Professor Church, and subsequently described by Tschirch. The former took chlorophyll that had become brown on standing, and acting on it with zinc powder obtained a body yielding green solutions, which he took to be regenerated chlorophyll. Tschirch acted on Hoppe-Seyler's chlorophyllan with zinc powder and observed the same phenomena, the conclusion at which he arrived being the same, viz., that chlorophyll is reproduced from chlorophyllan by reduction. It is probable, however, that what they obtained was in reality a zinc compound of phyllocyanin, and would have been formed just as well by using zinc oxide. Chlorophyllan is probably an impure substance containing some fatty acid along with phyllocyanin, so that by the action of zinc oxide it may yield a compound similar to those above mentioned. The experiment was tried with the crude product obtained by passing hydrochloric acid gas into a solution of chlorophyll. Some of this was dissolved in alcohol, and the solution was boiled with zinc oxide, when it gradually became of a bright green like a solution of chlorophyll, but its spectrum differed, being identical with that of the zinc compounds obtained directly from phyllocyanin.

IV. "On the Electric Resistance of a New Alloy named Platinoid." By J. T. Bottomley, M.A., F.R.S.E. Communicated by Sir W. Thomson. Received May 5, 1885. Read May 7, 1885.

In the course of a series of experiments on the electric resistance of various metals and alloys, and in particular on the variation of the electric resistance of these metals and alloys with temperature, I have examined a new alloy (called by the inventor platinoid), which has turned out to have important properties.

This alloy is the invention of Mr. F. W. Martino, of Sheffield; and I have to acknowledge my indebtedness to Mr. Martino for having provided me with specimens of his new alloy and given me information regarding it; and for having supplied me with wires specially drawn down to the finer gauges for my experiments.

The inventor, searching experimentally for a means of rendering tarnishable metals and alloys less tarnishable, had satisfied himself that the addition of pure metallic tungsten imparted greater density to alloys, and likewise less tendency to oxidation. Having found a mode of combining a small quantity of tungsten with copper, nickel, and zinc, he produced a white alloy resembling the alloys of silver, which proved very little tarnishable under atmospheric

influences. Accordingly he patented the process, and registered the alloy under the name platinoid.

Platinoid is practically German silver with the addition of a small percentage (1 or 2 per cent.) of metallic tungsten. The tungsten is added in the form of phosphide of tungsten, a considerable percentage of which is in the first place fused with a portion of the copper. The nickel is then added; and then the zinc and the remainder of the copper. The mixture requires to be re-fused more than once, and during the process the phosphorus and a considerable portion of the tungsten originally added is removed as scoriæ. In the end there is obtained a beautiful white alloy, which is platinoid. When polished the alloy is scarcely distinguishable in appearance from silver. To test the quality claimed for it as to being untarnishable, I have for some weeks been keeping ornamental specimens lying exposed to the ordinary town atmosphere; and I have satisfied myself that the alloy has a very remarkable power of resisting the tarnishing influence of the air of a large town.

It is, however, with the electric resistance of platinoid that I have chiefly interested myself. German silver wire has proved of great use in the construction of galvanometer coils and of resistance coils, on account of two important properties, viz., its very high resistance, and the smallness of the variation of its resistance with change of temperature. Both these properties are possessed in a still higher degree by platinoid alloy.

The resistance of German silver differs considerably in different specimens. It is commonly stated to be $21{\cdot}17 \times 10^{-6}$ B.A. ohms between opposite faces of a centimetre cube at 0°C.*; or, reducing to legal ohms, $20{\cdot}935 \times 10^{-6}$ legal ohms between the opposite faces of a centimetre cube. The table on page 342 shows the resistance of a number of specimens of platinoid wire.

It appears from these results that the specific resistance of platinoid is about one and a half times that of German silver.

The experiments on the variation of resistance of platinoid with temperature were carried on in the following way. The specimen of platinoid to be tested was wound on a wooden bobbin, on the surface of which a screw had been cut, and the spires of the helix were kept separate by lying between the threads of the screw. This coil was immersed in a bath of oil, and was connected in series with a known wire of German silver, the temperature of which was kept constant, and with a single Daniell's cell. The differences of potential between the two ends of the platinoid wire and the two ends of the German silver wire were determined by applying the electrodes of a high-resistance

* Given by Prof. Fleeming Jenkin, F.R.S., as expressing the results of Matthiessen's experiments.

Specifying number.	Diameter in decimals of a centimetre.	Cross section.	Resistance, legal ohms per metre.	Resistance between opposite faces of a centimetre cube, legal ohms.
16	·1610	·0204300	·181	36·98 × 10^{-6}
17	·1430	·0160200	·202	32·36
18	·1230	·0119400	·288	34·38
19	·1110	·0096770	·353	34·16
20	·0865	·0058760	·555	32·61
A	·0595	·0027810	1·250	34·76 × 10^{-6}
B	·0495	·0019240	1·707	32·85
28	·0402	·0012690	2·605	33·06
29	·0340	·0009070	3·412	30·94
32	·0290	·0006605	4·371	28·87
36	·0220	·0003801	8·219	31·24

galvanometer. The ratio of the differences of potential is the same as the ratio of the resistances of the two wires. This method of comparing the resistance of an unknown wire with that of a known wire gives admirable results, and I have recently made great use of it.

In the following table is shown the ratio of the resistances of a specimen of platinoid wire at different temperatures to its resistance at zero. The wire was the same as that specified as No. 20 in the table of resistances. The length of the wire experimented on was about four-fifths of a metre. The only trouble in the experiment was the keeping the oil-bath, which was filled with linseed oil, thoroughly stirred, and of uniform temperature throughout.

Temperature.	Resistance. The Res. at 0° C. being = 1.
0°	1·0
10	1·0024
20	1·0044
30	1·0075
40	1·0066
50	1·0097
60	1·0126
70	1·0134
80	1·0166
90	1·0188
100	1·0209

This gives for the average percentage variation of resistance per 1° C., between the temperatures 0° C. and 100° C., the number

0·02087. A second wire tested very carefully in a similar way gave for this average percentage variation between 0° and 100°, 0·022 per degree, with a steadily increasing rate of variation from the beginning.

To compare this increase in resistance due to increase of temperature with that observed in other metals and alloys, I find that the percentage increase of resistance for 1° C. at 20° C. for copper is 0·388, platinum-silver alloy 0·031, gold-silver alloy 0·065, and for German silver 0·044. These numbers were obtained by Matthiessen in the course of his experiments for finding a suitable metal or alloy for the purpose of constructing the British Association standards of electric resistance. It appears that the variation of resistance of platinoid with temperature is very much smaller than the smallest observed for any of the metals and alloys then examined.

Addition to the above Paper. Received May 12, 1885.

I have now (May 7th, 1885) obtained some information as to the mechanical properties of platinoid wire.

I have determined the modulus of rigidity of a wire of the substance, a portion of the wire marked A in the preceding paper being used for the purpose. This wire is a little larger than No. 24 wire of the Board of Trade Standard wire gauge, and has a diameter of 0·0595 cm. To determine the modulus of rigidity a cylindrical ring vibrator was attached by a cross-bar to the lower end of a length of the wire, the upper end being fixed by soldering to a brass plate, which was screwed to a beam in the roof of the laboratory. The moment of inertia of the cylindrical vibrator and cross-bar was ascertained; and the torsional vibrations of the vibrator hung by the wire were counted, and the period determined.* From this, and the dimensions of the wire, the modulus of rigidity is calculated.

The following are the particulars of the experiment:—

Length of wire used (l)	490·8 cm.
Diameter of wire ($2a$)	0·0595 ,,
Moment of inertia of vibrator (Mk^2)	29453·2
Time of vibration one way (half period) (T)	16·375 secs.
Rigidity in grammes weight per square cm. $\left(\frac{2\pi l M k^2}{g T^2 a^4}\right)$	$475 \cdot 8 \times 10^6$.

The Young's Modulus, or modulus for elastic longitudinal extension, and the breaking weight, have been determined for me by Mr. Magnus Maclean, Official Assistant to the Professor of Natural

* Sir William Thomson, "Elasticity and Viscosity of Metals," "Proc. Roy. Soc.," 1865.

Philosophy in the University of Glasgow, who also assisted me in the detemination of the rigidity modulus; they are as follows:—

Young's Modulus, ($Pl/\alpha\epsilon$ where P is the stretching weight, l the length of wire used, α the cross sectional area, and ϵ the elongation produced by the pull P) $1222{\cdot}4 \times 10^6$ grammes weight per square centimetre.

The breaking weight is about $6{\cdot}029 \times 10^6$ grammes per square centimetre.

I have also determined the specific gravity of a specimen of platinoid wire, and find it to be 8·78, compared with water at 20° C.

Platinoid when drawn hard, is softened like copper by heating and sudden cooling.

V. "Results of the Harmonic Analysis of Tidal Observations." By Major A. W. Baird, R.E., and G. H. Darwin, F.R.S., Fellow of Trinity College and Plumian Professor in the University of Cambridge. Received March 19, 1885.

[Publication deferred.]

The Society adjourned over Ascension Day to Thursday, May 21st.