As stated by the makers, "the principle on which the instrument works is the measuring of the strength of the electrical currents which are constantly flowing between earth and atmosphere, and which are always strongest in the vicinity of subterranean water courses." It would be interesting to know whether there is any scientific basis for this statement.

The writer has applied to the makers of the instrument for particulars relating to it, but beyond sending him a circular embodying the above quotations, he has been unable to obtain from them much information.

A. A. CAMPBELL SWINTON.

66 Victoria Street, London, S.W., October 7.

MOVEMENTS OF THE EARTH'S SURFACE.

IN the *Revue scientifique* of August 28 is an interesting address delivered by M. Ch. Lallemand to the Association française pour l'Avancement des Sciences. The address deals with two subjects:—(1) Tides in the solid earth; (2) gradual changes of level in large tracts of the earth's surface.

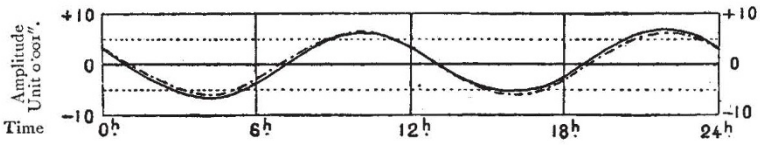

FIG. 1.—Semi-diurnal oscillation of a pendulum under the action of the moon.

——— Observed wave. — · — · — Calculated wave reduced in amplitude.

The first subject is introduced by a short historical account of the attempts made in the past thirty years to discover alterations in the position of the vertical relative to the earth's surface accompanying the changes of direction of the sun and moon. This is followed by a detailed account of the recent work of Dr. Hecker, of Berlin. An illustration of his apparatus is given, and an interesting account of the manner in which, by a mechanical and optical device, a horizontal pendulum, 0·25 m. in length, is made to produce effects such as could only be produced directly by a vertical pendulum of length equal to the height of Mont Blanc.

Dr. Hecker's apparatus was placed in a chamber, which was situated at a depth of 25 m. below the surface of the earth, and kept at constant temperature and humidity. The motions of the pendulum, greatly magnified, were registered continuously on a revolving drum. Roughly speaking, they amounted to a daily oscillation of the vertical of about 0·02″ north and south. The greater part of this oscillation was thermal in origin, being caused by the heating of the upper layers of the earth's surface by the sun's rays. It was possible to remove this term, and there was left as a residual effect a semi-diurnal oscillation, which could be traced to the varying attraction of the sun. More important, because it was more free from thermal disturbance and greater in magnitude, was the semi-diurnal oscillation of the pendulum, which Dr. Hecker found corresponding to half a lunar day. The close agreement between this observed oscillation and a theoretical curve for the deviation is shown in Fig. 1.

Whereas the phase and direction of the changes in the vertical agree closely with theory, the amplitude of the observed change is much less than that which theory indicates. Or, rather, we should say that the amplitude is about 2/3 of that which would be observed if the earth were perfectly rigid. The difference between this factor 2/3 and unity is a measure of the extent to which the earth's surface yields to the tidal force of the moon, and thus masks the deviation of the pendulum. It is interesting to note that in 1884 Sir George Darwin, from analysis of tidal records, found this factor to be 0·676, also that his and Lord Kelvin's earlier estimate of the rigidity of the earth accord closely with that now determined by Dr. Hecker, namely, 5/6 of the rigidity of steel. The difference between observation and theory is shown in Fig. 2.

One interesting fact is illustrated in Fig. 2. The reduction of amplitude from one curve to the other is different in different azimuths. Dr. Hecker has discussed this point, and shown it is in no way to be accounted for as an indirect effect of accompanying changes in the sea-level or the atmosphere. Whether it is due to local surface conditions at Potsdam, or whether it bears some relation to large structural deformations of the earth, these are questions which further research will alone elucidate.

The second question discussed by M. Lallemand is the examination of permanent or gradual deformations of the earth's crust. A short account of changes, which have been shown to have been caused by recent earthquakes, is followed by a discussion of attempts made in France to ascertain gradual changes of level. Accurate work of recent date has discredited Bourdaloue's result that the sea-level at Brest and Marseilles differs by a metre, that result being ascribed to systematic errors in the observations. The difficulty of ascertaining permanent changes of level is increased by secular alterations in the mean sea-level at the base of a level-line. Added to this are the errors of the actual work of levelling. M. Lallemand's estimate of the error that would probably be introduced in ascertaining the height of a hill-top 2000 m. above sea-level, at a distance of 600 kilom. from the sea-shore, is 12 cm. to 17 cm. even when the levelling is done by the most accurate methods at present available. In view of the slowness with which changes of level take place, an interval of at least thirty years ought to elapse between successive levellings undertaken to show changes of level.

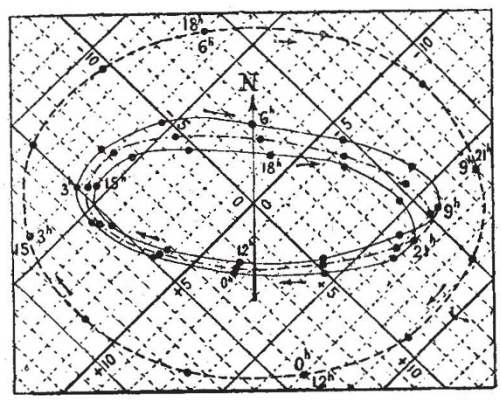

FIG. 2.—Daily apparent motion of the pendulum due to the action of the moon.

——— Observed oscillation.
· · · · Observed semi-diurnal oscillation.
– – – – Semi-diurnal oscillation calculated for a rigid earth.

In time we may hope to ascertain by repeated geodetical researches in what way countries, or even whole continents, are rising and sinking. In such work the geodesists will have the fullest support of all

men of science. In particular they may expect sympathy from the astronomical world, which will soon be faced by an allied problem. The question must, before many years, come up for decision as to when a repetition of the chart of the heavens, which is slowly nearing completion, will be justified by the conclusions to be drawn from it.

SCIENTIFIC STUDIES OF DEW-PONDS.

AN endeavour to solve the so-called mystery of the dew-pond has recently been made by Mr. E. A. Martin, and the results of some of his observations are shown in a paper which appears in the *Geographical Journal* for August. The paper was read before the Research Department of the Royal Geographical Society on April 22. Attempts were made by direct experiment to ascertain how the replenishment of such ponds takes place. During the autumn of 1908, Mr. Martin spent many nights and days on the Clayton downs, in Sussex, and thus was on the spot during the hours when, according to theory, the ponds should be receiving dew. The result of a large number of thermometrical observations went to show that very rarely does the temperature of the water of the ponds sink below that of the air above it, or below dew-point.

The term "dew" is widely used to mean any kind of condensation which does not fall as rain, hence "dew-ponds," "mist-ponds," and "cloud-ponds" are terms which are used for one and the same kind of pond. On the Sussex Downs no overhanging tree to condense moisture out of the air is found, as a rule. The bare down is all around, whilst in the water there is, as a rule, pond-weed, or reeds, sometimes projecting above the surface of the water. Where this happens, dew is undoubtedly precipitated on the reeds, and this helps to replenish the pond. But many ponds have no projecting vegetation, and yet do not suffer greatly in times of drought. It is pointed out that the measurements of some ponds and their surrounding basins give a receiving area sometimes double the area of the water. In one case the pond-area was 4120 square feet, whereas the shelving margin gave an area of 5795 square feet. Other similar examples are given, and it is this width of margin which has caused many observers to conclude that rainfall is the chief factor in filling the ponds; but not the only factor, as Mr. Martin points out, otherwise there would be little reason why the lowland ponds should dry up in times of drought, and leave the upland ponds fairly full.

Thermometrical observations show that the depth of a pond at the commencement of a drought has much to do with its continuance. A shallow pond was found rapidly to dry up by evaporation, the high temperature gained during the day being well maintained during the night. On the other hand, a deep pond will but slowly be heated, and may well be saved excessive evaporation until a break in the weather comes, and normal conditions again prevail. One pond which was but a foot deep was found so late as 8.20 p.m. in July to show no differences of temperature at 1 inch, 6 inches, and 9 inches, the thermometer registering 67·5° F., whilst that on the bank showed a reduction to 58·5° F. The water lost heat but slowly, and no doubt evaporation went on well into the night. Three weeks later it was dry. Another pond, 3 feet deep, showed, at 6 p.m., 76° F. at 1 inch, 74° F. at 6 inches, and 71° F. at 9 inches, and two hours later the 1-inch temperature had been reduced to 70¾° F., whilst the 6-inch and 9-inch temperatures were uniform at 71° F., the surface temperature showing a considerable loss. There was in this pond a large quantity of rushes, and the loss by evaporation was almost compensated for by the deposition of dew upon their exposed surfaces. This pond did not dry up.

Attention was given to the alleged chilling of the water below dew-point, but it was found that although such a circumstance rarely happened, it sometimes was seen that the temperature of the air resting on the water was below dew-point. Further observations in this direction are to be made. Numerous experiments were made to determine whether straw, wood, and woodwool were likely to effect a chilling of the water of a pond resting on a foundation of these materials, and the evidence pointed to these acting in the desired direction. A series of experiments showed that both "downward" and "upward" dew would be found on different nights according to certain atmospheric conditions, and it is pointed out that if a pond were to depend on the latter only for its replenishment, it would simply receive what it had previously lost by evaporation. The chilling effect of grass on the moisture-sodden lowest stratum of the atmosphere results in dew on the grass, but there is no such chilling of the air by the pond-water, and if dew is there deposited there must be some other cause at work.

It is found that out of seven localities quoted where straw has been used in the foundations of dew-ponds, in no case has it been used with the idea of inducing dew-deposition in the pond. Sections of dew-ponds are given in the paper, constructed according to various authorities. The most remarkable case seems to be that in Wiltshire, where foundations are laid in the form of six layers of straw and clay alternately, but here again the reason given is that the straw prevents the clay from cracking. Incidentally, Mr. Martin refers to the danger to clay-puddled ponds from the small red-worm, swarms of which were met with in some ponds. An estimate of dew-fall on grass was made, giving 0·77376 inch per annum.

So far as rainfall is concerned, it was found that in thirty-two days the amount measured on the downland was 2·57 inches, but a gauge placed in a hollow dug for an experimental pond measured 3·51 inches. This seems to show that a pond-depression on the downs would draw into it, by setting up currents and eddies of the wind, a greater quantity of rainfall. By experimenting with a gauge in the rim of which had been placed some straw and grass, in imitation of conditions which obtain in some ponds, it was found that when 0·37 inch was measured on the down, 0·54 inch was measured in the gauge; when the former showed 0·32 inch, the latter showed 0·69; when the former showed 0·46 inch, the latter showed 0·80 inch. The gauge with the straw and grass was placed in the hollow.

In order to determine whether the chemical composition of pond-waters would give any clue to their origin, a number of analyses of such waters was made at the South-Western Polytechnic, and the results are given in the paper. These seem to show that there is too much sodium chloride contained in the ponds to have come from rain-water, and in normal conditions dew certainly contains no common salt. The sea-mists may reasonably be held to be responsible for the saline qualities of the waters.

So far as the antiquity of the name and the idea of the dew-pond is concerned, Mr. Martin seems to think that puddling by cattle-trampling by accident may have caused artificial ponds first to have been made, and although proof must be lacking, it is possible that