The value of R in terms of the ohm was found to be

$$160{\cdot}520\,;$$

the temperature being 12°, the values in the above table have been reduced to this temperature.

From this we find as the value of the ohm—

$$\text{Series A} \quad {\cdot}98633 \, \frac{\text{earth quadrant}}{\text{second}}, \; 4 \text{ sets.}$$
$$\text{,,} \quad \text{B} \quad {\cdot}98558 \quad \text{,,} \quad , 2 \;\text{,,}$$
$$\text{,,} \quad \text{C} \quad {\cdot}98676 \quad \text{,,} \quad , 3 \;\text{,,}$$

while the mean of the whole set is

$$1 \text{ ohm} = {\cdot}986307 \, \frac{\text{earth quadrant}}{\text{second}},$$

this being determined from nine sets of observations. If we include Part I, giving to each observation only half the weight of one of those in Part II (reasons for this are given at full in the paper), we have finally

$$1 \text{ ohm} = {\cdot}986271 \, \frac{\text{earth quadrant}}{\text{second}}.$$

The value obtained by Lord Rayleigh in his latest experiments with the rotating coil is

$${\cdot}98651 \, \frac{\text{earth quadrant}}{\text{second}}.$$

The experiments have been made at the Cavendish Laboratory, and our thanks are due to Lord Rayleigh for much kind help and many valuable suggestions.

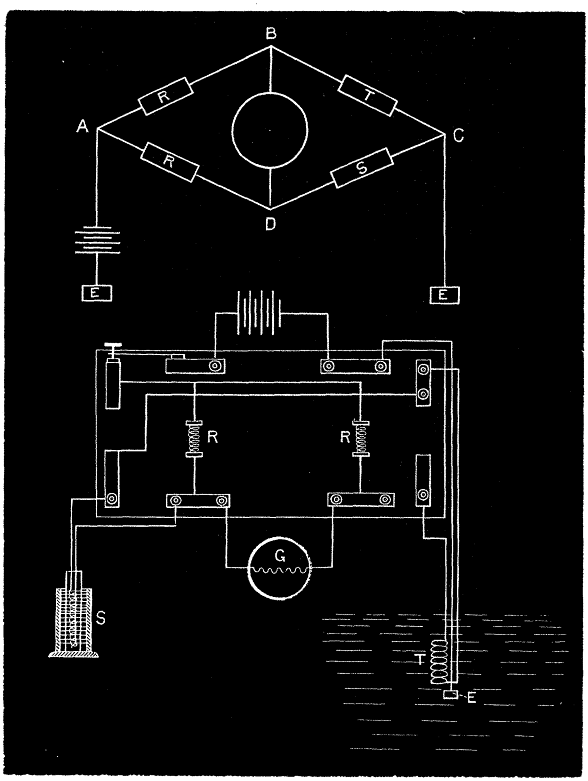
IV. "On a Deep Sea Electrical Thermometer." By C. WILLIAM SIEMENS, D.C.L., F.R.S. Received June 7, 1882.

In the Bakerian Lecture for 1871, which I had the honour of delivering before the Royal Society,* I showed that the principle of the variation of the electrical resistance of a conductor with its temperature might be applied to the construction of a thermometer, which would be of use in cases where a mercurial thermometer is not available.

The instrument I described has since been largely used as a pyrometer for determining the temperatures of hot blasts and smelting

* "Proc. Roy. Soc.," vol. 19, p. 443.

furnaces, and Professor A. Weinhold,* using the instrument with a differential voltameter described in my paper referred to, found its indications to agree very closely with those of an air thermometer within the limits of his experiments from 100° to 1,000° Centigrade. I am not aware, however, that any results have been published of its application to measuring temperatures where a much greater degree of accuracy is required, as in the case of deep sea observations. My friend, Professor Agassiz, of Cambridge, U.S., ordered last year for the American Government an instrument designed by me for this purpose, and during the autumn it was subjected to a series of tests on board the United States Coast and Geodetic Survey steamer "Blake," by Commander Bartlett.



The apparatus consists essentially of a coil of wire T, which is lowered by means of a cable to the required depth; and is coupled by connecting wires to form one arm of a Wheatstone's bridge. The

* "Annalen der Physik und Chemie," 1873, p. 225.

connexions of the bridge are shown in figs. 1 and 2. The arm CD is the comparison coil S made of the same wire as the resistance coil T, and equal to it in resistance. This coil is immersed in a copper vessel of double sides, filled with water, and the temperature of the water is adjusted by adding iced or hot water until the bridge is balanced. The temperature of the water in the vessel is then read by a mercurial thermometer; and this will also be the temperature of the resistance coil.

To avoid the error, which would be otherwise introduced by the leads to the resistance coil, the cable was constructed of a double core of insulated copper wire, protected by twisted galvanised steel wire. One of the copper cores was connected to the arm BC of the bridge, and the other to the arm DC, and the steel wire served as the return earth connexion for both.

The resistance coil and comparison coil were made of silk-covered iron wire ·15 millim. diameter, and each about 432 ohms resistance at a temperature of 66° F. To allow the resistance coil to be readily affected by changes in the temperature of the water, it was coiled on a brass tube with both ends open, allowing a free passage to the water. Sir W. Thomson's marine galvanometer with a mirror and scale was employed to determine the balance of the bridge.

Mr. J. E. Hilgard, assistant in charge of the United States Coast and Geodetic Survey, has sent me the following results of Commander Bartlett's experiments.

The apparatus was set up on board the "Blake," at Providence, in April, 1881, but owing to there being no ice machine on board, only preliminary experiments were made until the following August.

The "Blake" sailed from Charleston on August 4th, running a line over known depths in the current of the Gulf Stream. A 60 lb. sinker used in sounding was attached to the end of the cable near the resistance coil, which was allowed to hang freely below. When well in the strength of the stream a series of temperatures were taken by the Miller-Casella thermometers on the sounding wire, and immediately after the insulated cable was lowered to the surface, and water from the surface placed around the comparison coil on deck. The temperature of the attached thermometer read the same as that determined for the surface by the thermometer attached to the hydrometer case.

Under these conditions the pencil of light from the mirror was on the zero of the scale. During the experiments the vessel was rolling from 10° to 15°, and there was a moderate breeze from south-east. The resistance coil was lowered to five fathoms below the surface, and was allowed to remain five minutes, the circuit being closed, the pencil of light remained at zero. Lowerings were then made to 10, 20, and 30 fathoms, and in each case five minutes were allowed for

the resistance coil to assume the temperature of the water, and after adjusting the temperature of the water around the comparison coil, it was allowed to stand five minutes before the final reading was taken.

The rolling of the vessel affected the mirror so as to throw the light about 5° on each side of the zero point when the circuit was open, and nearly the same when closed; but as the deflection was the same on either side it was easy to determine the middle point. While at work in the stream it was necessary to work the engine in order to keep the wire vertical. The jar of the engine, however, affected the mirror to such a degree that readings could only be taken when the engine was stopped.

The Tables I, II, III, IV give the results of the several lowerings.

I.			II.		
Depth in fathoms.	Reading of attached thermometer coil.	Reading of Miller-Casella thermometer.	Depth in fathoms.	Reading of attached thermometer coil.	Reading of Miller-Casella thermometer.
Surface	81°·5	81°·5	Surface	81°·5	81°·5
5	81·5	81·5	30	68·5	
10	76·5	76·5	50	65·25	65
20	70·25	69·5	75	60	
30	69·5	69			
30	68·75	68·75			

III.			IV.		
Surface	83·5	83·5	Surface	84·5	84·5
30	68		30	81	80
50	65·25		50	75·5	
75	60·75		75	61·75	
100	56	54			
150	51				
200	47	47	200	49·5	49·75

On August 10th the "Blake" left Hampton Roads, steaming to the eastward until reaching the meridian of 74° 30′ W., when a sounding was taken, giving a depth of 1,024 fathoms. A serial was taken to a depth of 400 fathoms with two Miller-Casella thermometers, which had been carefully compared with the standard and found to agree at different temperatures. Immediately after the serial with the thermometers the insulated cable was lowered into the sea, and the temperature, by the galvanometer and comparison coil, recorded for the same depths as taken in the first serial. Five minutes was allowed at 5 and 10 fathoms, but there was no deflection of the

pencil of light. The temperature of the surface was 76°·5. Having lowered to 15 fathoms, at end of one minute the pencil of light was 9° to the left of zero on the scale. At the end of five minutes it was 22°, and at the end of ten minutes still 22°. A number of experiments were made with regard to the time necessary for the resistance coil to assume the temperature of the water. Five minutes was decided on as being necessary and sufficient, and was adopted in all succeeding lowerings.

The first lowering was to 400 fathoms, the temperature at that depth being 40°. The cable was then reeled in to 200 fathoms, when the current was made. There was found to be no deflection, the temperature of the water in the copper vessel having risen from 40° to 43°·5. This temperature agreed with that at 200 fathoms when lowering to the same depth.

During the experiments there was a light south-east breeze, and a very smooth sea. They lasted from 7.18 P.M. until 1.30 A.M., but special care was taken with every reading, and it is probable that fifteen minutes would be a fair average time for each observation with the electrical apparatus.

The results are given in the Table.

I.			II.		
Depth in fathoms.	Reading of attached thermometer coil.	Reading of Miller-Casella thermometer.	Depth in fathoms.	Reading of attached thermometer coil.	Reading of Miller-Casella thermometer.
Surface	76°·5	76°·5	30	54°	54°
5	76·5	76·5	50	54·25	53·5
10	76·5	76	100	50·5	50·5
15	69	68	150	46·5	46·5
20	58	58	200	43·5	43·5
30	54·25	54			
50	54·25	53·5			
75	52·5	52·5			
100	51	50·5			
150	46	46·5			
200	43·5	43·5			
300	40·5	40·5			
400	40	40			

Early on the morning of August 12th another serial to 800 fathoms was taken with the Miller-Casella thermometers, and immediately after with the electrical apparatus. Several readings were taken from the surface to 100 fathoms, and then the coil was reeled out to 800 fathoms, and the readings taken as it was drawn up.

Depth in fathoms.	Reading of attached thermometer coil.	Reading of Miller-Casella thermometer.	Depth in fathoms.	Reading of attached thermometer coil.	Reading of Miller-Casella thermometer.
Surface	76°	76°	Surface	77°·5	77°·5
5	76	75·25	5	76·25	75·25
10	73·5	69	10	75·5	69
15	61·25	68	15	66·5	63·5
20	55·5	59	20	58	57
30	51	52·5	30	51·5	51·5
50	53·75	52	50	54·5	53·5
75	52·5	52·5	75	53·5	52·5
100	50	49·5	100	51	49·5
			125	48·5	
			150	46·5	46
			200	43·5	43·25
			300	40·5	40·75
			400	40	39·75
			500	39·25	39
			600	38·75	38·75
			700	38·5	38·5
			800	38·5	38·5

In the last series of observations in reeling back the cable, the temperature at 50 fathoms was 54°·5, and fell to 51°·5 at 30 fathoms. Immediately after another series was taken with the Miller-Casella thermometer, and the same increase of temperature from 30 to 50 fathoms was observed. The cable was lowered three separate times to 50 fathoms, and the readings being taken both when lowering and reeling in with the following results:—

Depth in fathoms.	Reading of attached thermometer coil.	Reading of Miller-Casella thermometer.	Depth in fathoms.	Reading of attached thermometer coil.	Reading of Miller-Casella thermometer.
Surface	77°·5	77°·5		°	°
20	57·25	57	30	51·75	52
30	52·25	52	50	54·5	53·5
50	55·25	53·5	75	53	52·5
20	57·75	57			
30	52·75	52			
50	54·75	54			
75	53	52·5			

During the above experiments the sea was perfectly smooth, with no wind. The ship's engines were not used at all, the vessel lying almost motionless in the water. The temperature of the comparison coil was reduced by water from a carafe, the water contained therein being frozen

by a Carré ice machine. Two carafes were prepared at a time, and there was plenty of time to keep one constantly at hand.

In order to allow the Miller-Casella thermometers to record the high temperature of 50 fathoms in the last series, they were lowered very rapidly to that depth, and after eight minutes reeled back at the rate of 200 fathoms per minute, so that the minimum side had not time to assume a lower temperature.

The cable was led from a large reel through an 18-inch leading block, and was lowered and reeled in very slowly, and without jerks.

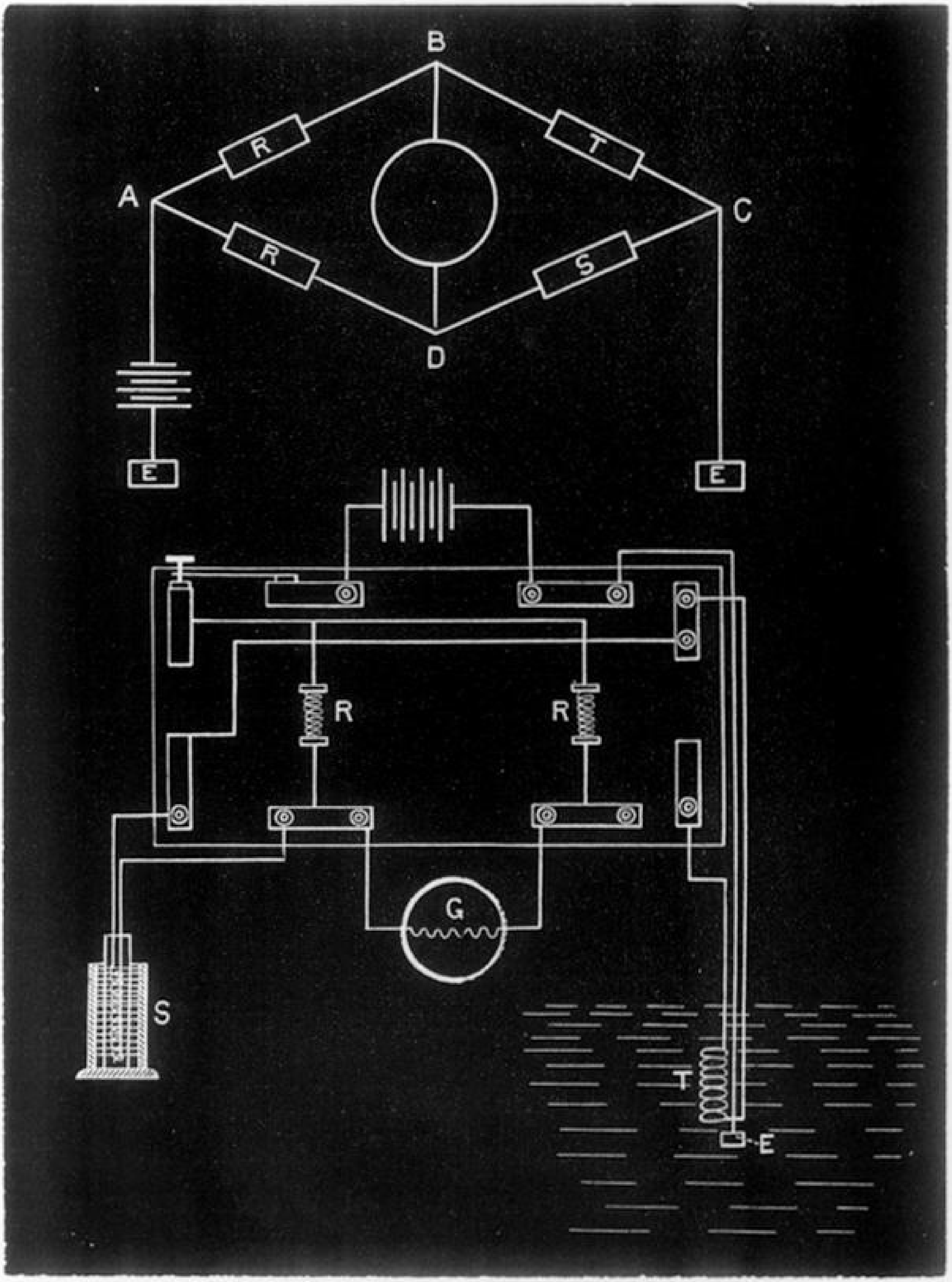
It may be noted in the above Tables that the two instruments gave precisely the same readings at positions of maximum or minimum temperature, but that in intermediate positions the electrical thermometer, in almost every instance, gave a higher reading. This discrepancy may be accounted for, I think, by the circumstance that the electrical thermometer gives the temperature of the water actually surrounding the coil at the moment of observation, whereas the reading of the Miller-Casella instrument must be affected by the maximum or minimum temperatures encountered in its ascent or descent, which may not coincide with that at the points of stoppage. A strong argument in favour of the electrical instrument for geodetic and meteorological purposes has thus been furnished.

V. "On the Coxal Glands of Scorpio hitherto undescribed and corresponding to the Brick-red Glands of Limulus." By E. RAY LANKESTER, M.A., F.R.S., Jodrell Professor of Zoology in University College, London. Received May 25, 1882.

In my essay entitled "Limulus an Arachnid,"* I have mentioned Dr. Packard's discovery of the "brick-red glands" of Limulus, situated at the junction of the coxæ of the prosomatic limbs with the body in the following terms:—"It is true that Packard has assimilated a brick-red coloured structure occurring at the base of the cephalothoracic limbs of Limulus to a shell-gland or renal organ. In this I cannot agree with him. It is not even apparent, at present, that this brick-red organ, which I have examined, is of a glandular nature at all."

Dr. Packard first described these glands in 1874, and figured them subsequently in his valuable memoir on the "Anatomy, Histology, and Embryology of Limulus Polyphemus," published in the Anniversary Memoirs of the Boston Society of Natural History, 1880.

* "Quart. Journ. Micr. Sci.," 1881.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