release of the mechanical locking in case a switch has not properly responded to the movement of the lever. But these electric locks present exactly the same defects as those which we have discussed—for, either these electric locks must be worked by a battery located in the cabin and they will then be liable to be falsely operated or they must be worked by batteries placed at each function and their installation then becomes excessively costly.

With the idea of avoiding these defects, a system has been proposed but is not yet fully tried out, in which the energy required for the operation of these locks is furnished by means of a generator placed at each function and so connected that it will develop the necessary current at the instant it is required, by the automatic release of a suitable weight when the switch is over and locked.

CONCLUSIONS.

Following this hasty examination of the applications of electricity to the working of safety appliances on railways, one is forced to conclude that it is the ideal force for such a purpose and that its employment will become more and more general. While such devices, only a few years ago, were regarded as of minor importance, they have to-day come to be regarded as absolutely essential to the conduct of heavy, high speed traffic.

For the operation of such devices it is necessary to employ an agency that is absolutely trustworthy, flexible, rapid and easy of maintenance,—all these being qualities possessed by electricity. But, in order that electricity shall assume its rightful place in this development, great care must be exercised to avoid the errors into which some of its users have fallen and on account of which its employment has been retarded, by throwing doubt upon its reliability—a doubt which is not merited and which is invariably due to the fact that an attempt has sometimes been made to accomplish too much without regard to certain simple requirements, the observance of which is absolutely essential to safe operation. In order to aid in the development of the applications of electricity to the control of safety appliances on railways, effort should be made to observe the following conditions:

For Block Systems:

Reduce to a minimum the number of line wires used and, if possible, dispense entirely with them.

Give indication of the "stop" position of an outlying signal arm, by means of a source of current located at the signal itself.

Repeat on the trains the indications of the fixed signals—and do this by means of an absolutely dependable connection between the train and the track occupied by it.

For Interlocking Plants:

Employ only such systems of indication as are absolutely trustworthy, by having the source of energy for such indication at the function.

Employ the smallest possible number of wires.

Avoid the use of circuits in which current is normally flowing.

Seek some positive and trustworthy means of indication for mechanical interlockings.

TRAIN STAFF ON D. L. & W.

The D. L. & W. R. R. has recentlly put into service on the Bangor & Portland division, under the supervision of Signal Engineer Smith, the Union Switch & Signal Company's Electric Train Staff System between East Bangor and Martins Creek Junction, a distance of four miles—with an intermediate junction switch at the shops. Mr. Frank Cizek, superintendent of this division, arranged for the operating requirements of the system.

The feature of this installation is that no operators are used, the instruments being operated by the train crews. The traffic over this piece of track is principally freight, the number of trains passing through the staff blocks being 18 each way, or 36 in all in 14 hours, no night service being run at the present time.

A topographical plan and diagram of the circuits used in the staff blocking of this section of track is shown in Fig. 1, and for convenience in this description East Bangor will be called "X," Junction Switch "J" and Martins Creek Junction "Y."

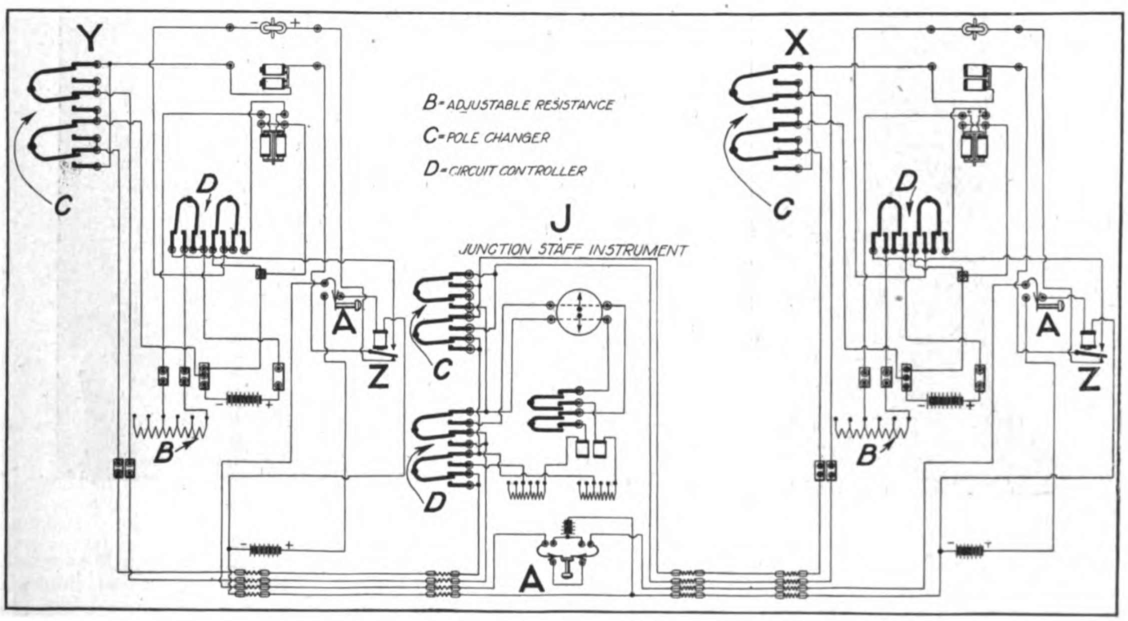

Fig. 1.

To move a train from X to J or Y, the manipulation of the instrument at station X is as follows:

The conductor at X presses the key A, Figs. 1 and 2, which closes a circuit through the relay Z at Y, Fig. 1, thus energizing it and thereby closing a circuit through the line coil of the releasing magnet at X. The conductor, seeing that the staff indicator shows "staff in," and that the current indicator is deflected, turns the preliminary spindle handle B, drawing the staff through the opening M, Fig. 2, and handing it to the engineer. In taking out the staff, the polarity of the operating current is reversed, thereby putting the instrument out of synchrony.

Upon receiving the staff, the engineer proceeds toward J and Y. If this movement is to be made through to Y with an ordinary stop to put off or

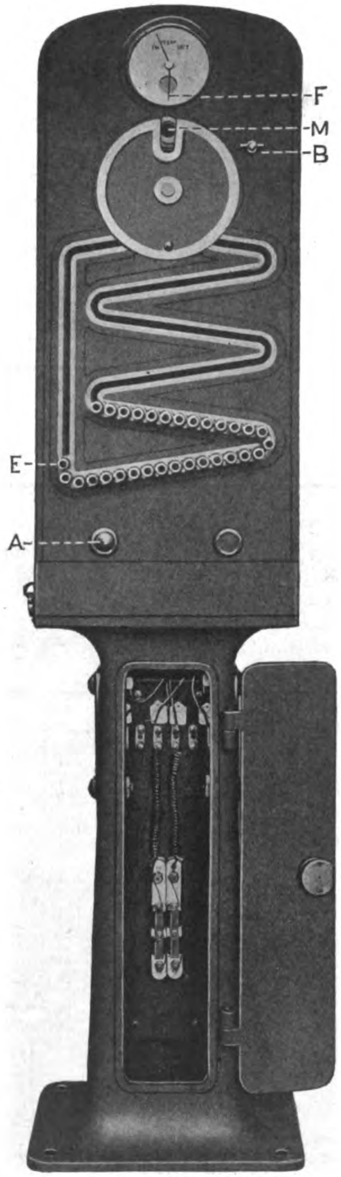

Fig. 2.

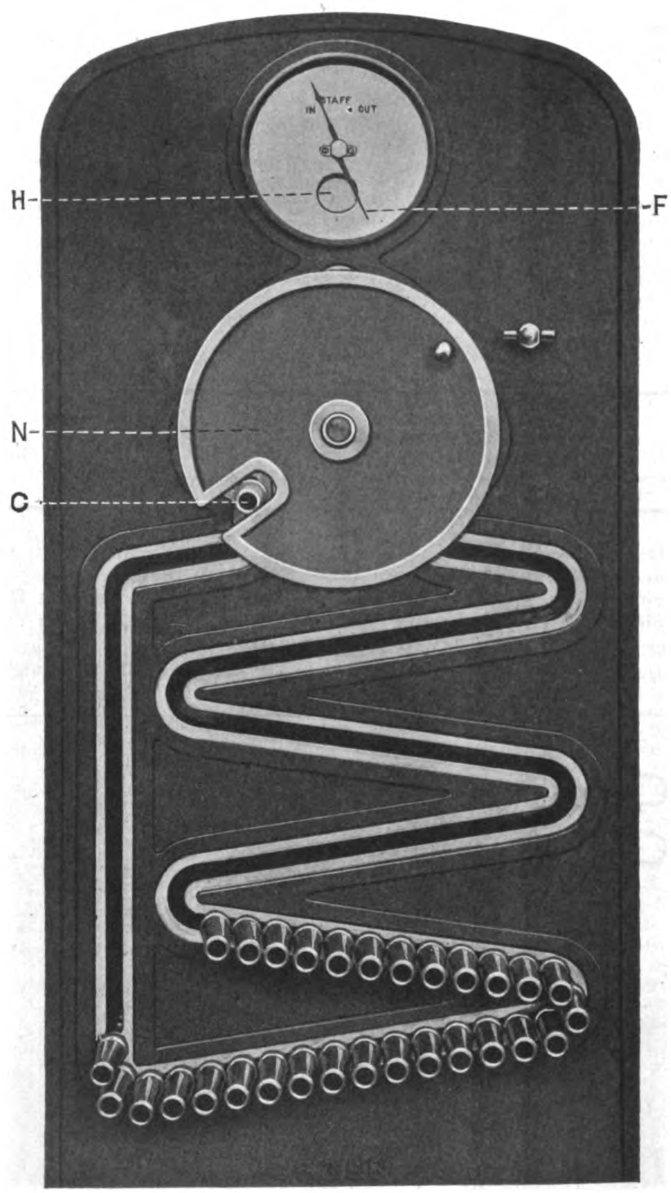

Fig. 3.

Fig. 1, to the right as far as it will go. This movement raises the armature (operating the locking dog) up to the magnets and also closes the circuit on the local coil. The preliminary spindle handle is then permitted to return automatically to its normal position, when, if a staff can be removed, the disc H, Fig. 3, will show white. The staff E, Fig. 2, is then moved up the vertical slot into engagement with the drum revolving the latter one-half turn, the conductor using the staff as a handle, and with- pick up cars, the staff is retained until Y is reached when it is inserted in the instrument at that place by the conductor.

Should the movement be made only to J, the staff is inserted in the instrument at that place in the same manner as at Y. The putting of the staff in the instrument at either Y or J synchronizes the instruments so that another staff can be taken out at either X, J or Y.

To move a train from Y to J or X, or J to Y or X, the manipulation of the instrument is the same as previously described.

To take a staff out at J it is practically necessary to get permission from Y and X. This is accomplished by energizing the relays Z at Y and X by pressing the key A at J, and when the preliminary spindle handle is turned to the right it raises the armature (controlling the lock) to the coils. This movement closes the two circuits on these coils, one from Y and one from X, and if the instruments are in synchrony, by letting the preliminary spindle handle return to its normal position, the disc indicator similar to H, Fig 3, will show white. A staff can then be taken out as described. A move can now be made either to Y or to X, but no move can be made from Y or X.

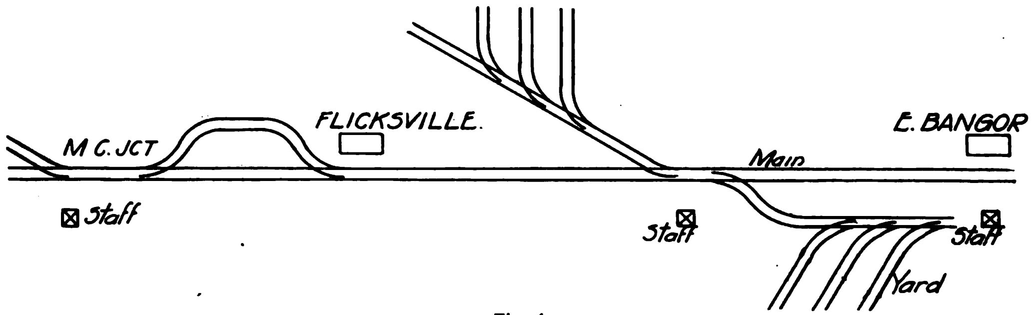

Fig. 4.

TRACK CIRCUITS AND BATTERIES*

By GEO. S. HODGINS

The ordinary track circuit used in automatic signaling is usually a battery current of low voltage, derived from 2 to 6 or 8 cells placed in a cast iron case or battery-chute sunk in the ground and protected by a substantial cast iron cap. The cast iron chute is set in the ground and there is a wooden frost cover on top. The cells of the battery are placed in an elevator which is simply an iron frame with several shelves one above the other. The cells stand one on each shelf, connected in multiple, and are raised or lowered by a rope. As the chute is 6 or 8 ft. deep, and as the battery elevator is only about half as high as the chute, the battery is well below the frost line, when lowered into place.

The battery used is, as we have said, composed of three cells. The cups containing the liquid are made of glass and at the bottom of each cup a quantity of blue vitriol is placed. Embedded in this are a couple of pieces of clean sheet copper riveted together at the centre, with ends spread something like the letter X. From the copper an insulated wire is brought to the surface of the cup. In the upper part of the cup a piece of cast zinc is suitably suspended from the edge of the cup and a wire leading from the zinc, when joined with that from the copper, forms a closed circuit.

The battery is completed by the addition of some water which is poured in until both metals are submerged. We have therefore in the glass cup copper, zinc, blue vitriol and dilute sulphuric acid. Chemical action manifests itself after a short time by the flow of an electric current if the wires are connected. Blue vitriol is a salt of copper, and is produced by dissolving copper oxide in sulphuric acid. Blue vitriol, or bluestone, as it is often called, is sulphate of copper, and is represented by the chemical formula $Cu\ SO_4$. Being crystalline it also contains what is known as the water of crystallization, and the full chemical formula may be written $Cu\ SO_4 + 5H_2O$.

The action of the battery begins after the dilute sulphuric acid has acted upon the zinc and the copper. A solution of zinc sulphate is formed in the upper part of the liquid in the cell and copper sulphate is formed in the lower part, with the liberation of hydrogen. The solution of zinc sulphate being lighter than that of copper sulphate, remains in the upper part of the cell surrounding the zinc, while the copper sulphate surrounds the sheet copper at the bottom. The separation of these two liquids takes place automatically, and with the heavier one below, and the lighter one above, the cell becomes what is called a gravity battery.

There is no absolute line of demarcation between the two fluids, but the amount of copper sulphate rising, although comparatively insignificant, nevertheless produces small copper pendants from the zinc which have to be broken off from time to time before they become long enough to reach down into the solution of copper sulphate. The chemical action taking place in the battery, when current flows may be represented by the chemical formula, as follows:

$$Zn + H_2SO_4 = ZnSO_4 + H_2.$$

This translated into English means zinc and sulphuric acid produce sulphate of zinc and hydrogen. The hydrogen, however, does not pass off in bubbles, but is seized upon for further chemical transformation where the copper is concerned. This may be represented as

$$H_2 + CuSO_4 = H_2SO_4 + Cu.$$

Translated, this formula reads: hydrogen and sulphate of copper produces sulphuric acid and copper. The reactions are apparent by the gradual wasting away of the zinc as it is dissolved and the deposition of metallic copper in the sheet copper. The copper grows while the zinc is diminished. The blue vitriol at the bottom of the cell maintains the requisite supply of dilute copper sulphate as it slowly dissolves in the liquid surrounding it. The original dilute sulphuric acid gradually changes into a solution of sulphate of zinc and the solution of sulphate of copper changes into dilute sulphuric acid. The battery operates continuously with a closed circuit until interrupted for the purpose of signaling.

The wires which come from the zinc and from the copper terminals of the battery are connected, as we have already said, in multiple, and with the three cells arranged as described a current of a little more than one volt flows. This is suitably connected to the rails and forms what is called the track circuit. The method of connection is such that for example let us say the zinc pole of the battery reaches the fireman's rail, and the copper pole is attached to the engineer's rail. The signals, operated by a separate, though similar battery circuit, stand at the entrance of the block and the battery for the track circuit is placed at the far end of the block. The rails are connected together at the signal end of the block, and thus form a closed circuit, from the copper down one rail, across the connection and up the other rail to the zinc.

This arrangement of track circuit provides that the entrance of a train into the block at the signal end, short circuits the battery and leaves the rails between the end of the train and the signal without any current, and the connection between the rails near the signals is also dead, while current flows from the battery along the rails toward the advancing train across wheels and axles and back to the battery. The connecting wire between the rails at the signal end is now dead, and this fact is made use of to operate the signals. The connecting wire does not stretch directly from rail to rail, but

*From Railway and Locomotive Engineering.