is $0.0187 per track circuit per day. It is difficult to make any direct comparison with gravity on an assumption of probable normal future prices for the caustic soda type of battery.

In the gravity battery test 3 cells of battery were connected in multiple on each track circuit without any external resistance. Had a slight external resistance been connected in the leads the battery would have made a somewhat better showing. In the comparisons no account has been taken of any difference in the cost of labor for maintaining the battery. As a matter of fact no difference is being made in this territory in the salary of the maintainer or his assistant, and, inasmuch as maintainers' sections at this point are quite long already, it is not anticipated that it will be possible to lengthen them out any if BSCO should be adopted to replace gravity batteries on all track circuits.

Wm. Robinson, Inventor of the Track Circuit

August 20 is a date which should occupy a prominent place in the calendar of signaling, for on that day, 44 years ago, the basic patent was issued on the closed track circuit. The man to whom credit for that invention is due—Dr. William Robinson—is now living in Brooklyn, N. Y., and in spite of his 76 years still refuses to consider any suggestions that he should give up active work. His own story of the incidents connected with his early studies in track circuit and signal operation is full of interest for present-day signalmen, and contains many facts of historical value. It is retold below from a personal interview amplified by information from his writings.

Dr. William Robinson.

In 1867, when he began work on the problem of controlling signals by moving trains, Dr. Robinson was a young man of 27, living in Brooklyn, New York, where he had lived the greater part of his early life. The total mileage of railroads in the country at that time was less than 40,000, and, compared with present standards, speeds were low and equipment crude. The accident problem had already become an important one, however, and it was through the consideration of a number of collisions that the inventive brain of this recent college graduate was fired to make the attempt to supply the roads with a means for preventing such occurrences. While Mr. Robinson had recently finished a technical education in Wesleyan University of Middletown, Conn., and had done some valuable work in the line of mechanical engineering, he entered an entirely new field in his researches on the track circuit. In spite of this and other handicaps, however, his invention embodied principles which were at that time declared to be contrary to all electrical laws, and, as the basis for practically all automatic signals installed since that time, has been of incalculable value to the roads in increasing safety and economy of operation.

His first work was with a model employing track instruments and line wires, the instrument at the entering end of the section setting the signal to stop, and, at the leaving end, clearing it. The control of the signal was effected by a relay energized through a contact at the entering track instrument, and de-energized by short-circuiting through the action of the releasing track instrument. This working model was exhibited at a fair held by the American Institute of Electrical Engineers in New York City in 1870, at the conclusion of which Mr. Robinson sent the remaining circulars which he had prepared to railroad companies throughout the country. This was probably the first published advertising of automatic signals distributed in this country; at least, it was the first advertising which brought results, for subsequent to an inquiry received from William A. Baldwin, general superintendent of the Philadelphia & Erie (now part of the Pennsylvania), arrangements were made with Mr. Robinson to make an installation on this road. Theodore N. Ely, who retired as chief of motive power of the Pennsylvania system in 1911 was at that time assistant general superintendent of the Philadelphia & Erie, and furnished Mr. Robinson the facilities and materials necessary for installing his system during 1870, at Kinzua, in northwestern Pennsylvania.

This system operated as it was designed to operate, but it was very soon apparent to Mr. Robinson and the others who were watching the installation that it was far short of perfection. He therefore determined to develop a system in which every pair of wheels in the train would have control over the signals throughout the entire section, and in which the signals would go to danger by gravity, electricity being used to hold them at clear. Having previously used the short-circuiting principle in his model and in the installation at Kinzua, he turned to this for his improvement, and in 1871 applied for a patent, which was granted the following year, broadly covering the closed track circuit. The first public demonstration of this system was at the State Fair in Erie, Pa., in 1872. A miniature car operating over a model section of track, including one track circuit, was installed in one of the buildings and a gong was located outside of the building, connected to a battery through the back point of a relay in the track circuit of the model. As this gong could be heard all over the grounds when the car was run on the insulated section it naturally attracted large crowds of people, and, among the crowd, a number of practical railroad men viewed its operation.

The improved system was explained to Mr. Baldwin, who requested that it be installed at Kinzua in place of the open-circuit system. The same signal mechanism, relay, battery, switches, etc., were used in the new installation, the only addition being the electrical connection of adjacent rails and the insulation between rails at the end of the section. The light rails in use at that time were connected at the joints by a 4-ft. wooden bar on the outside and a 12-in. iron fish plate on the inside. There were two holes through the fish plate, allowing one bolt for each rail and four holes through the wooden bar, two in each rail. By careful attention to each joint—filing off rust and tightening up bolts—they finally succeeded in getting a current working through the entire length of the first section, about a mile and a quarter. It was evident, at once, however, that a bond between rails would be necessary for reliable and continuous service, and Mr. Robinson conceived the idea of using wires, the ends of which were to be driven tightly into holes drilled in the adjacent rails. As an alternate form, he proposed to secure the ends of a wire or plate to the adjacent rails by soldering. On account of the difficulty and expense of boring holes in all the rails and the reluctance of the railroad to consent to such an innovation, and on account of the seeming impracticability of heating up the rail quickly enough to solder a wire, he was forced to develop other means for connecting the rails. One of these methods which proved successful used an elastic split spring at each end of the wire, held in place by small blocks secured to the ties and having one end resting on the flange of the rail. The movement of the rail caused a slight frictional movement between the rail and the spring, thus preserving a good electrical contact.

His battery on these experiments consisted of an early form of bluestone cell, and his relays were adapted from telegraph sounders. He first used four cells on track circuits, but later reduced this to one and developed a scheme for providing two which would be used alternately, one being switched out of the circuit and the other in at every operation of the signal. He found that by this means he could get 35 to 40 days' service out of each cell. Some of his relays were wound to a resistance of about one ohm, but most of them were a little higher. The signal mechanism was a simple electro-magnetic arrangement for displaying or withdrawing a colored disc from an opening in the top of a small cabin built beside the track. The connection which displayed this signal also rang a loud gong, which, it is stated, could be heard for a distance of half a mile.

The second installation was made at Irvineton, Pa., about 18 miles west on the same line. It was practically the same as the improved installation at Kinzua with the addition of a bell indicator in the station to repeat the position of the signal, and also a manual switch by which the agent could set the distant signal at danger at any time and receive a return signal indicating that it had gone to danger. During the early seventies Mr. Robinson made other similar installations on the Philadelphia & Erie and other roads in Pennsylvania and Maryland and sent out a number of circulars to railroad men in an endeavor to call their attention more directly to his new system. As an indication of some of his conceptions of the possibilities of the new system the following is quoted from one of his circulars issued about this time:

"A train when it leaves a station, and at various points as it passes, indicates to the stations along the line its location, direction, rapidity and length; thus all necessary information regarding moving trains is automatically announced every few minutes at the stations.

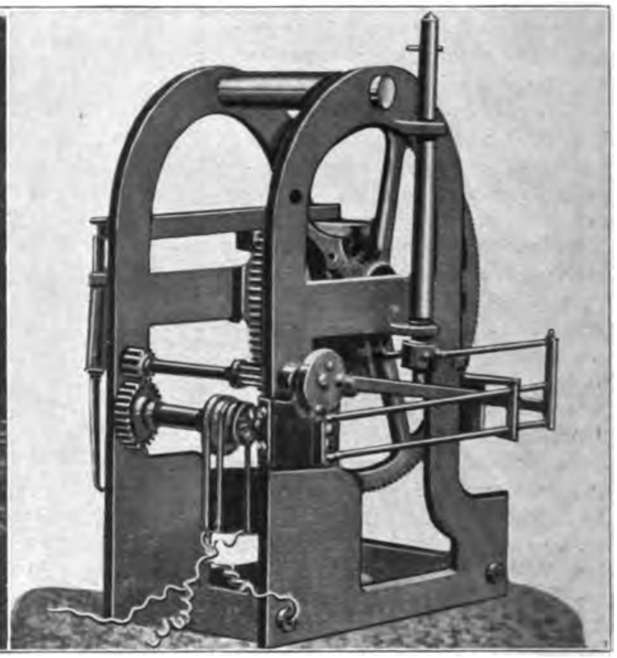
"The battery for operating the signals will last for months without attention, and one man can readily attend to all the signals and batteries throughout the whole extent of the road.

"In all cases where practicable the signal wires should be carried through the coils of a bell magnet in the nearest office. By this means the operator is informed when the battery power is decreasing and warned that it requires renewing.

"Office connections can be made when desired, so that the signals may be operated by a telegraph key from the office as well as by passing trains.

"The signal wires may be tapped at intervals all along the line and lead into small cast-iron boxes placed conveniently on the telegraph poles. Conductors of all trains furnished with keys to these boxes can, in case of special accidents, go to the nearest box, set the key within the same and thus set danger signals at some distance in front and rear of their train. The telegraph keys in these boxes not only set the danger signals as described, but they also place the said signals for the time being entirely out of control of moving trains."

The Second Signal Installation Made by Dr. Robinson.



A Signal Mechanism Installed in 1876.

In December, 1875, Mr. Robinson moved to Boston, where he actively pushed the work of installing his new signals. In January, 1876, he made an installation of the closed rail circuit type between Elm street and North avenue in West Somerville, Mass., on a branch of the Boston & Lowell Railroad. The station agent at Elm street, in a report dated June 2, 1877, nearly eighteen months after the signal had been installed, said, "Robinson's electric signal at this place has been working uninterruptedly since it was first put in operation. The signal is entirely reliable." It remained in service at this point for a number of years, until the wooden post on which it was mounted rotted down. The mechanism used in this signal is shown in the accompanying illustration.

During 1876, '77 and '78 a number of installations were made on the Boston & Providence, the Old Colony, and the Boston, Lowell & Nashua. On the latter road, at Wilmington Jct., a section of double-track, including six switches, was signaled, the switches being connected up so that they had to be closed and locked for the main line before a clear signal could be given to approaching trains. While this was the most extensive installation of switch protection made up to that time, it was not the first, as Mr. Robinson had equipped three switches in a similar manner in a track section on the Philadelphia & Erie in 1873. About the same time that the Wilmington Jct. installation was made in 1876, Mr. Robinson signaled the Old

Colony, including a drawbridge in one block section at Somerset. Protection for trains against an open draw was secured by including the track rails on the drawbridge in the track circuit, so that the withdrawing of the locking bolts and the moving of the rails would break the track circuit and set the signals to danger. Also about the same time the signals were installed in the Tehuantepec tunnel on the Southern Pacific in California. This installation was made by Stephen D. Field of the Electrical Construction & Maintenance Company, San Francisco, with materials and according to instructions furnished by Mr. Robinson. In letters written by Mr. Field, it was stated that this track section was two miles long, extending through the tunnel one mile and for one-half mile at each end, and that the rails in the tunnel "are buried in wet mud and outside no moisture touches them for six months of the year." A cut section with battery and relay was installed at the center of the tunnel.

In 1878, Mr. Robinson organized the Union Electric Signal Company, of which he was the president and owner. He assigned to this company the nine United States patents covering the track circuit, electro-pneumatic signal mechanism, etc. About two years later George Westinghouse and his associates bought a controlling interest in this company, which was reorganized under the name of the Union Switch & Signal Company. With this sale the control of signaling apparatus passed out of the hands of Mr. Robinson and he has since devoted his energies largely to other fields.

During his early years in Boston he was associated very closely with the three men to whom credit has been given at various times and to varying degrees for the invention of the track circuit and other fundamental signaling apparatus—Frank L. Pope, Oscar Gassett and Israel Fisher. The facts apparently establish pretty conclusively the correctness of Mr. Robinson's assertions regarding these three men. He gives Pope credit only for bringing out an open-circuit system, Gassett for his success as a promoter, largely through his relationship with Wendell Phillips and consequent personal standing, and Fisher as an excellent mechanic, who was instrumental in making a large part of the signal apparatus which Robinson installed on New England roads between 1876 and 1878.

Like most inventors of importance, Dr. Robinson has not received, either in money or in renown, the returns which would seem to be commensurate with the importance of his work. His financial return consisted of the sum received for the controlling interest in his Union Electric Signal Company, and while undoubtedly considered large at that time, would seem rather meager as compared with the magnitude of the signal business since that time. In the way of recognition, a number of writers on the early history of signaling have given him full credit for his valuable work. It is only fitting, however, that his standing in this regard be more generally understood and acknowledged before it is too late for him to experience the gratification which this honor should bring.

NEW YORK CENTRAL AND PENNSYLVANIA CHANGE COLORS

The New York Central Lines West commenced on August 8 to change the color signal indications to green for "Proceed" and yellow for "Proceed with Caution." The work was carried out on one division at a time, commencing with the Western division and completing on the branch lines.

A careful check was made on the ground to determine the actual material required, and this, together with a small number of additional switch and marker lamps, was then ordered. Two old baggage cars were fitted up with a work bench and a supply of oil, and in these cars were placed the surplus material, together with the necessary material for changing, enroute, the lenses in the switch lamps. All roundels for signals were sent to the maintainers who, prior to the day of the change, went over all bolts in the semaphore castings, loosening and oiling them so that they could be removed quickly.

On the day of the change, the two work trains started out, each covering one-half of the division. The men on these trains picked up all the old switch lamps, crossing flagmen's signals and lamps, and flags used by the section men, substituting the new standard colors, while at the same time the maintainers made the changes in the roundels on all automatic and train order signals and also changed out the lamps at the track tanks. Painters also were started out early in the morning to paint the switch targets, slow and release signs, take-siding signals and train order banners in the new colors. On the work train the lenses in the switch lamps that were picked up were removed and the lenses of the new standard color substituted. By handling the lamps in this way only a small quantity of extra lamps with new standard colors were required. On the night of "the day of the change" a round trip was made on the inspection engine to determine that all indications were correctly displayed. The inspectors and maintainers covered the portion of the division assigned to them to make any adjustments necessary. After one division was changed over, the cars and all surplus material were shipped to the next division, where the work was carried on in a similar manner. The changes in yards were handled by motor cars.

In the train marker lamps, in place of the green used heretofore, high transmission yellow lenses were substituted and in all new lamps purchased in addition to the high transmission yellow lenses, there was inserted a spreadlite high transmission red lens. This type of lens produces a beam of light with an extreme spread of 60 ft. at a point 100 ft. from the lamp, equal to an angular measurement of 34 deg. 17 min., whereas the optical lens displaced had a spread of but 13 ft., equal to an angular measurement of but 7 deg. 25 min.

With the high transmission spreadlite lens, the wider spread of the beam is obtained without diminishing the maximum range, due to the fact that theoretically the high transmission color gives an increase in range of about 20 per cent. The spreadlite lens was adopted for marker lamps primarily, to take care of any variation in the application of the lamp brackets on the cars and to permit more wear in the bracket without diminishing the intensity of the red marker indication.

In the semaphore signals, roundels of the arched type were installed, all new ones purchased being in high transmission color. The high transmission green purchased, which now gives the "Proceed" indication, is approximately 50 per cent higher in transmission than the green formerly used, and the high transmission yellow is purposely of somewhat diminished intensity, lying midway between the red and the green.

In yard switch lamps, lunar white and yellow are used, and in main track switch lamps, green and red. Lunar white in the yard switch lamps indicates that the switch is set for the lead. This lens gives a bluish white indication about equal in intensity to that of high transmission green and is very distinctive.

It was observed that with green for "Proceed," it was necessary, particularly on curves, to range the semaphore lamps somewhat differently than when white was used for "Proceed," due, no doubt, to the intensity of the light being diminished. Other than that, no difficulties arose and the entire change was accomplished without any irregularity. The above information was furnished by F. B. Wiegand, signal engineer.

A similar change in color indications will be made on the Pennsylvania system, both east and west of Pittsburgh, as soon as the necessary material can be obtained. This material is now being ordered and a detailed program will be worked out on each division on receipt of the notice fixing the date for the change. The announcement of this change issued by the Pennsylvania states that "the proposed signal system has been tried out on the extreme eastern end of the New York division and has been found to work satisfactorily." The red, yellow and green for the new indications are high transmission glass.