6-inch of the "King Edward VII." class launched three years previous. In this same year they also launched their first "all-big-gun" ship, the "Dreadnought," by abolishing the 9.2-inch guns, substituting in their place six 12-inch guns, and adding these to the four 12-inch guns, which the other two classes already had, making ten in all, and placing them in pairs in five turrets. This is the ship that in three years has revolutionized the navies of the world, all of whom are now building this class known as "Dreadnoughts." But was not this idea of the "all-big-gun" ship taken from one that was first produced in the American navy?

The definition of a "Dreadnought," as I understand it, is an armored ship with a high freeboard, carrying only guns of the largest caliber in use, these arranged on one deck in pairs and in armored turrets; the number of turrets not being restricted necessarily to five, can be one more or one less according to the tonnage of the ship.

In 1852 there was a steam frigate built by the United States at the Gosport navy yard at Norfolk, Va., and called the "Roanoke." She was 265 feet in length, with a breadth of 52½ feet, and a depth of 26. Her machinery was built by the Tredegar Iron Works at Richmond, Va., and consisted of a pair of trunk engines with cylinders 72 inches diameter and 26 inches stroke.

This frigate was anchored in Hampton Roads at the time of the battle between the "Monitor" and "Merrimac." After this fight, which introduced to the world the revolving armored turret with its pair of heaviest guns afloat (15-inch smooth-bores) she was taken to New York and razed at the Brooklyn navy yard. Her masts and sails were removed, her sides were armored, and she was equipped with three Ericsson turrets at the Novelty Iron Works in 1863. Each of the turrets contained a pair of the heaviest guns in use, and they were placed fore and aft on the center line of the vessel, which is the arrangement of the turrets on American "Dreadnoughts." The vessel had no masts and no secondary or auxiliary battery, only the "all-big-gun" armament.

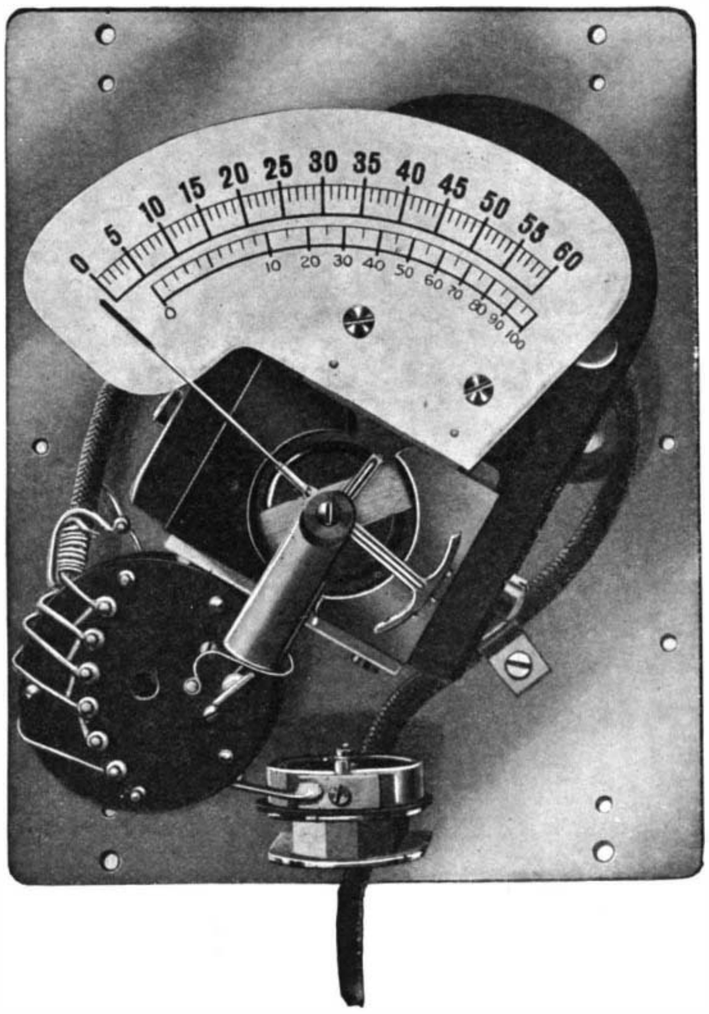
It seems to me that the "Roanoke" complies in every way with the definition of the modern "Dreadnought"; that the idea of the "Dreadnought" was first developed in her; and that she *was* the first "Dreadnought"—or in other words, the great "Dreadnoughts" are developed "Roanokes." Their arrangement of guns, armor, and turrets is from her. The "Roanoke" had no military or skeleton masts or rapid-fire guns, these at that time not being necessary, as wireless telegraphy and torpedo boats were not then known.

The American navy had the first steam vessel of war and the first "Monitor," and should it not be credited with the first "all-big-gun" ship, the "Roanoke," of which the "Dreadnoughts" are but an enlargement of the same idea? I inclose a photograph of the "Roanoke," taken from a large lithograph made for the Navy Department, and presented to me by the Assistant Secretary, G. V. Fox, with a number of others in 1863. WILLIAM BOERUM WETMORE.

Allenhurst, N. J.

## POWER INDICATOR FOR INTERNAL-COMBUSTION ENGINES.

A strikingly novel instrument, the invention of Prof.




**Interior details of the indicator.**

N. Monroe Hopkins of the George Washington University, is pictured in the accompanying engravings. The instrument is a combination power indicator and precision speedometer without a flexible shaft, and when the equipment is installed upon a stationary engine, automobile, motor boat, or aeroplane, shows what the cylinders of the engine are doing separately or together; which, if any, cylinder is missing; the power of the engine and the conditions under which it is doing the most useful work; how to adjust the carbureter perfectly when the engine is idle as well as under load; speed with absolute precision from 1 to 60 or 100 miles per hour, and mileage; and the revolutions per minute of the propeller in aeroplane and marine work.

The instrument is an original application of the fact that an electric current is produced by the simple heating of the junction of two dissimilar metals, and the magnitude of the current so generated is proportional to the junction temperature.

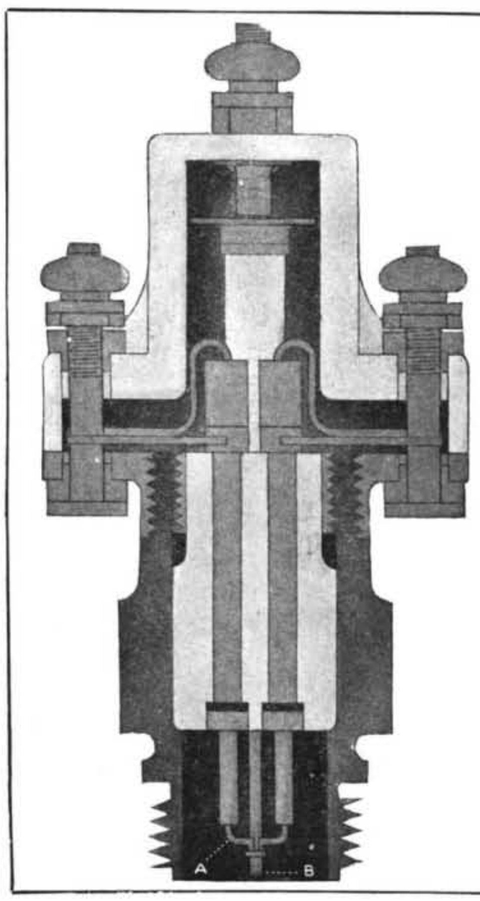
Ordinary thermo-couples as evolved by Becquerel, and used for general temperature measurement in the arts and sciences, would never "live" to operate under the high temperature and peculiar chemical conditions in a gasoline engine cylinder, because they would become so heated as to pre-ignite the charge and cause the gas engine to buck, hitch, or back-fire, and in addition would become brittle and drop apart, either through oxidation or the absorption of carbon, after a short period of use. Actual temperature measurements by means of thermo-couples or thermometers could not be made in gasoline engine cylinders.

Prof. Hopkins's thermo-couples are of original construction and are designed to give an idea of the temperature in a gasoline engine without actually attempting to measure it. His instrument faithfully and continuously shows, by modified temperature readings, the working conditions of gasoline engine cylinders. The "thermo-plugs" give the same "electrical pressures" after 50,000 miles' use on an automobile as when first applied.

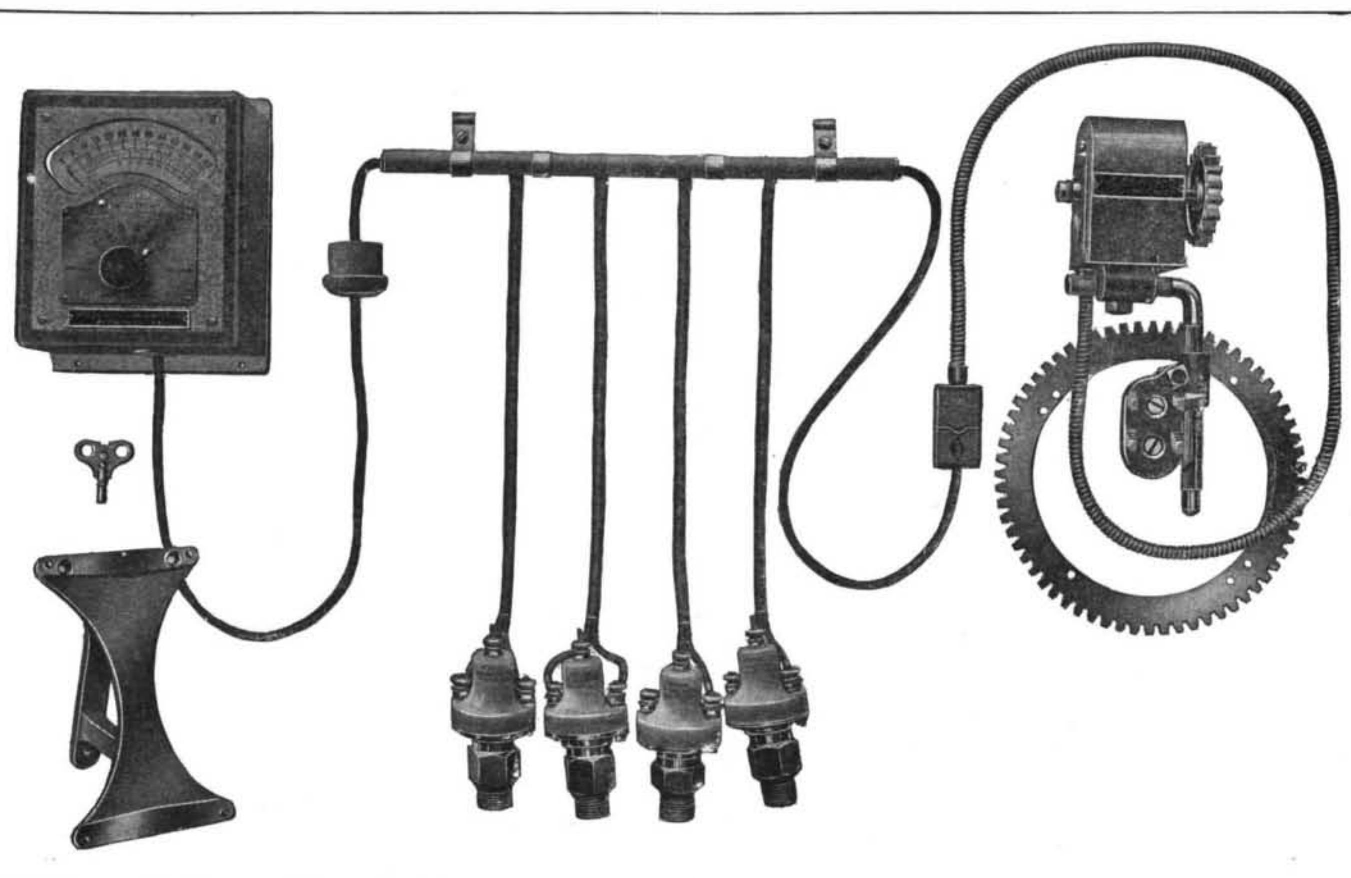
One of the illustrations shows a sectional view of a combination firing and indicating plug. The thermo-couple may be seen at *A*. It consists of special alloys drawn into wires surrounded by massive metal tubes closely fitting the wires and adjustably receiving them. These metal tubes are connected at their upper ends through the agency of heavy metal lugs connecting with the binding posts, and dissipate the heat by conducting it at a predetermined rate away from the tip of the thermo-couple within the engine cylinder to the binding posts without. All plugs are calibrated and are interchangeable. The adjustment in such plug being obtained by sliding the thermo-couple wires through the heavy metal tubes to a greater or lesser distance into the engine cylinder. Stuffing boxes screw on to the top of the metal tubes, making a gas-tight joint between the thermo-couple wires and said tubes. In practice they protrude beyond the lower end of the metal tubes about 3/64 of an inch.

An engine should have these specially constructed thermo-couples in each spark plug. They may be selectively or collectively connected with an electrical indicating instrument which gives an accurate reading of the current delivered by one particular cylinder or by the combined cylinders if the spark plugs be connected in series.

There is a switch on the instrument for obtaining separate or combined cylinder indications. The instrument has two scales, the upper a speed scale and the lower a power scale. On the switch there is also a speed contact *S* which connects a small magneto-dynamo with the indicating instrument and electrical current is furnished in direct proportion to the speed at which the dynamo is driven. In addition to this com-




**Spark plug fitted with thermo-couple.**



**General view of the indicator and speedometer.**

**POWER INDICATOR FOR INTERNAL-COMBUSTION ENGINES.**

bination speedometer and dynamometer, Dr. Hopkins has also invented an electric speedometer indicator and tachometer of great sensitiveness and accuracy.

## THE SOLAR AND LUNAR ECLIPSES OF 1909.

BY PROF. FREDERIC R. HONEY, TRINITY COLLEGE.

The intervals of time between the dates of the eclipses of the sun and moon this year, which occur alternately, illustrate the effect of the rotation of the plane of the moon's orbit in a direction contrary to her orbital motion. If this plane moved parallel to itself, there would never be more than two eclipse seasons in the year; and eclipses would occur when the earth would be at or near opposite points in its orbit, at average intervals alternately of a little more and a little less than six months. This inequality, due to the eccentricity, would evidently disappear if the line of nodes were always parallel to the axis of the orbit.

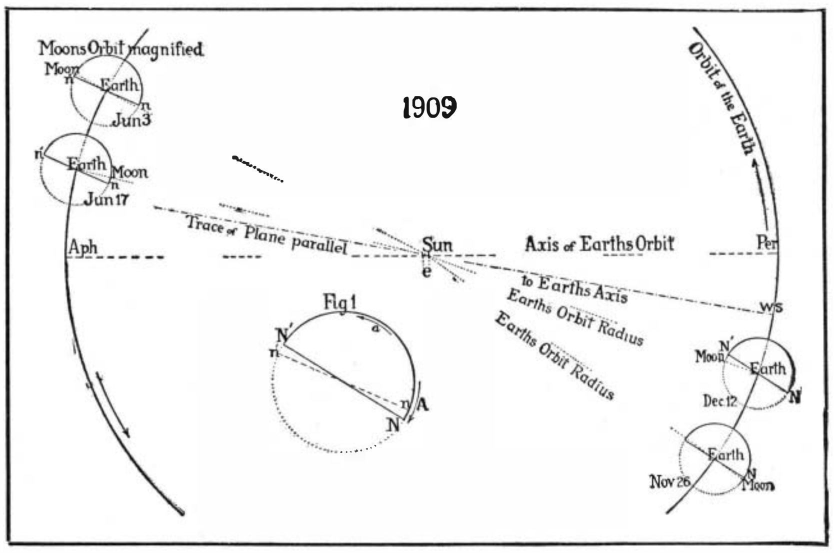
Fig. 1 illustrates the rotation of the moon's orbit between the months of June and December this year. The lines *nn'* and *NN'* are drawn parallel respectively to the line of nodes for these months. The angle included between them is about 9 degrees. The arrow *A* shows the direction of rotation of the orbit; the arrow *a*, that of the moon's motion. The rotation of the line of nodes into the position *NN'* obviously will bring it into coincidence with the radius of the earth's orbit at an earlier date than the line *nn'*, which will coincide with the orbit radius when the earth has reached the opposite point in its orbit.

The eclipses of both the sun and moon in June occurred when the moon was in that part of her orbit which was *above* the plane of the ecliptic. The eclipses in November and December will occur when the moon will be *below* that plane. In order to show this clearly, it is necessary to represent the moon's orbit on a scale very much greater than that of the earth's orbit, only a portion of which, including perihelion and aphelion, is plotted. The position of the earth is shown for the dates of the eclipses on June 3 d. 13.3 h. and 17 d. 11.5 h.; also for November 26 d. 20.75 h., and December 12 d. 8.15 h., Greenwich mean time. Since the diameter of the moon's orbit is less than a half a million miles, it would be correctly represented in the plot by a diameter a little less than a third of the linear eccentricity of the earth's orbit ($=e$). The dimension has been magnified forty times, in order to show the earth's and moon's orbit radii and the line of nodes clearly, which would be indistinguishable by the smaller scale. It should be noted that in magnifying the moon's orbit, the relation between these lines is not disturbed, that is, the angles included between them are preserved. In the drawing the diameter is enlarged sufficiently to show that on June 3rd, the date of the first lunar eclipse this year, when the earth's and moon's orbit radii were projected in the same line on the plane of the ecliptic, the moon was approaching the descending node *n'*, and was above the plane of the ecliptic. On June 17th, the date of the solar eclipse, the plot shows that the moon had recently passed the ascending node *n*; but her distance was so far from the node and above the plane of the ecliptic, that while the eclipse was central, the moon's shadow was projected on the earth very near the north pole.

On November 26th, the date of the total eclipse of the moon, the plot shows that the moon will be below the ecliptic and approaching the ascending node *N*. On December 12th, the date of the partial eclipse of the sun, the moon will be below the ecliptic, and will have recently passed the descending node *N'*. The distance below the ecliptic will be so great, that the eclipse will be visible principally in the region of the south pole.

The enlarged plot of the moon's orbit shows the position of the moon at Greenwich noon for each day from November 21st to December 18th; and also at the dates of the eclipses. On November 26th, when the moon will be near perigee, *P*, and very nearly a minimum distance from the earth, she will come wholly within the earth's shadow. On December 12th the enlarged plot shows more clearly the great distance between the moon and the node at the time of the eclipse of the sun. These plots may be compared with those printed in the Scientific American for May 15th, 1909 ("The Lunar and Solar Eclipses in June, 1909"). Figs. 2 and 3 are projections of the earth on a plane parallel to its axis, and perpendicular to the plane of the ecliptic. Its trace on the plane of the ecliptic drawn through the sun evidently intersects the earth's orbit at points which the earth reaches at the dates of the summer and winter solstices. In these projections less than one-half the visible hemisphere is illuminated between the autumnal equinox and the winter solstice.

The direction in which the eclipse of the moon will be seen, Fig. 2, is shown by the arrows. It will be visible at Washington; the beginning visible generally in North and South America, and northeastern Asia; the ending generally visible in North America, northwestern South America, eastern and northern Asia, and Australia.

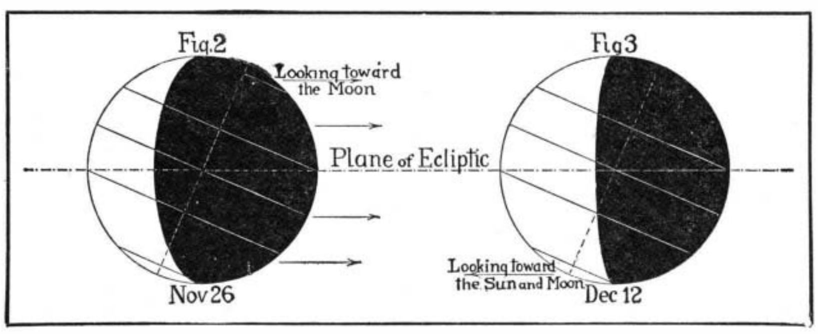



ROTATION OF MOON'S ORBIT BETWEEN JUNE AND DECEMBER.

In Fig. 3 the arrow shows the direction in which the eclipse of the sun will be seen. The limit of visibility will include a very small part of Australia, New Zealand, Tasmania, and the South Shetland Islands.

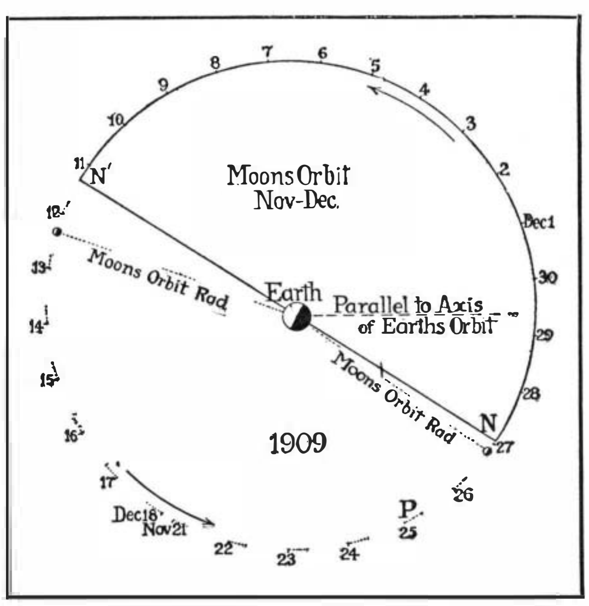
### Why the Pole Shifts.

It is well established that, at least during historic times, no changes of any considerable magnitude have occurred in the latitudes of places on the earth. It has long been suspected by astronomers, however, that minute changes of latitude were taking place, but it is only during the last quarter century that the methods of observation and calculation have reached that degree of refinement necessary to detect these small changes.




DIRECTION IN WHICH ECLIPSES WILL BE SEEN.

In 1884 and 1885 Dr. Küstner, astronomer at the Royal Observatory of Berlin, made a series of observations upon certain stars for the purpose of determining the constant of aberration—the maximum apparent displacement of a star due to the finite ratio between the speed of the earth in its orbit and the velocity of light. One of the quantities used in the reduction of these observations is the latitude of the place of observation. Dr. Küstner found his results to be discordant, much more so than he had good reason to believe that they should be from the known care and precision with which the observations were made. Upon investigation it was found that these discrepancies could be almost entirely explained away by assuming a change in the latitude. Dr. Küstner, therefore, in 1888, made the bold announcement that the latitude of the Berlin Observatory had changed during the period over which his observations extended.




ENLARGED PLOT OF MOON'S ORBIT.

This announcement aroused widespread interest, and steps were immediately taken by the International Geodetic Association to test the reality of the announced variation. Through the co-operation of the observatories at Berlin, Potsdam, Prague, and Strasburg, observations for latitude were begun in 1889 and carried on continuously over a year. These observations agreed in showing a minute but appreciable change in the latitude. In order to test the matter still further, an expedition was sent in 1891-2 to Honolulu, and observations for latitude were made there simultaneously with others made at the observatories just named. As Honolulu is on the opposite side of the earth from Europe, it is seen at once that if the latitude were increasing at the European observatories, a corresponding decrease should be shown at the Honolulu station. The results came out as expected, and this was generally accepted as a complete demonstration of the reality of this phenomenon.

What is the cause of this wandering of the Pole? In an article by Dr. Sidney Dean Townley of Stanford University, this explanation is given:

In 1765 Euler, a famous Swiss mathematician, demonstrated, as a proposition in dynamics, that if a free rigid oblate spheroid rotates about an axis which differs slightly from the axis of figure, or shortest axis, then the axis of figure will revolve about the axis of rotation in a period the length of which will depend upon several factors. He computed that, if the assumed conditions obtained for the earth, then the period of revolution of the axis of figure above the axis of rotation would be 306 days. Obviously, however, the earth is not rigid; the oceans are quite plastic and the ground itself is possessed of some elasticity. Prof. Newcomb computed some years ago that, if we assume the earth as a whole to possess the rigidity of steel, then the period of revolution of the one axis about the other would be 441 days, as against 306 days found by Euler on the assumption that the earth is perfectly rigid. The actual observed period is fourteen months, or 427 days, and the legitimate conclusion to be drawn is that the earth as a whole is somewhat more rigid than steel—a conclusion that agrees with that derived by Lord Kelvin and others from entirely different considerations.

Now the question arises, Why does the earth not rotate upon its shortest axis? The explanation is simple. If the earth ever did rotate upon its shortest axis it could not continue to do so because of the shifting of matter upon and within the surface. Winds, rains, rivers, and ocean currents are ceaselessly transporting matter from point to point, and during the winter great masses of snow and ice accumulate in the temperate and frigid zones only to disappear again in the summer. Although these effects will, to a large extent, neutralize each other, the sum total can not be other than to produce at least a theoretical lop-sidedness to the earth; and as soon as this takes place there must be a shifting of the axis of rotation. The time of revolution of the one axis about the other could be accurately computed if the exact form of the earth, the structure of the earth's interior, and its coefficient of elasticity were known.

In addition, there are other phenomena, namely, volcanoes and earthquakes, through which considerable quantities of matter may be displaced. That the amplitude of the polar motion might be affected by earthquakes was pointed out by Prof. Milne ten or fifteen years ago and a French scientist has more recently compiled a table showing the number of severe earthquakes each year and the amplitude of the polar displacement. A rough proportionality between the two seems to exist; that is, the greater number of earthquakes each year, the greater the amplitude of the polar displacement. Such results, however, are to be taken with several grains of allowance. The term "severe earthquakes" is rather indefinite and by modifying the definition quite a variety of results may be obtained from the given data. It might be pointed out that in 1906, the year of the great earthquakes in California and Chile, the amplitude of the polar displacement was small.

We have then a rational explanation of the phenomenon of the variation of latitude. The axis upon which the earth rotates is not in exact coincidence with the