DISCUSSION AND CORRESPONDENCE

ORIGIN OF SINK-HOLES

THE writer has read with much interest Professor A. H. Purdue's paper in the issue of SCIENCE of July 26, 1907, on "Origin of Limestone Sink-holes." In this connection it may be of further interest to call attention to a type of sink-hole very frequently met with in Florida formed under conditions apparently not included in Professor Purdue's discussion.

The surface deposits throughout much of the interior of Florida consist of sands and clays with occasional limestone layers. These deposits are variable, being in some places almost entirely absent, while in others they are of considerable thickness. Beneath these surface accumulations occurs a limestone of undetermined thickness. This foundation limestone, which is for the most part porous, holds inexhaustible supplies of water, and is traversed by solution cavities.

When first formed, the typical sink throughout this area is an opening leading from the surface through the superficial deposits to or into the limestone below. Many of these sinks are perfectly cylindrical, not funnel-shaped. This is especially true of the smaller sinks. As a result of subsequent caving of the banks, the bottom usually becomes clogged and the sides sloping. The formation of these sinks is practically instantaneous and results from a sudden caving of the earth. In size they vary from a few feet to many rods in diameter. So frequent is their formation in certain sections, notably the phosphate mining area of Alachua and Columbia counties, that one must be on the lookout in driving through the country for newly formed sinks. Indurated layers exposed along the sides of the sink are rough-edged and bear evidence of fracture due to the sudden giving away and breaking under the weight of the load above. The depth of the sinks is probably quite variable. As a rule, they reach through and connect with the permanent underground water horizon. Some reach much below the water line.

The type here described is not merely a modification of the type described by Professor Purdue. This is evident from the fact that the static head of the water in many, though not all, of these sinks is such as to bring it above the top surface of the limestone. There is abundant evidence of solution in the limestone at all depths, both above and below the static head of the underground water. It is apparent, however, that the conditions existing in the limestone below the water level are not such as to bring about a funnel-shaped cavity. This point would scarcely seem to call for emphasis were it not that Professor Purdue considers the cave-in sink the rare exception.

A sink of this type was examined by the writer within a few hours after its formation about one mile south of Juliette in Marion County in 1905. This was a small sink, not more than eight feet in diameter, and of the usual cylindrical form. The sides down to the water level were, so far as could be determined, entirely of clay. The sink which had formed directly under the railroad track was caused possibly by the jar of a passing train, the engine of which had passed safely over. The water rose immediately in the sink to the static head of the water of that locality.

The writer recalls having often seen similar tubular openings reaching from the surface to the runway of abandoned coal mines, the "cave-in" occurring in these cases through a thickness of forty or fifty feet of clays and shales. From analogy it seems probable that the formation of the sinks in question results from a gradual caving of the clay from the bottom, assisted, perhaps, by the removal mechanically of a part of the material by underground water. Finally a point is reached at which the entire remaining mass suddenly gives way. While some of these sinks are in clay formations entirely, others break through considerable thicknesses of limestone.

E. H. SELLARDS

SPECIAL ARTICLES

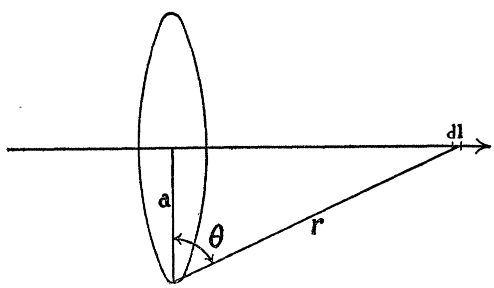
NOTE ON THE MAGNETIC FIELD DUE TO AN ELECTRIC CURRENT IN A STRAIGHT WIRE

The force in dynes on a unit magnetic pole at any point outside an infinitely long straight wire carrying a current is, as we know, tangent to a circle through whose center the wire passes at right angles, and is numerically equal to $2C/a$, where C is the current in absolute units, and a the distance in centimeters of the point from the axis of the wire.

While the approximate direction of the force is easily found experimentally, its numerical value is determined only by integrating the effects of all parts of the current. And since the force is in a plane at right angles to the wire, it is not an easy matter to make clear to students beginning the subject why it is necessary to consider parts of the wire off this plane.

This is one of the many places where the electron theory can be used to marked advantage, and besides, if, as many believe, it is the correct theory—or embraces a larger number of facts than any other—then it should be used both in this case and in all others.

Let electrons, all moving in the same direction with the constant velocity V centimeters per second, be uniformly distributed along a straight wire, and let E be the total amount of electricity per centimeter length of the wire. Then, assuming the field of force from each electron to be the same in all directions, that is, moving slowly and undisturbed by other electrons, the rate of change of induction, due



to the electricity at all parts of the wire, through a circle at right angles to it of radius a; or in other words, the work required to carry a unit magnetic pole once around this circle (see the figure) is given by the equation

$$\frac{dF}{dt}=2\int_0^\infty \frac{Edl}{r^2}\,2\pi a V\cos\theta.$$

But $\cos\theta dl = rd\theta$, $1/r=\cos\theta/a$, and $EV=C$, the current.

Hence

$$\frac{dF}{dt}=4\pi C\int_0^{\pi/2}\cos\theta d\theta = 4\pi C,$$

and therefore the force on a unit pole at any point on the circumference of a circle of radius a is

$$\frac{4\pi C}{2\pi a}=\frac{2C}{a}.$$

However, presumably the field due to each electron is influenced by all others, and so influenced that it is confined to a plane at right angles to the wire, but equal in every direction from it. From this it follows at once that

$$\frac{dF}{dt}=4\pi EV=4\pi C,$$

and

$$f=\frac{4\pi C}{2\pi a}=\frac{2C}{a}.$$

According to this conception, which I believe to be the correct one, the magnetic force at any point is due entirely to that part of the current nearest to this point; the more distant parts having no direct effect whatever. But, of course, as just explained, all electrons produce their full effects indirectly by compressing each other's fields into planes at right angles to the wire.

While the above contains nothing new in physics, it is given because it, or some modification of it, may be of use in the class-room.

W. J. Humphreys
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REFLEX PROTECTIVE BEHAVIOR IN BUFO VARIABILIS

During the past year, while studying the *Opalinae* parasitic in the recta of different species of frogs and toads, I have had to kill many of these batrachians. In each case the backbone and spinal cord were cut behind the head and the brain destroyed by "pithing" with a needle. In this way *Rana fusca, Rana esculenta, Rana agilis, Bufo variabilis, Bombinator igneus, Bombinator pachypus* and *Hyla arborea* have been killed. In all but one of these species I find that, on cutting the