oval, not an ellipse; a new illustration, in Dr. Hill's opinion, of the fact that the ability of members of two groups of forms to assume an intermediate form affords but a very slight presumption, if any, for a community of origin in the group.

FRICTION OF LUBRICATING OILS.

By C. J. H. Woodbury.

The resistance existing between bodies of fixed matter moving with different velocities or directions presents itself in the form of a passive force, which results in the diminution or destruction of opponent motion. Modern science has demonstrated that this destruction is only apparent, being merely the conversion of the force of the moving body into the oscillation of the resisting obstacle or into that molecular vibration which is recognized as heat. Direct friction refers to the case where the two bodies are in actual contact and mediate friction where a film of lubricant is interposed between the surfaces, and it is this which applies to nearly every motion in mechanics where bodies slide upon each other. The coefficient of friction is the relation which the pressure upon moving surfaces bears to resistance. Mr. Woodbury limited his discussion to a description of the apparatus for measuring the friction of lubricating oils, the method of its use and the results obtained with a number of oils in the market which are used for lubricating spindles. Previous investigation of nine different oil-testing machines used showed that none of them could yield consistent duplicate results in furnishing the co-efficient of friction. The paper mentioned the circumstances which must be known or preserved constant,—temperature, velocity, pressure, area of frictional surfaces, thickness of the film of oil between the surfaces, and the mechanical effect of the friction. The radiation of heat generated by friction must be reduced to a minimum, and no oil should be allowed to escape till subjected to attrition. Therefore a dynamometer is required which is instantaneous and automatic in its action. Mr. Woodbury described in detail the construction of his instrument and the mode of its operation, which was too elaborate to be reproduced in an abstract. The operation of the machine under equal conditions with the same oil gives results which are as closely consistent with each other as could be expected from such physical measurements. Much of the slight irregularity was due to the variable speed of the engine. The results were remarkably uniform, but they do not agree with the laws of friction, as given in works on mechanics, but the co-efficient of friction varies in an inverse ratio with the pressure. Friction varies as the area, because the adhesiveness of the lubricant is proportional to the area, and the resistance due to this cause is a larger fraction of the total mechanical effect with light than with heavy pressures. The lubricant used is one of the most important factors in the cost of power. In the present condition of engineering science it is impossible to state what exact proportion of the power used by a mill is lost in sliding friction, but in a print-cloth mill only about 25 per cent. of the power is utilized in the actual processes of carding, spinning and weaving the fibre, not including the machinery engaged in the operation, leaving 75 per cent. of the power as absorbed by the rigidity of the belts, the resistance of the air and friction. Mr. Woodbury concludes that the successful operation of a spinning frame is far more closely dependent upon the individual management in respect to the conditions of band-tension, lubrication and temperature of the spinning room than all other causes combined. Not that some forms of spindle are not superior to others, but without wise supervision the most desirable forms of spindle must fail to show the merits due to the skill of their promoter. The lubricating qualities of an oil are inversely proportional to its viscosity; the endurance of a lubricant is, in some degree, proportional to its adhesion to the surfaces forming the journal. An ideal lubricant, in these respects, would be a fluid whose molecules had a minimum cohesion for each other, and a maximum adhesion for metallic surfaces. Viscous oils adhere more strongly to metal surfaces, hence it is obligatory to use such thick lubricants on heavy bearings. With light pressures more fluid oils are admissable, and in all cases the oils should be as limpid as possible. Oils with great endurance are likely to give great fractional resistance, and in the endeavor to save gallons of oil, many a manager has wasted tons of coal. The true solution of the problem of lubricating machinery is to ascertain the consumption of oil and the expenditure of power, both being measured by the same unit, namely, dollars. Mr. Woodbury detailed his experiments in measuring the fluidity of oils, and gave the data for determining the safety and efficiency of a lubricant.

THE LAW OF LAND-FORMING ON OUR GLOBE.

By Prof. Richard Owen, M.D., LL.D.*

The truth of a general law can best be proved by such a large collection of co-incident facts as to carry conviction to the scientist. But in a synopsis all that can be done is to state the law and suggest a few prominent demonstrations, leaving it for the reader to trace with compasses or string, on a good globe or large map of each separate continent, those phenomena presented, and such other analogous details as may suggest themselves.

General Law: *The land shows itself above the ocean level, in definite multiple proportions, by measurement; the unit is the angular difference between the axis of revolution and the axis of progression.*

For convenience, as that angle has been lessening for some centuries, we might call it $24^\circ = \frac{360}{15}^\circ$.

The greatest width and length of continents $= 3 \times 24^\circ = 72^\circ = \frac{360}{5}^\circ$.

Consequently, the radius for continents $= 36^\circ = \frac{360}{10}^\circ$.

The measure for oceanic distances is the complement of $24^\circ = 66^\circ$.

The ratio of land to water is as 100 : 275.

The ratio of 24° to 66° :: 100 : 275.

All measurements are to be estimated at the equator.

The above general law may, for the purpose of demonstration, be subdivided.

I.—*First subdivision or section of the law.*—Many longitudinal elevations and depressions on the earth's surface, especially near the greatest median, north and south, extension of each continent, coincide with some meridian. Although this is partly due to early cooling and shrinkage, probably all continents have been extended north and south by successive depositions, as great river-deltas are usually found near the southern terminus of that median line. On these median lines we seldom find volcanoes.

Demonstration.—As the details regarding North America are most familiar, illustrations will be taken chiefly from that continent, although the law applies as well to all the others. In North America the greatest elongation is about in long. 96° W. of Gr. Near that line, as we shall see later, are found the foci of land forming for our continent, and not far distant the great rivers which drain the Mississippi valley. From Boothia Felix to the Gulf of Mexico we have no volcanoes, and the only earthquake action (near New Madrid, etc.) is due to a great circle of force crossing diagonally as shown subsequently.

II.—*Second Subdivision of the Law.*—Although the median lines of continents run north and south, the outlines or trends of continents form, with the meridians, angles of about 23½° (as I pointed out in "Key to the Geology of the

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Globe," published in 1857) and thus constitute great circles from the Arctic to the Antartic circles, along which (perhaps from the earth's crust being thinner than in the middle of continents) important seismic phenomena, such as volcanic and earthquake action are frequent and abundant.

Demonstration.—Elevating the north pole of the globe 23½°, and bringing the straits of Macassar and of Bali* to the eastern horizon, we find the wooden horizon mark the general trend of Asia from the volcanoes of Java and Celebes, passing through the volcanic regions of Japan, Kuriles, and Kamchatka, and skirting the Japan warm stream. On the opposite side of the globe this great circle passes from Alaska to the basaltic region of Lake Superior, then through South Carolina and the Bahamas to the earthquake region of Caraccas, etc., explaining the convulsion in South Carolina of 1811–12, just before the destruction of La Guayras and Caraccas. Revolving the globe from west to east 72°, or 1-5th of 360°, we bring the coast of Africa to the horizon; 72° more will give the trend of South America, passing between Madeira proper and Porto Santo, where Lyell observed a *continental* difference, especially among the mollusks, as well as the seismic force adequate to elevate the British coast (Lyell says in glacial epoch) at least 600 feet, and Scandinavia, in historic times, at some points five feet per century, total as much as 700 feet (see Lyell's "Principles," vol. I., p. 133.) On the other side ef the globe it may have furnished the dynamics of some volcanoes in Japan and Solomon's Archipelago, as well as the earthquakes of New Zealand near Cook's Straits. The trend of North America, just 72° west of the above, passes from a volcanic region between Mexico and Central America, along between the Appalachians, which it raised, and our Atlantic seaboard, nearly parallel to the Gulf Stream, and up to the Geysers and volcanoes of Iceland, coming round by the Field of Fire (Baker) on the Caspian, and through the ancient volcanic trap of Hindostan, consequently is older than the South American trend. The last or fifth trend either separated Australia from New Zealand, or more probably brought the latter up recently, as in it we find quaternary formations, such as the gigantic Dinornis.

III.—*Third subdivision of the law.*—An addition to the dynamics of land-forming is found in there being for each northern continent two foci of consolidation, which may have resulted from shrinkage causing depression of adjoining seas or seismic elevation of the plastic crust. The northern focus, when two exist, is near the continental median line and arctic circle; the other occupies the geographical centre of the continent. Concentric circles around these foci not only mark important additions to the land and orography of each continent, but especially pass as they enlarge from the areas of older geological formations to those of newer.

Demonstration.—A radius of 24° from the geographical central focus often marks the outline of the continent proper, while that of 36° embraces usually some of the adjoining islands, leaving out perhaps some peninsulas. Between these two circles we find almost exclusively cenozoic formations (tertiary), and outside of 36° in the three southern continents quaternary. The details of North American geology must suffice in an abstract, designating for the other continents simply the position of the foci. The northern focus for North America is in Boothia Felix. With a radius of 24° from that point we reach the southern point of the V shaped area near Lake Superior, as laid down by Prof. Dana at p. 149 of his "Manual," where the archæan meets the paleozoic. A more extended radius passes through the coal of northern Iowa, of Michigan, New Brunswick, and Newfoundland. A radius of about 29°–30° gives us the mesozoic of Kansas and the Triassic (a red sandstone with bird tracks) of Connecticut and Massachusetts.

Removing our center to the west shore of Lake Superior, a radius of 11° to 12° gives us Silurian (Lower and Upper) from Niagara to near Springfield, O., Lexington and Frankfort, Ky., Nashville, Tenn., dominating at least the eastern half of the circle, while the west was still under water. A radius of 12° to 13° marks the Applachian and other coal fields from north of Harrisburg, southwest through Tuscaloosa, Ala., to Arkansas and Texas. A radius of 15° is Mesozoic, curving from the Cretaceous of Utah and Colorado through that of Arkansas and Tennessee to that of New Jersey. A radius of 24° outlines the continent from Cape Breton and Cape Sable to the Golden Gates; while with from 18° to 24° we pass through the *marine* Tertiary of Nevada, California, Northern Mexico, Texas, Louisiana, Mississippi, Florida, Georgia, South and North Carolina, Maryland and New Jersey to Martha's Vineyard and Barnstable, Mass. The circle of 36° embraces Yucatan and Honduras; reaching to near Lake Nicaragua it encloses several islands near our Pacific Coast and takes in part of Alaska, as well as a portion of Greenland.

The northern focus for *Europe* is in Scandinavia, Lat. 68° N., Long. 22° E.; the geographical and later centre is in Lat. 49½° N., Long. 20° E.

The northern focus for *Asia* is in about Lat. 71° N., Long. 99° E.; the centre is in same Long., and in Lat. 51° N.

For *South America* the centre is on the Tropic of Capricorn, in about Long. 65° W.

For *Africa* the centre is at St. Thomas' Island, where the Magnetic Equator of dip crosses the terrestrial Equator.

For *Australia* the centre is on the Tropic of Capricorn, Long. 148° E.

These are approximate, and may require slight modifications.

IV.—*Fourth Subdivision of the Law.*—Besides these three modifying influences, toward the close of the Mesozoic and beginning of the Cenozoic, the Western Alps became a dynamic focus, reaching, according to Elie de Beaumont, their present height during the Miocene Period or at its close, while the eastern Alps reached their present height during the Pliocene. Mount Rosa is nearly, if not quite, the geographical centre of the entire dry land on the globe; and the Alps connect with the Himalayas and Andes of similar geological age by a great circle or belt of immense seismic activity.

Demonstration.—A radius of 9° from Mt. Rosa defines accurately the Miocene Tertiary on the east coast of England, also in the middle of Denmark; through Prussia it is Eocene, but Miocene again in Austria, Calabria, Sicily, Algiers and Central Spain. With a radius of 36° from Mt. Rosa, we describe a curve from the Miocene of the eastern flanks of the Urals to that of Spitzbergen and Greenland; contrasting this radius somewhat, we follow the Carboniferous and Peruican rocks of the Urals to Spitzbergen. The great circle pointed out as passing from the Alps to the Himalayas and Andes marks chiefly Tertiary regions.

Summary.—The dynamics of land forming would seem, from the foregoing demonstrations, to comprise first a longitudinal force, scarcely if at all seismic, adding to continents chiefly by aqueous depositions, as each northern continent, near the termination of the median line, has a large river delta. Secondly, there is an Arctic-Antartic force, mostly along continental coast lines, and connected with active seismic phenomena of elevations and depressions; apparently from these being thinner portions of the earth's crust than at continental medial elongations. Thirdly, in each continent there are radii and circles connected with one or two important foci, which have not only aided in defining the geographical limits of each continent, but also in bringing geological deposits in successive curves of increase to or near the surface; possibly because the wave impulse directly under the plastic focus sends its molten contents to equidistant circles beneath the plastic crust. Lastly, the geology of each continent has also been somewhat modified, especially in cenozoic times, by the Alpine central focus (or terminal axis from the centre) of the dry land hemisphere.

As corollaries, attention may be called to two additional great circles of activity which are secondaries to that phase

* At these straits, though only about fifteen miles across, Wallace found as great a difference between the flora and fauna as if they had been a thousand miles apart, nearly all the animals south-east of that line being marsupial, while northwest the chief type was and is carnivorous.

of the ecliptic whose longest and shortest day, for our northern hemisphere, would coincide with the north and south plane, passing through the Alpine focus and also through the node of intersection for the terrestrial and magnetic Equator. This gives us one great circle from Behring's Straits to its antipodal Antarctic, due south from Mt. Rosa; the other from Scandinavia, at the Arctic Circle, to the antipodal point on the Antarctic, which will be found due south from Behring's Straits. As these ran through the northern hemisphere, the course of one from the volcanoes of Sumatra is nearly parallel to the formerly described Asiatic continental trend as well as the Japan Gulf Stream, and nearly parallel again through North and South America to said Asiatic trend prolonged, whereby a region is inclosed of Nevada geysers, New Madrid earthquake region, Arkansas and Virginia hot springs, Cuban, Venezuelan, Grenadan, Peruvian, and Chilean volcanic and earthquake regions. The course of the other, while running nearly parallel to the North American east coast trend, is from the thirty-nine volcanoes (see Dana's Manual, p. 703) of Central America to the geyser and volcanoes of Iceland, thus inclosing between it and the North American trend our Gulf Stream, probably even aiding to heat it; while on the opposite side of the globe the inclosed line embraces the Hindoo Cush and Western Himalaya elevations; the disturbed regions of Hindostan and islands in the Bay of Bengal (some brought up within the Historical Period) as well as the numerous volcanoes of Sumatra.

The evident connection of these laws with Terrestrial Magnetism, Mining and Mineralogy, Archæology and Ethnology, is left for future discussion.

AN INVESTIGATION OF THE VIBRATIONS OF PLATES VIBRATED AT THE CENTRE.

By THOMAS R. BAKER.

MOST of the plates used were window panes of various shapes and sizes. They were vibrated by rubbing an attached glass rod. The tubes, which were about $\frac{3}{16}$ of an inch in diameter and 20 inches long, were attached at right angles to the face of the plate with sealing wax. The support for the plate was a rubber cap, the common lead-pencil eraser, fitted on the end of a post projecting from a disk of lead. A short rubber-capped lead pencil fixed upright in a wooden block answers the purpose just as well.

The plate was balanced on the support, the tube standing upright and held loosely between the thumb and forefinger of the left hand. Then catching the tube between the moistened thumb and forefinger of the right hand and rubbing downward the vibrations of the plate were produced.

Different tones were obtained from the same plate by varying the pressure and the position of the thumb and finger. Each plate yielded from *one* to *six* tones, the number increasing with the size and thinness of the plate. A plate 10 in. by 14 gave *six* tones, one 4×4 gave *two*, and one 3×3 gave but *one*.

The interval between the lowest and second tones of a 10×12 plate was *two octaves and one tone;* between the second and third, a *diminished sixth;* and between the third and fourth, an *augmented fourth*. The greatest interval found between the lowest and highest tones of a plate was more than *four* octaves, and the greatest interval observed, considering the tones of all the plates tried, was more than *five* octaves.

Plates were reduced in size by cutting strips an inch broad from them, and a test was made of the tones of each plate thus produced. A plate 12 inches square was cut down to 11 in. by 12, then to 10x10, and so on until it was reduced to one 2 inches square. By this operation there was furnished a series of eleven plates closely alike in thickness and structure.

The intervals between consecutive tones of each plate of this series down to the plate 7x7 were almost uniform, namely; *two octaves and a fourth* between the lowest and 2nd tones, a *seventh* between the 2nd and 3d, and a *fourth* between the 3d and 4th. From the plate 8x8 to that 3x3 the intervals between the lowest aud 2nd tones were almost uniform, being about *one octave and a fourth*. The other intervals were variable. The difference in pitch of corresponding tones of consecutive plates was with few exceptions, uniform down to the plate 7x7, namely; *three semitones*.

The following is a summary of the facts derived from these experiments: 1. The difference in pitch of the lowest and 2nd tones of all plates tried between the sizes 10 in. by 14, and 7 in. by 7, was *two octaves* to *two octaves and a fourth*, and the difference in pitch of corresponding tones of square plates between the sizes 8 in. by 8, and 3 in. by 3 was *one octave and a fourth*. 2. The intervals between the tones of plates giving *not more than five* tones diminished as the pitch increased, but this was not true of plates giving *more than five* tones. 3. The pitch of tones given by a series of plates which varied in size as the square of a series of numbers whose common difference is one made a sudden leap from one uniform scale to another.

The forms of these variations were learned in the usual way by vibrating the plates with sand sprinkled over them. The figures were copied by placing the plate over paper which had been wet with a solution of potassium bichromate and dried in the dark. The plate and paper were exposed to diffused light or to the vertical rays of the sun. The paper not hid by the sand soon darkened and when this change had taken place the plate was removed and a lead pencil run along the bands of lighter colored paper representing the sand lines. This paper was then placed on white paper and the figures copied by pressure. About 150 sand figures were copied and traced.

The vibrating of plates at the centre as here described, seems to be the best method for class illustration, the main object being to show the formation of sand figures. To vibrate a plate at the centre in this way, expensive apparatus is not needed, a pane of window glass, a glass tube and a rubber eraser—the essential articles—being procured at the cost of a few cents. To vibrate a plate in the ordinary way, a clamp and bow costing several dollars are necessary. Moreover a plate vibrated at the centre will, I think, yield to the ordinary experimenter more tones than one vibrated at the edge.

A simple method of showing the vibration in parts of a rod and a string was suggested by the vibrating plate.

The end of a piece of glass tubing was drawn into a long fine thread, and the tube attached with sealing wax to a long narrow plate near one end. Then when the plate was vibrated so as to yield a low tone, the glass thread vibrates in parts forming a series of spindle-like segments.

A piece of sewing thread was stretched from one end of the narrow plate to the other over the free end of the vibrating rod and fastened to the plate with bees-wax. Then at a low tone of the plate the thread vibrated in segments.

TYPES OF POTTERY.

By PROF. EDW. S. MORSE.

The earlier types belonging to the shell heaps of Japan were described and illustrated by specimens from each of the deposits examined by Prof. Morse and his special students.

The pottery of Yeso was nearly all cord-marked, while the shell heap pottery of the middle of Japan had a much less proportion cord-marked.

In the southern portions of Japan, at Higo, cord-marked pottery was extremely rare.

He remarked on the extreme diversity in the shape and ornamentation of the pottery in different places in Japan.

The pottery of Yeso resembling the pottery of the Northern United States; the pottery from the central portions of Japan finding their resemblance to the pottery found in Porto Rico and Jamaica. He also spoke of the hard blue pottery supposed to be Korean, and associated with it a red pottery, which might have been made by the same people. This was lathed-turned. Other forms were mentioned and illustrated by examples.