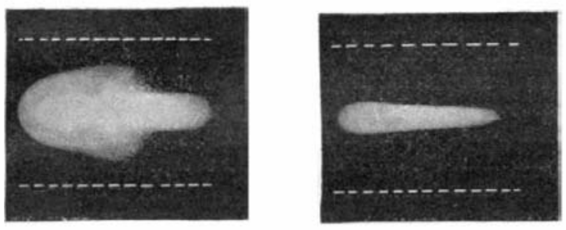
BALL LIGHTNING.

BY PROF. JOHN TROWBRIDGE, HARVARD UNIVERSITY.

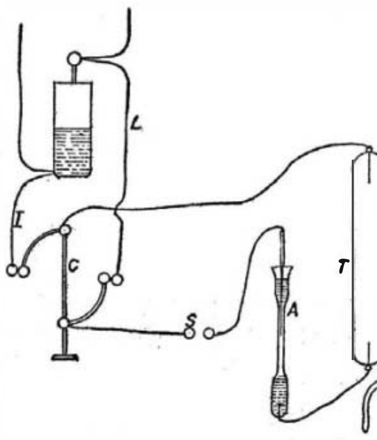
There is still much skepticism in the minds of many people in regard to the so-called phenomenon of ball lightning. We hear of strange luminous masses, which travel so slowly that one can easily follow their passage across a room or witness their perching on this object and that. It must be remembered, however, that there are not many persons who are in a sufficiently stable and philosophical frame of mind in a thunder storm to be trustworthy observers; and there may be



PHOTOGRAPHS OF ARTIFICIAL BALL LIGHTNING.

a hypnotic state induced by repeated fearful shock which tends to states of hallucination.

A very exhaustive paper on the phenomena of electrical storms has been written by Toepler, who has done so much to perfect the electrical machine. (Annalen der Physik, 1900, vol. 2, p. 560.) He gives considerable space to a consideration of ball lightning, and evidently considers that there is reliable evidence of its existence.



Circuits of Righi's Apparatus.

It does not seem impossible, therefore, to produce electrical discharges by the powerful sources of electricity now at our command, which should resemble the slowly-moving effects that have been observed in thunder storms. The most notable attempt to reproduce such effects was made by Prof. Righi, the distinguished Italian physicist. His experiments are described in a memoir presented to the Royal Academy of Sciences of Bologna, with the title "New Researches upon Electric Sparks, Constituting Luminous Masses which Move Slowly."

Prof. Righi used a large plate electrical machine, driven by one-quarter of a horse-power, to charge a large condenser. This condenser was then discharged through a great resistance of distilled water and a glass tube filled with rarefied nitrogen. The diagram shows the disposition of his apparatus. *C* is a reversing key, which enabled him to discharge from the outside or the inside of the condenser. *S* is a spark gap. *A* is a tube of distilled water. *T* is a tube of rarefied nitrogen.

I have repeated Rhigi's experiments, using, instead of the discharges from large condensers, the current from a storage battery of 20,000 cells without the interposition of a spark gap, and I have obtained slow-moving luminous effects such as are described in Rhigi's memoir. These luminous masses move slowly from the anode toward the cathode with increasing strength of current, and retreat to the cathode with decreasing strength of current. A striking fact is this: the movement is toward the cathode when the pressure of air is suddenly increased in the discharge tube. The method was as follows: The electrical resistance was running water. At the base of the reservoir, the water issued through a glass tube ½ inch in diameter. A wire introduced in this tube could be pushed in and out, thus modifying the resistance. This high resistance was found highly satisfactory for this form of experimentation; for it did not heat, whereas graphite resistances developed a large amount of heat under the effect of the powerful electric current.

The slow movement of the luminous masses was shown best in tubes of two inches internal diameter. The photographs show the typical forms of such luminous masses. It will be noticed that the ends of the masses are curved, as if the center of the luminous mass constituted an anode, the interval between the luminous masses acting like cathode spaces.

I believe that the slow movements of electrical discharges produced in this manner are due to ionization, and that ball lightning is a similar ionization produced in rarefied channels of air formed during the thunder storm. One can conceive of a non-luminous condition of ionization pervading the space between the terminals of the battery in a wide tube at a comparatively high pressure of the gas in the tube. The positive carriers of electricity are not restrained or held back by the swifter-moving carriers, which cannot manifest their energy in a limited free path. On a sudden increase of pressure luminous clouds emerge from the anode. This phenomenon seems to indicate a greater proportional falling off in the energy of the negative carriers. The cloud of collision between the two moves slowly to the cathode, the conductivity of the gas changing under the difference of electric stress in the tube.

From the time of Benjamin Franklin down to the invention of the step-up transformer, our views of lightning gathered from electrical machines have been extremely limited. Even to-day one sees frequently in print the assertion that the quantity of electricity in an ordinary lightning discharge is small. My experience with the large number of storage batteries I possess makes me realize the extreme fallaciousness of this assertion. A very large quantity of current can pass over the path opened by even a short spark. This is also true of sparks six feet long, which manifest very little resistance, and which can open a path to discharges which can melt metallic rods an inch in diameter. During thunder storms discharges have often occurred which have melted lightning conductors of this diameter. The phenomena of ball lightning must result from a great quantity of electricity, which manifests itself by slow ionization of rarefied air.

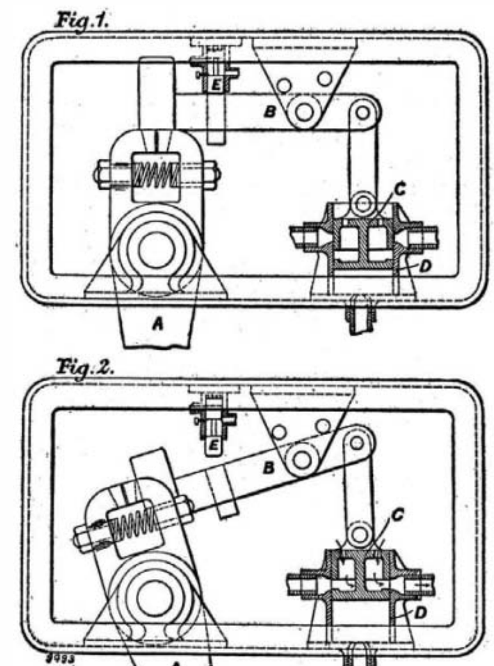
A NEW SIGNALING MACHINE SYSTEM FOR THE AUTOMATIC CONTROL OF RAILROAD TRAINS.

BY THE ENGLISH CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

There have recently been carried out at the Stoke-on-Trent junction of the North Staffordshire Railroad of England, tests and demonstrations with a new system of automatically controlling railroad trains. This method which has been evolved by Mr. Thomas E. Raymond Phillips, of Liverpool, follows original lines, and possesses several ingenious and novel features which render it distinctly different from other devices that have been contrived to insure the absolutely safe control of railroad operation.

Briefly, the invention may be described as a system whereby the engineer of the locomotive is supplied in his cab with a visual repetition of the signal of the semaphore, "danger" or "line clear," combined with an arrangement for further drawing his attention to the conditions prevailing, should the visual signs be overlooked, by the blowing of the engine siren or whistle, and the gradual application of the brakes. But not only is the locomotive engineer thus informed of the condition of his road, but the signalman in his cabin is similarly protected, there being a dial showing the position of the semaphore assisted by the ringing of a bell, which continues until the signalman releases the stopped train, so that it is impossible for any accident to occur unless the visual and audible warnings are deliberately neglected.

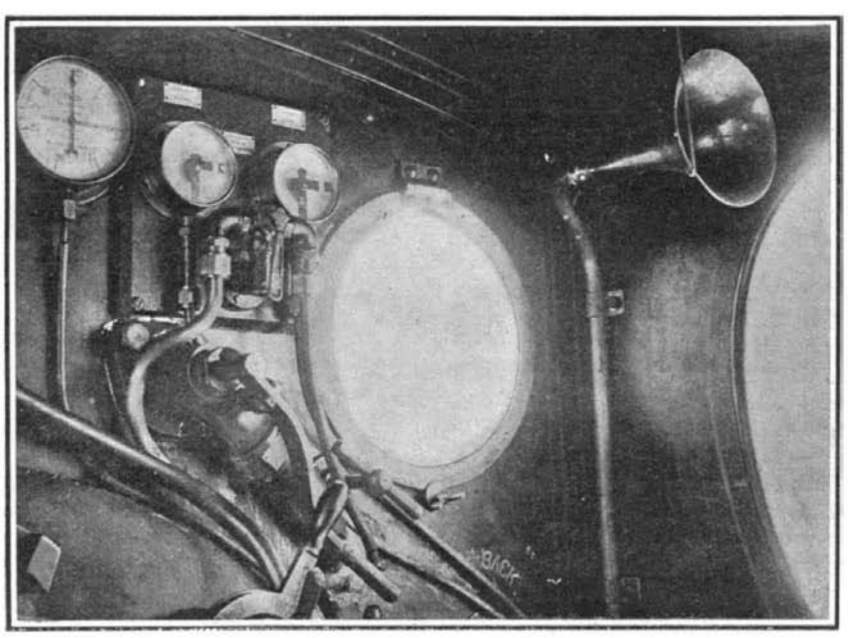
The apparatus is divided into two essential sections—that carried on the locomotive, and a second installed upon the railroad track, the latter being in connection with both the semaphore and the signal cabin. In the cab of the locomotive are fitted two small semaphore indicators corresponding to the "distant" and "home" signals respectively, pneumatically operated, and showing whether the line is clear or otherwise. There is



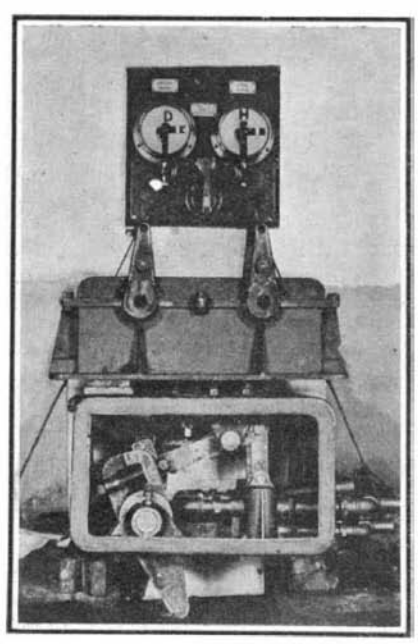
Mechanism Carried on Engine.

Fig. 1.—Normal position of apparatus. Fig. 2.—Position after lever A has struck trigger on track, showing rising of piston C, operating engine indicator, siren and brakes simultaneously.

a vacuum reservoir, to which these two indicators are connected by gages, together with two other control pipes—one leading to the engine siren or whistle, and the other to the vacuum brake pipe of the train. This vacuum reservoir is normally in connection with the semaphore gages in the cab, so that the arms are kept depressed, i. e., in "clear" line position. The actuating mechanism is carried in a casing fixed to the front of the locomotive, and placed slightly to one side of the center line. There is a vertical lever *A* of the scissor-leg type, with the limbs held tightly together so as to form one member. Upon the upper end of this lever rests the weighted end of a horizontal lever *B* which, at its opposite end, is connected to a hollow piston *C*. By coming into contact with the rigid section of the apparatus fixed on the track, the lever *A* is pushed over, thereby permitting the horizontal lever *B* to drop at the weighted end. In this action the hollow piston *C* is lifted, and in rising the latter brings ports in the piston *C* into coincidence with ports in the cylinder *D*. The falling of the lever *B* permits air to enter the gage of the indicating semaphore in the engine cab, lifting the arm to the danger position, so that it corresponds with the railroad signal. Simultaneously the locomotive siren is brought into action, and continues sounding until the engineer attends to his brakes, though meanwhile the apparatus has, by the falling of the piston valve *E*, admitted air to the brake pipe of the train, so that speed is gradually decreased. In the operation of the apparatus in connection with the "home" signal, which necessitates immediate action on the part of the engineer in pulling up the train, the three functions are appreciably accelerated, especially in regard to the automatic application of the brakes. In passing the "distant" signal, when the arm is at danger, rapid retardation of the train is not generally requisite, so that the automatic application of the brakes is not so powerful, but yet at the same time sufficient to attract the attention of the engineer. In the case of



Semaphore Indicators and Siren Installed in Engine Cab.



Indicators and Actuating Mechanism Carried by Locomotive.

A NEW SIGNALING MACHINE SYSTEM FOR THE AUTOMATIC CONTROL OF RAILROAD TRAINS.

the "home" section of the apparatus coming into action, the "distant" part of the mechanism is similarly operated, so that the two semaphores within the cab have their arms set at danger, as in ordinary railroad signaling work.

The track mechanism consists of trippers comprising balanced pendulums swinging in cases, there being sets of trippers for home and distant signals, and each working in conjunction with its respective striker on the locomotive. These trippers are placed to one side of the road, so as to clear coupling chains, hooks, etc., carried on the rolling stock. These trippers are connected with the semaphores, and should the latter be at "danger" position they project upward, the upper parts being struck by the projecting levers of the locomotive mechanism. If the line is "clear" and the semaphore arm depressed, in setting the latter the signalman also draws the trippers down clear of the strikers on the engine.

The track part of the apparatus is electrically connected to the signal cabin, these connections being of a simple character, so as to be as immune from breakdown as possible. In the signal cabin is a dial with a repeater, which indicates whether the semaphore arm is set "clear" or at "danger" positions, and if the apparatus from some cause or another breaks down, the record "out of order" is indicated. In connection with this dial is the electric bell, which continues ringing after an operation until the signalman releases the train out of his section. It will thus be realized that it is impossible for a signalman to forget that a train is blocked at one of the signals in his section even though he be prevented from seeing, owing to thick or foggy weather.

To reset the apparatus on the locomotive, the engineer simply turns a three-way cock, which renews the vacuum in *D* under the piston *C*, thereby causing the horizontal lever *B* and the vertical striker *A* to revert to their normal or set position, the arms of the semaphore indicator being depressed to the "line clear" position, and the blowing of the whistle stopped thereby. In the event of any part of the mechanism suddenly failing through breakage, the piston *C* immediately rises, drawing the engineer's attention to the fact that something is amiss. Similarly, in the event of the striker becoming fractured by the force of an abnormally hard blow against the triggers on the track, or the lower point becoming so worn under repeated contacts as to miss striking, the same effect results. In this case the spring, which is compressed between the upper ends of the scissor limbs of the vertical striking lever, forces the two members open, with the result that the weighted end of the lever *B* falls between the two opened parts, and cannot be removed until the broken striker is replaced.

At first sight it may appear that the risk of breakage, which is always existent in signaling systems depending upon the contact of a striker with a tripper, constitutes an inherent weakness of the Phillips invention, inasmuch as when, say, a striker breaks, the locomotive engineer would be liable to frequent false indications, and the application of the brakes when in reality the line is quite clear. Such, however, is not the case. The integral parts of the apparatus are all standardized, and any fractured part can be replaced in a few seconds. In the event of a breakage occurring in the engine mechanism, the indicating semaphore arms immediately rise to "danger," the siren sounds, and the brakes are applied as already mentioned. The engineer would then, after seeing that the line is actually clear, though his apparatus indicates the reverse state of affairs, endeavor to remedy the wrong reading by setting the apparatus with the three-way cock provided for the purpose. But the handle of this three-way cock is painted and shaped like an ordinary semaphore arm, so that although the engineer would reset his indicating semaphore arms to "line clear" position, the handle of the three-way cock would remain at "danger" position. Thus the apparatus would show two different readings, and from this the engineer would immediately realize that the apparatus was at fault, would stop his train, and ascertain the defect. Should he ignore the divergent readings, he would be running against "danger signals." Before an engineer actually gets the "line clear" position, the brakes must first be released, the gage indicators must show line "clear," and the handle of the controlling or resetting three-way cock must show the same reading. False indications are thus impossible. For the past two years the appliance has been in daily use upon a stretch of the North Staffordshire Railroad, and never on a single occasion has the slightest breakage occurred to either the engine or track portions of the apparatus, nor has a solitary instance of failure to act been recorded. In fact, owing to the unique success of the system, it was removed to the important and busy junction at Stoke-on-Trent, where it is subjected to far heavier and rougher usage. On this system so far the highest speed at which the train has passed over the apparatus has been 45 miles per hour, at which speed the apparatus has withstood the shocks of contacts remarkably well; and though the working parts have been in use for two years, no appreciable signs of wear are perceptible. The removal of this particular installation to a busy junction has imposed a supreme test upon the invention, since the trains travel at high speeds over a network of crossovers and switches, in negotiation of which under such conditions considerable oscillations and vibrations are produced.

The electrical connections of the tripper, and those running to the signal cabin repeater, are so arranged that so long as the trippers remain either at the "danger" or "line clear" positions the circuit is closed, the indicators in the cabin being held up by magnets. Directly the tripper arm is struck by the lever on the engine the circuit is automatically opened, thereby causing the indicator to fall, and thus showing whether the tripper acted upon is either the "distant" or "home" signal. In the act of falling the indicator also closes a local circuit, causing the bell to ring, and this action continues until the indicator is restored to its position by means of a plunger provided for the purpose in the repeater. In the tripper the wire connecting the contacts is carried over the top of the arm internally, so that in the event of the arm being broken the conductor is also broken, thereby cutting off the current, and thus the indicator pointer within the signal cabin falls to its middle position, marked "out of order." The bell, however, is set in action and continues ringing until the tripper is repaired. In this it will thus be seen the signal operator is duly warned of the failure of the apparatus, and cannot in the event of an accident to the train in his section attribute the cause thereof to the failure of the apparatus.

The invention is also so devised that the locomotive engineer can apply his brakes without causing any movement of the semaphore indicator within his cab, or by the pulling of the communication cord extending throughout the train. This end is assured by means of a check valve, which is placed between the braking pipe of the train and the reservoir, which works in conjunction with the indicators in the cab of the engine.

THE PROTECTIVE WORKS OF THE ASSOUAN DAM.

(*Continued from page 488.*)

year, when it was replaced and the second half of the river bed similarly treated.

The whole task has now been successfully completed; there being a granite and masonry apron stretching from one side of the river to the other, from the lips of the sluices to points ranging from 100 feet to 200 feet downstream, according to the conditions prevailing. So efficient have the earlier sections of the apron proved in resisting the heavy impact of the water rushing through the sluices that no doubt is entertained as to the permanence of this work. The apron will necessitate but little attention beyond periodical examination, and the possible renewal of the pointing.

Sir William Garstin, the well-known irrigation engineer and adviser to the Egyptian Ministry of Public Works, who has been closely identified with the barrage since its inception, considers that the completion of this protective masonry apron has completely removed any apprehensions that might have prevailed concerning the stability of the barrage itself. The construction of the apron, which was carried out by the Irrigation Department's engineers under Mr. Macdonald, the resident engineer, is a remarkable feat considering the difficulties that had to be surmounted both in the use of native labor, and in the short space of time available for the completion of the undertaking.

It is due to the thorough nature of the work that the raising of the barrage itself is considered to be feasible and is now being pushed forward with all speed. This work in itself will be a remarkable one. The extension is not to be built immediately upon the old work; but the whole cross section of the dam is to be increased from top to bottom. There will be a space of about 8 inches between the old and the new walls, which will be connected by steel ties, the intervening space being subsequently filled with cement grouting, and the whole structure thus converted into one homogeneous whole. The total cost of building the masonry apron has approximated $1,500,000.

Official Meteorological Summary, New York, N. Y., May, 1907.

Atmospheric pressure: Highest, 30.33; lowest, 29.70; mean, 30.00. Temperature: Highest, 83; date, 14th; lowest, 36; date, 12th; mean of warmest day, 70; date, 19th; coolest day, 44; date, 12th; mean of maximum for the month, 62.8; mean of minimum, 47.8; absolute mean, 55.3; normal, 59.7; deficiency compared with mean of 37 years, —4.4. Warmest mean temperature of May, 65, in 1880. Coldest mean, 54, in 1882. Absolute maximum and minimum of this month of 37 years, 95 and 34. Average daily deficiency since January 1, —1.8. Precipitation: 4.08; greatest in 24 hours, 1.10; date, 16th and 17th; average of this month for 37 years, 3.18. Excess, +0.90. Accumulated deficiency since January 1, —0.58. Greatest precipitation, 7.01, in 1901; least, 0.33, in 1903. Wind: Prevailing direction, N. W.; total movement, 8,683 miles; average hourly velocity, 11.7; maximum velocity, 48 miles per hour. Weather: Clear days, 9; cloudy, 10; partly cloudy, 12; on which 0.01 inch, or more, of precipitation occurred, 12. Thunderstorms, 10th, 11th, 16th, 19th, 20th, 27th. Frost, light, 5th, 12th. Remarks: Coldest May with the exception of May, 1882, in 37 years.

Santos Dumont's Airship No. 16.

Santos Dumont is not only engaged in perfecting his new aeroplane which we already had occasion to mention, but is also constructing a new airship which has some interesting points. We expect to give a more complete account of the airship, but at present will speak of its leading features. As regards the balloon body, it is one of the smallest in cubic contents that has ever been constructed, seeing that it gages but 99 cubic meters (349.7 cubic feet), but on the contrary it is to carry a light-weight motor of no less than 50 horse-power. No doubt it will be able to reach a high speed under these conditions. The balloon envelope is of varished Japan silk, and the total length of the balloon, which is a very long cigar shape, is 21 meters (68.9 feet). The surface is 151 square meters (1,625 square feet). The main balloon contains a ballonet which measures 2 meters (6.6 feet) in diameter. There is a single propeller which is mounted upon the light framework below the balloon body. The propeller is mounted direct upon the motor shaft and is 2.05 meters (6.76 feet) in diameter with a pitch of 1.70 meters (5.8 feet). In front of the propeller and attached to the framework is a movable plane formed of a frame covered with canvas which measures 3 meters (9.8 feet) in length across the balloon and 0.50 meter (1.64 feet) in width. Toward the rear is placed a second and similar plane which is 4 meters (13.1 feet) in length and 1.20 meters (3.9 feet) wide. Behind it lies the rudder, which is formed of a circular frame and is 2 meters (6.6 feet) in diameter. The aeronaut will be seated on a simple bicycle saddle, which is suspended, as is also the mechanical part, to a frame made of light steel tubes placed vertically and fixed from a bamboo pole, the latter being held just under the balloon body. The center of resistance is placed as nearly as possible in coincidence with the center of traction. As the propeller is mounted quite near the balloon, it will almost touch it when it is running. Good protection is afforded to the motor by a wire gauze covering which surrounds the carbureter, thus avoiding any risk of fire to the gas escaping from the balloon. The new airship is to be known as the "Santos Dumont No. 16," and it is now in construction at the shed which had been erected again at Neuilly near the Bois de Boulogne. To the same shed is soon to be brought the new aeroplane "No. 14." Its sustaining planes have been modified since the last accident it had at St. Cyr.

The Current Supplement.

The highlands east of the Jordan River are strewn with ruins marking the rise and fall of successive civilizations. The strangest and most beautiful of these ancient ruins is the Rock City of Petra, described in the current Supplement, No. 1641. Dr. Franklin E. Hoskins writes most interestingly on the old town. Exceptionally handsome illustrations accompany his description. An important article on the compression of steel ingots by wire drawing, with cuts, is given. Mr. Hall's excellent paper on artificial fertilizers is continued. W. F. Badgley tells us something on the shape of molecules. By far the most valuable article in the Supplement to the amateur is undoubtedly Mr. E. F. Lake's description of how a 5-horse-power stationary gas engine can be built at home. He describes clearly and simply how each part is made and what metal must be used. The usual notes will be found in their accustomed places.

Consumption of Pulp Wood in 1906.

The Census Bureau has prepared a preliminary report on the consumption of pulp wood in the United States for the calendar year ended December 31, 1906, which shows that during that period 3,646,693 cords were used, as compared with 3,192,123 cords utilized in the previous year. This is an increase of 454,570 cords. The principal wood used in 1906 was domestic spruce, of which 1,785,680 cords were consumed. Classified according to methods of reducing into pulp, the mechanical process took 1,197,780 cords; the sulphite process, 1,944,136 cords, and the soda process, 504,777 cords. The figures cover the operations of 250 mills in 1906 and 237 in 1905.

A new 72-inch plate mill at the Homestead works of the Carnegie Steel Company has been put in operation. The mill, it is said, will have a capacity of 60,000 tons annually.