III. "Additional Observations on the Development of *Apteryx*." By T. Jeffery Parker, B.Sc., F.R.S., Professor of Biology in the University of Otago, Dunedin, New Zealand. Received December 15, 1891.

(Abstract.)

The paper is founded upon the study of three embryos of *Apteryx australis* obtained since the author's former communication on this subject was written.

The youngest (stage E′) is intermediate between E and F of the former paper, the next (F′) between F and G, the most advanced (G′) between G and H.

In E′ the characteristic form of the beak has already appeared.

In F′ the pollex is unusually large, giving the fore-limb the normal characteristics of an embryo wing.

Several important additions and corrections are made to the former account of the skull, especially with regard to the pre-sphenoid region, the basi-cranial fontanelles, and the relations between the trabecular and para-chordal regions.

The account of the shoulder-girdle is amended. In *Apteryx oweni* the coracoid region is solid, and no pro-coracoid appears ever to be formed: in *A. australis* a ligamentous pro-coracoid is present at a comparatively early period (stage F′ and perhaps E′).

An intermedium is present in the carpus in all three specimens in addition to the elements previously described.

The brain in stage G′ is interesting, as being at what may be called the critical stage; the cerebellum is fully developed, and the optic lobes have attained the maximum proportional size and are lateral in position. In all essential respects the brain of this embryo is typically avian.

IV. "On a Differential Electrostatic Method of measuring High Electrical Resistances." By Major Cardew, R.E. Communicated by Sir William Thomson, D.C.L., P.R.S. Received January 6, 1892.

The following method has been found useful for determining the relative value in insulating quality of small samples of materials, the insulation resistance of short pieces of cable, and other very high resistances.

The arrangement is also suitable for continuously indicating the position on any electrical circuit, worked at a high pressure, of the

resultant fault or point of zero potential; and for measuring the insulation of the circuit while the pressure is on.

Connections.—The method consists in connecting the quadrants of an ordinary quadrant electrometer to the terminals of a source of fairly high E.M.F., while the aluminium vane or needle is connected to earth.

The resistance to be determined is connected to one side of this arrangement, and a variable resistance of the same order of magnitude to the other side, the free ends of each being connected to earth.

The centre of the battery, or other source of E.M.F., is then earthed for a short time, bringing the needle to the zero reading, and, after the removal of this earth connection, the needle will travel to one side or the other, unless the resistance to the passage of electricity from each pole to earth is exactly equal, in which case the needle will remain permanently at zero.

By observing the motion and varying the comparison resistance accordingly, this balance is soon arrived at, if within the range of variation provided.

The arrangement is shown in the figure, where B is the battery or other source of E.M.F., Q the quadrants, N the needle, X the unknown resistance, and R the variable resistance. The earth contacts are shown by E.

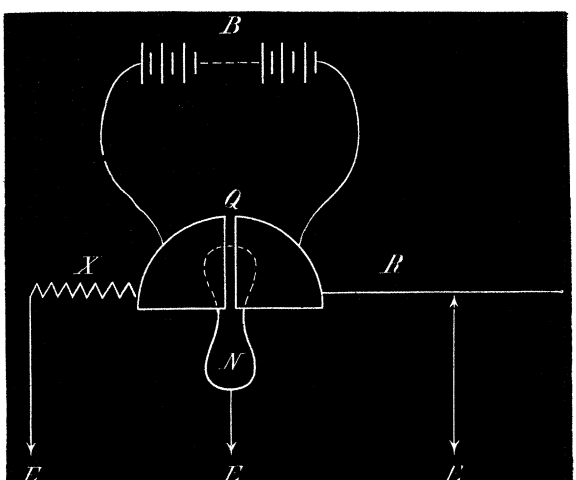


Diagram of connections for electrostatic balance for very high resistances. The opposite quadrants of electrometer are not shown.

Principle.—The method depends upon the well-known fact that every source of electricity produces equal quantities of what are

commonly called the two kinds of electricity in any time, however extended, and at any instant at an equal rate.

I have recently drawn attention to this law as determining the potentials from earth of the two sides of any system of electric supply (*vide* my paper read on the 23rd April, 1891, at the Institution of Electrical Engineers).

If we conceive, therefore, a perfectly insulated voltaic battery, the potentials of the terminals of this source from earth would be determined by momentarily connecting any one of the metal plates with the earth. Under such conditions, the smallest leakage from either pole to earth through a resistance amounting to many millions of megohms, if unbalanced by any leakage from the other pole, must rapidly reduce the potential of the imperfectly insulated pole to zero.

The only limit, therefore, to the sensibility of the method is the imperfection of the insulation of the measuring apparatus, and this insulation, with proper precautions, can be easily maintained at a value exceeding 1,000,000 megohms.

Sources of E.M.F.—A very convenient source of E.M.F. for the purpose is the arrangement of small zinc-copper couples in series, moistened by dipping the whole into a pan containing acidulated water, which is in use at the Physical Laboratory at Glasgow University.

Four hundred such couples are usually arranged on an ebonite support, and the sensibility with this number is ample.*

A still better source, when alternating currents are available, is a special form of transformer, the secondary coil being suspended in air by a silk cord.

The highest insulation can thus be secured. But when the resistance to be balanced possesses appreciable capacity, the use of an alternating E.M.F. is unsuitable, on account of the masking of the effect of the leakage current proper by the capacity current.

Comparison Resistances.—The variable resistance is, most conveniently, some material of uniform cross section, so that its resistance varies as the length put in circuit. Reels of white silk, cotton, thread, and string are very suitable, and with a few such simple materials, balances can be obtained through a great range of value, although no multiplying or dividing power is possible. Thus, a white embroidery silk has been found to have a resistance of approximately 250,000 megohms per inch; a green thread, partly silk and partly cotton, 10,000 megohms per inch in a dry atmosphere;

* The mahogany legs supplied with this battery should be replaced by grooved ebonite legs, to improve insulation, and it is also of advantage to insert under each leg a piece of sealing-wax. The couples require to be taken out and cleaned occasionally; if allowed to get dirty, the E.M.F. becomes low.

an ordinary measuring tape, 1400 megohms per inch, &c., down to a piece of wet tape, which gave 64,000 ohms per inch.

These resistances are, to some extent, affected by the degree of humidity of the air, but, when necessary, they can be rapidly standardised with sufficient accuracy by determining one of the lowest by the usual method; or, as a check, when time allows, a highly insulated condenser can be shunted by a length of silk, and the loss of charge, in a given time, measured.

Unsymmetrical Insulation of Apparatus.—If, from any cause which cannot be discovered or removed, the insulation resistance of the apparatus is unsymmetrical, indicated by the needle taking up a false zero when connection is made between the battery and quadrants, symmetry can be always secured by connecting a length of silk, found by trial, between the more highly insulated pole and earth.

Limits of Accuracy.—The accuracy attainable by this method depends on the sensibility of the electrometer and the potential difference employed.

With an ordinary suspension, however, it has been found that with a battery giving about 350 volts the difference in reading between that with the centre of the battery earthed and that with the earth connection made at 1 volt from the centre amounted to 12 scale divisions.

This sensibility should, therefore, be ample to secure an accuracy within 1 per cent., which, for resistances of several thousand megohms, is generally sufficient.

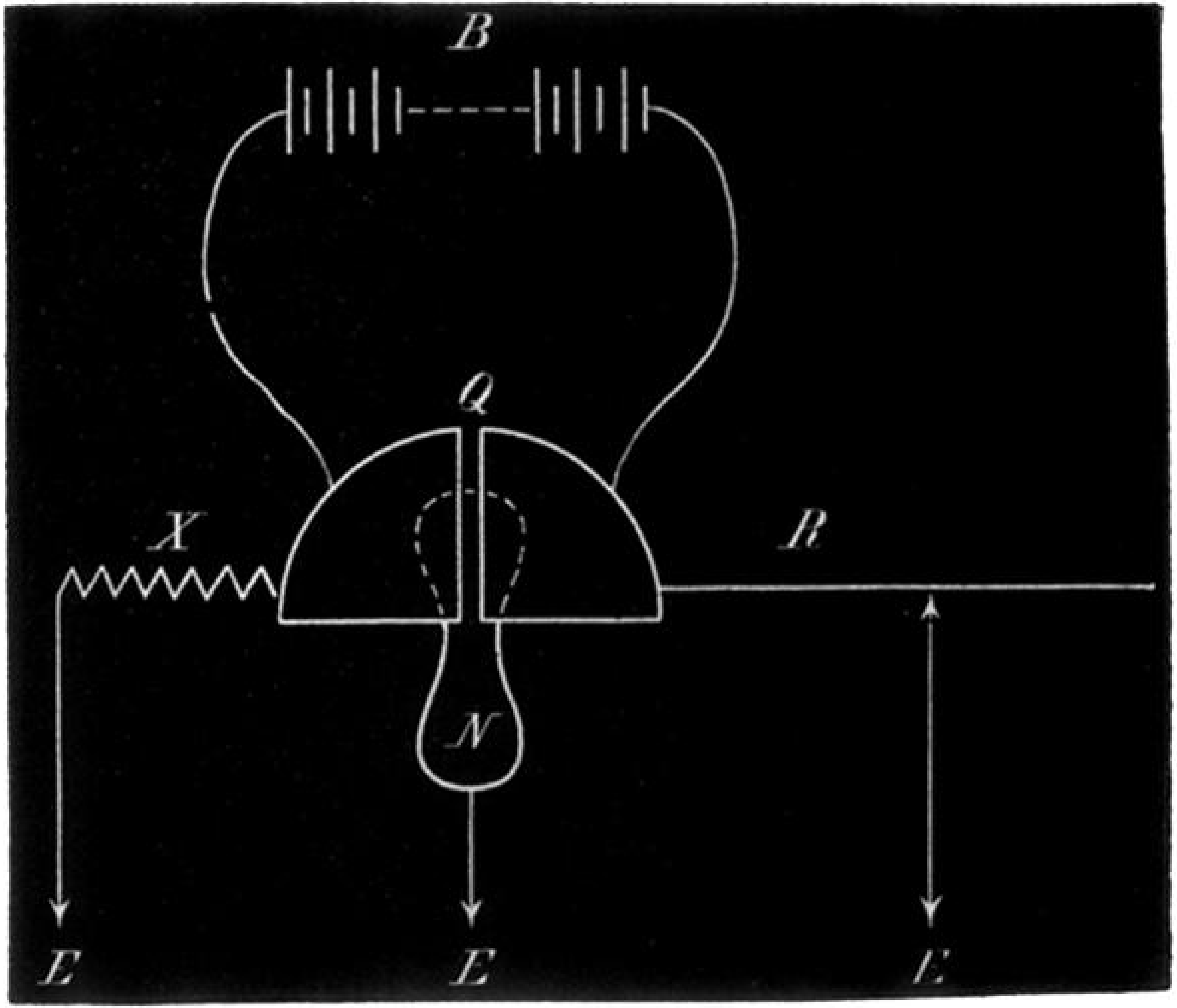
Leakage Indicator.—The same principle of balance may be usefully adapted as a leakage indicator for electric supply circuits worked at high pressure.

For this purpose a special pattern of electrometer is requisite.

The quadrants are connected, respectively, to the two mains constituting a circuit, and the needle to earth. If the insulation of the entire circuit is good, the potential from earth of the two mains will probably be nearly equal, and the needle will remain at zero; any leakage taking place will disturb the balance to one side or the other.

By temporarily switching a small leak first on one side and then on the other, and noting the effect, the absolute value of the insulation may be approximately assessed.

The arrangement is not applicable, however, to a concentric system of mains with alternating currents, or in any case where the capacities are large and seriously unequal.



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