XXIII. "On Radiation from Dull and Bright Surfaces." By J. T. BOTTOMLEY, M.A., F.R.S.E. Communicated by Sir W. THOMSON, Knt., F.R.S. Received May 26, 1887.

In connection with an investigation on heat radiation which I have been carrying on for some time past, and on which I recently presented a communication to the Royal Society, I have had occasion to examine the important results obtained by Mr. Mortimer Evans on the radiation of light and heat from bright and dull surfaces when incandescent ('Roy. Soc. Proc.,' vol. 40, 1886, p. 207); and I have repeated and verified some of his experiments. Mr. Evans experimented on carbon filaments of incandescent lamps; and in calculating, for my own use, the resistances of the filaments at different degrees of incandescence I was led to an unexpected result, and hence to an investigation of which I desire just now to offer a preliminary notice.

In order to explain, it is necessary for me to state briefly the object and nature of Mr. Evans' experiments. Their object was the comparison of the radiation from surfaces having a bright, polished appearance with that from dull surfaces having the appearance of lampblack; and he was led to an important practical conclusion as to the superior light-giving efficiency of the brilliant-looking filament. For these comparisons the *same* filament was treated in such ways as to alter the surface from dull to bright and back again. It was taken out of the glass globe for the purpose, and after treatment placed in a fresh globe, which was then exhausted. The lamps thus constructed and reconstructed were tested at various candle-powers, the energy for each candle-power being determined.

The tables given in Mr. Evans' paper show for the filaments in different conditions the potential and the current required to maintain different candle-powers from four candles upward. Using his numbers, and supposing Ohm's* law to hold for the carbon filaments, I have calculated the resistances of the filaments at different candle-powers.

Two filaments used by Mr. Evans afforded satisfactory data for my calculations. They are designated in his paper D, DD, DDD, and C, CC, CCC. They had been treated in the following manner:—The filaments D and C were "flashed" so as to have a dull surface with the appearance of lampblack. DD and CC are the same filaments flashed so as to have a brilliant surface, which, though black, has something of the appearance of frosted silver. DDD, CCC, are the same filaments again rendered dull as at first. The following table shows the volts, amperes, and calculated resistances at the candle-powers given in the left-hand column:—

* I have already commenced an investigation into the question of the conformity of carbon filaments at different temperatures with Ohm's law.

Table I.—Carbon D.

	D.			DD.			DDD.		
Candles.	Volts.	Amp.	Resist.	Volts.	Amp.	Resist.	Volts.	Amp.	Resist.
4	46·5	1·02	45·6	37·3	1	37·3	34	1·28	26·6
10	52·5	1·20	43·8	42	1·13	37·17	38·5	1·52	25·3
20	58·3	1·40	41·6	47·8	1·32	36·29	43	1·77	24·3
40	65	1·62	40·1	52·5	1·53	34·3	48	2·06	23·3
50	68	1·70	40·0	54·2	1·60	33·9	50	2·12	23·6*

Table II.—Carbon C.

	C.			CC.			CCC.		
Candles.	Volts.	Amp.	Resist.	Volts.	Amp.	Resist.	Volts.	Amp.	Resist.
4	45	0·86	52·33	34	0·95	35·79	39	1·16	33·62
10	56	1·12	49·99	39	1·12	34·82	44·5	1·38	32·24
20	62	1·28	48·43	44	1·28	34·37	49·5	1·53	32·37*

Now if we suppose the resistance of the carbon filament to depend on the temperature, the resistance diminishing as the temperature increases (though very probably not in simple proportion); and if (as we should do in the case of a metallic wire) we use these resistances in order to compare the temperatures of the filaments at different candle-powers, we are led to a remarkable result. Taking the filament D and dividing the resistances of D, DD, and DDD at four candles by those at the higher candle-powers, we obtain numbers, which may be looked on as ratios of conductances, and which may be taken as indicating, though not exactly representing, corresponding changes in the temperature of the carbon.

Table III.

	D.	DD.	DDD.
To pass from—			
4 candles to 10 candles {increase of conductance is} from 1 to	1·041	1·006	1·047
4 ,, 20 ,, ,, ,,	1·096	1·028	1·095
4 ,, 40 ,, ,, ,,	1·137	1·087	1·137
4 ,, 50 ,, ,, ,,	1·14	1·100	—

* The two results which appear last in these tables seem anomalous, and therefore I have not used them in my calculations.

The filament C gives confirmatory results, but unfortunately it seems to have broken down early in the condition CCC. I find, however,—

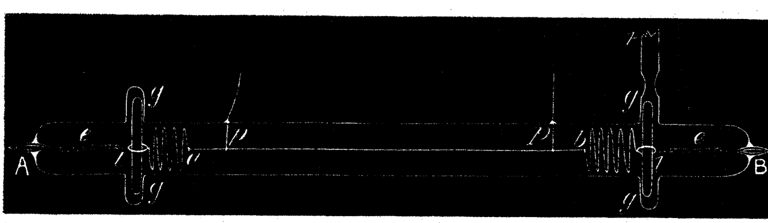
Table IV.

	C.	CC.	CCC.
To pass from—			
4 candles to 10 candles {increase of conductance is} from 1 to	1·047	1·028	1·043
4 „ 20 „ „ „	1·081	1·041	—

Comparing these numbers we are led to the result that, if we admit the assumptions I have made, the temperature to which the carbon must be raised in order that it may give out light of a definite candle-power is higher when the surface is in the dull condition than when it is in a brilliant metallic-looking state.

This result was to me so unexpected that I proceeded to test it directly by the following experiments:—Two glass tubes, similar in every respect, were constructed, containing two precisely similar platinum wires cut from the same hank, which had been specially drawn for me some months before by Messrs. Matthey and Johnson. One of the wires was in its natural bright condition, while the other was covered with the thinnest possible coating of lampblack, which was put on by passing the wire quickly and steadily through the flame of a paraffin lamp. The construction of these tubes is shown in fig. 1. The platinum wire *ab* is kept stretched by two spiral

FIG. 1.



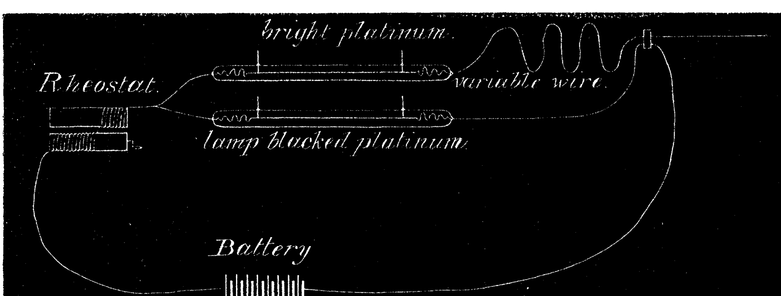
springs of copper, being silver-soldered to two extremities of these springs. Two loops *l* at the other extremities of the spirals pass over two pieces of glass rod *gg*, *gg*, which are passed in by side tubes, blown on to the main glass tube; and the spirals pull on the glass rods. The ends of the side tubes are sealed up after the glass rods are in their places, with the exception of one, which is used for connecting to the Sprengel pump, and is finally sealed when a complete

vacuum has been made. Flexible copper electrodes, *ee*, are silver-soldered to the loops at the ends of the copper springs, and to multiple platinum wires which are sealed into the glass tube at A and B. Fine platinum wires, *pp*, are attached to the main wire, and are brought through the sides of the glass tube; and these serve as potential testing electrodes. The two tubes and their fittings are, as has been said, perfectly similar in every respect, except that one platinum wire is covered with an extremely thin coating of lamp-black.

The two tubes were attached to a glass fork, and were simultaneously exhausted with the Sprengel pump down to about two millionths of an atmosphere, all the well-understood precautions as to drying, &c., being carefully attended to; and they were then at the same moment sealed off from the pump. The length of the tubes AB is 22 inches over all; and the internal diameter of the tubes $\frac{7}{8}$ inch. The distance between the potential electrodes *pp* is 15 inches (38·1 centimetres). The diameter of the platinum wire *ab* is 0·022 inch (0·0599 centimetre). On testing the resistance of the two platinums between the potential electrodes, *cold* and at the same temperature, it was found to be the same for both to less than one one-thousandth part of the resistance of either of them.

The tubes having been prepared as described above, they were connected in parallel arc to a battery of six secondary cells in series, a variable platinoid wire being added in series with the tube containing the bright platinum, in order to regulate its current; and a rheostat designed for carrying strong currents was used to control the whole. The connexions will be readily understood from a glance at fig. 2.

FIG. 2.



With the rheostat and the variable platinoid wire the two platinums were then brought to the same incandescence (as judged by the eye) at various brightnesses from just visible redness up to nearly white heat; and the resistances of the platinums between the potential

electrodes were measured by means of a high resistance reflecting galvanometer, suitably arranged, with shunt and interposed resistance, for the purpose in hand.

The result of my experiments is to bear out completely the deduction which I had made from Mr. Mortimer Evans' numbers; and to show that the temperature which produces, for example, the appearance of a certain red heat, is very much higher when the surface of the heated body is dulled than when it is bright as in a polished metal. I am not yet prepared to give a definite numerical comparison; but in order to show that the difference of temperatures referred to amounts to many degrees of temperature, I may be allowed to give the following statement.

The two wires being at the same dull red heat, which from previous experience I estimate at perhaps 600° C., in the case of the bright-surfaced wire, the ratio of the resistance of the lamp-blacked platinum to the bright platinum was 130 : 93. Platinums differ very much as to variation of resistance with temperature; but in most specimens the resistance is doubled, when the temperature is raised from 0° C. to a temperature of from 300° C. to 400° C.; and for any particular platinum wire the change in resistance is almost in simple proportion to the change in temperature. From this statement it may be judged that the difference of temperatures between the two platinums, dull and bright, when giving out the same light, was a great many degrees centigrade.

The difference of temperatures of the two glass envelopes was also very striking. The glass tube containing the bright wire was not even unpleasantly warm; while in the case of the other it was so hot as to blister the skin of the hand; and in this connection it is to be remembered that the vacuum in the two tubes was the same.

I propose as soon as possible to continue this investigation and render it more complete.

XXIV. "Note to a Paper on the Blood-vessels of *Mustelus Antarcticus* ('Phil. Trans.,' 1886)." By T. JEFFERY PARKER, B.Sc. Lond., Professor of Biology in the University of Otago. Communicated by Professor M. FOSTER, Sec. R.S. Received May 2, 1887.

My attention has been called by a perusal of Professor Milnes Marshall and Mr. C. H. Hurst's 'Practical Zoology' (London, 1887), to an omission in my description of the venous system. These authors describe and figure, in *Scyllium canicula* (pp. 218 and 224) a transverse anastomosis, the *inter-orbital sinus*, connecting the right and

FIG. 1.

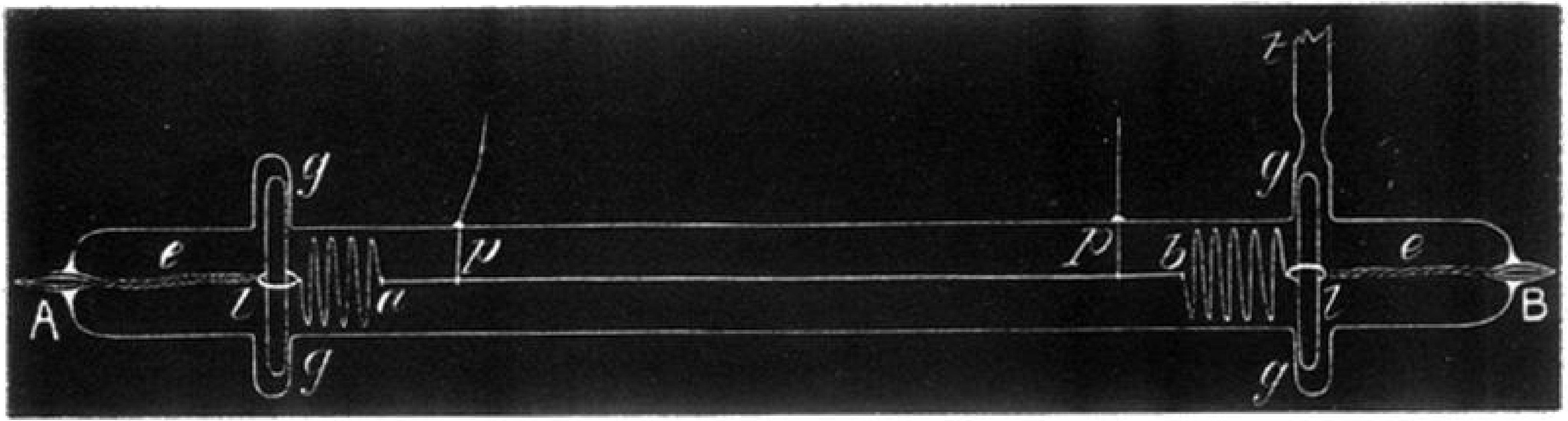
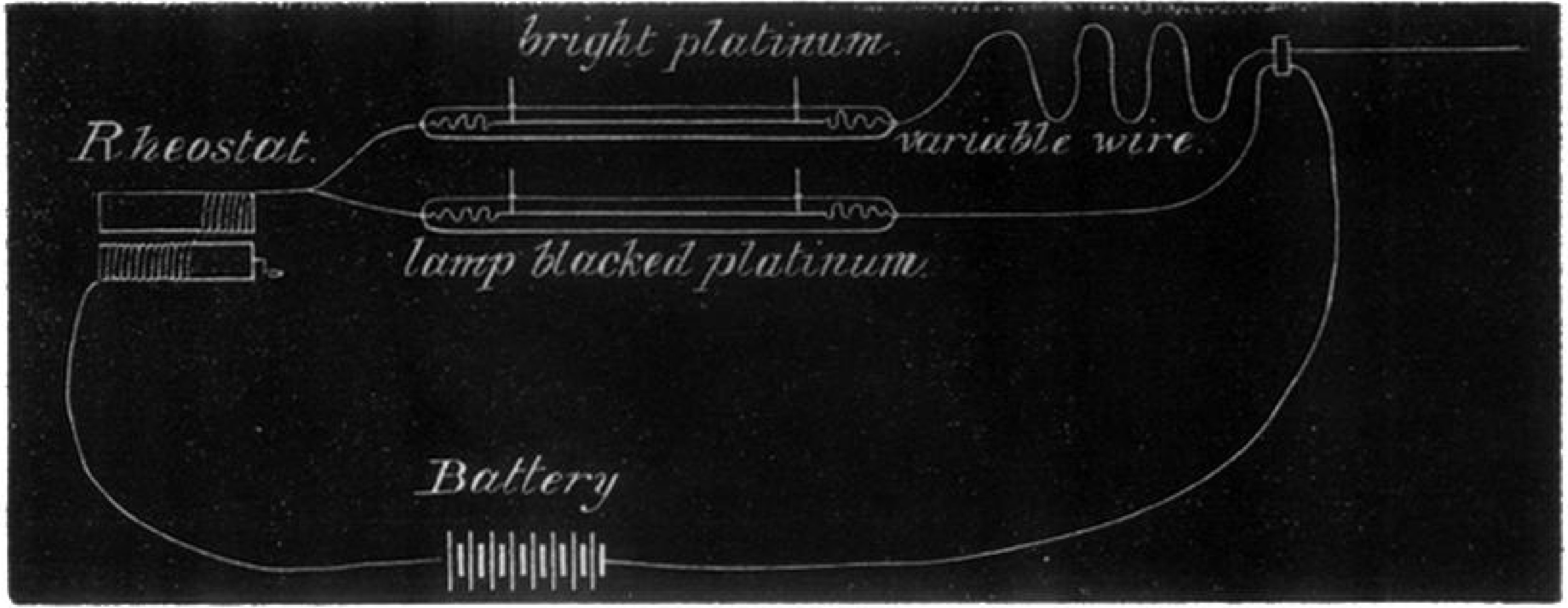


FIG. 2.


bright platinum.
Rheostat.
variable wire.
lamp blacked platinum.
Battery