hours, the ultraviolet light still caused membrane formation. This effect of the ultraviolet rays was not prevented by even an excessive quantity of NaCN, which inhibits oxidation in the egg. The membrane formation under the influence of ultraviolet light took place in neutral solutions as well as in weakly alkaline ones.

The calling forth of the membrane formation was due to a direct action of the ultraviolet rays upon the egg and not to a product formed by the rays in the sea water or in the air. For sea water which had been exposed to the influence of the rays, no matter how long, without containing eggs, did not cause membrane formation when the eggs were put into it after the ultraviolet light was turned off.

These experiments show that causation of membrane formation in the unfertilized sea urchin egg and the subsequent inducement to development were due to the direct effect upon the egg of ultraviolet waves below 2607 Å. u., since, according to Dr. and Madame V. Henri, waves below this range can not penetrate a cover glass of 0.14 mm. thickness. It is not possible to state in which way the ultraviolet waves caused the membrane formation in the egg except that it could take place without free oxygen as well as in the presence of NaCN.

The results mentioned thus far were obtained in the egg of the sea urchin. The egg of *Chætopterus,* after an exposure of from five to ten minutes to the ultraviolet rays under the conditions mentioned above, developed into swimming larvæ, without cell division.

Since Röntgen rays are only very short light waves, and since they also cause cytolysis, they should also cause membrane formation of the unfertilized egg. It is of interest that G. Bohn states that Röntgen rays induce artificial parthenogenesis. His experiments were made before the rôle of the membrane formation (or the alteration of the surface of the egg) was recognized as a necessary step in development, and he therefore does not mention whether or not Röntgen rays induce membrane formation.

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ON THE FEASIBILITY OF DETERMINING EXPERIMENTALLY THE LUNAR AND SOLAR DEFLECTION OF THE VERTICAL BY MEANS OF TWO CONNECTED WATER TANKS

FOR some time I have had in mind the essentials of the arrangement or apparatus described below, the purpose of which is to ascertain the deflection of the vertical as disturbed from its mean position by the attraction of the moon and sun. It may not be new; but I have never seen it described or referred to elsewhere.

Briefly described, such apparatus would consist of two tanks or cisterns of equal diameters and of equal depths, located some distance apart, upon the same level, and connected by means of a pipe. This pipe should be of metal excepting for some distance near its central portion where a glass section or length of much smaller diameter should be inserted. The pipe should be attached to the bottoms of the tanks in order to avoid complications which would otherwise arise should the temperatures of the water in the two tanks become somewhat unequal. But if the pipes are attached to the bottoms of the tanks, the unequal expansion of the water will not seriously affect the equilibrium and so will not set up any flow of consequence from one tank to the other.

At any given place upon the earth's surface the direction of the instantaneous vertical continually deviates from its mean position by a small angle dependent upon the time (or local hour angle) selected and the positions of the moon and sun relative to the earth's center.

Ignoring the attraction of the disturbed oceans, the plumbline upon an unyielding earth deviates in accordance with the impressed horizontal forces. These forces, in terms of g or terrestrial gravity are:

Eastward force,

$$= -0.0000001684 \cos\lambda [M_2 \sin(m_2 t + \arg_0 M_2) + S_2 \sin(s_2 t + \arg_0 S_2) + \cdots].$$

$$- 0.0000001684 \sin\lambda [K_1 \sin(k_1 t + \arg_0 K_1) + O_1 \sin(o_1 t + \arg_0 O_1)$$
$$P_1 \sin(p_1 t + \arg_0 P_1) + \cdots].$$

Southward force,

$$= 0.0000001684 \cos\lambda \sin\lambda [M_2 \cos(m_2 t + \arg_0 M_2) + S_2 \cos(s_2 t + \arg_0 S_2) + \cdots].$$

$$- 0.0000001684 \cos 2\lambda [\mathrm{K}_1 \cos (\mathrm{k}_1 t + \arg_0 \mathrm{K}_1) + \mathrm{O}_1 \cos (\mathrm{o}_1 t + \arg_0 \mathrm{O}_1) + \mathrm{P}_1 \cos (\mathrm{p}_1 t + \arg_0 \mathrm{P}_1) + \cdots].$$

Here M_2, S_2, K_1, O_1, P_1, denote abstract numbers or coefficients of tidal constituents bearing these names and are equal to 0.4543, 0.2114, 0.2652, 0.1886 and 0.0878, respectively. The angles in the parentheses are the arguments of the forces which give rise to the various constituent tides. λ denotes the latitude of the place or station selected.

The above expressions also denote the instantaneous deviation of the vertical expressed in radians (1 radian $= 206265''$).

Let L denote the horizontal distance between the centers of the two tanks. Let d denote the inside diameter of the small transparent pipe used and l its length. Let Ω denote the area of the water surface in either tank.

For convenience, consider here only the principal periodic term of the lunar semidiurnal tide and let the two tanks be situated upon the earth's equator. The foregoing expressions will enable one to make similar computations for all terms given, for any latitude, and for any orientation of the apparatus.

At a time three lunar hours before the upper or lower culmination of the mean moon, the surface of the water in the eastern tank will be $L \times 0.0000001684 \times 0.4543 = 0.0000000765\, L$ units higher than the surface of the water in the western tank. The reverse will be the case three lunar hours after either meridian passage.

The amount of water passing through any cross section of the connecting pipe will be

$$\Omega L \times 0.0000000765$$

cubic units.

If $2b$ denote the entire distance over which the water in the glass section of the pipe moves, we must have

$$2b \frac{d^2}{4} \pi = \Omega L \times 0.0000000765;$$

$$\therefore 2b = L \times 0.0000000765 \times \frac{\text{area tank}}{\text{cross section small pipe}}.$$

If this ratio be 10,000, then

$$2b = 0.000765\ L$$

units, and if the length of L be 10,000 units (say centimeters) then

$$2b = 7.65 \text{ units (centimeters)}.$$

Now the time required in making this transfer of water is 6 lunar hours, or 22,357 seconds; $\therefore$ the average velocity in the small tube will be $2b \div 22{,}357 = 0.00034$ units per second, and, because the disturbing force here used is harmonic, the maximum velocity will be $2b \div 14{,}233 = 0.00054$ units per second, and the maximum flux, $0.00054 \frac{\pi}{4} d^2$ cubic units per second.

This small velocity in a pipe say 1 cm. in diameter implies stream-line motion; and so we can compute by Poiseuille's laws the flux, or rate of discharge, under given or assumed conditions as regards the diameter and length of pipe and the difference of pressure at the two ends of this pipe. The formula for this is

$$\text{Flux} = \frac{\pi}{8\mu} \left(\frac{d}{2}\right)^4 \frac{p_1 - p_2}{l}$$

cubic centimeters per second. In the first place, assume that

$$p_1 - p_2 = L \times 0.0000000765\ g\rho.$$

Here ρ denotes the density of the water and is about unity;

$$\mu = \frac{0.0178}{1 + 0.337\theta + 0.000221\theta^2}$$

θ denoting the temperature Centigrade; and $g = 981$ centimeters per second.

If $l = 100$ cm., and $L = 10{,}000$, the flux, ignoring the resistance in the larger pipe, would amount to

$$\frac{\pi}{8\mu} \frac{1}{16} \frac{0.000765}{100} g$$

cubic centimeters per second, a quantity many times greater than the maximum flux necessitated by the water transference.

For a pipe 100 meters long and of diameter $\sqrt{10}$ centimeters, the flux will be the same as for the small pipe one meter long just considered.

From the above it can be seen that the effect of all pipe resistance can be so reduced by varying the diameters and lengths as to not seriously interfere with the quantity of water actually transferred; and a little consideration will show that the amount of such interference can be calculated with some certainty.

Nothing has been said as to the nature of a float suitable for indicating the motion in the glass pipe. Somewhat as Forel in his "plemyrameter" used corks weighted to the specific gravity of water, so here a cylinder having a diameter somewhat less than the inside diameter of the glass pipe, and having the specific gravity of water, could be used. Each of the metal ends of such cylinder should be pierced by a hole, so that the cylinder could be threaded loosely on a fine wire stretched along the axis of the small pipe. However, some other style of float may be preferable to this. The readings should be made at regular hourly or half-hour intervals.

The amount whereby the observed b, properly corrected for pipe resistance, may fall short of its simple theoretical value, *i. e.*, its value on a perfectly rigid earth devoid of oceans, is an important factor in the determination of the amount of yielding of the earth to the known tidal forces, and so in the determination of the earth's rigidity. The interpretation of such measurements, however, constitutes no part of the present communication.

R. A. HARRIS

WASHINGTON, D. C.,
March 28, 1914

[Since the above was written, I have seen the surprisingly consistent results obtained by Professor Michelson and published in the *Journal of Geology* and in the *Astrophysical Journal* for March, 1914; also the account published in SCIENCE for June 26, 1914. It will be recalled that in these determinations, the vertical oscillation of the water's surface at the two ends of a half-filled horizontal pipe was the quantity measured. R. A. H., September 29.]

APPROXIMATE MEASUREMENT OF TEXTILE FIBERS

THIS note is hardly the place for the demonstration of the following theorem. However, it is readily capable of demonstration, and the reader of a mathematical turn of mind will at once perceive the line of proof.

THEOREM. If an infinite series consisting of straight parallel linear elements of every possible length, each element arranged perpendicularly to and symmetrically to a given straight line, be bisected along that line and the two half-series thus produced be placed with the former outer edges of adjacent, then if the elements of one of the half-series be systematically rearranged, its longest element matched to the shortest of the other half-series and its next longest to the next shortest of the other half-series and so on, a new parallel-sided uniform series will be produced, each of whose elements has a length equal to the mean length of the elements of the original series.

If the theorem be changed so that the elements are stated to vary in length within prescribed limits, then for this modified theorem the line of demonstration as well as the final result is the same.

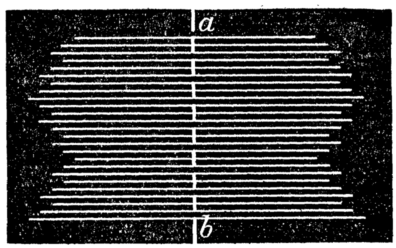

FIG. 1. Straight elements varying in length within prescribed limits, arranged symmetrically with reference to a given straight line, a–b, in accordance with theorem.

If the number of elements is limited, say, for example, to a few thousand, the result becomes approximate; and if the elements instead of having their middle points on the given straight line are arranged so that their middle points fall at random on either side of the given straight line a distance less than half the length of the shortest element, then the reconstructed series will have a width approximately equal to the mean length of the original elements; for it will always be pos-