A NOTE ON EARTH PULSATIONS AND MINE GAS.

By John Milne.

The following notes on the possible relationship between the escape of gas at certain collieries and the occurrence of wave-like movements which are frequently observed in the crust of the Earth, is an abstract, with a few additions, of a paper by the same writer "On Earth Pulsations and Mine Gas," published in Vol. V. of the Transactions of the Federated Institution of Mining Engineers, 1893. In this paper, observations which led to the conclusion that so-called Microseismic Storms or Earth Tremors are long flat undulatory movements are described. Italian observers tell us that these movements can be recorded at considerable depths beneath the surface, while on the surface they affect large areas. They cannot be felt, but their presence is indicated by the repeated tiltings of horizontal pedulums, the resultant movements on these instruments being very much greater than those which are produced by small earthquakes. Many earthquakes which we feel appear to be elastic vibrations, the periods and amplitudes of which have never been satisfactorily recorded. The earth pulsations which we do not feel, and which may continue for twenty-four hours or longer, are movements not unlike the swell on an ocean. Earth pulsations can not be recorded by Earthquake instruments, and small earthquake-like vibrations due to traffic or the beating of a

steam hammer can not be recorded by the extremely slow period pendulum arrangements which are employed to record earth pulsations. These latter instruments, however, will record undulations on the surface of the earth which are the resultant of large earthquakes or earthquakes in which there is a vertical component of motion.

Other work undertaken by the present writer bearing on this subject may be found in the following publications :—

1.—" Observations of Tremors, etc., in Takashima Colliery." *Japan Gazette*, Jan. 12th, 1884.

2.—" Earth Tremors." *Trans. Seis., Soc.* Vol. VII., part 1, 1883.

3.—" Earth Tremors in Central Japan." *Trans. Seis. Soc.*, Vol. XI., 1887.

4.—" Earth Tremors in Central Japan." *Trans. Seis. Soc.*, Vol. XIII., part 1, 1888.

5.—" Earth Tremors and the Wind." *Jour. of the Royal Meteor. Soc.*, Vol XIV., 1888.

6.—" Earth Pulsations in relation to certain Natural Phenomena and Physical Investigations." *Seis. Jour.*, Vol. I., 1893.

7.—" On the Movements of Horizontal Pendulums." *Seis. Jour.* Vol. I., 1893.

8.—" Reports on Volcanic Phenomena, etc., in Japan." British Association, 1881-83, 1884, 1885, 1887, 1888, 1892, 1893.

The observations at Takashima, which had but a bare commencement, were discontinued in consequence of a fall in the roof, which left the instruments isolated in buried workings beneath the Pacific Ocean.

Reference is made to these attempted observations by Mr. M. Walton Brown. " On the observation of Earth Shakes or Tremors in order to foretell the Issue of Sudden Outbursts of Fire Damp." *Trans. N. E. Institute, Min. Eng.*, Vol.

XXXIII., and again by M. G. Chesneau, *Annales des Mines*, Mai-Juin, 1888. Subsequently to Mr. Walton Brown's paper, a committee was appointed to enquire into the observations of earth tremors in mining districts, but as seismoscopes rather than tromometers were established no results of importance were obtained. (*Trans. N. E. Institute Min. Eng.*, Vol. XXXVII. p. 55. Plate VIII.)

In 1893 the same Committee in a report to the British Association on "Earth Tremors," drawn up by Mr. C. Davison, described a beautiful instrument designed by Mr. Horace Darwin to record slight tilts of long period. At present it is established near Birmingham. It has recorded movements of about 18 seconds period, but I do not know whether it is too slow to record pulsations which have a period of 2 or 3 seconds, which certainly give well defined records with very light horizontal pendulums having periods of about 5 seconds. As I have established a pendulum with a period of 55 seconds in Japan, and others have been constructed, the solution of this problem is of considerable importance.* In the same report we find an epitomized history of most that has been done in England, Germany, Italy, France, and Japan by those who have interested themselves in these hitherto almost neglected movements of the Earth's surface.

M. Chesneau describes the results of the observations with a tromometer and the amount of fire damp given off at a colliery at Douai. The general result is that "microseismic" movements are more clearly related to the escape of fire damp than barometric movements.

An exceedingly important point exhibited in certain of M. Chesneau's diagrams to which, however, no reference is made, is that although the increase in microseismic movements, the increase in gas and the barometric fall have sometimes commenced simultaneously, the microseismic movements reached

* These long period pendulums are greatly disturbed by earth pulsations.

a maximum six hours *before* the gas reached a maximum, while the lowest point of the barometric curve occurred even twelve hours later or eighteen hours after tbe maxima of the tromometric movements.

Other interesting facts connected with the subject under consideration are:—

1.—The explosions due to fire damp in Germany as arranged as a monthly curve show a close relationship with a similar curve for the "microseismic" disturbances in Italy, and as "microseismic" disturbances extend over considerable areas it is not unlikely that the fire damp curve for Germany would agree with an earth pulsation curve for the same country.

2.—Earth pulsations, and generally for England and Germany explosions of fire damp, are more frequent during the winter months.

3.—From Mr. Chesneau's measurement at Douai, the writer observes that the greatest quantity of gas escapes between November and March or during the winter.

4.—During winter months in the Northern Hemisphere at least, barometric gradients are steeper, and larger fluctuations occur in their value than in summer.

5.—Pulsations nearly always accompany steep barometric gradients. Therefore it follows, as has been noted by observation, that they often accompany strong winds even if these are blowing at a distance.

6.—Pulsations although common with a low barometer also occur when it is high, provided that the gradients are steep.

7.—A local barometrical fall is directly connected with the escape of gas from old workings.

8.—A local barometrical fall has in the majority of instances no appreciable effect on the escape of gas from coal.

9.—From the observations of Köhler in Silesia, it would seem that the quantity of gas escaping is not so much de-

pendent on the height of the barometer as it is upon the rate at which it changes.

From these and other considerations, the writer suggests that in a district where gas escapes it would be well to repeat the observations of M. Chesneau but with an instrument giving more definite records. He suggest the use of those which are in use by himself in Japan, but it is quite likely that the apparatus designed by Mr. Horace Darwin or that used by Dr. E. von Rebeur-Paschwitz is equally applicable. The phenomena to be observed are Earth Pulsations and not Earthquakes. Further he suggests that the quantity of gas escaping be compared with the states and directions of the barometric gradient existing at the time of observation and this may be done by the analysis of existing material—unfortunately such material is not obtainable in Japan.