plying the method so as to obtain in a compact form and at a small cost a dispersive power exceeding that of any spectroscope on the old plan, and free from the defects inherent in a complicated instrument.

In conclusion, I may allude to an application of the remarkable property of the half-prism which may perhaps prove of practical use. From what precedes it will be clear that the half-prism, as far as its magnifying-power is concerned, is equivalent to a combination of an object-glass and cylindrical eyepiece, the peculiarity being that it magnifies the angle between two pencils of parallel rays without affecting the parallelism of the rays in each pencil. The half-prisms which have so far been considered are constructed so as to give great dispersion, and the sun is seen through them as if through a telescope with an object-glass formed of a convex flint lens and a concave crown. But it is obvious that an achromatic prism may be formed on the same principle as the achromatic object-glass, giving cylindrical magnifying-power without dispersion. If two such prisms be crossed at right angles, one behind the other, the magnifying-power will be the same in both directions, and the combination will act as an achromatic telescope with the advantage of great compactness, since the eye can be applied close to the second prism.

Whether, however, this advantage would compensate for the greater quantity of glass required and for the loss of light is a matter for practical consideration; and I therefore defer the discussion of the achromatic half-prism till I have satisfied myself that it has some practical utility, even though it may never replace the refracting telescope for general use.

Royal Observatory, Greenwich,
1877, Jan. 17.

March 8, 1877.

Dr. J. DALTON HOOKER, C.B., President, in the Chair.

The Presents received were laid on the table, and thanks ordered for them.

The following Papers were read:—

I. "On Magneto-electric Induction in Liquids and Gases.—Part I. Production of Induced Currents in Electrolytes." By J. A. Fleming, B.Sc. (Lond.). Communicated by Prof. Stokes, Sec.R.S. Received February 6, 1877.

(Abstract.)

This paper contains an account of an experimental inquiry into the production of induced currents in liquids by magneto-electric induction. Faraday examined one such case of induction, in which a conducting

liquid was used as a secondary circuit. He coiled round the armature of an electromagnet an india-rubber tube filled with dilute sulphuric acid, and found, on making and breaking the primary circuit, the induced currents generated in it, as in the case of metallic conductors; but he could not obtain any effect when brine, sulphuric acid, or other solutions were rotated in basins over a magnet, or enclosed in tubes and passed between the poles. He failed also to detect any magneto-electric current in water flowing across the earth's lines of magnetic force (viz. in the river Thames).

Since the reason for these negative results is not at once obvious, it seemed desirable to repeat and extend them to other cases, so that, if possible, the analogy of electrolytic with solid conductors might, in respect to magneto-electric induction, be completed. In addition, the subject involves the interesting question of the magneto-electric phenomena accompanying the flow of ocean-currents and other large masses of water.

Three cases of induction in liquids flowing in a magnetic field or traversed by lines of magnetic force have been examined.

1. *Production of induced current in a liquid stream flowing uniformly in a constant magnetic field.*—When a stream of conducting fluid flows vertically down between the poles of a magnet a transverse current is produced in a direction at right angles to the lines of force and line of flow. This was obtained in the following way:—A glass tube, about 200 centims. long and 2 centims. wide, had platinum plates 15 millims. wide placed along its inside and at opposite sides, with their lengths parallel to the axis of the tube. Platinum wires welded to these plates were sealed through the glass. The plates were curved to lie closely against the sides of the tube. This tube was placed vertically between the poles of a large electromagnet, the line joining the platinum plates being at right angles to the line of the poles.

To the upper end of the tube was attached another, leading to a reservoir of dilute sulphuric acid placed high above the floor; to the lower end a tube leading to a receptacle on the floor. The platinum plates were then connected with a distant galvanometer. When the magnet was not excited, no flowing of the liquid had any effect on the galvanometer; but when it was excited, at the moment the flow began the galvanometer showed a deflection of 10° to 15°. Since the only part of the galvanometer circuit in motion is the liquid, this deflection was due to the magneto-electric current generated in it by its movement. It was noticed that the plates were *polarized* by the currents so created. As a consequence of this, the deflection of the needle soon fell to zero; and on the liquid flow being stopped, a polarization current in the opposite direction was obtained. This proved that in experiments on induction in liquids, in order to obtain any constant current, non-polarizable electrodes must be used.

2. *Production of induced current in a mass of liquid rotating over a magnetic pole.*—In this case radial currents should be produced. They were obtained as follows :—Flat porous cells were placed round the circumference of a large basin, and in the centre a cylindrical one. These were filled with a solution of cupric sulphate, and contained copper plates. The basin was filled with dilute sulphuric acid. The centre copper plate was connected with one pole of the galvanometer, and the circumferential ones with the other. The whole was placed over the pole of the electromagnet. On exciting the magnet and rotating the dilute acid, a constant current was obtained, flowing from centre to circumference or the reverse according to the direction of rotation. With platinum electrodes the effect cannot be obtained, but with non-polarizable electrodes it is easily produced. Mercury was likewise tried with still better results.

3. *Production of induced current in a liquid at rest in a variable magnetic field.*—If a flexible tube filled with conducting liquid is wound round an electromagnet, and into the ends electrodes placed so as to include a galvanometer in the circuit, then induced currents are obtained whenever the strength of the magnet varies. This is the case examined by Faraday. His experiment was repeated by MM. Logeman and Van Breda (Phil. Mag. [IV.] vol. viii. p. 465), who noticed that the electrodes were left polarized after the induced current had passed. These experiments were repeated with more powerful apparatus, using a soft iron wire core within the inducing helix instead of solid iron, and employing a condenser in the primary circuit. Very strong induced currents were obtained, and correspondingly great polarization of the electrodes placed in the ends of the coil of acid. It was hoped that the currents might produce visible inductive electrolysis, but even this improved arrangement did not yield that result. Other saline solutions were tried with similar results.

Lastly, the phenomenon observed by Arago, of the retardation in the vibrations of a magnetic needle oscillated near the surface of liquids, is examined. Evidence is brought forward to show that this is *not*, as in the case of solid plates, due to induced currents created in the liquid—(1) because the retardation is, *cœteris paribus*, not proportional to the conductivity of the liquid but dependent on its volatility; (2) because it takes place equally when a light brass needle, oscillated by torsion, is substituted for the magnet, provided the needle is light and the period of oscillation not very small. Thus a magnetic needle which required 4 min. 20 sec. to suffer a decrement of 25° in the semi-arc of vibration when in air, required over dilute sulphuric acid 3 min. 30 sec., over ether 2 min. 25 sec. A brass needle of the same dimensions exhibited similar effects.

In conclusion the magneto-electric induction taking place in moving masses of water on the earth's surface under the influence of terrestrial magnetism is briefly discussed.

Before the introduction of the absolute system of electro-magnetic measure, there was no means of estimating the electromotive force so brought into play by the flow of a river or ocean stream, and the magnitude of the effect was perhaps overestimated.

A Table is given, showing the electromotive force in volts produced in two or three cases.

	Difference of potential between two sides in volts.
Gulf-stream at lat. 30° N., long. 60° W.	8·6
Equatorial current, lat. 10° N., long. 40° W. ..	10·0
Dover and Calais tidal current	3·0
Thames at Waterloo Bridge	·016

This electromotive force without doubt generates a current transverse to the direction of the flow; but since the surrounding still water or the river bed or channel is not a non-conductor, any attempt practically to detect it by plates placed on either side of the stream is not likely to succeed, since the current through the galvanometer is only a derived portion of the current in the stream.

A comparison of a chart of ocean-currents with one of the isogonic lines does not seem to show any distortion of the lines of equal variation where they cut across. If, now, electric currents of any great magnitude were generated in ocean-currents, such would undoubtedly be the case. Though Faraday's failure to detect any magneto-electric current in the Thames may have been partly due to his employment of polarizable electrodes, still there is evidence enough to show that these currents, though certainly existing and capable of being produced on a laboratory scale, cannot be regarded as contributing in any sensible degree towards affecting the form and distribution of the isogonic lines. Those who have looked to this as a possible partial cause of the irregularity observed have been led, no doubt, by the dimensions of the streams to exaggerate the magneto-electric induction caused by their flow.

II. "On the Structure and Development of Vascular Dentine." By Charles S. Tomes, M.A. Communicated by John Tomes, F.R.S. Received February 6, 1877.

(Abstract.)

The nomenclature and classification of the varieties of dentine have hitherto been based solely upon the appearances discoverable in dried teeth; in the present communication the author seeks to amend and place upon a more satisfactory basis the grouping of these several kinds of dentine, by bringing to bear upon their arrangement observations upon the nature of the contents of those large tubes which give to the tissues their name of "vascular" dentine, and, more especially, observations upon the methods by which they are developed.