A CONCRETE COAL MINE SHAFT.

A NEW WAY OF REACHING INACCESSIBLE VEINS.

BY DAY ALLEN WILLEY.

AN engineering project of unusual interest is being carried out in the coal-mining regions of Pennsylvania, where the use of concrete and steel has been demonstrated to be of much importance in the formation of a shaft from the surface to coal veins.

Among the mines in the vicinity of the city of Wilkes-Barre is the Woodward. In the operation of the mine a deposit of coal has been located below such a formation that it was considered impossible to reach it by constructing a shaft according to the ordinary method. Situated in a stratum of rock below the level of the Susquehanna River, which flows through this section of Pennsylvania, the water from the river seeps into the formation above the coal. The surface is so near the level of the river, that it is frequently submerged when the water is at flood height, and the land in the vicinity is marshy.

The conditions are such that an ordinary shaft supported by timbering could not be constructed because the formation is more or less affected by water to a depth of fully 80 feet below surface where rock occurs. The problem which has confronted the engineers is how to reach the coal by the employment of some other plan of shafting. Mr. A. C. La Monte, chief engineer of the coal mine, decided upon a shaft with concrete walls to be reinforced with steel. A novel feature of

The dimensions of the shaft make it no small project, even if put down through an easier formation to pierce. After piercing the rock stratum referred to, about 700 feet more must be excavated before operations on the coal veins begin. This portion of the shaft will be completed in the ordinary manner, and it is believed that the superstructure of steel and concrete will prevent any drainage or leakage of surface water below the rock on which it rests. Precaution has also been taken to prevent the shaft from being flooded when the river is high by extending the concrete wall to a height of fully 20 feet above the surface.

In carrying out this novel mining work, over 3,000 cubic yards of concrete were utilized in addition to the steel, the quantity of metal required being about 145 tons. The upper section of the shaft might be called a huge caisson, since so much of it is set in a water-soaked formation.

As the photographs show, the shoe is constructed of heavy steel with numerous braces, while the concrete walls of the shaft are 2 to 7 feet in thickness, and the interior is divided by a thick bulkhead of the same material. It will be noted that the steel reinforcing rods used in the work are of spiral design, giving the metal a much greater adhesive strength.

This work presents an interesting example of what

cism concerning truth and reality fails to be justified by events. Unless indeed even the present tendency be discounted, and skeptics prefer to wait till future times for a more thorough justification of these theories before even tentatively accepting them—a legitimate though not a prolific or fertile attitude.

The attribution of the material property of "mass" or inertia to elasticity entirely depends upon the magnetic properties of an electric charge in motion. *The magnetic properties of an electric charge in motion.* In that sentence I have mentioned the three fundamental attributes, or manifestations, or phenomena, of the material universe: Electric charge, magnetic field, and mechanical motion; or electric force, magnetic force, and mechanical force. These three vectors are essentially perpendicular to each other, and correspond to the three dimensions of space. They also correspond to the three chief known properties of the ether of space, which is the substratum or material basis of all activity. We do not yet know the constitution of this continuous and omnipresent medium, but it is certainly so constituted that each of these three vectors is physically possible at any point in space; and moreover it is so constituted that wherever two of them exist, the third springs into being—at right angles to both.

INTERIOR AT BOTTOM OF SHAFT, SHOWING CUTTING SHOE AND PART OF ROCK BED ON WHICH IT RESTS.

COMPLETING THE STEEL CUTTING SHOE FOR WORKING THROUGH THE SOFT FORMATION.

A CONCRETE COAL MINE SHAFT.

this design is that the shaft literally sinks itself by reason of the manner in which it is constructed and the shoe or base upon which it rests. The first operation was the construction of a steel cutting shoe of oblong shape, 59 feet and 6 inches by 28 feet. This shoe consists of a sheet of $\frac{1}{2}$ -inch steel, 30 inches high, to which is bracketed about 8 inches from the bottom a 24-inch steel shelf, forming the foundation for the shaft walls. The shoe was placed at the bottom of an excavation 15 feet deep, the resting place of the shoe being accurately leveled. Forms were then erected on the shelf and concrete poured in, in the manner followed in the pouring of any concrete wall. Steel reinforcing rods were placed at regular intervals in both directions. The shoe was thus forced through the soft earth by the weight of the wall; and as the shaft sank the wall was built up, the forms being removed as soon as the concrete set, and replaced above to be repoured. The shaft kept sinking of its own weight as its height increased, the walls always being kept a little above the ground level.

The greatest problem encountered was in keeping the shoe absolutely level, so that one side of the shaft would not sink faster than the other. The rock bed was reached about 80 feet below the ground, and as this stratum was not level, the walls of the shaft had to be propped on one side, and a concrete joint formed between the bottom and the bed of rock. This joint was made absolutely waterproof. Then the engineers began blasting through the rock, and have reached a point over 100 feet below ground. A concrete lining has been placed in the rock portion of the shaft, making it of uniform diameter and giving it a smooth operating interior surface.

can be done to reach coal and other mineral deposits in formations which are water-soaked or may be composed of loose sand. By employing this method, undoubtedly many valuable veins of coal and ore which are at present inaccessible can be reached by the miner.

THEORY OF ELECTRONS.

By SIR OLIVER LODGE.

THE whole idea of being possibly able to express matter in terms of electricity is one that needs reiterated explanation and emphasis. The mode in which the electrons themselves have been weighed and counted, I will not here again enter into. It may be taken as known; and if not, it can be found described in many places—among others in my book called "Electrons." But the fundamental fact on which is based the notion that matter may be an electric phenomenon, is deserving of more expanded and repeated notice; and part of this lecture must be devoted to that. For to the superficial eye nothing could be more distinct than matter on the one hand and electricity on the other. Anyone would suppose that an electric charge, whatever it is, must be a mere appanage or decoration of matter, and that by no conceivable ingenuity could it be thought of as constituting the substance of matter itself. Benjamin Franklin—whose ideas concerning electricity have in many respects become so singularly justified—would, I conjecture, have been profoundly interested, but somewhat astonished and probably skeptical, if such an idea could in his day have been authoritatively mooted. If so, it would be one of the many instances when ultra and exaggerated skepti-

A charge in motion constitutes a current—"current" is our shorthand expression for charge in locomotion—and a current is always and essentially surrounded by a magnetic field. A magnet in motion generates a current in conductors, and an electromotive force in insulators. A varying magnetic field does the same, for its lines are then in lateral motion. A magnetic pole in the neighborhood of an electric charge, even when stationary, sets up a theoretical spin in the ether, round the line joining them—a hypothetical spin which can display itself by its gyrostatic action.

The result is that when a charge is in motion, the magnetic field due to the motion, when once generated, tends to preserve and prolong that motion, so that mechanical force is needed to obstruct or stop the moving charge. Similarly to accelerate or set in motion any electric charge involves the generation of a magnetic field, and therefore requires the application of mechanical force and the expenditure of energy. No such force is necessary so long as the motion is steady, no more than if the motion was zero; but directly the motion changes, whether in the way of increase or of decrease, force is immediately exerted; nor can there be any kind of change produced in the motion, either in magnitude or direction, save by the exertion of force. In other words, an electric charge in motion, not acted on by any force, will continue to move in a straight line with a uniform velocity. And if a force acts upon it, the acceleration produced is exactly proportional to the force.

Thus the reaction between electric and magnetic fields precisely simulates all the effects of mechanical or Newtonian inertia. It is an acceleration-coefficient, not a velocity-coefficient; it is not of the nature of re-

distance or viscosity, but it is of the nature of mass. But when I say simulates—I would rather say that it accounts for, or rationalizes, or carries one step further on, the otherwise blank and bald idea of Newtonian inertia.

The first two of Newton's laws of motion are thus obeyed by electricity. Is the third law obeyed likewise? I say yes; but the answer is not so simple and easy. The peculiar condition of an advancing wave-front has to be taken into account, and we have to admit that an ethereal wave advancing with the speed of light may possess attributes which hitherto have been thought to belong only to matter, and may—indeed must—sustain the reaction of a stress whose other end acts upon the source. So that light or radiation of any kind must exert a pressure and must be the seat of a stress—a fact which, predicted by Maxwell, has now indeed been directly and experimentally observed.

If somehow there should be acceleration without the action of any material body, then waves are generated in the ether; and the mechanical force essential to the action is supplied by the reaction of the train of ether waves. It is a singular but very important case; the wave-front seems to represent adequately some of the properties of matter, and the generation of such a wave-front is the inevitable consequence of either accelerated or retarded or curved motion of an electric charge. This and this alone is the source of ethereal radiation.

To pursue this subject would lead us into the intrinsic

potential may be high—comparable indeed to a million volts; an astonishing value, which reduces itself to only a few volts at any distance comparable with molecular dimensions. It is indeed possible to specify the bulk of an electron which will enable us to say that its mass is wholly of the electrical kind. Every experiment made—both direct and indirect—goes to confirm the extraordinary smallness and consequent penetrating power of electrons.

At one time, not so long ago, we were in doubt about the size of atoms; some few may perhaps have been in doubt as to whether such a phrase had a legitimate meaning. I hope that this unnecessary skepticism is now set at rest, and that everybody admits the estimate of size or molecular magnitude which we owe to the genius of Lord Kelvin, among others. The extreme minuteness of the atom can be brought home to the imagination in many ways; but one striking way is to point out that in spite of the extreme rarity or dilution of the gold chloride dissolved in sea water—estimated at 1/50 grain per ton, or say one part in a thousand million, so that it appears not to be possible to extract it economically—yet that in every cubic millimeter drop of that liquid, the number of gold atoms amounts to several hundred millions. And the number of atoms of radium in any 50 cubic centimeters, or say a half pint of sea water* or of ordinary rock is about the same.

Yet in spite of their excessive minuteness we know of one definite structure which can only be about ten or a dozen molecules thick—namely the soap bubble on

It is on this basis that I have been led to attribute so excessive a density or massiveness to the ether—that is to say, on the supposition that it is of ether that the electrons are really composed, that they are, as it were, "singularities" or some kind of structure or strain or motion-center in the ether, differing from it only in the circumstances of their arrangement, not in their density or concentration. A really continuous fundamental medium cannot be either rarefied or condensed; it must be uniformly everywhere. Accordingly, whatever density a discrete aggregate of scattered particles may possess, the density of the continuous medium, which composes them and fills up all the intervening spaces, must be greater, and may be immensely greater.

The reason why matter appeals to us so clearly and strongly is because our present bodies are composed of it, and because our sense-organs have been evolved to respond to its various motions; but matter turns out to be a mere faint misty modification of the great medium itself; and, compared with it, is like a gauzy cobweb or mist or a milky way. I repeat this because I believe it will be found to be a fact of profound significance—a significance as yet undreamed of—significance which could only at present be dealt with in terms of speculation, a thing desirable to avoid until we can adduce a more substantial foundation for it.

A movement to connect nearly all the groups of islands in the South Pacific by a system of radiotelegraphy is on foot, according to the Western Electric

ATTACHING STEEL CUTTING SHOE TO BASE OF SHAFT FRAMEWORK.

VIEW OF THE INTERIOR OF SHAFT.

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cacies of spectrum analysis, which has already begun to throw light upon atomic constitution, but what little I propose to say on that subject will come better later.

Leaving this as a digression, and returning to electric inertia, it may be truly said that an electric charge has the property which we know as mass or inertia; and it becomes a possibility that no other mass or inertia need or does exist. This is the chief basis of the electric theory of the nature of matter. It is one of the foundations on which the notion that an atom of matter is built of electric charges must fundamentally rest.

But, admittedly, the extra mass of any ordinary charged body, due to the charge, is excessively and absurdly small. The mass depends not only on the charge but also on its concentration; in other words, on the charge and its potential. It is in fact proportional to the electrostatic energy of the charge. The mass or inertia of an electric charge is such that, if moving with the velocity of light, its kinetic energy would equal the electrostatic energy of the charge at rest. In other words, considering the charge uniform-

ly distributed through a sphere of radius, a , — $mv^2 = \frac{1}{2} \frac{e^2}{ka}$

— e —; but it is known that $v^2 = \frac{1}{3} \frac{e^2}{ka}$, so $m = \frac{1}{3} \frac{e^2}{ka}$, a simple formula which is the sheet-anchor of the electrical theory of matter.

To build up an atom out of a reasonable number of electrons, therefore, the charge of each electron must be excessively concentrated, that is to say, must occupy exceedingly small bulk, so that an electron's

the point of bursting, in the region which shows itself to the eye as a black or non-reflecting spot.

Waves of light are excessively small things, of which a hundred thousand only span an inch, and yet waves of light are coarse, unwieldy things compared with atoms; so that the fineness of microscopic vision must break down in the attempt actually to see the atoms, although by more or less indirect means there is some hope that the larger kind of molecular aggregates may some day become in a manner visible, by the diffraction and other effects which they cause in a beam of light. Moreover, the excessively thin ether pulse known as an X-ray appears to be distinctly thinner than molecular dimensions, since it is able to pass through a mass of material with only a moderate amount of loss.

But although the atom is so minute, it is huge compared with an electron; and if it be true, in any sense, that an atom is mainly composed of electrons, they must be as far apart from each other inside the atom, in proportion to their size, as the planets of the solar system are in proportion to their size.

The porosity of matter so constituted is extreme, and the ultimate specks of which even an atom is composed are as it were few and far between. Though an atom may perhaps contain thousands altogether, it consists mainly of intervening space in which there is nothing but continuous unmodified ether.

That is the kind of picture which we are beginning to form in our minds, not dogmatically but as a guide to investigation; it forms a mental image of which we can trace some of the consequences, so as to be able to check and amend it by observation and experiment.

* Joly estimates the proportion of radium in sea water as 2×10^{-14} . Phil. Mag., March, 1908.

It is proposed to include in this system Australia, New Zealand, and the Fiji group as well as the New Hebrides, the Solomon, Samoan, Cook, Society, and Marquesas Islands, and the phosphate islands of Ocean, Pleasant, and Makatea. It is expected that the various governments having possessions in the South Pacific will aid in the establishment of the proposed system. Negotiations have already proceeded so far that the success of the efforts seems to be almost assured, says Mr. J. D. Dreher, the United States consul in Tahiti. As the nearest available ocean-cable office to Tahiti is at Auckland, 2,250 miles away, from which a steamship arrives at Papeete once every twenty-eight days, and a direct communication by steamship with San Francisco, 3,658 miles distant, is had once in every thirty-six days, it will be understood how deeply interested the French colony of Tahiti and its dependencies are in the complete success of these negotiations. The name of the proposed company is the Pacific Islands Radiotelegraph Company. Of the proposed capital of \$340,000, the owners of the phosphate-deposits on Ocean and Pleasant islands have subscribed about one-seventh. In this radial system there will probably be ten or twelve circles, the largest having a radius of 1,250 miles, and requiring for each station an engine of 60 horse-power. It has not yet been decided where the main office of the proposed company will be.

The best all-round rock-drill steel contains, according to the manufacturer's rating, 0.50 to 0.60 per cent carbon, for this combines maximum toughness with a hard cutting edge. Milder steel should be used for the shanks, since it is cheaper, welds up to the cruciform easier, and is less liable to crystallize and break.