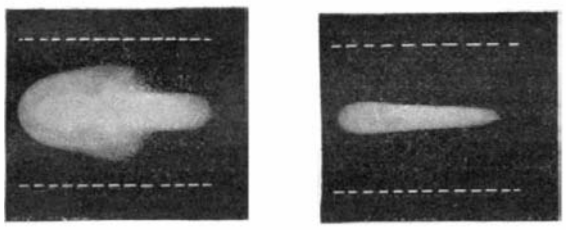
BALL LIGHTNING.

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

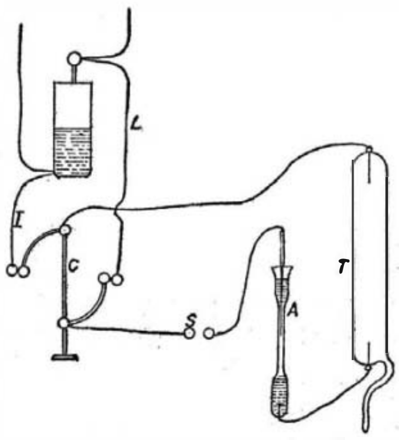


PHOTOGRAPHS OF ARTIFICIAL BALL LIGHTNING.

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.

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."



Circuits of Righi's Apparatus.

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.

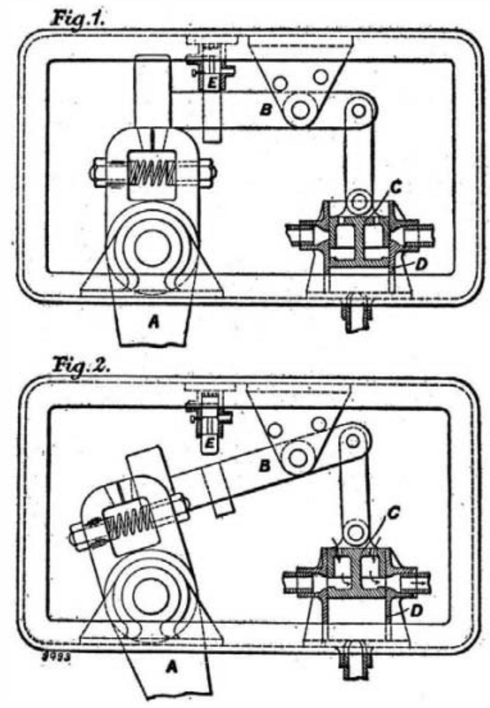
A NEW SIGNALING MACHINE SYSTEM FOR THE AUTOMATIC CONTROL OF RAILROAD TRAINS.

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.

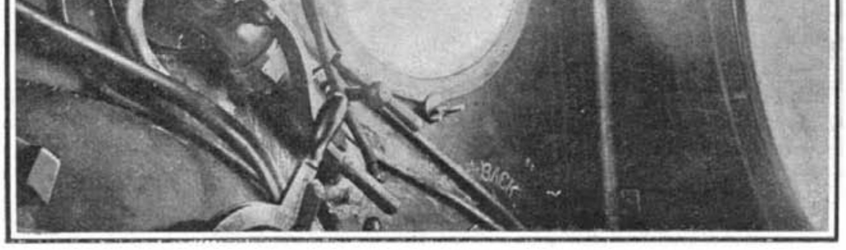
The apparatus is divided into two essential sections—that carried on the locomotive, and a second installed upon the railroad track, the latter being in connection with both the semaphore and the signal cabin. In the cab of the locomotive are fitted two small semaphore indicators corresponding to the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



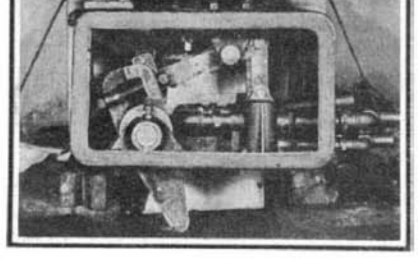
Mechanism Carried on Engine.

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.