	Total Mileage Worked by the Block System.	Total Mileage of Manual Block.	Total Mileage of Automatic Block.
Jan. 1, 1901	25,814.6	23,525.9	2,288.7
Jan. 1, 1903	29,733.7	25,856.7	3,877.0
Jan. 1, 1904	39,263.9	35,007.1	4,391.3
Jan. 1, 1905	44,574.7	35,560.5	5,116.3
Sept. 30, 1906	48,743.2	41,916.3	6,826.9
Jan. 1, 1908	58,678.7	47,875.7	10,803.0
Jan. 1, 1909	59,548.7	47,358.1	12,190.6
Jan. 1, 1910	65,758.0	51,520.3	14,237.7
Jan. 1, 1911	71,269.1	53,557.6	17,711.5

CONTACT SIGNALS FOR ELECTRIC RAILWAYS.

CARL P. NACHOD.

The following article is a summary of the arguments presented by Mr. Nachod at the meeting of the joint committee on block signals of the Engineering and Transportation and Traffic Associations, held in Chicago on March 22, 1911 (see The Signal Engineer for April, 1911, page 156).

Although the principle of the track circuit for automatic signaling is not new, and its theoretical advantages were early recognized, yet refinements of electrical design, together with the delicacy of the apparatus required, delayed its introduction. There was, consequently, a previous development of signaling by means of so-called "track instruments," which, by mechanical movement as the train passed over them, operated a switch in an electrical circuit to control the signals. It has so happened in the evolution of signaling that for steam roads these have been almost entirely discarded or relegated to the less important functions in favor of the continuous track circuit.

It is conceivable that a train in a block may control its signals in two ways: (1) by a change in certain electrical conditions due to the actual presence of the train in any part of the block and regardless of its movement therein, which is the system of track-circuit signaling; and (2) by the fact that a train has passed a point where a registering device, as a track instrument, is located. This may be termed an intermittent contact system, or, for brevity, a contact system.

The fundamental argument in favor of the track-circuit system is that a train in the block, having set signals, will hold them regardless of what other trains may do, and of how the signals may fail in other respects. It admits of a design such that when a signal failure occurs the signals will indicate as though a train were in the block, when it is not. This is technically known as a "danger failure." A failure indicating a clear block when it is really occupied is known as a "clear failure."

The essential distinction between the two methods may perhaps be illustrated by an analogy. For the contact system, suppose that every possible entrance to a block of single track were guarded by an agent, such that every train entering the block were to receive a token, and every train leaving the block were to give up the same; then the agents checking up the tokens among themselves could determine at any time the condition of the block as to the number of trains in it, and in what direction they were proceeding. Granting the accuracy of the agents, the only limitation of operation in this case would be that the trains could not be divided within the block limits.

In the analogy for the track-circuit system the signal indication may be compared to that given by the eye of an observer standing in a tangent track. This is admittedly an imperfect comparison, for the track-circuit indication usually shows nothing more than the fact that at least one pair of wheels is within the block limits.

It is plain, then, that, as far as indicating that a train occupies the block or not, the two systems are entirely equivalent; curiously enough, a fact that the protagonists of track circuits seem loath to admit. Also that, of the two, the contact system gives the more complete information.

As applied to steam roads, the track circuit requires a source of energy continuously dissipated—until recently batteries with their high cost of maintenance, or else a separate power line fed from a central source, and therefore liable to complete accidental failure. It requires particular road-bed conditions affecting the insulation of the rails such as inhibit its use in certain locations or conditions. It requires greater electrical continuity of the rails than is afforded by the mere mechanical connection of the fish plates; and an electrical discontinuity at intervals by insulated rail joints, which are mechanically poor and depreciate in service. Moreover, the greatest power available, as limited by the leakage between rails, is so minute that the apparatus is of delicate and expensive nature. Owing to the use of the earth as a return conductor by the ever-increasing number of electric railways, these relatively powerful currents may conflict with the small signaling battery current and cause a most dangerous class of failures.

In applying the track circuit to electric railways, further difficulties are encountered. The rails must be divided into blocks for signaling, but maintained electrically continuous for the return of the traction current. A separate current, having different characteristics from the traction current, must be superposed on the rails, and relays selective thereto provided; nor can the convenient traction current already at hand in practically unlimited quantities be utilized for such signaling. All this means additional apparatus and greater cost.

With this review of track circuits, we may consider the intermittent contact system. The ideal contact would be made by each car separately, some part of the car not added for the purpose, directly affecting an electric circuit, the contact device itself not being moved by the passage of the car. The parts practically available are the car wheels, the third rail contact shoes or the trolley wheel.

The car wheels may be used with two short lengths of insulated rail at the block terminals, connected as setting and clearing sections such that the wheels will either close or shunt a relay across each section. The wheels of a train are too numerous and pass too rapidly to be recorded separately on a counter, as for permissive signaling; and to make the rail sections of such length that a car will be recorded as a unit will also cause the entire train to be recorded as a unit. This means that the time of contact, which should be kept as short as possible, will be that required for the whole train to pass over both sections. While any part of the train is on a section, some parts of the signal apparatus are then inoperative. In order to avoid this, the signal apparatus must be further complicated, every complication being, of course, a source of weakness. Even with this incorporated, however, should a pair of wheels of the train touch the first section, then the entire train must pass through and out of both sections in order to record the train direction properly, and this would be inconvenient for shifting, greatly limiting flexibility of train operation. Should two trains leave the block too closely together, only one would be registered out; but should two enter too closely, only one would be registered in, and when the first left the block apart from the second, there would then follow a clear failure. There will always be a danger condition possible, in that a failure of insulation between the rails on the clearing section will clear the signals with the train on the block.

With regard to the manner of energizing the rail sections, if a battery is employed, it will require considerable maintenance. To use the power in the trolley line, a high resistance may be connected between trolley and ground and the rails energized by a tap relatively near the ground terminal in the manner of a potentiometer. This is objectionable because very wasteful of energy, and because an open circuit in a resistance unit would place a high voltage on the rail, with danger to life.

We think the disadvantages of the insulated rail section as enumerated above are so great as to condemn it, even though at first sight it seems attractive because operated by the wheels, which are always on the rails.

Contact with an insulated third rail section may be made by placing it on the opposite side of the track from the continuous third rail and connecting it by wiring through the signal relay to ground. Since the car has two contact shoes on each side, and connected together, the relay is actuated by the bridging of the continuous third rail with the contact section through the car shoes. This arrangement has the advantage that the clearing connection is not likely to be made accidentally, to do which would require a bar across both contact rails.

It is also possible to place shorter insulated sections directly into the continuous third rail, and to insulate each from the other and from the third rail. The contact would be made by the fact that the two shoes on the same side of the car are connected together. The objections are that there would be the high voltage between the insulated sections, and the signals might easily be cleared by the accidental dropping of a metallic object on the third rail at the insulated section. The control of signals through an extra contact rail is far from a general solution since comparatively few electric railways are third rail.

In considering the trolley as a contact maker the most obvious objection is that it may leave the wire at times. It should be remembered that with modern high-class overhead construction maintained in good alinement this is comparatively rare; and it would be still more unusual that the wheel should leave the wire at the contactor. Excepting this, it has most advantages of the ideal contact maker for trolley roads. Among these are: it is out of the way of interference with other traffic as of teams or of malicious interference; it does not require the paving to be disturbed; it is not easily short-circuited; it may be made without moving parts and subject to small stresses and therefore requiring almost no maintenance. Since the power for operation of the signals when taken from the trolley line is not minute, but may be as great as desired, the time of contact to operate the magnets may be reduced to the minimum, which means that the trolley contactor can be quite short, so that the problem of simultaneous operations is greatly simplified. This is still further reduced in a mechanical type of trolley contactor arranged so that the wheel throws a finger or pendulum in its path one way or the other, according to the direction of the car. This design, however, means maintenance of moving parts in an inaccessible location, serious problems in inertia due to high speeds and mechanical complications introduced to prolong the excessively short time of contact.

A contactor which operates the plunger type electro-magnets of the relay at car speeds of 55 miles per hour was described in *The Signal Engineer* for February, 1911, page 49.

In a trolley-operated signal system with power supplied by the trolley line it is necessary that the wheel should be on a live wire at the contactor, in order to operate the signals. But this operation of the signals can be insured by placing the signal aspect in advance of the trolley contactor and imposing the additional discipline that the motorman shall observe the change of signal produced by his car at the contactor. The signal must be so constructed as to act affirmatively, i. e., to make a change of some kind on the aspect by every passage of a car under it.

A disk signal for day indication and a colored light signal for night, both being simultaneously displayed, can be easily read by day under ordinary conditions from 800 to 1,000 feet, and as the braking distance is about half of that, they would seem to be sufficient. We are of the opinion that, as a result of experience, the disk signal is favorable for most electric railways, and its low cost, on account of its being entirely protected from adverse weather conditions, makes it admissible where the more expensive semaphore mechanism would be out of the question. It should be understood, however, that a contact signal system could utilize any kind of aspect, it not being limited in this regard in any manner.

It must be recognized that signals on electric railways can be much more favorably read than on steam roads, for these reasons: The driving of an electric car requires less mental and physical effort than of a steam locomotive, therefore there is less distraction on this account; there is no steam, smoke or flying cinders to obscure the vision; the motorman is most favorably placed at the head of the car, and the braking power is relatively very much greater.

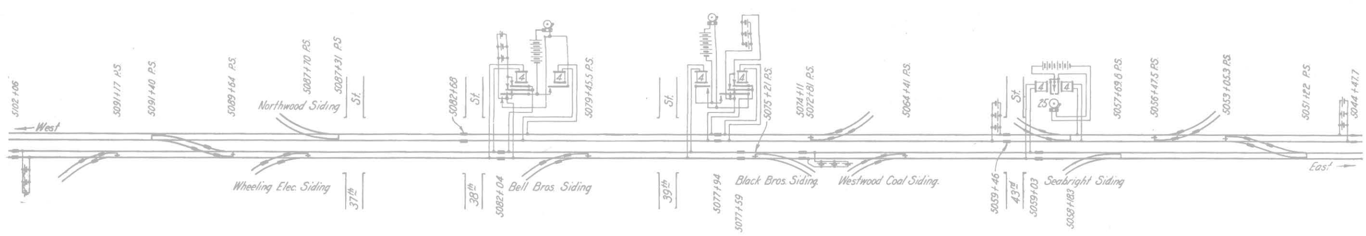
Regarding the use of distant signals, we believe that in the majority of cases these would not be required, as a conspicuous siding sign, properly placed, would call the motorman's attention that he is approaching a signal that he must read.

The great advantages of a trolley contact system are: the simplicity and small quantity of the apparatus; ease of installation; no disturbance to track; low cost; low maintenance; power for operation already at hand. The field for such trolley signals is eminently not for what is known as intensive signaling, but rather where comparatively few signals are spread over a large territory.

DOUBLE-TRACK CROSSING BELL CIRCUIT.

BY G. H. DRYDEN.

The plan shows a double-track crossing bell circuit governing bells at 38th, 39th and 43rd streets in Wheeling, W. Va., on the Baltimore & Ohio. A west-bound train passing 43rd street starts the bells at 39th and 38th streets. The former stops ringing when the train has passed 39th street, and the latter continues ringing until the train has passed it. A train on the east-bound track starts both bells as soon as it enters the section, and each bell cuts out as it is passed. The bell at 43rd street is on an independent circuit. This arrangement eliminates all line wires and pole fittings and is very satisfactory in operation.



Wiring Diagram for a Double-Track Crossing Bell Circuit at Wheeling, W. Va.

An ingenious scheme to prevent the effects of vibration on relay contacts has been worked out by the signal department of the Erie and put in service temporarily on that road. Certain relays, the back points of which control automatic and other signal circuits in connection with the reverse traffic route locking on the Erie Terminal in Jersey City, N. J., are placed in relay boxes on the high trestle structure which carries the tracks from the Jersey City yard to the entrance to Bergen cut. It was found that the vibration due to passing trains was sufficient to cause the back points of the relays to vibrate so as to open the circuits momentarily, thereby causing some of the signals to "kick off" occasionally. To remedy the trouble a circular rubber hot water bag, inflated with air, was placed beneath each relay. It has been found that by this means the trouble has been completely overcome, as the bags absorb all shocks and do not transmit enough vibration to open the relay points.

This scheme cannot be used permanently on account of the rapid deterioration of the rubber, and other means of avoiding the troubles due to vibration are being considered. The plan of putting in a supplementary shelf supported by spiral springs will probably supersede the temporary scheme above described. We are indebted to W. H. Willis, signal engineer of the Erie, for the foregoing information.