eye and the relative energy of a black body. It may be added that the relation between the limiting effective wave-length and temperature is generally so nearly linear as to allow

* Hyde Cady and Forsythe, 'Phys. Rev.,' vol. 6, p. 70 (1915); 'Astrophys. J.,' vol. 42, p. 294 (1915).

† Foote, 'Bull. B.S.,' vol. 12, p. 483 (1915); see also Henning, 'Z. Instr.,' vol. 45, p. 530 (1925).

‡ For recent values see Gibson and Tyndall, 'Bull. B.S.,' vol. 19, p. 131 (1923).

the effective wave-length for a temperature interval of several hundred degrees to be taken as the mean of the limiting effective wave-lengths for the two extreme temperatures of the range.

The advantages of working in different parts of the spectrum have been discussed by Forsythe* and in the present investigation the Corning glass (high transmission red 53 per cent.) has been employed in a thickness of 5 mm. This has an effective wave-length for the gold-palladium interval of $0 \cdot 656\ \mu$. The form of pyrometer used does not differ essentially from those used elsewhere† and therefore calls for no detailed description. It should, however, be mentioned that the Bureau of Standards kindly presented the Laboratory with several of their pyrometric type of lamp having a cylindrical glass envelope closed with optically flat ends. These lamps have proved to be of great assistance, since they allow a high magnification without distortion. In order to determine the ratio of the radiation intensities at the two melting points, a rotating sector was employed, of such aperture that, for the wave-length above-mentioned, the radiation from a black body at the higher melting point was reduced by it to be about equal to that at the lower melting point. The sector consisted of a disc of planished steel, 35 cm. in diameter, with two accurately cut radial slots with bevelled edges, and its effective aperture was found by direct measurement‡ with a probable accuracy of $\pm 0 \cdot 5$ per cent. The rotating sector could be interposed in the pyrometer system just in front of the pyrometer lamp and rotated at speeds of the order of 3500 revolutions per minute in order to eliminate flicker effects.

We describe below, in detail, the experimental procedure adopted in order to obtain black-body radiator at the two melting points. No special originality is claimed for most of the devices adopted, the experience of previous investigators having been freely utilised.

III. *Experimental Procedure.*

In the present investigation three methods of realising a black-body have been employed, differing from each other as regards the type of enclosure or the method of measuring its temperature. The first method consists in the use of a tubular furnace with a series of diaphragms giving an inner chamber

* 'J. Opt. Soc. Amer.,' p. 85 (1921); see also Henning and Heuse, 'Z. Physik,' vol. 32, p. 799 (1925).

† See, *e.g.*, Forsythe, 'Astrophys. J.,' vol. 43, p. 295 (1916); Worthing and Forsythe, 'Phys. Rev.,' p. 163 (1914); Fairchild and Hoover, 'J. Opt. Soc. Amer.,' p. 543 (1923).

‡ The discs were cut and measured by the Metrology Dept., Nat. Phys. Lab.

the temperature of which is indicated by the melting, inside the chamber, of a wire of a pure metal, *e.g.*, gold or palladium. In the second method a black-body chamber in the form of a stopped-down tube is inserted into an ingot of pure metal and the radiation is observed either at the melting or freezing point of the metal. In the third method the black-body radiator consists of a hollow cone made up from the pure metal in the form of foil, and the radiation from the interior of the cone is observed during its collapse on melting. For convenience the three methods are referred to respectively as the "wire," "ingot" and "cone" methods.

"*Wire*" *Method.*—The general practice is to employ a radiator formed by stopping down a furnace tube consisting of some highly refractory material with a heating element in contact with its outer surface. For the material of the latter platinum is very convenient and this may be applied to the tube in various ways, *e.g.*, a spiral winding of wire, or of ribbon, or a complete sheathing of thin foil. With the spiral winding a variable spacing of the wire or ribbon, or in the case of the ribbon a variable width,* may be used to counteract the cooling effects of the ends and give a reasonable length near the centre of the furnace at a constant temperature. The objection to a fixed compensation of this type is that it may not be equally effective at temperatures so widely separated as the melting points of gold and palladium, which are some 500° C. apart. It is preferable, therefore, to provide for a variable regulation of temperature distribution.

In the present case this has been done by means of auxiliary heating coils. After experiment with several different types, the arrangements shown in fig. 1 were adopted. The main furnace tube of alundum was wrapped with a sheath of platinum foil 42 cm. long which at the ends was 0·0025 cm. thick and at the central portion 25 cm. long, was 0·0037 cm. thick. The sheath was made up by welding on to a sheet of platinum of the first stated thickness an extra sheet of half the thickness, the ends of the latter being deeply serrated so as to avoid an abrupt change of resistance where the sheets were joined.† A permanent grading of the heating element was thus provided, so chosen that it was of itself insufficient to counteract the cooling effect of the ends. In addition there were inserted into each end of the furnace the auxiliary heaters shown. These consisted of alundum tubes spirally grooved and wound with

* See, *e.g.*, Coblentz Art. on "Radiation," in vol. 4, "Dictionary of Applied Physics" (Macmillan & Co.); Ferguson, 'Phys. Rev.,' vol. 12, p. 81 (1918); Waidner and Burgess, 'Bull. B.S.,' vol. 00, p. 163 (1907).

† See Hoffmann and Meissner, 'J.X.Z.,' vol. 60, p. 201 (1919).

platinum wire 0·5 mm. in diameter. A bifilar system of winding the heaters was adopted, in order that both leads should emerge from one end. For

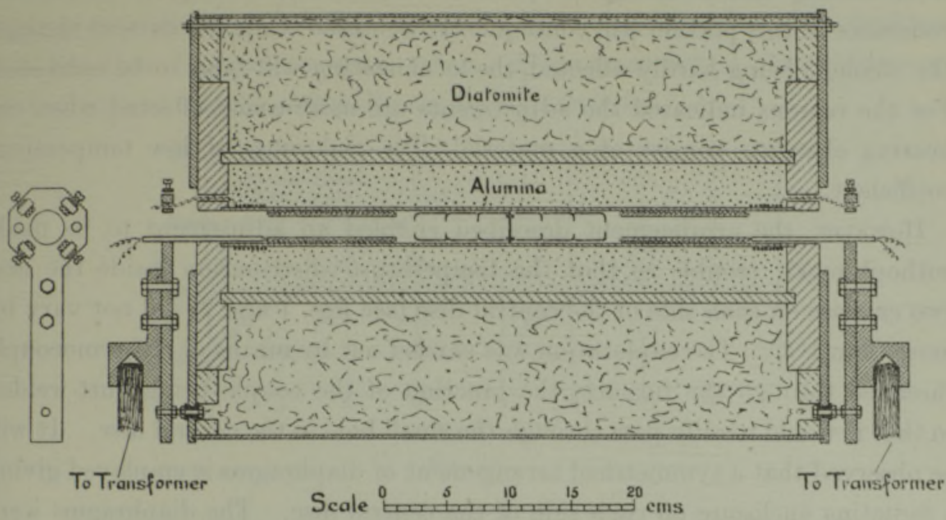

Fig. 1.

this purpose two parallel longitudinal cuts were made through the screw thread on the outside of the tube as shown in section in fig. 2. Starting

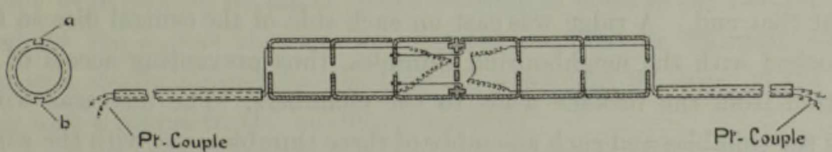

Fig. 2.

from the centre of the wire, the winding of one half of the wire was commenced in the end section of the thread until, on reaching the gap *a*, it returned on itself in the next groove and similarly at *b*, and so on until the other end of the heater was reached. Each half of the wire was thus wound on a separate half, formed by the cuts *a* and *b*, of the tube. The ends of the wires, after being anchored through holes in the tube, were led out of the furnace inside a twin bore alundum sheath. A compact assembly was thus obtained, which could easily be moved about in the furnace without interfering with the other wires threaded through it. The heaters above described gave two methods of temperature adjustment, namely those afforded by movement of the heater and the variation of the heating current. Incidentally it may be remarked that any system of the type described tends to be rather unstable

owing to the large temperature coefficient of resistance of platinum. Thus if the current through one of the auxiliary heaters is raised, this will cause a local heating of the contiguous portion of the main heating element. The resistance of this portion will consequently be raised while the current through the element being hardly affected, the local heating will tend to be enhanced. For the reasons indicated the adjustments are more easily effected when the heating elements consist of a material, like nichrome, of low temperature coefficient.

However, the arrangement described enabled an adjustment to be made without much trouble so that the temperature distribution inside the first two cavities on each side of the central disc (see figs. 1 and 2) did not vary by more than 1° C. The exploration was carried out by means of a thermocouple threaded through the furnace, the junction of the couple being butt-welded so that it would readily pass through the small hole in the central disc. It will be observed that a symmetrical arrangement of diaphragms is employed giving a radiating enclosure on each side of the central disc. The diaphragms were formed by cutting central holes* about 3 mm. in diameter in the bases of the alundum "thimbles," which were about 20 mm. in diameter. Smaller holes were also provided for threading through the two pairs of thermocouples, one pair passing from each end of the furnace into the innermost chamber nearest that end. A ridge was cast on each side of the central disc so that it interlocked with the neighbouring thimbles, thus preventing access of direct radiation from the furnace walls to the chambers. The disc was wired to one of the thimbles and each assembly of three thimbles, one with the wired-on disc, could readily be withdrawn from the furnace for replacement of the specimens of gold or palladium used for a melting point determination. The specimens, consisting of wire 0·5 mm. in diameter, were connected across the arms of one of the couples. The usual process of observing the melting points was followed. This consisted in raising the temperature of the furnace at a steady rate, not exceeding 1° C. per minute and taking successive readings of the four thermocouples, two of which had specimens of gold or palladium joining their arms and two of which had the usual welded junctions. In fig. 2, for purposes of clearness, only one of each type of couple is shown. On reaching the melting point the two former couples (which we may call the "melt-couples") remained constant in E.M.F., while the other couples (referred to below as the "control-couples") continued to rise. Usually the rise of the control-couples continued for about 2° C. before the circuits of the

* *Cf.* arrangement adopted by Hoffmann and Meissner (*loc. cit.*).

other couples broke on complete fusion of the metal, but in all cases the melting point was taken as that temperature at which the halt in the E.M.F. value of the melt-couple was first detected. The furnace was then adjusted to remain constant at this temperature, as given by the control-couple, while readings with the optical pyrometer were taken. A specimen set of observations on the two pairs of control- and melt-couples is given in fig. 3.

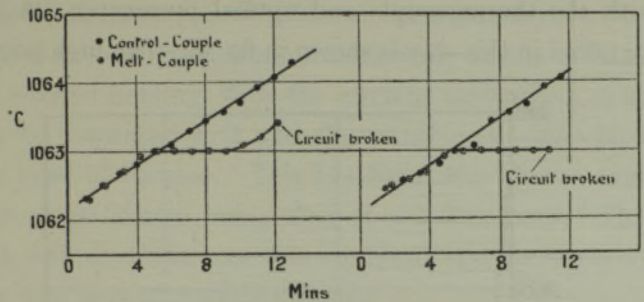

Fig. 3.

The following additional particulars of the apparatus may also be given. The leads to the main furnace winding consisted of 16 platinum wires of 0·5 mm. diameter. These, after being twisted round the foil on the tube, passed out in four batches to the electrode shown, both in elevation and section, in fig. 1. Here they were gripped by metal blocks working in holes in the electrode and clamped by the screws shown. The current required to maintain such a furnace at a steady temperature of 1550° C. was about 90 amps. in the main winding and 4 amps. in the auxiliary windings.

The observations taken with the apparatus above described, and also with similar furnaces and radiators of less elaborate construction, are dealt with in Section IV below.

"*Ingot*" *Method.*—This method has so far been used only for the melting point of gold. A section of the ingot, about 2000 gms. in weight, with a black-body radiator in position, is shown in fig. 4. The radiator referred to is similar in shape to that employed by Hoffmann and Meissner and was made of pure china clay.* Another type of radiator used is also shown in fig. 4. This consisted of a thin-walled silica sheath with a number of

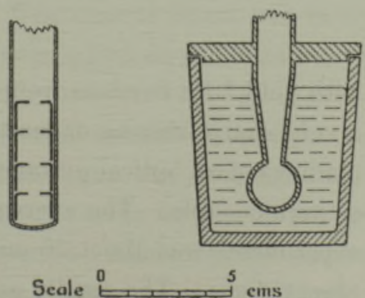

Fig. 4.

* Made by a casting process by the Metallurgy Dept., National Physical Laboratory.

perforated alundum thimbles arranged to act as diaphragms. In addition to the radiator a sheathed thermocouple (not shown in fig. 4) was inserted into the ingot.

In making an experiment the usual procedure of observing a melting or freezing point was followed: namely, of raising or lowering the temperature of the furnace at a certain rate and taking of readings of temperature against time both with the thermocouple and optical pyrometer. A specimen of a freezing curve taken in this way is shown in fig. 5. The high purity obtainable

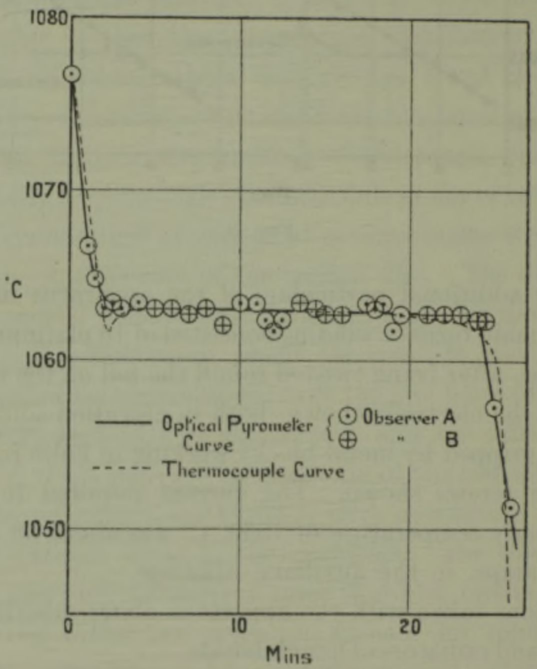

Fig. 5.

with gold,* its freedom from oxidation and high latent heat combine to give a very sharp freezing or melting point which is readily distinguishable by the readings of an optical pyrometer as well as by the more sensitive indications of a thermocouple. The average period at constant temperature in the present experiments was about 20 minutes, which afforded ample time for the optical observations. The results are dealt with in Section IV below.

"*Cone*" *Method*.—Several experimenters have made use of thin sheet metal to form the walls of a black-body enclosure, the object generally being to obtain the emissivity of the metal by comparison of the radiation intensity

* The specimen used in these experiments was of pure assay gold supplied by Messrs. Johnson, Matthey & Co., and stated to be of $99 \cdot 99_9$ per cent. purity.

from the internal and external surfaces of the enclosure. Thus Mendenhall* used two electrically-heated strips so juxtaposed as to give a narrow-angled wedge, Worthing† used a hollow filament with a minute observation hole, and Ives‡ a larger cylinder of platinum foil with a longitudinal slit. In all these cases the heat was supplied by the passage of an electric current through the walls of the enclosure.

Where, as in the present case, the object is merely to make a single brightness determination of the radiation from a black-body at the melting point of the metal, direct electric heating, with the obvious limitations of shape which it imposes, may be dispensed with and the metallic envelope placed inside the usual tubular type of furnace. This has been done in the experiments here described, the shape chosen being that of a hollow cone. The thickness of the foil used in making up the cone was 0·004 cm. and the assembly for insertion in the furnace took several slightly differing forms of which two are illustrated in fig. 6. In one of these the cone was contained in an alundum thimble with a sighting hole in the bottom, which also served as a "stop" on the rather wide-angled cone. In the other arrangement a very narrow angled cone and a thicker-walled container were used, the latter generally consisting of "mabor" material, though graphite§ could be employed in the case of gold. A hole parallel to the axis was provided in this container, so as to allow a thermocouple exploration after the assembly had been inserted into the central region of the tubular furnace shown in fig. 1. The central block was fairly short, but was flanked on either side by extra blocks which served as radiation shields (see fig. 6).

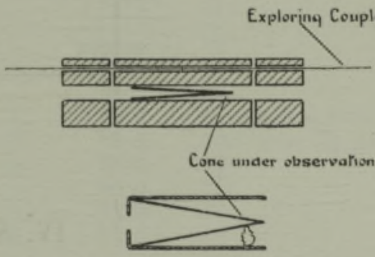

FIG. 6.

The process of observing the melting point consisted in taking simultaneous readings with the optical pyrometer, sighted into the cone, and with a thermocouple in its vicinity, *e.g.*, in the longitudinal hole shown in fig. 6. When the cone commenced to collapse on melting there appeared a black crescent-shaped patch of growing size, corresponding with the increasing area of unobstructed

* 'Astrophys. J.,' vol. 33, p. 91 (1911).
† 'Phys. Rev.,' vol. 10, p. 377 (1917).
‡ 'J. Franklin Inst.,' vol. 197, p. 147 (1924).
§ Roberts, 'J. Opt. Soc. Amer.,' p. 723 (1925).

view through the furnace. It was found that, during the period of melting, the pyrometer readings remained sensibly constant.

A specimen series of readings with a thermocouple and pyrometer is given in fig. 7.

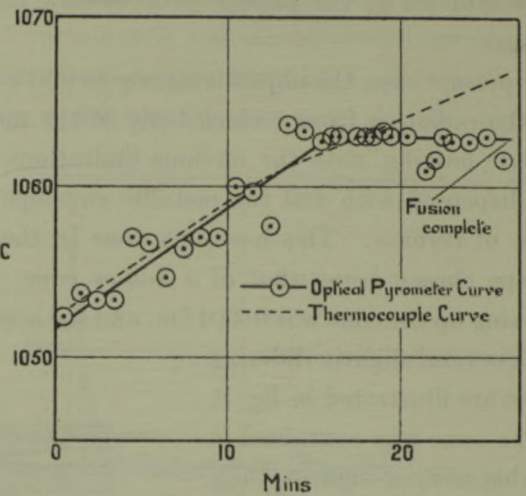

Fig. 7.

IV. *Summary of Results.*

As has already been indicated, the measurements made in the present investigation take the form of :—

(1) A determination of the current in the pyrometer lamp required to give a match in brightness, at a particular wave-length, with a black-body held at the melting point of gold.

(2) A similar measurement in the case of palladium, employing a rotating sector to reduce the brightness to about the same intensity as at the gold point.

These measurements enable the ratio of brightness, for a particular wave-length, of a black body at the two melting points to be determined, or, expressing the result in another way, enable a definite value to be assigned to the melting point of palladium, on the basis of an assumed value for the melting point of gold and the constant c_2.

Dealing first with the measurements at the gold point, the "ingot" method appears to give, as would be expected, the most reliable determinations. A summary of the observations obtained with this method is given in Table I.

Table I.—Gold Point Observations by "Ingot" Method.

(Pyrometer reading expressed in temperature relative to mean value of the series assumed to be 1063° C.)

Freezing points.		Melting points.		Type of radiator.
Rate of fall of furnace.	Pyrometer reading.	Rate of rise of furnace.	Pyrometer reading.	
° C./min.	° C.	° C./min.	° C.	
4·5	1063·0	4·5	1063·0	Bulb (fig. 4).
4·5	61·0	5·0	63·5	
4·0	63·0	4·5	62·5	
4·0	62·5	6·0	63·5	
6·5	63·0	5·0	62·5	
6·0	63·0	8·0	63·0	
4·5	63·0	7·5	63·0	
4·0	62·5	3·5	63·0	
—	—	5·0	62·5	
4·0	1063·5	8·5	1063·0	Diaphragmed tube (fig. 4).
7·0	61·5	8·5	63·0	
5·5	63·0	8·0	63·5	
6·0	63·0	7·0	63·5	
6·5	63·5	2·0	62·5	
6·0	63·0	8·5	63·0	
2·5	63·0	8·5	63·5	
5·5	62·5	8·5	62·5	
6·0	63·0	6·0	62·5	

the values being expressed in terms of temperature, relatively to the mean value of the whole series, assumed to be 1063° C. It will be noted that the considerable variations of the rate of cooling or heating, as the case may be, and the change in the type of radiator appear to have no appreciable effect on the values obtained. The observations summarised in Table I were obtained early in the investigation. At its conclusion, a repetition of the experiments with a larger ingot and a new radiator gave a result identical with that of the former series.

The values given by the "cone" and "wire" methods are summarised in Table II and are expressed in terms of temperature, taking as standard the mean value found by the ingot method and assumed to be 1063° C. Comparatively few observations were taken with the latest type of apparatus in view of the satisfactory results given by the "ingot" method and the close agreement of the latter with the mean of the numerous experiments carried out with earlier arrangements of the "cone" and "wire" methods. The mean values just referred to are given in the table.

Table II.—Gold Point Observations by "Cone" and "Wire" Methods.
(Pyrometer reading expressed in temperature relative to mean value given by "ingot" method (Table I) and assumed to be 1063° C.)

Rate of rise of furnace.	Pyrometer reading.	Range of values.	Remarks.
° C./min.	° C.		
0·6	1063·5		Cone method (individual readings with narrow cone, fig. 6).
0·8	64·0		
0·6	64·0		
0·4	62·0		
0·6	62·0		
0·9	63·5		
Mean	1063·5	±1° C.	
—	1064·0	± 2° C.	Cone method (mean of 13 determinations with wide cone, fig. 6).
0·2	1063·5		Wire method (individual readings with arrangement in figs. 1 and 2).
0·2	63·0		
0·4	64·0		
0·3	62·5		
0·2	63·5		
Mean	1063·5	± 1° C.	
—	1063·5	± 5° C.	Wire method (mean of 71 readings with miscellaneous arrangements of diaphragms).

In the case of the palladium, owing mainly to difficulties with the refractory materials, satisfactory results have not, so far, been obtained with the "ingot" method. The values given by the "wire" and "cone" methods, in their latest forms, are set out in Table III, together with the means of the values given by earlier work. Column 2 of the table gives the apparent temperatures, viewed through the sector, of the black body, held at the palladium point, while column 3 gives the true temperatures calculated from the Wien relation :

$$1/T_1 - 1/T_2 = (\lambda/c_2) \log R.$$

T_1 and T_2 being the true and apparent temperatures in absolute measure, λ the effective wave-length, R the transmission value of the sector, and c_2 being taken, as 1·432 cm. degrees. The range of values (± 3° C.) found at the palladium point is somewhat greater than at the gold point. This is to be accounted for, partly at any rate by the fact that any error of observation when using the sector to obtain a reading of apparent temperature in the neighbourhood of 1063° C. becomes approximately doubled when converted

Table III.—Determination of Melting Point of Palladium by "Cone" and "Wire" Methods).

(Constant $c_2 = 1 \cdot 432$ cm. degrees.)

Rate of rise of furnace.	Temperature. Apparent (with sector).	Temperature. True.	Temperature. Range of values.	Remarks.
° C./min.	° C.	° C.		
0·7	1064·5	1552·5		Cone method (narrow-angled cone, see fig. 6).
1·6	66·5	56·5		
1·6	66·0	55·5		
0·7	65·5	54·5		
0·9	66·5	56·5		
0·7	66·5	56·5		
0·4	67·5	58·0		
0·8	67·5	58·0		
0·9	65·0	55·5		
0·8	65·5	54·5		
Mean	$1066 \cdot_1$	$1555 \cdot_5$	± 3° C.	
0·8	1067·5	1558·0*		Wire method (see figs. 1 and 2).
0·7	65·5	54·5*		
0·9	65·5	54·5*		
0·5	65·5	54·5*		
0·7	64·0	52·0		
0·4	65·0	53·5		
0·8	65·0	53·5		
0·8	66·0	55·5		
0·8	66·5	56·5		
0·4	65·5	54·5		
Mean	$1065 \cdot_6$	$1554 \cdot_5$	± 3° C.	
—	$1065 \cdot_7$	$1554 \cdot_5$	± 5° C.	Wire method (mean of 28 experiments with miscellaneous arrangements of diaphragms).

* Sample of palladium from Bureau of Standards (No. 138). All other specimens from Messrs. Johnson, Matthey & Co.

into a true temperature in the neighbourhood of 1550° C. Thus if the range of variation in setting up a black body at both the gold and palladium points were taken to be ± 1° C. and the range of observational error ± 1° C., then the total range of error at the gold point would be of the order of ± 2° C. and at the palladium point of the order of ± 3° C. In the case of the "wire" method the control-couple enables the furnace to be maintained at the temperature of the observed melting point for an indefinite period, so that readings can be taken with and without the sector. This would lead to a reduction of the observational error, but on the other hand there would be some risk of change

in the pyrometer lamp when run at high temperature. In order to avoid this risk and for the purpose of obtaining a comparison with the "cone" method, which does not allow sufficient time for the taking of readings with and without the sector, the recent observations with the "wire" method have been obtained with a sector only.

From the experiments summarised in Table III the value of the melting point of palladium on the International Temperature Scale ($c_2 = 1 \cdot 432$ cm. degrees ; M.P. of gold = 1063° C.) may be taken as 1555° C. to the nearest 1° C. The accuracy of this determination is estimated to be of the order of ± 2° C.

V. *Comparison with Previous Work.*

It is of interest to compare the value found in the present investigation for the melting point of palladium with those given by previous work of a similar nature. In Table IV are set out the values of the melting point as determined by radiation methods at the following laboratories, viz., Nela Research Laboratory (Nela), Physikalisch-Technische Reichsanstalt (P.T.R.), Bureau of Standards (B.S.), National Physical Laboratory (N.P.L.). The figures have been reduced to a common value of the constant c_2, namely, $1 \cdot 432$ cm. degrees, as prescribed for the International Temperature Scale.*

Table IV.—Melting Point of Palladium.

($c_2 = 1 \cdot 432$ cm. degrees ; M.P. of gold = 1063° C.)

Laboratory.	Reference.	Melting point on International Temperature Scale.
		° C.
Nela	Hyde and Forsythe, 'Astrophys. J.,' vol. 51, p. 245 (1920).	1557
P.T.R.	Hoffmann and Meissner, 'Ann. d. Physik,' vol. 60, p. 201 (1919).	1556
B.S.	Fairchild, Hoover and Peters, 'B.S. Jour. of Research,' vol. 2, p. 931 (1929).	1553·6
N.P.L.	Present paper (1929)	1555

The table shows the high degree of reproducibility obtained with this melting point. It seems probable that the agreed value of 1555° C. taken as the melting point for the purposes of the International Temperature Scale† is not in error by more than 2° C.

* Comptes rendus des Séances, Sept. Conférence générale des poids et mesures, Paris, 1927.

† *Loc. cit.*

For comparison with a direct determination of the melting point on the thermodynamic scale, reference may be made to the gas thermometer work of Day and Sosman* which yielded a value of 1549° C. with an estimated accuracy of ± 2° C.

Though of less fundamental importance, it is of interest to recall that, by extrapolation from the sulphur boiling point of his parabolic formula for the platinum resistance thermometer, Callendar† obtained the value of 1550° C. for the melting point. He had previously given a value of 1062° C. for the melting point of gold, as had Heycock and Neville, also using a platinum thermometer. These values are in remarkable agreement with the most recent determinations.

In conclusion, the author desires to record his indebtedness to the Director of the National Physical Laboratory, and to Dr. Kaye, the Superintendent of the Physics Department, for their interest in the work and the ample facilities provided. He is also much indebted to Mr. B. J. Gibbs, B.Sc., lately an Observer in the Physics Department, who constructed the greater part of the apparatus and rendered valuable assistance with the observations.

* 'Amer. J. Sci.,' vol. 29, p. 93 (1910).

† 'Phil. Mag.,' vol. 47, p. 191 (1899); see also Burgess and Le Chatelier "Measurement of High Temperatures" (John Wiley & Sons, New York), pp. 199, *et seq.*