at an ordinary temperature, or six hours at 100°, it has returned to its transparent state. With Ford blotting-paper the time of recovery is longer. On the other hand, if a paper be made only slightly moist, this facilitates the passage of the peroxide through it. If different substances be dissolved in the water used for wetting the paper it modifies the result obtained. With some substances the paper is not permanently affected, but with others—such, for instance, as alum—the paper remains opaque.

If paper be either written or printed on, the different effects which are produced have been already described.

FIG. 7.

The ordinary writing ink, allowed to dry on paper, renders it perfectly opaque to the action of the peroxide and retains this power for a very long time. The direction of a letter written in 1801 shows the writing with remarkable sharpness. The picture was produced by placing a zinc plate behind the letter. Then with regard to printing ink, it is a body which in itself is active, so that it has only to be brought in contact or in proximity to a photographic plate to give a picture. Naturally the activity of the ink varies much in different cases, and is in most cases capable of giving, not only a picture where the ink is facing the plate, but the printing

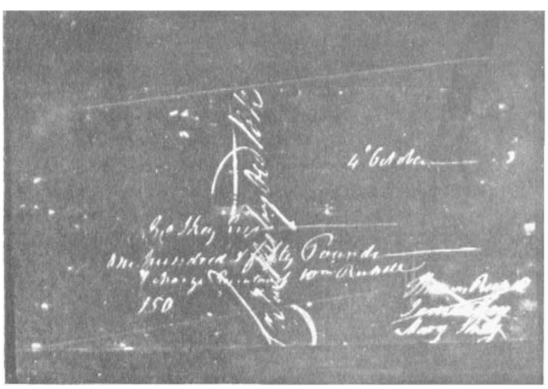

FIG. 8.

on the other side of the paper will also be depicted on the photographic plate. Fig. 6 shows this very well, the printing on both sides of the paper being very evident.

This difference of the action of writing and printing ink is well shown in the two pictures of an old cheque, Figs. 7 and 8. No. 7 is simply an ordinary photograph of the cheque, but No. 8 is a picture of the same cheque produced by placing it on a photographic plate with a zinc plate behind it; the printing-ink has become inactive, but the writing ink is still able to prevent the hydrogen peroxide from passing through.

W. J. RUSSELL.

WHAT ARE SEISMOMETERS INDICATING?

ONE thing which a modern seismometer does, and does in a satisfactory manner, is to indicate the time of arrival of the various phases of motion which constitute an earthquake. With two similar instruments at the same station, the time of commencement of a given earthquake is practically identical; but if the installations of the instruments are different—for example, if the instruments rest upon piers of different heights and construction—it will only be the pronounced phases of the subsequent movements that can be identified and which, therefore, can be compared. If our instruments, instead of being in the same room, are 100 to 800 feet apart, the only points in the two seismograms which can be identified will be the commencements and the pronounced shocks, which latter are of rare occurrence (see British Association Reports, 1885). As a rule not only will the general appearance of the seismograms be different, but measurements will show the existence of differences in period and amplitude. This being the case for seismograms obtained at stations near to each other, what coincidences can we possibly hope for in seismograms obtained at stations located at a few, several hundreds or several thousands of miles from each other?

Next, if we turn to a consideration of the character of the earth movements which produce seismograms relating to earthquakes the origins of which are at a great distance, we meet with observations the explanation of which is not simple. The first rapidly recurring tremors that a seismograph records are regarded as elastic waves of compression and rarefaction. One reason for this belief is that the observed velocities with which these precursors traverse either the surface materials or the body of the earth are such as would be expected for this particular form of wave in the media considered.

Following these forerunners by an interval of time which increases with the distance of the observing station from the earthquake origin are a series of more pronounced movements, usually referred to as shocks or large waves, about the character of which there have been differences of opinion. For earthquakes originating within a few hundred miles of an observing station we find that the records of such waves obtained from bracket seismographs are described as horizontal movements, whilst those from spring-lever seismographs are referred to as vertical components of motion. So long as the latter records are not shown upon a seismogram the former have always been regarded as described, their apparent magnitude being dependent on the multiplication of the writing indices. When, however, in a register we see entries for "vertical motion," neither the measurements for this nor for the corresponding entry for horizontal displacement can be relied upon. The reason for this statement, first made more than ten years ago, is that with severe earthquakes for 100 or more miles round the epicentre we have a vast amount of evidence showing that the ground is thrown into a series of surface-waves. These angular displacements cause horizontal pendulums to swing from side to side, whilst the levers of lever seismographs move up and down, the result being that both types of instruments, instead of measuring components of motion relatively to steady points, act as indifferent clinographs. In consequence of these considerations, at the end of 1891 I designed a clinometer for earthquakes. Briefly, this consisted of a balance-beam loaded at its two extremities, which when its frame was tilted in a direction at right angles to its length was assumed to retain its horizontality. A pointer like that of an ordinary balance attached to this beam acted as a steady fulcrum for the short arm of a light lever, the outer end of which rested on a smoked glass surface. An example of the seismograms giving the period and slope of earthquake-waves obtained by this apparatus will be found in the British Association Reports, 1893.

Inasmuch as these surface-waves could be recognised at a distance of a few hundred miles from their origin, it was naturally assumed that the movements resulting from unusually large disturbances which not unfrequently travel to their antipodes should exhibit the same undulating characteristics. Some support to this view was found in the large movements of delicately adjusted horizontal pendulums, the movements recorded in the traces from magnetographs and barographs, whilst the movements occasionally noted of the bubbles in astronomical levels or the shifting of a star in a telescopic field, together with other phenomena, tended to strengthen the view that the large waves in seismograms represented actual earth tilting. Although I do not yet see how certain of these phenomena can be explained on the assumption of purely horizontal movements, especially when the period of these may exceed twenty seconds, in a British Association Report (September 1900) I published observations indicating that the surface-wave theory met with so many objections that it could not be generally applied. One objection rested upon observations indicating that the velocity of propagation of these waves did not appear to be constant.

Although for certain practical purposes it may be assumed that the arcual velocity of these movements is 3 km. per second, there is evidence to show that they have an initial velocity of about 2 km., whilst their quadrantal velocity approaches 4 km. per second. Dr. C. G. Knott, who has done so much for practical and theoretical seismology, at once pointed out that any change in speed was a serious stumbling-block to the surface-wave theory, which he had always regarded with disfavour. As an alternative, in the *Scottish Geographical Magazine* (January 1899), and in other publications, he showed that the observations relating to speed could be satisfied by the assumption of a distortional mass wave, and it is to the outcrop of such waves to which Dr. Knott looked for the explanation of the large movements of the seismograph.

This hypothesis, however, does not tell us whether the movements actuating a seismograph are vertical, horizontal or angular. Many years ago Dr. A. Cancani pointed out that if these waves represent tilting, from the angular values of the same and the length of the waves which can be deduced from their period and velocity, then on the assumption of simple harmonic motion the height of such waves could be calculated.

Such heights have been frequently estimated, but in the British Association Report (September 1900), p. 83, attention is called to the fact that as these represent accelerations not unfrequently 1/50 of gravity, the existence of these vertical displacements is doubtful, and an experiment to confirm or modify our views was in progress.

The "experiment" referred to consisted in observing the movements of a pointer attached to the earth relatively to the pointer of a clinograph similar to, but much larger than, the one described above. Any relative movement of these pointers would be shown by the displacement of a spot of light reflected from a mirror hung by a bifilar attachment to the two pointers. Subsequently the record was made mechanical. With the first installation 1 mm. deflection $=0''\cdot7$, and in the second $6''\cdot0$. Although several large earthquakes occurred, no record was obtained.

In another experiment slight records were obtained from the photographic registration of a spot of light reflected from a mirror which was caused to rotate by the rising or falling of a weight attached to an ordinary spiral spring. The length of the spring under the influence of its own weight is 9·5 inches. With a load of 1 lb. 8 ozs. its length was 3 feet 5 inches and its natural period 2 seconds.

The earthquake of October 9, 1900, caused ripples on the photogram each about ·5 mm. in range, which would correspond to a change that might have been produced by increasing and decreasing the load by 1/700 part of itself. The period of motion was approximately 6·5 minutes, which corresponded with the period of maxima in the large waves as in an ordinary seismogram.

The Venezuela earthquake of October 29 gave deflections of half the above and with periods of about 7 minutes. Other earthquakes caused somewhat similar movements, but usually nothing more than slight blurs upon the photographic traces were to be seen.

The records from the clinometer indicate that earth tilting has not been measurable by the instrument employed, whilst the records from the spiral spring show that there is a possibility that vertical motion may exist, but if it does it is exceedingly minute.

The general inference is that the large waves due to earthquakes originating at a distance, whether they are surface waves or mass waves, actuate horizontal pendulums by horizontal displacements of the ground, rather than by the tilting of the same.

The distinguished seismologist, Dr. F. Ōmori (see "Publications of the Earthquake Investigation Committee," Tokyo, No. 5, January, 1901), and Dr. Wilhelm Schlütter (see his "Inaugural Dissertation," Göttingen, 1901) have recently expressed similar views. Dr. Omori's objection to the surface-wave theory is based partly upon the impossibility of accepting the vertical accelerations calculated on the assumption that seismographs have acted as clinometers, a view already expressed by Dr. C. G. Knott, Dr. C. Davidson, myself and other physicists, and partly upon the observations he has made showing that the amplitude of seismograms depends upon the multiplication of the writing pointers rather than the sensibilities of seismographs to tilting.

Dr. Schlütter's conclusions are arrived at from the fact that some twenty earthquakes failed to yield any record on the photograms obtained from a "klinograph," which in general arrangement is not unlike those already referred to, but very much more sensitive. The care which Dr. Schlütter took to ensure accuracy can only be realised by reference to his memoir, which, as an essay relating to this class of investigation, stands *facile princeps*.

The general conclusions arrived at are that for severe earthquakes with a near origin, surface earth-waves may be marked. To record these clinographs are required, and the entries in registers referring to the same should be correspondingly modified. In designing instruments to record earthquakes with a distant origin, the principle introduced by Prof. J. A. Ewing into seismometry relating to steady points must be carefully observed, and in our registers we must regard our entries as referring to displacements which are horizontal rather than angular.

J. MILNE.

ELEMENTARY MEDICAL EDUCATION.

WE have received a memorial to the General Medical Council concerning the relegation of the teaching of elementary chemistry, physics and biology to the school, as distinguished from the medical school. The memorial is signed by a number of men of science, teachers of botany, zoology, chemistry or physics. In the opinion of these gentlemen the above subjects should be permanently retained as part of the medical curriculum proper, and their relegation to the schools is, according to them, likely to have a prejudicial influence upon medical education. The most powerful argument, so far as we can see, brought forward in support of this hypothesis is that the schoolboy, as distinguished from the medical student, is intellectually less capable of grasping those scientific generalisations without which the teaching of the elementary scientific subjects above named would not be productive of the desired result, viz. the