comes warmed to steam temperature; but as the mercury is being pushed steadily downward where the tube is still cold, the oscillations continue. Inasmuch as the center of gravity

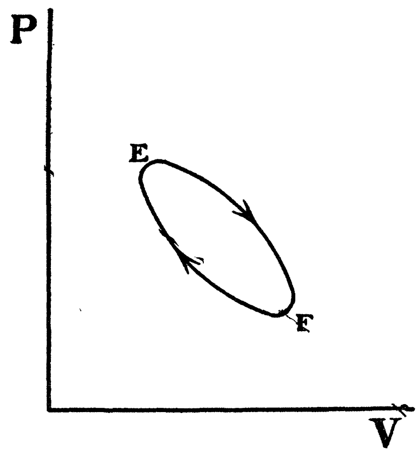

Fig. 2

of the mercury is not permanently changed during one oscillation, the only work done is that against friction. Energy must be supplied to maintain this motion.

The explanation given here is the one advanced by Griffiths[1] to explain a similar phenomenon where a bulb of air was connected to one end of a U-tube partly filled with mercury. On heating the bulb with a gas flame the mercury oscillated. Griffiths pointed out that it would be useless to compare the quantities of heat received and rejected, because the expansive substance is constantly in contact with conducting bodies at different temperatures. He stated also that the action of hot-air engines is of the same nature as the one described; a prediction that was verified by Webster[2] who, by means of an ingenious device on a small hot-air engine, projected its indicator diagram on a screen in a lecture room. The diagram was of the form shown in Fig. 2.

F. R. Watson

University of Illinois,
May 19, 1910

[1] E. H. Griffiths, "The Thermal Measurement of Energy," pp. 49–52, Cambridge Press, 1901.

[2] A. G. Webster, "A Hot Air Engine Indicator Diagram," *Phys. Rev.*, 30, 264, No. 38.

MICROSEISMS

Ever since sensitive earthquake instruments have been built, it has been found that outside of earthquakes, which show characteristics in their records peculiar to themselves, there are other disturbances recorded; disturbances that manifest themselves by their continuity, extending over hours, days and even weeks. They appear as small pulsations, the undisturbed trace of the seismogram being converted to a finely serrated line. The amplitudes may gradually increase to a millimeter or even more on our instrument, and then disappear again. In general they are far more prevalent during the winter season than in the summer. These pulsations or tremors I call microseisms. The question naturally arises, what produces these vibrations? Are they due to a constant stress in the earth's crust which at times adjusts itself by a rupture along some weak line, along a fault, or are they produced by thermometric or barometric conditions of the atmosphere. Among phenomena of the latter we may consider winds, and the position and movements of the area of low barometer.

A very superficial examination of the facts eliminates the temperature effect, that is, the varying heat from day to day.

For the barometric conditions of the atmosphere there was available at the observatory the record of the Shaw microbarograph and also the Canadian daily weather maps. The microbarograph has a magnification of 20, so that rapid fluctuations in pressure are very well shown, as shown by local strong winds. The daily weather maps show the position of the isobars from the Pacific to Newfoundland in the Atlantic, with differences of pressure of 0.1 inch for adjoining isobars.

The seismograms are the records of two Bosch photographic horizontal pendulums mounted N.–S., E.–W., respectively, on a concrete pier free from the cement floor in the basement of the observatory. The theoretical magnification of the record is 120 and the pendulums have air-damping. The periods of the pendulum are adjustable and lie generally between 6 and 10 seconds. The time-scale on the seismogram is represented by 15 mm. to the minute, so that individual seconds are easily read. The daily sheets are therefore about a yard long and seven inches wide.

For the past two years the writer has made daily comparisons between the seismograms, barograms and weather maps to find what connection, if any, existed between the different phenomena. That on the seismogram we had to deal with earth-movement and not with oscillations of the pendulum becomes obvious to any one examining the record. Undoubtedly the pendulum may be set in vibration by an impulse, but the former would soon die down on account of the damping, which however is not the case, but instead the pulsations are kept up at times for hours and days. When the period of pulsation is nearly that of the period of the pendulum we find a crescendo and diminuendo showing a spindle shape in the record, and the repetitions of figure take place when the pulsations have gained or lost one on the number of vibrations of the pendulum.

As already intimated an earthquake record, with its various phases of longitudinal, transverse and surface waves, can never be confounded with microseisms.

Let us first compare the microbarograms with the seismograms, taking of the former one that shows rapid fluctuations of pressure, being accompanied by more or less gusty strong winds. On the seismogram will be found simultaneously disturbances, well-marked, but their character is totally different from the microseisms under consideration. Instead of being of the regular form, more or less like saw-teeth, spoken of, they are irregular, a sort of "drunken" record, involving probably undulatory movement beside some pulsations and vibrations. This record differentiates itself very clearly from that of earthquakes and microseisms.

Next we compare the weather map with its isobars and areas of high and low barometer. We are soon led to the belief that we are dealing in broad outlines at least with two records of the same phenomenon. When in summer the isobars run almost across the continent, areas of low and high barometer are ill-defined, and the gradients, or lines at right angles to the isobars, are long, it will be found that the seismograph is almost or wholly quiescent. However, with the advent of autumn the isobars begin to move more closely together, areas of low become confined figures which move regularly across the continent, then the microseisms make their appearance, and seem to some extent to be a counterpart of the atmospheric conditions. We appear now to be on the right track. But a nearer relationship is yet to be found. Of one thing we are certain so far, and that is, that if the isobars stretch far over the continent with few and long gradients then there will be no microseisms. The converse, however, as experience has shown, can not be so definitely stated, viz., that when isobars are close together, surrounding a low with steep gradients that then strong microseisms will be recorded. Some microseisms will be shown undoubtedly, but not necessarily as a measure of the gradients about a low anywhere. Examination from day to day revealed the important fact that the position of the low is a very material factor in the production of microseisms. For instance, we have a low approaching over land from the western quadrant, as they always do, showing on the face of it a strong cyclonic movement, yet our seismograph does not seem to be affected by it as long as it is to the west of Ottawa. However, after it has passed Ottawa and descended the St. Lawrence valley or passed along the Atlantic coast to the Gulf of St. Lawrence and over Newfoundland to the Atlantic, then the microseisms become very active and we obtain a sheet of serrated lines with amplitudes indicative more or less of the steepness of the gradient. The important discovery that we have made is that the area of low with steep gradients to be most effective in producing microseisms must be over water, *i. e.*, the ocean.

So far our facts seem to be well correlated, but there is one essential link still missing, viz., "How does the area of low barometer with steep gradients resting on the water produce the microseisms?" To this question

I am not as yet prepared to give an answer. As intimated in my report of the International Seismological Association, a special committee has been appointed to investigate this particular point.

We may sum up then the conclusions so far arrived at:

1. Microseisms are essentially due to meteorological phenomena, that is, to barometric pressure and the accompanying gradients.

2. The amplitude of microseisms is largely a function of the steepness of the barometric gradient.

3. Areas of low barometer with steep gradients, but west of Ottawa have little effect in producing microseisms.

4. Strong microseisms are almost invariably accompanied by steep gradients in the Gulf of St. Lawrence, with the St. Lawrence valley, containing the Great Champlain Fault, on a line of steep gradients.

5. A well-marked low sweeping up the Atlantic coast from Florida to Newfoundland is almost always accompanied by marked microseisms.

6. Microseisms are but slightly, if at all, influenced by the movements of lows across the continent.

7. Microseisms are not produced by local winds, frictional excitation of the earth's surface.

8. Microseisms represent vibrations in vast blocks of the earth's crust, covering tens of thousands of square miles; and the period is possibly dependent on or modified by marked geological configuration and depth.

9. Microseisms once produced may continue for some time when the immediate cause has passed.

To the above may be added that, as the microseisms are mainly dependent on the action of the low on the ocean, and as at Ottawa they are recorded *after* the low passes, the reverse should be the case in Europe, where the ocean is to the west, and the low passes over it *before* reaching the continent.

OTTO KLOTZ

SOCIETIES AND ACADEMIES

THE IOWA ACADEMY OF SCIENCE

THE sessions of the Iowa Academy of Science were held in the zoological lecture room in Blair Hall, Iowa College, Grinnell, beginning at 1:30 P.M., Friday, April 29.

The public address by Professor William A. Noyes, of the University of Illinois, on "A Scientific Revolution," was given Friday at 8:00 P.M., in the college chapel.

The Digestibility of Bleached Flour: E. W. ROCKWOOD.

The Effect of Continued Grinding on Water of Crystallization: NICHOLAS KNIGHT.

A Study in the Determination of Calcium: GEORGE W. HEISE.

A Notice on the Cast Iron Casing in Well Four at Grinnell: W. S. HENDRIXSON.

The Iowa Lakeside Laboratory (illustrated): R. B. WYLIE.

A brief account of the first session of this biological laboratory, summer, 1909, with lantern slide illustrations of the grounds, buildings and points of interest near the station.

The Flower of Elodea (illustrated): R. B. WYLIE.

Details of an undescribed type of staminate flower, which at maturity elongates similarly to the pistillate flower of this genus.

Preliminary List of the Parasitic Fungi of Fayette County, Iowa: GUY WEST WILSON.

The results of field work in this region since the autumn of 1907 are embodied in this paper. While the number of species found is quite large, and many of them of no small interest, further field work will greatly augment the list. This is especially true of the Jung Imperfecti, which have been least thoroughly studied.

Prairie Openings in the Forest: B. SHIMEK.

A discussion of the prairie flora of these openings, and of the conditions which cause its appearance.

The Influence of Air-currents on Transpiration: Miss MAUD A. BROWN.

An account of the results of laboratory experiments showing the effect which currents of air of various velocities have on transpiration.

Delayed Germination: L. H. PAMMEL and CHARLOTTE M. KING.

For some years we have made a study of the germination of weed seeds under different condi-