sons of it with regard to power costs which are very misleading. Some have been imprudent enough to assert its economy for power purposes in connection with uneconomical water-power plants as the means of making such developments commercially available, and several large plants for cotton mills have been developed on this line with blindness as to their true commercial value.

For the purposes of this paper we will take up the investigation, by tabulated data, from the actual everyday operation of the plants, and we shall designate the two plants as No. 1 and No. 2. No. 1 is a steam-driven mill, having a steam plant geared up with ropes, heavy headed gearing, and large tapering shafts as such plants are usually geared up in the best practice of to-day. The steam engine is an 800-H. P. Corliss cross-compound, built in 1895, with cylinders 20 and 40 × 60-in. stroke, and a rope wheel 24 ft. pitch diameter, grooved for 26 1¾-in. ropes, weighing 35 tons. This engine is being operated at an exceptionally low cost per horse-power for steam. There was in the mill during the period for which comparison of power is made 11,776 spindles and 720 looms; all the spindles and preparatory machinery were run full, but the looms did not average more than 682 per day. No 2 is an electric driven mill which rents its current from a central station and distributes it through a continuous reading wattmeter to four 150-H. P. inverted motors bolted to the ceiling in convenient locations for economical distribution of the power, and belted to the shafting. The mill has been in operation since Jan. 1, 1897. This mill had in operation during the period named above on an average of 12,448 spindles, with preparatory machinery and an average of 356 looms out of 500 in the mill. The weight of the shafting in the steam mill is approximately 136,000 lbs. and the electric mill 122,000 lbs.

From the data obtained from the steam-driven mill we have the following distribution of power during the test—for the steam-driven mill:

Total power.	Looms and shafting.	Friction.	H. P. spds.	Looms.
535	340	226	196	114

and for the electric driven mill:

Total power.	Looms and shafting.	Friction.	H. P. spds.	Looms.
418	206	149	208	60

Hence, the difference between 226 and 149 H. P., 77 H. P. must be credited to the electric mill in its present condition.*

The following points from the foregoing can be stated as existing under the present conditions: the steam mill is operating under a disadvantage of an underloaded engine; the electric mill is operating under the disadvantage of driving more shafting per motor than it will when the full complement of machinery is installed.

The steam mill requires more supplies in the shape of oil, sizing for ropes, and other necessary incidentals due to the method of transmitting the power. The electric mill has cost nothing for its motors in six months of operation, not even the necessity of putting oil in the bearings, which was simply renewed once in that time as a precaution. The convenience of operating any section of the mill *ad libitum*, without reference to the other sections, is an advantage which is felt in dollars and cents in plants using the electric transmission.

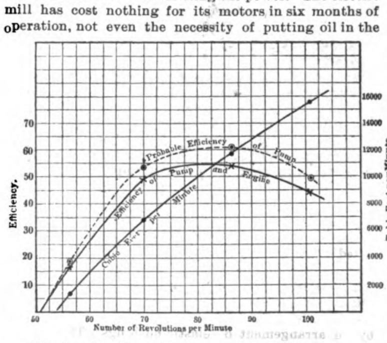


Fig. 5.—Results of Tests on a Centrifugal Pump.

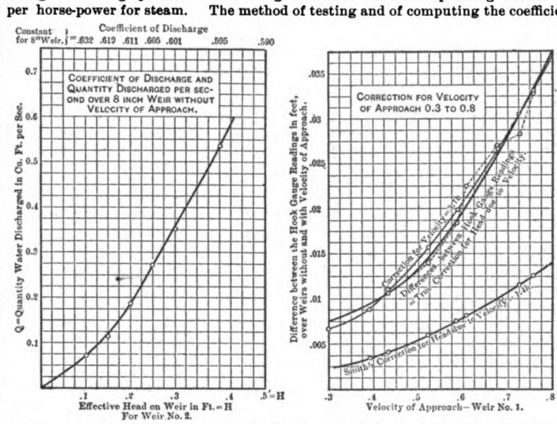
The question which arises as to whether a generator directly connected to an economical type of engine to produce the power would consume the difference in the frictional horse-power, is one which can only be answered from data from institutions having such plants.† It is the author's opinion that this difference of power would not be exceeded, and he hopes subsequently to give more specific data from further experiment from the actual operation of these two plants under better conditions, viz., when both mills are completely filled with machinery and motors and engine run at their full load; also in obtaining the efficiency of direct connected engines and generators. It must be borne in mind that, unlike a machine shop and other manufacturing establishments, where a large amount of shafting is required to cover the ground and where intermittent power is used, a cotton mill drives in useful effect 95 per cent. of its shafting and uses actually in continuous operation almost the maximum power at all times.

* In this case, it will be noted that about 42 per cent. was lost in friction with the steam-driven mill and 35 per cent. in the electric driven mill.
† See *Railroad Gazette* of Nov. 19, 1897, p. 820, for some information covering this point.

TEST OF CENTRIFUGAL PUMP, ETC.—BY PROF. R. C. CARPENTER.

The paper first contained a description of the plant in which diagrams were used in explaining the details. The method of testing and of computing the coefficients of discharge were then considered at some length. The results which would probably prove of most interest to our readers is given in the accompanying diagrams, Figs. 5, 6 and 7, which show the efficiency of the pumping machinery. The tests which were made show the indicated horse power for each engine corresponding to different heads and different volumes of water discharged. The work of raising the water against the head for the stated

(*Continued on page 854.*)



Figs. 6 and 7.—Observations and Results Showing Sibley College Tests on Effect of Velocity of Approach.

A Government Armor Works.

Congress will be asked this winter to appropriate $3,000,000 to erect a mill for manufacturing armor for warships, though there are now two plants in this country equal to the capacity of the proposed mill, and the demand for armor will probably not keep the proposed mill running half of the time. The prices paid to the Bethlehem and Carnegie companies were high enough to remunerate those companies for erecting the necessary machinery, which is almost or wholly useless for other purposes. Investigation by the Navy Department showed that $400 would be a fair price, and a Senate Committee reached the conclusion that a lower figure would be enough. At $400 a ton the Bethlehem and Carnegie companies were willing to make contracts; at any rate, they were willing to reduce the prices substantially.

But the Illinois Steel Company represented that it could make armor for $240 a ton, and it secured the introduction of a bill making that figure the limit. Congress did not quite take the company at its word, but it did limit the price to be paid to $300. The Bethlehem and Carnegie companies refused to make armor for this price, and the Illinois Steel Company explained that it had no plant for the production of armor plates, but it would erect such a plant if it had an exclusive contract for all armor for 20 years, the minimum amount to be taken annually being 6,000 tons.

The Illinois Steel Company had procured the fixing of the price below what the other two companies would accept, and it had no means of doing the work itself, and a naval board has been figuring on a government mill. This mill is to produce 6,000 tons a year, the minimum stipulated for by the Illinois Steel Company. As that will cover more than two battleships, and we trust we are not going to build two battleships every year, this factory would lie idle much of the time. The Navy Department knows very well that it costs vastly more to build a ship in a government yard than it does in a private yard, and after the government has spent $3,000,000 in erecting an armor mill, which will be idle half the time, it will find that its armor costs it a good deal more than the Bethlehem and Carnegie companies asked.—*Journal of Commerce.*

Automatic Semaphore Block Signals on the Illinois Central.

As recently announced in the *Railroad Gazette*, the Hall Signal Company has furnished for the Illinois Central a large number of automatic block signals, which are to be operated by electric motors, a ⅛-H. P. motor for each signal. Exposed semaphores are used, of standard size, and distant, home and starting signals are provided at each station. The signals stand normally at danger, approaching trains clearing them, if the track is clear, by means of a preliminary track circuit, which the wheels shunt at a point some distance before reaching the distant signal. From information furnished by Mr. W. J. Gillingham, Signal Engineer of the road, we now give some further particulars concerning these signals, with a diagram of the electric circuits by which the signals are automatically moved by the passage of trains.

That portion of the Illinois Central Railroad lying between Carbondale and Cairo, 57 miles long, a part of the St. Louis Division, is an extremely busy line. It is the throat, so to speak, through which passes the traffic between the Chicago, Amboy and St. Louis Divisions on the north and all the lines of the company south of the Ohio River. Until 1896 all this traffic was done on a single track, but the difficulties of operation became so apparent that a second main track was laid between the points mentioned. Most of this line lies in a spur of the Ozark Mountains extending diagonally from northwest to southeast through the southern part of Illinois. The sharpest curves and steepest grades are between Dongola and Bosky Dell. The gradients and curves are shown on the accompanying diagram, Figs. 1 and 2. On this section automatic block signals are now in use between Cobden and Makanda, and they are being put in from Cobden to Dongola on the south and from Makanda to Bosky Dell on the north, a total distance of 28 miles.

After careful deliberation it was decided to use the standard semaphore and fittings, identical with those used in interlocking practice, except that certain modifications were made to reduce friction by the introduction of ball bearings. In 1894 the Illinois Central had erected in Chicago an automatic electric semaphore signal (which is still in service) for the purpose of experiment and to determine the reliability and efficiency of an exposed semaphore signal worked by an electric motor (fixed to the signal post). The signal is located on the lake shore where it has been subject to all conditions of weather, and as a result of those tests the company decided to adopt this type on the St. Louis division.

The signals are located with special reference to the grades, so as to make it as easy as possible for trains to start after having been stopped at a signal; the uniform length of blocks being made secondary to this. The locations having been thus determined on the plan, the next step was to make the ground locations with reference to the line of vision, bearing in mind the grades. In determining these locations the division officers and the signal department co-operated; and it is of interest to note that in no instance was it necessary to vary a signal more than 200 ft. from the original location; and there were but four instances where the home signals could not be sighted from a good distance. As previously stated, the blocks are not of equal lengths, but at the stations and at all groups of switches, both home and advance ("starting") signals have been provided, the home signals permitting trains to pull into stations to work when the block in advance is occupied. The advance signal is placed far enough ahead of the switches to permit the longest train to do switching without delay when the next succeeding block is occupied.

The complete application, extending from Bosky Dell to Dongola, consists of 56 signals electrically operated and controlled, all of the standard semaphore type. The accompanying diagram, Figs. 3 and 4, showing the arrangement of circuits and locations between Cobden and Makanda, illustrates the plan followed throughout the entire application; but the complications are such that a diagram of a single block is shown in Fig. 5, which, with the explanation appended, will make the arrangement easier to understand.

Each block section is provided with a distant and a home signal and at stations there is also an advance signal. Each switch is provided with a vibrating bell. The signals being normally in the caution and stop positions, a train approaching the distant signal will, upon entering the preliminary section (assuming that the block in advance is unoccupied), clear the advance, home and distant signals. Where switches are located in the block the vibrating bell sounds simultaneously with the entrance of the train on the preliminary section. If, however, the block controlled by the advance signal is occupied, the signals are not cleared by the train on the preliminary section, but upon the train passing the distant signal the home signal clears and the bells sound.

The application of vibrating bells at switches was first made on the Chicago terminal of the Illinois Central. While it is true that theoretical objections have been made to their use, from a practical standpoint they are believed to be more efficient than visual indicators, not only because they more effectually arrest the attention but because they give indication or warning to a greater number of trainmen. Instructions governing trainmen using main line switches within the block system are very explicit. They are not permitted to move a switch for the passage of a train from a side track to the main track or from one main track to the other when the bell at such switch is sounding, nor to proceed after reversing a switch for a siding unless the bell begins to ring when the switch is turned. It is apparent, therefore, that if on opening a switch the bell does *not* sound, there is necessity for extra precautionary measures, and the trainmen are governed accordingly.

The apparatus for operating the signal directly necessarily differs from that operating disk signals, but it is of simple construction, and the likelihood of failure to perform its function is very remote, in fact is no greater than with disk signals.

The distinctive features of these signals are the method of bonding the rails for track circuit, the vibrating bells

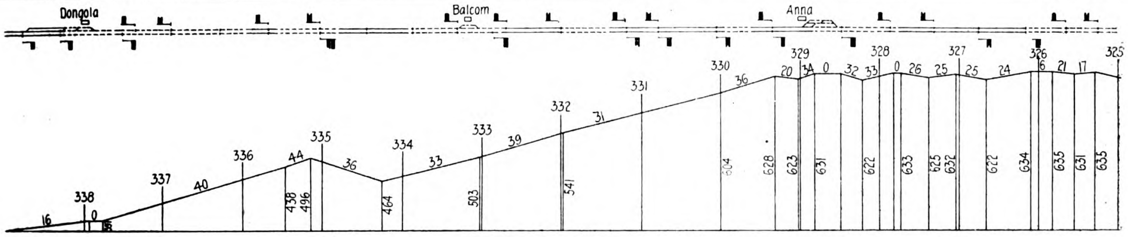
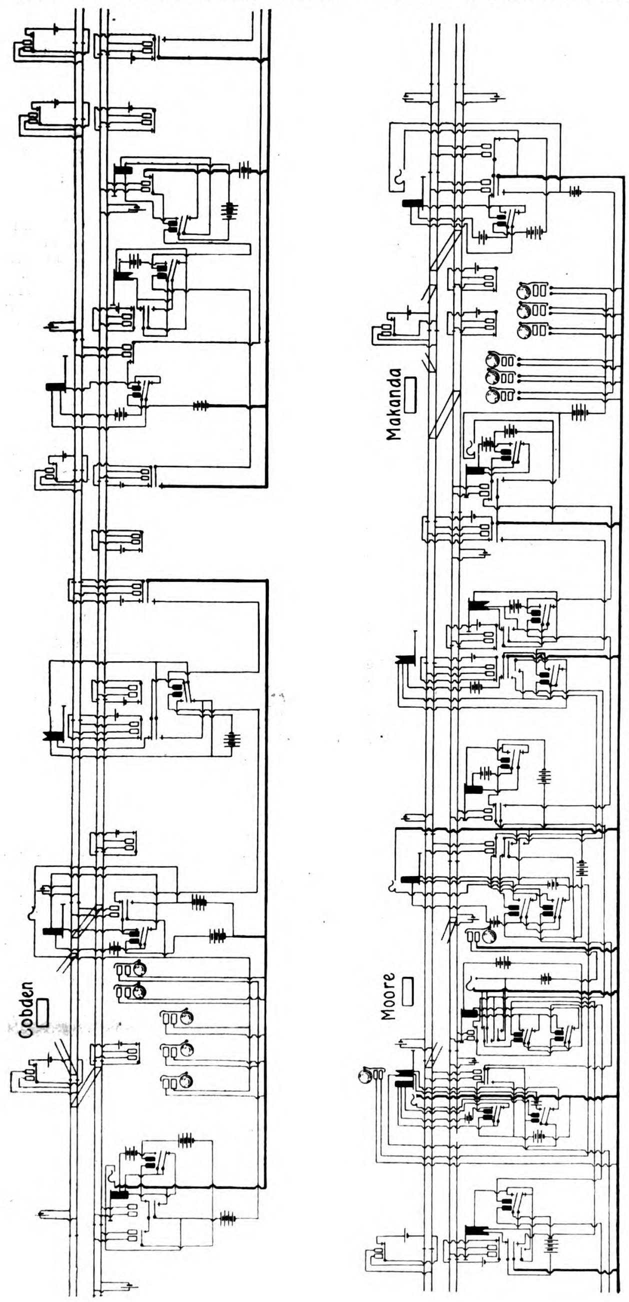


Fig. 1.—Profile and Diagram of the Line of the Illinois Central Railroad from Dongola to Bosky Dell, 28 miles—*Continued in Fig. 2.*

NOTE.—In the diagram each line represents a track; solid lines represent tangents and dotted lines curves.

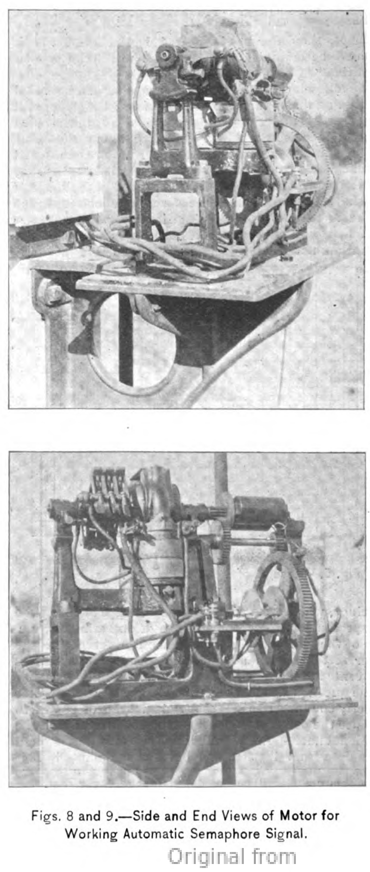
at switches, and the manner in which the semaphores are operated. Until quite recently the practice has been to bond the joints by fastening the wires to the base of rail; but this has not proved altogether satisfactory, for the reason that bonds are sometimes forced out or broken, either by contact with the ties or by shearing off by the spikes in consequence of creeping of the rails. So much trouble was experienced from the latter cause on the approaches to the Cairo Bridge that it became necessary to provide some other form of bonding. The method now pursued both on the bridge and on the St. Louis division is to bond through the web of the rail, using two wires, in substantially the same manner as that employed on electric street railroads. It obviates entirely the troubles experienced in the other method, and reduces the cost of replacements.

In the operation of the semaphore a one-sixth horse power motor is used, the power necessary to operate it; varying (according to the resistance of circuit) from 10 to 16 cells of Edison-Lalande type S battery. The motor, as will be seen from the illustrations, is fastened to the side of the signal post, directly above the counterweight lever. Attached to this lever is a stranded cable ¼ in. in diameter, the other end of which, extending upward to the motor, is fastened to a drum keyed on to a shaft geared into the armature shaft as 25 to 1. The drum shaft is provided with a worm into which is geared a circuit-closing device for controlling the motor and brake circuits. On one end of the armature shaft is fastened a soft iron circular disk which, in connection with a high resistance coil, acts as a brake to stop the motor, there being lateral movement enough in the shaft to permit of the disk being attracted and held by the brake coils when they are energized. On the base supporting the motor are insulated strips forming a part of the circuit-closing device. The action of this circuit-closing device is such that when the block is unoccupied and no train is in the preliminary section the battery is on open circuit. When a train enters the preliminary section a circuit is automatically closed through the motor, which thereupon causes the signal to assume its clear position. Just before the signal reaches the clear position, the motor circuit is automatically broken, and a circuit is closed through the brake magnet coils, causing a retardation of the movement of the arm and bringing it without undue shock against the stop, where it is held by the brake magnet. In this connection it should be understood that the circular disk is never in contact with the brake magnet poles, the brake being purely magnetic and not a friction device. Thus there is no possibility of sticking due to residual magnetism. The signal remains in the clear position until the first wheels of the train pass the signal, when the brake magnet circuit is broken and the signal returns to the stop position; its speed, however, being retarded just before the signal arm reaches the stop by the counter current developed in a circuit at that time automatically closed through



Figs. 3 and 4,—Electric Circuits, Rail and Wire, for Automatic Block Signals, between Cobden and Makanda—Illinois Central Railroad.

The right-hand end of the upper diagram joins the left-hand end of the lower.



Figs. 8 and 9.—Side and End Views of Motor for Working Automatic Semaphore Signal.

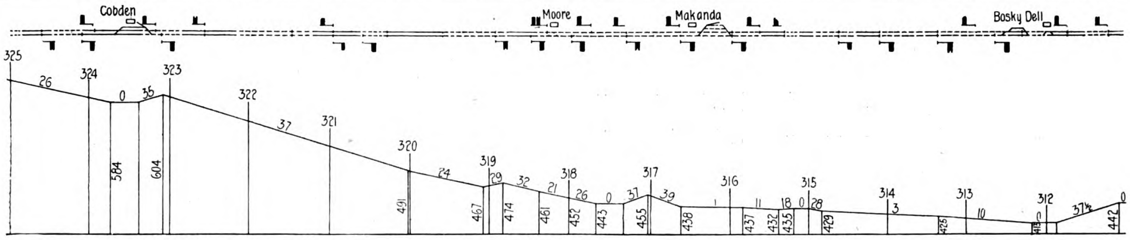


Fig. 2.—Continuation of Diagram Shown in Fig. 1.

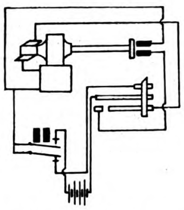


Fig. 10.—Wiring of Electric Motor.

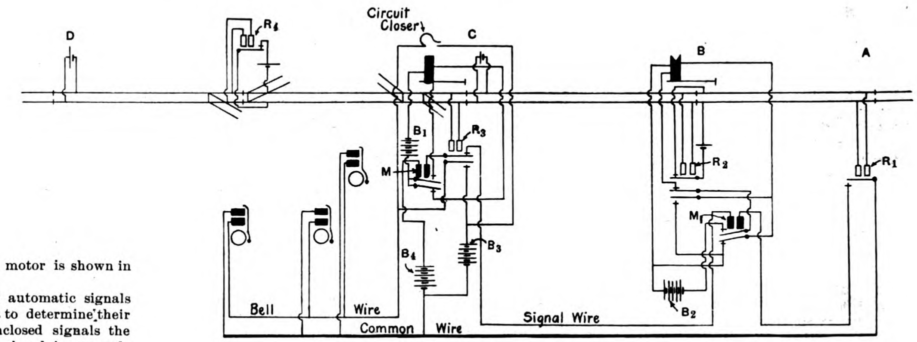


Fig. 5.—Electric Circuits for Automatic Signals for one Block Section.

the motor only. The wiring of the motor is shown in Fig. 10.

In considering the application of automatic signals generally, the important question is to determine their reliability and efficiency. With enclosed signals the apparatus directly controlling the signal is not subjected to wind, rain or snow, and the question of a normally danger or normally clear system becomes one of individual preference. With semaphores, however, the conditions are changed, and it becomes a matter of expediency that the signals be normally at danger. The actual time a signal is in the clear position (for train movements) is very much less than in the danger position (this will vary with volume of traffic); but assuming it to be relatively as one to five, the failure of apparatus should be on the side of safety, and the tendency of the signal arm to stick in sleeting or snowy weather is certainly greatest in the position at which it is the longest time at rest, and in contending against such possibilities, it must be remembered that the failure to move from the stop or danger position is safe, while failure to move from the clear position is likely to be unsafe. It may be argued that the danger of failure is remote, but whether this be true or not the principle of keeping signals normally at danger is correct, and it presents no obstacle to economical and successful operation.

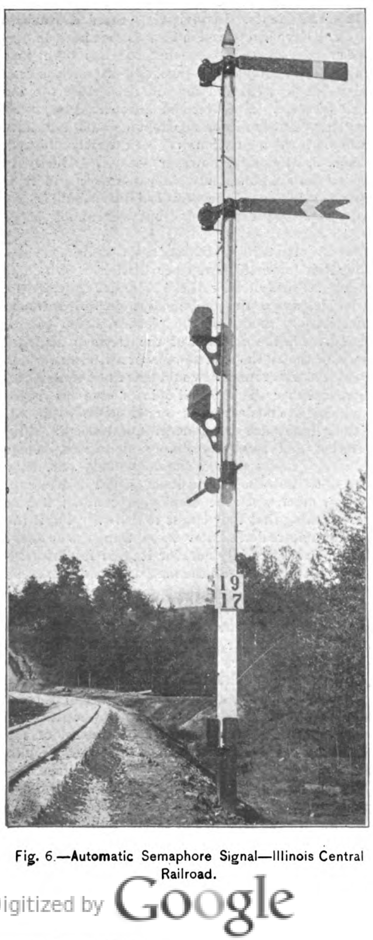


Fig. 6.—Automatic Semaphore Signal—Illinois Central Railroad.

Number 8 E. B. B. iron wire is used for the line on the telegraph poles, and all batteries are placed underground; those for the track circuit in cast iron chutes and for the motors and switch bells in cedar tubes specially made for the purpose.

The cost of maintenance and operation of these signals, so far as it has been possible to judge from experience thus far, will be but little if any greater than that of disk signals.

This article is published simultaneously in the *Railroad Gazette* and the *American Engineer, Car Builder and Railroad Journal*, by special arrangement.

EXPLANATION OF DIAGRAM, FIG. 5.

A B, *B C*, *C D* are sections of track constituting a block with its distant signal and preliminary circuit. R_1, R_2, R_3, R_4 are track relays; M and M_1 are relays directly controlling the motor circuit; B_1 and B are the batteries operating the motors, B_3 is the battery for operating the bells, and B_4 is the battery for operating the relays M and M_1. All the track relays are normally closed and the relays M and M_1 are normally open. The entrance of a train on the section *A B* shunts the track battery from track relay R_1, closing the path for battery B_4 through back contact point of relay R_1 and thus energizing relays M and M_1. The energizing of relay M closes the front contact on that relay, thus completing the circuit for battery B_1 through this contact and the home signal motor, thus pulling this signal to the clear position. A similar result follows with relay M_1, battery B_2 and the distant signal. When the home signal is in the clear position a circuit is closed through the circuit closer, battery B_3 and the bell magnets, causing the bells to sound at all switches in the section of track controlled by this signal. When the train enters the section *B C*, relay R_2 is demagnetized and the distant signal arm resumes the horizontal position, this being effected by the breaking of the circuit for battery B_2 through the opening of the front contact of this relay. The train entering section *C D* demagnetizes relay R_3 and the home signal resumes the stop position by reason of the breaking of the circuit of battery B_1 through the opening of the circuit through relay M, which is effected by the opening of one of the contact points on relay R_3. It will be noticed that the home signal is in the stop position and the circuit closer open; but the bells will continue to sound as long as the train is in the section *C D* because a circuit is completed through the back contact point of R_3, battery B_3 and the bell magnet coils. When the train passes out of section *C D* all apparatus is restored to the normal position.

If, at the time a train passes *A* the block *C D* is occupied by a preceding train or car, or a switch is open, the demagnetization of R_1 by the action of the wheels has no effect on relays M and M_1, for the circuit of battery B_4 is held open at R_3 by the preceding train (or car); and consequently the signals remain at danger and stop the train at *C*.

The lower armature of relay M_1 when down—that is, when in the position that it takes when a train passes it and the signal at *B* goes to the horizontal position—closes a circuit through the path indicated by the line shown at the underside of the arm of signal *B*. This circuit, which has no battery, runs through the motor, and the office of the lower armature of relay M_1 is to close a circuit through the motor, outside of the motor battery, and thus aid in retarding the motion of the signal arm as it approaches the end of its stroke. The relation of relay M_1 to the motor is shown in Fig. 10. Relay M has connections to its motor similar to those of relay M_1.

If, while a train is between *B* and *C*, a following train should pass *A*, this second train, by holding M_1 closed, would prevent the closing of the no-battery circuit described in the preceding paragraph; to avoid this the dropping of the third armature of R_2, which is effected by the presence of the first train in the section *B C*, is made to close the no-battery circuit around M_1.

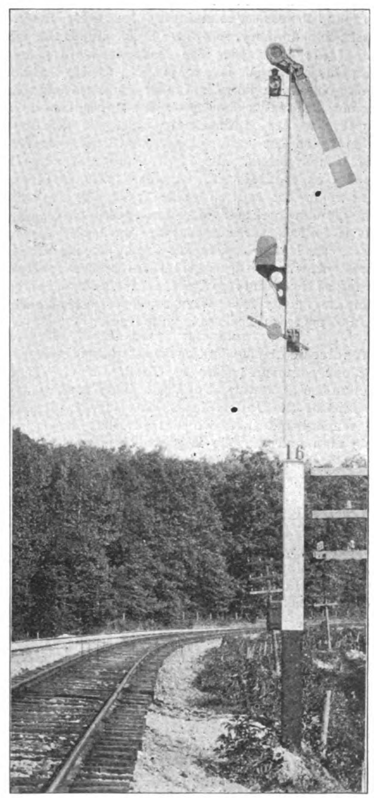


Fig. 7.