THE NEED OF AUTOMATIC TRAIN CONTROL

With Facts Concerning Its Development and Present Status

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For more than twenty years past it has been the editorial policy of the Railway Review to encourage the use of the automatic train stop, as a necessary supplement to the block-signal system. In this way it has fallen to the writer to study the possibilities of such a means of promoting the safety of train operation, and to follow the progress of the development of it. The ideas and facts comprised in this brief treatise are the result of frequent scrutiny of railroad accidents and the circumstances relating thereto; and essentially all of these have been expressed, in various connections, in the course of my editorial work. As here presented they are a digest of matter of my own authorship which has appeared in the Railway Review, but now rewritten and arranged in connected form.

Even this short account should not fail to pay tribute to the industry, the intelligence and the perseverance with which many worthy men have labored on this problem of the automatic control of trains. Encountering the disinterested attitude of many railway officials, in the early days, and not a little prejudice, they had a hard row to hoe. Some of the most efficient of these men of genius are now dead and gone, and the chapter of railroad history that should do justice to their efforts will probably never be written, adequately. They deserved better recognition, for the quality of their work, at a later day, and in a more sympathetic environment would no doubt have achieved better success. But, as a rule, one inventor builds upon the work of another, and I am inclined to think that the labor of many in this field who were destined not to see the finish, has not, after all, been entirely lost. Such is the story of civilization, all through: the march of progress is often over ground well trodden by those who have gone long before.

The cause of automatic train control is no longer frowned upon nor easily dismissed by those charged with the responsibility of railway operation. The practical utility and the availability of means to put this thing into being have well been demonstrated. The fog is rising, and the imaginary difficulties that have so long stood in the way of progress have well-nigh vanished. The tune has changed from "it can't be done" to "wherewith shall we get the money?" That is not an unanswerable argument with American people—if it were, this question of automatic train control would never have come into existence, for, to begin with, we would never have had railroads.

W. M. Camp.

RAILWAY ACCIDENTS.

The accident record in the operation of our railroads has always been a sad reflection. And while there is no other modern means of transportation without some fateful compensations, there has long been a conviction in the public mind, nevertheless, that more safeguards against accidents on railroads were reasonably attainable. Compared with European standards, American railroads have, in some respects, been cheaply constructed. Very commonly they cross public highways at grade, and about 88 per cent of the mileage is still single track. The former condition is a prolific source of accident to people on the highways, and the latter is a factor of certain hazards of train operation, more remarkably so with increase in traffic density. In accordance with both public and corporate policy grade highway crossings with railroads are being gradually, but very slowly, eliminated, at much expense; and the building of second track, the so-called double-tracking of line, is proceeding as rapidly as the resources of the railroad companies will permit. The progress in this direction also has been very slow, particularly during recent years.

The phase of the subject here discussed has to do with train accidents, and with certain improvements or devices which can, relatively speaking, be provided at moderate cost, to promote safety of operation on the roads as they stand, single, double or multiple tracks, and without regard to future progress of roadbed development.

Train accidents are mainly of two kinds—derailments and collisions—and the casualties of the latter far exceed those of the former. Adoption of the best recognized standards of construction for track and rolling equipment, and proper attention to inspection and maintenance of the same, is about all that may consistently be expected of railway managements as an effort to reduce derailment accidents to a minimum. As for collisions, however, the negligence of employees and their liability to error are elements of uncertainty that must be guarded against.

Of the two classes of accidents, collisions are the more deplorable. A derailment might be caused by a broken wheel or journal, a washout, a landslide or by some other casualty that no amount of human foresight could anticipate; but collisions almost always occur through negligence or error. It is just this contingency in railroad operation that mechanical experts have sought to overcome by ingeniously contrived checks and warnings. In view of the frequency of preventable train accidents it is therefore pertinent to inquire whether precautionary means have been carried far enough.

Historically speaking, train operation in this country has developed on or from the time table and dispatching system. In train dispatching the meeting of trains on single track, and the spacing of following trains, or the passing points for the same, on either single or double track, is controlled by written orders. At points distant from the headquarters of the dispatcher it is necessary to convey the order by telegraph or telephone, necessitating the participation of three or more parties in the issuance and receipt of the written order, namely the dispatcher, the telegraph or telephone operator and the conductor and engineman of one train or more. Upon receipt of the order by the trainmen they proceed to carry out the intended movement unmindful of any contingencies that may arise through error or mistake of any one concerned. Long experience has demonstrated that this system of operation is time consuming, it results in delays to trains, and it has frequently led to collisions through oversight or mistakes of the dispatcher, errors of transmission, misunderstanding of the order by the trainmen, or, finally, through failure of either the engineman or the conductor to bear in mind and obey the full or exact meaning of the order. Furthermore, the mere issuance of running orders, even when correctly transmitted and interpreted, does not afford protection against rear-end collisions. The faulty aspect of a system that is liable to so many sources of error must be evident in any study of train operation.

Owing to the aforementioned shortcomings and the necessity to increase track capacity, railroads have been working away from the dispatching method, to a large extent, by substituting the block system. By this means there are manually-operated or automatic wayside signals at the entrance of designated sections of the road, called "blocks," which serve to inform an engineman whether the block ahead of him is clear or occupied. At interlocked crossings the block section radiates over all tracks to a safe distance from their point of intersection, and the signals determine on which of the routes the right of way is permitted. By the block system enginemen, if attentive to the signals, are kept informed, step by step, as it were, as to conditions a safe distance ahead, and trains following at speed may be kept at proper intervals, independently of special orders. Running by block signal is, therefore, a great advance over the more or less haphazard movements that may take place under the latitude and the chance of error of the dispatching system alone. And it may here be noted that some measure of the train-order method is usually retained with block-signal operation, to select meeting points with extra trains or with delayed trains, or to devise run-arounds for trains of different class in the same current; but, on double or multiple tracks, trains may, with timetable and block signals, be operated with but little, if any, direction through train orders. On single track, also, train dispatching may largely be dispensed with through the installation of block signals, although the services of operators are usually called upon for arranging head-on meets and run-arounds.

During the past thirty years block signals have been extensively installed on American railroads and they may now be found on nearly all of the heavy-traffic lines or on the densely-operated portions of such lines. Block signals are now in service on more than 100,000 miles of road, of which about 37,000 miles is protected by automatic block signals.

Controlled-Manual Block.—To protect manual blocking against mistakes of the signalmen the levers operating the block signals are sometimes electrically controlled in such manner that the co-operation of the operators at both ends of the block is necessary before a signal can be cleared to admit a train to the block. This is commonly known as controlled-manual blocking, or "lock and block." As the operator at the leaving end should have knowledge as to whether or not a train reported in the block has passed out of it, he is thus in position to check the operator at the entrance end. Still, should the operator at the leaving end be at fault, then the joint action of the two might result in admitting two trains to the block.

Track-Circuit Control.—To guard against errors of the men at both ends of manually-operated blocks a complete and positive check may be had by the use of a track circuit, making it impossible for either to clear a signal governing entrance to the block as long as the block is occupied.

As for automatic block signals it may be said that they have been perfected to such a degree that their operation is extremely reliable. It is the first principle of operation of these devices that the signal will be found in the stop position or will go to that position, in event of derangement or obstruction of the apparatus by weather conditions or accident of any sort. Very seldom or almost never does it occur that a signal will "stick to clear" or be found giving a false clear indication. In other words, the failures or shortcomings of such devices are practically always on the side of safety, and the worst thing that may happen will be the stopping of a train unnecessarily.

And yet, as reliable as automatic block signals and controlled-manual block may be, neither is of any avail unless observed and obeyed by the enginemen; for some of the worst collision wrecks that have occurred in this country have happened because the engineman either did not see or disregarded a signal set against him. While there can be no question but that the equipment of the busy roads with block signals has greatly reduced the chances of collision accidents, yet by no means have such installations entirely prevented them. Bad collision accidents do happen every year on track that is well equipped with block signals, and through no fault of the signals.

Statistics proving the frequency with which enginemen do overrun signals are surprising. The latest annual report of the Bureau of Safety, Interstate Commerce Commission, shows that of the 53 collision accidents that were investigated during that year (1919), no less than eleven were caused by disregard of fixed signals by enginemen. Beginning with the year 1911, the official record for five years was 31 collisions, in which 166 people lost their lives, caused by the failure of enginemen to observe or obey the indications of fixed signals. At the end of seven years the record showed 50 collisions, in which 270 persons were killed and 1405 others injured, where the primary cause was the disregard of signal indications; and at the end of the eighth year the number of collisions from this cause had increased to 61.

Seemingly such accidents fall into a class which modern block signaling is unable to prevent. The Bureau of Safety, in its reports on such, has repeatedly pointed out that the best system of signaling, properly installed and in perfect working order, would not prevent accidents; "that employees of the highest class, with long records for faithful performance of their every duty, have failed at critical times;" and that "there is some weakness in our system of railroad operation that has not been overcome by the best engineering talent of to-day or by careful selection and training of employees."

Necessity for Derails.—The widespread distrust of wayside signals alone as adequate protection to trains in all situations is well enough attested in the general use of derails at interlocked crossings. At crossings protected by interlocked signals without derails there have been disasters, and there has been frequent derailment of trains at crossings where there were derails, so that either experience proves the case. Near Atlantic City, N. J., on July 30, 1896, at a crossing of the Philadelphia & Reading Ry. and the West Jersey & Seashore R. R., two passenger trains collided, killing 42 people outright and injuring more than 50 others, several of whom died afterwards. In this case the interlocked signals were properly displayed and the accident occurred in daytime in clear weather. As another instance (July 4, 1908), two Southern Pacific passenger trains collided on a crossing in Oakland, Cal., killing six people and injuring 30 others. A train from Alameda struck and cut in two a train from Santa Cruz. The crossing was an interlocked one, without derails, and the signal stood against the Santa Cruz train, but the engineman did not observe it. In almost countless other instances the "moral effect" of the derail has not been realized, and trains, with both signals and derails against them, have been derailed, often with serious consequences. When enginemen will disregard an interlocking signal or fail of timely action in its presence, with the certain knowledge that a derail is open in front of them, it obviously can not be expected that the chances for proper attention to block signals in all cases can be any better.

Necessity of Flagging, with Block Signals.— The universal practice in this country of requiring flagging, as an additional protection to trains in block-signal territory, also is significant of the negligence of enginemen in observation of signals. The chance of enginemen overrunning block signals set to stop is too great to dispense with this extra means of precaution, yet, as will be seen, collisions have occurred where not only were the automatic block signals working perfectly, but flagging also was properly done. However, the reliability of flagmen, as a class, is no better than that of enginemen, if even as good, for instances where their negligence has resulted in disaster are almost too numerous to mention. Moreover, an engineman who would disregard or overrun a stop signal would be equally disposed to commit the same error in the presence of a flag signal.

So, unfortunately, this means of protection, also, is not to be depended upon in all cases, as has been only too well proven by the results of long experience. Some discussion of the contingencies that may arise in the work of flagging, and how difficult it is to realize obedience to the rules, is pertinent to this question.

Flagging, or the use of hand signals, is the oldest method of protecting trains while they are stopped on main track, and, as stated, it is still in practically universal use in this country, where block signals are in service as well as on roads where they do not exist. The proper method of protection by rear-end flagging is a simple matter. The essential thing is that a flagman be far enough from the train he is protecting to signal an approaching train in time to make a safe stop. In addition to flag or lantern he may carry torpedoes, to make audible signals in case of bad weather or inattention on the part of the engineman of an approaching train, or he may carry and use fusees. With proper vigilance on the part of a flagman a train can hardly get past him without observation of a signal, of one kind or another, by its engineman.

The fact that many collisions have taken place where no flagman was present or where the flagman was not out far enough to protect his train seems to have given rise to an impression, more or less general, that flagging, after all, is a loose method of train protection; and such, indeed, it really is when not properly done. The cause of trouble from improper flagging usually has been that the flagman either did not go far enough back, or that a train slipped up on him before he had time to get back a proper distance, or while he was running to catch his train after being called in. In any of such circumstances the fault lies with negligence of duty and not with the system if the latter be guarded with proper regulations. Protection while a flagman is running back can be had by throwing off a lighted fusee while the train is slowing down, the flagman then making a run to the rear as soon as his train stops. Protection while running to the train, after being called in, can be had by the use of either fusee or torpedoes. Torpedoes are objectionable in many instances, as they may stop trains unnecessarily a long time after the train they were left to protect has departed, but where the view is obstructed to the rear of the train, or in case of a heavy wind, or whenever the weather conditions are bad, as in storm or fog, either torpedoes or fusees should be used to protect trains while the flagman is running in. The alternative is for the train to proceed without calling in its flagman, but such practice also results in stopping the following train unnecessarily, in most cases, and as it leaves the train short one of its flagmen it is evident that on repeated stops a flagman could not be left behind each time.

Unless the precautions mentioned be taken, the greatest danger from following trains is while flagmen are getting out or returning to their trains, and right here is where negligence is most liable to occur. It is just as negligent for a flagman to run to his train without leaving some signal at proper flagging distance to warn an approaching train as it would be for an army to draw in its picket lines while breaking camp and getting ready to march. The question of safety in flagging is not at all one as to whether the train to be protected shall proceed without calling in its flagman, or otherwise, but entirely a question as to whether or not that flagman immediately goes to the rear a safe distance as soon as his train stops, and takes due precaution to protect the train while running back to it upon being called in. The only consequence of such careful practice is a few minutes of additional delay to the train. But the efficiency and reliability of this method of train protection, as every one must appreciate, are too largely a question of discipline to be entirely dependable. Unless the employee does his full duty, by obeying the rules practically to the letter, flagging may fail utterly to protect the train.

HOW MISTAKES OCCUR.

Weather Conditions.— Any person who has driven an automobile in bad weather has been in position to appreciate the difficulties which enginemen encounter who are charged with the safe operation of a railway train under like conditions. Perhaps the most trying test of eye and nerve in driving a fast train is to proceed cautiously, making time as best one can, in thick fog or in a blinding snow storm. In such a situation much vigilance must be exercised to avoid passing signals unnoticed. At a speed of 50 miles an hour a train travels about 73 feet per second, and, at this rate, it might happen that while one was merely turning his head the train would run farther than the maximum distance at which he could see a signal in a thick fog. This fact makes it almost obligatory upon an engineman when running at high speed in heavy fog to keep his eyes constantly to the front, for should he glance across the cab to speak to the fireman, or turn to test his water gage he might easily pass a signal without seeing it.

It is evident from the recorded testimony of enginemen that they often take chances when running under these conditions. The truth of this situation was no doubt well expressed by one who said, at a public hearing, that he did not allow fog to interfere with his business as long as he was "sure of his signal indications;" but the uncertainty of always being "sure" may be inferred from his further remark to the effect that if he missed one of the signals he would know that he had done so and would then get ready to stop at the next signal. He meant, of course, that his knowledge of the route was so intimate that he could not miss a signal without being almost immediately aware of the fact. Such frank testimony of running practice in foggy weather raises questions which operating officials might reflect upon soberly.

Mental Conditions.—The uncertainties with which train operation is sometimes involved through stress of weather are, perhaps, no greater than another class of contingencies that arise in the mental state of even the most reliable of men, at times. The man who could be constantly alert on every occasion, under the routine of handling a train over the same route repeatedly, would be exceptional, to say the least. Periods of indisposition, absent-mindedness or momentary lapses of consciousness are only ordinary experiences. To concentrate the mind on what is before the eyes, for hours at a time, without distraction, is something of a tax, yet on a fast run an engineman may be passing block signals oftener than one each minute; and to him observation of signals becomes a commonplace thing. To pull one's watch without noting the time of day, or to straightway forget what time it was, is familiar to the experience of every normal person, yet an act of no greater inattention in the observation of signals might, in less than a minute of time, bring an engineman into trouble. Many railway accidents have been chargeable to the failure of men who have ranked high in ability and record. Momentary lapses of consciousness are common with the best of men, and may happen to any one at the most critical time. There can therefore be no absolute security, as long as the human element must be depended upon.

Such mental deficiencies may befall any person, through fatigue or loss of sleep, but there are other causations in the every-day experience of people which might render the mind unfit for concentration on exacting duties. A hard cold, constipation, bereavement, or agitation of the mind over trouble might exert fully as much influence to distract the mind of the employee as would loss of sleep or overwork. The indiscretion of eating a heavy meal, with resulting stupor or drowsiness, especially with people in sedentary occupations, is not a rare occurrence; and as the occupation of enginemen is not one of continuous physical activity, it is no unheard-of thing that one will occasionally fall asleep at his post. In this connection it need only be mentioned, without dwelling upon it, that many of the conditions on a locomotive in operation induce sleep—the heat, wind blowing in the face, the monotony of rocking motion, vibration, etc.

Enginemen Falling Dead on Duty.—It is rather remarkable that so few accidents have happened to trains running without control through the sudden illness or sudden death of enginemen at their posts. Occasionally an instance of this kind has occurred, and it has always suggested to the mind of the thinking person the grave possibilities of accident from such a cause. How many of the accidents from unexplainable causes might have happened in this way is at least an interesting question to reflect upon, as the facts of experience are sufficiently numerous to uphold a view of the reasonableness of such an explanation, a few of the known instances may here be cited.

During July, 1907, a collision occurred on the Mobile & Ohio R. R. caused by the engineman of a passenger train falling unconscious, the train running past a station where a stop should have been made, and the fireman not discovering what was wrong in time to stop the train before it collided with a switch engine. A week or two later the engineman of a passenger train of the Lake Shore & Michigan Southern Ry., approaching Cleveland, was overcome by heat and fell unconscious at the throttle. Fortunately the fireman observed the engineman's condition in time to prevent accident to the train. During the same week the engineman of a freight train on the Chicago, Rock Island & Pacific Ry. became suddenly insane and ran his train a considerable distance at extraordinary speed, in fear of an imaginary enemy in pursuit, in spite of the vigorous efforts of his fireman to prevent him. Eventually the head brakeman returned from a trip to the rear and he and the fireman overpowered the unfortunate man and assumed control of the train. This engineman had just recovered from a spell of sickness and had gone out on his regular run without displaying any evidence of his mental condition.

In December of the same year the engineman of a Lehigh Valley R. R. freight train died in his cab, suddenly, the fireman not aware of it, and the train collided with another freight train, causing a bad wreck in which the engineman was found with no apparent injury to the body and not pinned fast, so that he could have extricated himself without difficulty had he been alive. Just before the collision the train was flagged by the rear brakeman of the train ahead, who, failing to get attention, threw stones against the cab, but there was no response, so that it is reasonably certain that the engineman had died before the collision occurred. Soon after this the engineman of a Pennsylvania R. R. express train running from Jersey City to Philadelphia was stricken with paralysis in his cab, near Torresdale, and was found entirely helpless by his fireman in time to prevent accident. Six weeks later the engineman of a freight train of the Erie R. R., west of

Marion, Ohio, became suddenly ill and unconscious, and his fireman had reason to think that the train had run a considerable distance before his condition was discovered.

These two collisions and four instances where collision or other accident might have occurred but for great good fortune, all happened within a period of eight months. It is needless to remark that they afford good ground for argument for automatic control of trains. In this connection, the Central London Tube Ry. at one time employed an assistant motorman at the side of the motorman in control of the train, for such emergencies.

COLLISIONS THAT BLOCK SIGNALS DID NOT PREVENT

Having outlined the manner in which enginemen and other trainmen may and do commit errors and bring trains into collision, it will be impressive as well as instructive to narrate the circumstances and the particulars of a few of the serious collision wrecks that have occurred in recent time on railroads that were well equipped with block signals.

The Terra Cotta Collision, B. & O. R. R.—On Dec. 30, 1906, there was a rear collision of passenger trains at Terra Cotta, D. C., on the Baltimore & Ohio R. R., in which 43 people were killed and about 100 others were injured. A train had stopped at the station and was just pulling out, when a following train, running at high speed, on a down grade, collided with it, smashing up three coaches. The track was under block signal protection and the signals were properly displayed, but there was a thick fog and the engineman of the following train said that he failed to see any signal.

The Fowler Collision, Big Four Ry. — On Jan. 19, 1907, at Fowler, Ind., a passenger train of the Cleveland, Cincinnati, Chicago & St. Louis, Ry. collided, head on, with a freight train. In a fog the passenger train, running 50 miles an hour, overran a block signal set at stop. Sixteen people were either killed outright or burned to death, and ten others were injured.

The engineman who, in this instance, ran by a red light signal at high speed when the weather conditions called for unusual caution, was an employee with a good record, which would have entitled him to confidence in any situation. It was then the custom of that road to test the observance of signals. On his last previous eastbound trip this engineman had been checked up by what is considered the strongest test of an engineman's caution and strict observance of rules. The rule required that he should stop if a signal light was out, even though the signal itself might show the line to be clear. At a certain station the light was purposely extinguished, with the signal remaining at safety, but the engineman distinctly saw that the signal was at clear. He knew therefore that he would be safe in running by, and that the technical violation of the rule would not cause serious results; yet he stopped his train with the emergency application and reported in the station that the light was out. The fact that the same man on his next trip caused a terrible disaster, simply shows that reliance upon good men and thorough discipline is not the final solution of the problem of safety.

Accidents on the N. Y., N. H. & H. R. R.—

A bad derailment accident at Westport, Conn., on the New York, New Haven & Hartford R. R., Oct. 3, 1912, was caused by too fast speed through a crossover. The investigation showed that the train struck the crossover at a speed of 50 to 60 miles per hour. The engineman disregarded not only the company's rule that train speed should not be higher than 15 miles per hour passing through the crossover, but he also disregarded an interlocking distant signal at "caution," and a home signal in stop position, properly located to govern train movements through the crossover. The train entered the crossover at high speed, in spite of the attempts of a work-train conductor and a section foreman (the latter standing in the track, ahead of the train) to flag the reckless engineman down.

The wreck at Bridgeport, Conn., July 11, the year previously, happened in the same way, in all essential particulars. The Federal Express train, running 60 miles an hour, passed both distant and home signals, 2,200 feet apart, displayed at caution and stop, respectively, without slackening speed, and took a crossover lined up for the train. Twelve people were killed outright and 40 others were injured.

On the same road, Sept. 2, 1913, a collision wreck occurred, between North Haven and Wallingford, Conn., in which 21 people were killed outright, five more were fatally injured and about 50 others were injured more or less seriously. A passenger train had stopped at a signal on a piece of straight track where, ordinarily, there is a clear view for two miles, but at the time of the accident a dense fog was on. The road was properly block-signaled, the signals were in working order, and in addition to this a flagman had gone back to protect the rear of his train, but to an insufficient distance.

The Amherst Wreck, New York Central R. R.—On March 29, 1916, there was a double collision wreck of three passenger trains, near Amherst, Ohio, on the New York Central R. R., which resulted in the death of 27 people and injury to 47 others. The accident is of peculiar interest, owing to the failure of an engineman to observe a block signal that was properly displayed and the neglect of a flagman to do his plain duty.

The first section of an east-bound passenger train had been stopped at the home signal of an interlocking station. When the signal was cleared the train started, but slipped and stalled and then got started again, but before it had proceeded more than six or seven car lengths it was struck by the second section, running about 50 miles per hour. The result of the collision was that the locomotive lifted the rear end of the rear car, a steel coach, which, in turn, threw the car ahead, a wooden club car, across the adjoining west-bound track. This collision took place at 3:18 a. m., and before any movement could be made to stop approaching trains the club car was struck and cut in two by a west-bound train, known as the "Twentieth Century Limited," running at a speed of something between 50 and 60 miles per hour. At the instant the first collision occurred this train was passing the interlocking tower, only 1,200 feet distant, and all three trains were in collision within the short period of 30 seconds.

The road at this point was protected by modern automatic block signals, but there was a heavy fog, so that signals were distinguishable only at close range—one to three car lengths, according to the varying testimony of trainmen who were on the ground at the time. The engineman saw neither the home nor distant signal, or misread them if he did see them. The fireman testified that he did not see any signals for six miles approaching the point of collision, and was lost in the fog so completely that he did not know where he was within a mile or two. Aside from this, the engineman had a bad record for observance of signals, having been disciplined five times in the preceding sixteen years for over-running block signals or points designated by orders.

Let us now consider how protection by flagging failed. When the first train began to slow down in making the stop the rear brakeman lighted and threw off a five-minute red fusee. This was not seen by the engineman of the second section and, in all likelihood, had burned out before the second section came along, as sufficient time had elapsed for it to do so. When the first section started, the flagman got aboard, but when the train stalled he got off again and then, for the first time, heard the second section approaching, and that under steam. He then lighted a fusee and ran west, but got out only three or four car lengths by the time the second section had arrived. This seems to have been the first signal indicating a train in the block that either the following engineman or his fireman recognized. This fusee was so near the train it was intended to protect that, practically speaking, there was no flagman out; or, in other words, protection by flagging did not exist.

The flagman of the first section started out right by throwing off a lighted fusee when his train slowed down. Where he failed was in not getting back a safe distance as soon as the stop was made and planting another fusee or torpedoes when called in. Instead of doing this he hung around the rear of his train until after the fusee had burned out, so that, in reality, and in short, that indispensable adjunct of block signaling, the flagman, was absent.

Mt. Union Collision, Pennsylvania R. R.—On Feb. 27, 1917, a passenger train of the Pennsylvania R. R. had stopped at Mt. Union, Pa., at the station, and, when attempting to start, the brakes on some of the cars failed to release, as a result of which the train was detained at the station longer than the usual time of making a stop, and a freight train following came into collision, killing 19 passengers, and a porter and injuring five others.

The wreck occurred about midnight and in a heavy fog. The block signals at this point were about 4,000 feet apart, and as the freight train, running at a speed of more than 40 miles an hour, passed the second signal bridge in advance of Mt. Union, on which were located the signals for four tracks, the engineman called out a white signal. The fireman and head brakeman, however, who were looking ahead at the time, both called "green" and, noticing their disagreement with the engineman, the fireman crossed over and inquired of the engineman if he did not make out a green signal. But the engineman still insisted that the signal was white, and proceeded under steam until the home signal for the next block was reached, when he found a red signal against him and immediately applied the emergency brakes, shut off steam and pulled the sand; but as the passenger train was standing only 276 feet beyond the signal, the speed of the freight train could not be appreciably reduced, and the collision was inevitable. As has happened so freqently, the flagman of the passenger train was dilatory and had gotten to the rear no further than 300 feet when the collision occurred.

All of the employees concerned in this accident were experienced in train operation and had excellent records, and the signals were in good working order, so that human liability to error must be set down as the cause. As a matter of official record, this was the fourth accident of the same kind that had happened on this one railroad within a four-year period, all of the collisions being due to non-observance of signals or mistaking the indications thereof, by enginemen of long experience and good records.

The Earlville Collision, C. B. & Q. R. R.—On Sept. 17, 1917, a freight train of the Chicago, Burlington & Quincy R. R., near Earlville, Ill., collided with the rear of a stock train, smashing four cars and killing seven men in a passenger coach at the end of the stock train. The operation of these trains was under the block system, and the cause of the collision was that the engineman on the following train was asleep, and had unconsciously run past several signals, the last one he could recall before meeting with the accident being the signal at Meridian, ten miles from where the accident occurred. At the coroner's inquest the engineman testified that he had been ill with a cold, not having worked for three days previous to the accident. The only way in which he could account for his failure was that he was not feeling well at the time and had been taking medicine for his illness which he thought might have caused him to go to sleep at his post.

The Ivanhoe Collision, Michigan Central R. R.—On June 22, 1918, before daylight, an empty troop train of 20 sleeping cars, following a circus train, on the Michigan Central R. R., near Ivanhoe, Ind., ran into the rear of the circus train, killing more than 60 people. Fire broke out and many injured passengers were burned alive.

This acident occurred on track completely block-signaled, with modern automatic appliances which were working perfectly. The responsibility for this disaster was wholly with the engineman who, at the moment of the collision, was fast asleep; and so soundly had he slept that he had not only failed to see the cautionary distant signal, and a stop signal at the entrance of the block, nor the tail lights of the circus train, visible a long distance down the track, but in addition to these he had passed a fusee burning in the track and another lighted fusee thrown at the cab window by the rear brakeman of the circus train when he saw that no effort was being made to stop the following train, which was coming right on at good speed. The man who failed in this instance was an engineman of 28 years' experience with a good previous record.

South Byron Collision, N. Y. C. R. R.—On Jan. 12, 1919, there was a rear-end collision of passenger trains on the New York Central R. R., at South Byron, N. Y., while the train in front was at a standstill. The engineman of the following train failed to observe the block signal indications, and the flagman of the first train had not gone back a sufficient distance to protect his train, nor did he display a lighted fusee, as required by the rule. This engineman had a faulty record, having once been dismissed for using main track without flag protection.

Fort Washington Collision, P. & R. Ry.—On Jan. 13, 1919, a through passenger train of the Philadelphia & Reading Ry. collided with the rear of a local passenger train while the latter was standing one-quarter mile from Fort Washington station, Pa., killing 14 people and injuring more than 20 others. Failure of the engineman to observe and obey a block signal was the primary cause. The flagman of the local train had not gone out far enough to prevent the collision.

The Elwood Collision, Pennsylvania R. R.—On August 24, 1919, there was a rear-end collision between two passenger trains on the

West Jersey & Seashore division of the Pennsylvania R. R., near Elwood, N. J., resulting in the death of one passenger and the injury of 25 passengers and one employee. This collision occurred on straight track, well protected by automatic block signals. A contributing factor was the foggy condition of the weather, though the testimony shows that signals could be discerned for a distance of ten or twelve car lengths. In addition to passing both caution and stop indications of automatic block signals without regarding them, the engineman also overran a burning fusee.

WHAT IS THE REMEDY?

The foregoing recital of facts shows that the best systems of block signals known to engineers and operating officials, assisted by flagging, frequently have failed to protect trains from collision. After all, block signals are nothing more than a means of conveying information, and they afford no protection whatever when overrun by a sleepy or negligent engineman, or by one who fails to see the signal in a fog or snow storm, or when it is obscured by a cloud of smoke or steam or in the glare of a powerful electric headlight.

The most perfect signaling appliances in extensive service on American railways today fall just one step short of accomplishing all that is necessary to put train operation beyond the fortuity of human error or neglect.

It is certain, therefore, that some automatic device or mechanism that would take the control out of the engineman's hands in event he failed to observe or regard a signal indication that restricts the movement of his train is indispensable to safety of operation. The need of automatic train control has been established beyond any question, and the demand for it is real and urgent. Automatic brake setting, or some other, as yet unknown, scheme providing an equivalent check, when signals are disregarded, is bound to come into general use.

A fundamental conception of the present situation was expressed as long ago as 1879, by Charles Francis Adams, Jr., in his book "Notes on Railroad Accidents." The accuracy with which he foresaw the danger points of present operating conditions is well recorded in the remarks here quoted:

"The American block system of the future will be essentially different from the present English system. While the operator is everywhere in the English block, his place will be supplied to the utmost possible degree by automatic action in the American.....The effort in America, somewhat in advance of that crowded condition of the lines which makes the adoption of something a measure of present necessity, has been directed towards the invention of an automatic system which at one and the same time should cover all the dangers and provide for all the needs which have been referred to, eliminating the risk incident to human forgetfulness, drowsiness and weakness of nerves. Can reliable automatic provision thus be made?.....The complicated and unceasing train movement depends upon many thousand employees, all of whom make mistakes or assume risks sometimes; and did they not do so they would be either more or less than men. Being, however, neither angels nor machines, but ordinary mortals whose services are bought for money at the average market rate of wages, it would certainly seem no small point gained if an automatic machine could be placed on guard over those whom it is the great effort of railroad discipline to reduce to automatons."

Considering the time when these observations were made, they show that Mr. Adams was somewhat in advance of his day in grasping the needs of American railways in the way of block signals. The extensive use of automatic block signals predicted by Mr. Adams has come to pass, and his suggestion of the automatic control of trains points to that essential feature of operation in which our railroads are now found deficient.

The Inadequacy of Discipline.—The arguments that were once used to discourage the idea of automatic train control might have led some to believe that a gradual improvement in the discipline of trainmen in this country was to be expected. Whoever may have entertained such a view has certainly been disappointed, for neither generally observed conditions nor results have confirmed it. Neither is the situation in other countries satisfactory in this respect.

Some of those who have been opposed to the idea of automatic train stops, on the ground that a good system of block signals with enginemen trained to a high standard of discipline, should afford adequate protection, have often referred to the accident records of English railways to substantiate their contention. It is known, however, that the English railways, obviously for some good reason, have for years been experimenting with cab signals as an additional precaution for safety, nothwithstanding the prevailing block system of train operation and the good reputation of their enginemen for discipline. According to official accident records, however, the reliability of block signal equipment and of enginemen to observe signal indications do not come as near perfection as is generally supposed to be the case.

In one ten-year period there were 137 railway accidents in Great Britain, due to overrunning signals and to imperfections in the signaling system itself. Of these, 47 accidents were caused by the overrunning of signals by fault of the enginemen, either through nonobservance or disregard; 61 accidents were due to irregularities of the block system (manual block), including 8 failures of signals; and 21 more accidents were caused by faults of the signalmen. Subsequent records have shown that improvement of the signal installations, including the use of the track circuit, had reduced the number of accidents caused by irregularities in the operation of the block system by fifty per cent, but there was no reduction in the number of accidents caused by overrunning signals.

Train operation in Great Britain having always been held up as the criterion for safety, such an exhibit ought to be convincing testimony to the fact that human error, even in the presence of the most reliable of block signal arrangements, is a cause of railway accidents the world over; and comparisons of the accident records of the United States, England and other European countries, while they may indicate some differences in degree, really show no differences in kind. In England the liability to error with block signals in the hands of highly-trained men is recognized, and in addition to this they have more fog to contend with than we have. For this reason the use of detonators (torpedoes) as an auxiliary to fixed signals, to call the attention of enginemen to the signal indications in times of heavy fog, is in very general practice. The expense of stationing "fogmen" at the side of the track to repeat the signal indications by means of audible signals is considerable, and this has led to the development of a device known as the torpedo placer, which has been used to some extent. This automatically places a torpedo upon the rail simultaneously with the setting of the signal. The explosion of the torpedo warns the engineman of the position of the signal. The use of safeguards as auxiliary to the wayside signals is therefore in considerable and regular service, so that the proposition of placing an auxiliary system on the locomotives in the form of cab signals is not at all inconsistent with English ideas.

Thus it has been shown that our own country is by no means the only one where carefully-operated block signal systems and studiously prepared and strictly enforced rules for the use of the same fail to safeguard trains as well as could be desired. To some extent, however, a false standard of ethics with block signal experts has stood opposed to the pursuit of further means of protection. Signal engineers, with both railroads and manufacturers, have labored industriously and ingeniously, and have produced apparatus remarkable for its high order of perfection, yet the practical efficiency of the whole system is still dependent upon human reliability as much as upon perfection of mechanism. This fact might be expected to strike signalmen in an unwelcome manner, but the further consideration that the responsibility for lapse of discipline is not theirs does not change the situation. Pride over the high efficiency of existing equipment is commendable, but it should not stand in the way of possibility of further progress toward safety. In the light of every-day railroad experience, one cannot dismiss from his mind that the idea of placing both men and machines under automatic control is a "consummation devoutly to be wished."

PROGRESS WITH AUTOMATIC TRAIN CONTROL

As clearly as the necessity for automatic control of train operation has been seen in the past three decades, the progress, nevertheless, has been very slow, especially so when one takes account of the great advance that has been made in the construction of track, rolling stock, station buildings and terminals, as well as in the refinement of passenger equipment, increase in speed, train tonnage, etc. Automatic train stops are now in use on a few railroads in this country, covering a small mileage, and they have been used or experimented with in a spasmodic sort of way for upwards of 25 years, about the first notable experiments being those installed on elevated railways in Chicago during, and immediately following, the World's Fair. On the Boston Elevated Ry. and in the tunnels and subways of New York and Philadelphia there is an aggregate length of 105½ miles of road equipped with automatic train stop devices.

It must be said that but little effort has been made by the railroads in this country to develop automatic train control. Very few railroad managements have encouraged it by either moral or financial co-operation, and various pleas, of more or less plausibility, have been made to put the matter off. Among these have been the insistence that proper discipline on the part of the trainmen, in obedience to the indications of approved installations of block signals, should afford adequate protection to trains; and another has been the claim that no system of automatic control sufficiently developed to meet all the requirements was available. As hereinbefore shown, experience has abundantly proven that the excellence of discipline in contemplation has never been realized; and as for the state of the art of designing automatic train control devices, it is the opinion of the writer, supported by the views of men of long experience in signaling and train operation, that if anything has been wanting in this direction it has been because whole-hearted efforts have not been made to follow up excellent and promising beginnings.

The prospect of the expense of installation and maintenance has undoubtedly been the chief reason for the hesitancy to undertake experiments in automatic train control; and about the only consistent line of defense which has been made was that trial of control systems in earnest would result in a popular demand for the general equipment of railroads with such devices in advance of the financial ability of the roads to install the same. The Government has been interested in this question for some years, and the Safety Bureau of the Interstate Commerce Commission has repeatedly recommended that railroads generally should undertake experiments with automatic train stops, with a view of developing something which could be adopted in standard practice.

Government Investigations. — The urgent public demand for some means to promote the safety of railway travel led to congressional enactment, in 1906, directing the Interstate Commerce Commission to investigate and report upon the use of and necessity for block signal systems, and appliances for the automatic control of trains. The first report of the Commission, after investigation, was made to Congress, Feb. 23, 1907, and was published as Senate Document No. 342, 2nd Session, 59th Congress.

This report gave quite full information on the use of and necessity for block signal systems in train operation, but, because of the limited extent to which automatic train control appliances had been installed on the railroads, had but little, other than merely theoretical, information to give concerning them. Accordingly the Interstate Commerce Commission recommended to Congress that an appropriation be made sufficient to secure the services of men competent to supervise and conduct experimental tests of any automatic train-control devices that appeared to be worthy of trial. By an act of March 4, 1907, an appropriation of $50,000 was made available for this purpose, but restricted to such signal systems and appliances as might be furnished in connection with the investigation "free of cost to the Government."

In order to carry out the terms of this Act the Commission organized and established the Block Signal and Train Control Board, which was appointed July 10, 1907. Under the auspices of this board two experimental installations of a system of automatic train control designed by the Rowell-Potter Safety Stop Co., of Chicago, was made on the Chicago, Burlington & Quincy R. R., and put in service in October, 1908. One of these installations was on 5½ miles of single track, between Sugar Grove and Big Rock, Ill., and the other on 3 miles of double track, between Aurora and Eola, Ill. These trials were in every way practical, as the signals governed the operation of all trains passing over the road, in each case.

The same system had previously been installed, experimentally, at an interlocking plant of the Peoria, Decatur & Evansville and the St. Louis, Peoria & Northern Roads, at Hawley, Ill., in 1899; and again on four blocks of the Chicago, Milwaukee & St. Paul Ry., between Pacific Junction and Edgebrook, Ill., on the Milwaukee division, in 1902. This system was of the mechanical trip type, automatic train control being effected by means of track instruments interlocked with the signals, so that should an engineman ignore or fail to observe a stop signal against him his brakes were automatically applied by contact of the brake-setting device on the locomotive with the track instrument in the "up" position. A unique feature of this system was that the power for moving the signals and train stop trip was stored in a series of twelve heavy coiled springs that were wound up, like a watch, by a lever and ratchet operated by the undulations of the track rails under passing trains. The mechanism*, all told, was the most elaborate design for the purpose that has been installed anywhere, even to this day.

The operation of these two installations was put under the observation of an inspector appointed by the Interstate Commerce Commission, who made daily record of the behavior of them. After these trials had been under way for six months the Block Signal and Train Control Board reported that if certain minor faults in the details of the design of the mechanism were remedied, and the board saw "no reason why they should not be substantially overcome, the system would be safe and reliable and its use would tend materially to promote safety of operation on a railroad using it."

In its report of Dec. 26, 1911, the Board,

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*Completely described and illustrated in the Railway (and Engineering) Review of Jan. 6, 1900; March 15, 1902; and Dec. 26. 1908.

with further information obtained from tests of two automatic stops of the intermittent electrical contact type, and another of the mechanical trip type, concluded that there were "several types of apparatus and methods of application which, if put into use by the railroads, would quickly develop to a degree of efficiency adequate to meet all reasonable demands. Such devices properly installed and maintained would add materially to safety in the operation of trains. In many situations, under conditions existing in this country, the Board is convinced that the use of automatic train stops is necessary to the safe operation of trains."

This board was in existence four years, and made annual reports, but general interest on the subject was lacking to such an extent that the board was finally abolished for dearth of experience to report upon in the way of actual practice with automatic train control. In its discussion of progress in this direction the railroads were charged with being "decidedly lax in developing the automatic stop." It was urged that the roads should be "expected to develop the art of automatic train control so as to provide devices which will meet their operating conditions. This appears to the Board to be entirely practicable, and should it not be done with a reasonable degree of expedition, steps should be taken by the Government to stimulate such action."

In its final report of June 29, 1912, besides recommending the compulsory adoption of the block system by all interstate passenger railroads, the conclusion of the board was that "The development of the automatic train stop has proceeded far enough to warrant the expectation that by its use greater safety can be secured in the operation of trains. Railroads should be given to understand that the automatic train stop must be developed by them as rapidly as possible."

The commendable work accomplished by this Board, in its investigations and recommendations, seems to have been forgotten or ignored by railroad managements, in general, for in the eight years intervening they have sat by and awaited "developments." An automatic train control committee appointed by the United States Railroad Administration, in January, 1919, after some investigation, reported, at the end of the year, without, however, having made any considerable study of automatic train control systems "undergoing test upon various lines of railroad," as they had been instructed to do, although there was opportunity to have done so with systems in regular operation on the Chicago & Eastern Illinois R. R. and on the Chesapeake & Ohio R. R. The report of this committee, which is mainly descriptive, and but mildly recommendatory, might mislead the younger generation to suppose that experiments in automatic train control are a new thing; whereas the need of the improvement, the practicability of it, and the adaptability of available devices had all been settled by the Block Signal and Train Control Board eight years before.

ELEMENTARY PROBLEMS

Early ideas on automatic train control contemplated nothing further than stop devices operating in unison with the wayside signals. However, it soon became a question whether, if such were applied to the usual arrangement of home and distant signals, either at interlockings or with block signals, it would not operate to delay trains unnecessarily in some situations, and to reduce the capacity of tracks—this for the reason that the stop device would have to be placed maximum braking distance from the home signal; for to place it at the home signal would not allow sufficient stopping distance to protect a train near the entrance to the block unless overlap were provided. The overlap is an arrangement of circuits which allows braking distance beyond the home signal. One of the utilities of it is to dispense with distant signals, although it has sometimes been used with both home and distant signals, as on the electrified lines of the New York Central R. R.

Having in view these possibilities, some systems of train control have been designed for adaptation with the overlap arrangement.

The installations of the Rowell-Potter system of automatic train control, heretofore referred to, were with signals operating on the overlap principle.

Speed Control.—As the use of distant and home signals is the prevailing arrangement in this country, there arises the problem of compelling obedience to the indications of the distant signal without unnecessary delay and still retain the protective feature. This can be done only through some means of speed control, whereby, if a train passes the distant signal under proper control, "prepared to stop at the home signal," the automatic brake-setting mechanism is rendered inoperative; or, should the train pass the distant signal at too high speed the brakes will be applied to bring the train under control.

One way of accomplishing this purpose is through the use of a centrifugal governor connected with an axle of the engine, the adjustment of the device being such that control of the brakes is not brought into action so long as a designated speed is not exceeded. Several systems of automatic train control employ such a mechanism to effect speed control, but there are other contrivances to accomplish the same purpose. Some of the objects for which speed control may be used, including the aforesaid, are the following:

1. To permit a train to pass a brake application point at designated speed, or slower, without receiving an automatic application.

2. To permit a train to proceed at low speed after having been stopped by an automatic application of the brakes.

3. After automatic application of the brakes to permit release of the same when the speed has been reduced to a designated rate.

4. To permit a train to pass an approach indication point without an automatic application of the brakes, providing the engineman properly observes the approach indication.

5. To permit a train to proceed without an automatic application of the brakes as long as the speed is controlled in accordance with the signal indications.

6. To prevent a designated speed being exceeded regardless of block conditions.

7. To prevent a designated speed being exceeded between certain points, as on a sharp curve. This result may be arranged for by proper location of ramps or equivalent control appliances.

In itself, the train-stopping feature is simple, but it has been commonly supposed that the requirements of speed control would introduce complications. Some have seized upon this as an excuse for hesitating to undertake experimental installations of train control. In defense of their tardiness in this respect speed control has been a convenient scarecrow.

One feature of block signal operation in this country which has stood in opposition to the principle of automatic train control, is the quite prevalent, but more or less dangerous, practice of "permissive" use of blocks. By this readers understand the permission given to an engineman, in a following movement on double track, to pass a home signal in the stop position and proceed into an occupied block, providing he does so at slow speed, with his train at all times under ready control. The regulations usually require that the train must first be brought to a stop before passing the signal, and sometimes the rule requires that the engineman must wait one or two minutes before proceeding. The dangerous tendency in such practice is that of enginemen to fall into the habit of proceeding in the block at too high speed, without first stopping at the signal, thus disobeying the rule and often causing a collision, especially in foggy weather. With automatic block signals there is no telltale to serve as a restraint on enginemen against taking such chances. The too prevalent use of "permissive" running has had most to do in bringing about the existing widespread prejudice against the idea of putting a complete check on enginemen, which the most highly developed systems of roadside signals fail to do.

As illustrating the importance of speed control on safe carrying capacity of tracks the experience of a certain elevated railway in the early days of automatic train control on such roads may be mentioned. After the automatic stops had been installed it was found that the schedules could not be maintained by absolute blocking, thus making it necessary to resort to permissive running, but still the automatic stopping of the trains caused exasperating delays, and the system was finally taken out of service.

As another illustration the experience of the Interborough Rapid Transit Ry. in one of the subways of New York City, will be cited. That road was equipped, many years ago, with the Kinsman system of automatic train control, which uses automatic stops of the electrically-controlled mechanical trip type. As first arranged, a train, at whatever speed, could not pass a stop signal without being "tripped" and brought to a stop. Under these conditions the shortest practicable headway between trains was 2 minutes; and, with station stops of 46 seconds, the maximum movement over one track was 30 trains per hour. Owing to congestion of traffic it was highly desirable to increase the track capacity, and this was accomplished by means of speed control,* which resulted in decreasing the headway between trains to 1 minute, 39 seconds, and increasing the track capacity to 36.4 trains per hour, or a gain in carrying capacity of 21.3 per cent on each track.

By means of the speed-control signals there installed a train may, if under proper control,

*The details of the change are described in the Railway (and Engineering) Review of July 2, 1910, page 645.

approach a station at which a preceding train on the same track is discharging passengers, without being stopped, where, formerly, a train in like circumstances was stopped and held at a signal until the preceding train had cleared the station. The automatic train stop is the "control" feature of this system and, so far as this road is concerned, the automatic stop is a highly dependable device, and no experiment.

It is not to be inferred, of course, that the identical system of signals which is working so satisfactorily on this road of very heavy traffic would be adaptable to general conditions of the heavy-traffic railroads on the surface, yet the principles of installation and operation there followed may undoubtedly be studied with profit.

LINES OF DEVELOPMENT

Cab Signals—In a general way signal engineers have sought to improve upon block signaling as a means of train protection in two ways. One of these, as already shown, is by the use of automatic devices to apply the brakes should the engineman fail to observe a stop signal or disregard it. The other is by the use of signals in the locomotive cab, to repeat the indications of the wayside signals, in order that the engineman might be warned should he, for any reason, pass a caution or stop signal unawares. Such are generally known as cab signals, and they may consist of miniature semaphore or position signals, colored lights, or audible signals, (bells or whistles); or a combination of two or more of these.

The desirability of cab signals, as an auxiliary of wayside signals, was seen in England long ago, owing to the trouble and uncertainty of running in fogs. They have, therefore, been more extensively used or experimented with in England and other European countries than in this. Some experimenting with cab signals has been done in this country, however, and particularly with installations combining both cab signal and automatic stop functions. The Julian-Beggs* experimental installation on 20 miles of the Cincinnati, New Orleans & Texas Pacific Ry., in 1916, combined cab signal, automatic stop and speed control appliances. The Miller automatic stop system, which has been in regular operation, with automatic block signals, on 106 miles of double track of the Chicago & Eastern Illinois R. R., between Chicago and Danville, Ill., for more than four years past, is designed to include cab signals, but is being operated without them.

The use of cab signals as a means of block operation, with or without the automatic train-stop feature, and without wayside signals, is possible, but the idea has not gained

*Described in detail in the Railway Review of May 27, 1916, and May 26, 1917.

footing in this country, as yet. Perhaps the best argument against such a proposition would be that, with the double system—that is with wayside signals in addition to cab signals or automatic train stops as an auxiliary, there would still be an independent system of signals for protection in case the devices on the train were, by any chance or accident, put out of service. Moreover, unless fixed, or wayside, signals were used there would be no signal protection to foreign or unequipped locomotives passing over the road.

Types of Apparatus.—The variety in designs of automatic train control devices that have been experimented with, or are now available for trial, is large. The Automatic Train Control Committee has found sixteen different devices or systems sufficiently developed to be worthy of test. These comprise electrically-controlled mechanical trip, intermittent electrical contact, inert roadside element, induction, and continuous induction types. Excluding the, as yet, experimental installations, those that are now operating in regular service employ, for transmitting the indication to the train, either electrically-controlled mechanical trips, or intermittent electrical contact by means of ramps, at the roadside. A ramp is a long metal bar or length of rail, with down-sloping ends, in a fixed position on or near the ends of the ties, to engage a shoe or brush on the train, to make the desired contact.

The Kinsman automatic train control apparatus is in regular service on the New York Municipal (569 stops), the Interborough Rapid Transit (1813 stops), the Hudson & Manhattan (290 stops), and the Pennsylvania Tunnel & Terminal (52 stops) subway lines in New York City; in the Philadelphia Rapid Transit subway (136 stops) in Philadelphia; and on the Boston Elevated Ry. (207 stops). All of these installations have electrically-controlled mechanical trips, in most cases at the roadside, the trip arm being operated electrically or pneumatically. In addition to the Interborough, as already stated, the Municipal and the Hudson & Manhattan roads have speed control, time-limit relays being used to define the time allowed for a train to run a definite distance. In these installations the roadside trip arm may be moved from the stop to the proceed position, by the trainmen standing on the ground, when necessary to pass a signal in the stop position; but the trip assumes the stop position as soon as it is released.

The American Train Control system, which has been in regular operation on the Chesapeake & Ohio R. R. for three years past, is now installed on a busy section of 21 miles of single track, between Charlottesville and Gordonsville, Va. It combines automatic stop, cab signal (both visible and audible), and approach indication features, but no speed control.

It works in connection with automatic block which has color light signals, but is designed to be used without wayside signals; and the first installation, on 7 miles of track, was so installed and operated for a time. The installation of this system of automatic train control displaced the existing system of manual block, and the saving effected in wages of block operators dispensed with has paid interest on the new investment for train control.

This system has ramps located in pairs, in advance of the signal, the right-hand ramp being used for the stop, and the left-hand for the approach indication for the next block. For back-up movements there is a circuit reverser, which transposes the normal functions of the contact shoes, in order to receive the proper sequence of signals. This arrangement provides the engineman with a second shoe for automatic stopping in case either shoe should be lost, damaged or otherwise be put out of commission; the stop shoe, in that case, being made to work the caution signal, or the caution shoe to work the stop valve. The usual accidental conditions on track, such as open switches, cars fouling main line, and broken rails, cause the system to operate on train control with full effect, and automatic stopping for such reasons has been among the experiences of this installation.

The visible type of cab signal first installed is a standard two-position tower indicator, with miniature semaphore, but, on the locomotives later equipped, lights are used. The clear indication is by a white light and the caution by a green light, and when the automatic stop valve drops the lights go out; although the design is such that a red light can be added for the stop indication if desired; but it is considered against good practice to use it. A vibrating bell, operated by the engine battery, gives a signal every time either shoe goes over a ramp. This audible signal has been found to be a desirable auxiliary for service in fogs and other unfavorable weather conditions. The system is described, in all its details, in the Railway Review of April 12, 1919.

The Casale system of automatic train control has been installed, for regular service, on 21 miles of double track of the Chicago, Rock Island & Pacific Ry., between Blue Island and Joliet, Ill. It is of the intermittent electrical contact type, with automatic stop and speed control features. The centrifugal type governor for the latter is rigidly bolted to the outside of an engine truck wheel, and securely enclosed, so the operation of it is not dependent upon belt or gearing. The method of operation prevents exceeding a designated speed after receiving an automatic brake application at the approach signal. A three-position relay, in accordance with the polarity of current on the ramp, controls the train apparatus to provide proceed, caution or stop indications.

REQUISITES OF INSTALLATION.

Some of those opposed to the idea of automatic train control early sought to obstruct the practical development of it by demanding, at the beginning, a system that would fulfill every conceivable exigency, no matter how complicated or unusual the situation might be. The realm of imagination was ransacked to the extent of quite overreaching practical requirements, and no distinction was drawn between essentials and possible adjuncts. In time, however, the various questions and differences were threshed out in the Railway Signal Association, with the result that a set of requisites, stripped of superfluous exactions, was evolved and adopted.

The requisites of installation of automatic train control, formulated by the Railway Signal Association, after careful study and several revisions, were adopted by the American Railway Association, and later by the United States Railroad Administration. They are now the recognized standard of practice in this country, and are as follows:

1. The apparatus so constructed as to operate in connection with a system of fixed block or interlocking signals, and so interconnected with the fixed signal system as to perform its intended functions:

(a) In event of failure of the engineman to obey the fixed signal indications; and,

(b) So far as possible when the fixed signal fails to indicate a condition requiring an application of the brakes.

2. The apparatus so constructed that it will perform its intended function if an essential part fails or

is removed; or a break, cross, ground or failure of energy occurs in electric circuits, when used.

3. The apparatus so constructed as to make indications of the fixed signal depend upon the operation of the track element of the train control device.

4. The apparatus so constructed that proper operative relation between those parts along the roadway and those on the train will be assured under all conditions of speed, weather, wear, oscillation and shock.

5. The apparatus so constructed as to prevent the release of the brakes after automatic application, until the train has been brought to a stop, or its speed has been reduced to a predetermined rate or the obstruction or other condition that caused the brake application has been removed.

6. The train apparatus so constructed that, when operated, it will make an application of the brakes sufficient to stop the train or control its speed.

7. The apparatus so constructed as not to interfere with the application of the brakes by the engineman's brake valve or to impair the efficiency of the air brake.

8. The apparatus so constructed that it may be applied so as to be operative when the engine is running forward or backward.

9. The apparatus so constructed that when two or more engines are coupled together or a pusher is used it can be made operative only on the engine from which the brakes are controlled.

10. The apparatus so constructed that it will operate under all weather conditions which permit train movements.

11. The apparatus so constructed as to conform to established clearances for equipment and structures.

12. The apparatus so constructed and installed that it will not constitute a source of danger to trainmen, other employees, or passengers.

The most approved systems of block signals alone do not adequately protect trains against collision. I am not aware that any will presume to dispute this, but if some one should the facts are against him; and facts can not be argued away, or even changed. The facts in this case are so well established and so open to public knowledge as to have been the occasion for forceful appeals to Congress for remedial legislation. While the foregoing review of the progress of experiments with automatic train control has shown that these experiments have been few, relatively speaking, in view of the railway mileage and traffic volume of the country, yet these trials, under service conditions, let it be understood, date back nearly thirty years for elevated railways and full twenty years with surface steam railroads. So little encouragement has been given to the promotion of automatic train control by railway managements, even when prompted by the Government, that most of the studies on the question have been initiated and carried on by men outside of railway service. Likewise, by far the larger part of the expense of installation and tests has been borne by private enterprise. As a result of this, practically all of the score or more of systems or devices that are now available for practical tests are, at least partially, covered by patents; but that situation is not exceptional in the railway equipment field.

Although, to repeat, the service trials of automatic train control have not been numerous, in one way of thinking, yet in the past two decades there have been enough of them, and the degree of success attained has been sufficient, to demonstrate that such means of protection to train operation is both practicable and feasible; and now, in spite of all the contentions, is actually at hand. The much-studied requisites have all been met, so the last prop that has held this question on debatable ground for many years has been knocked from under.

If it is really necessary to refer to the achievements of the past few years to support the foregoing conclusion, then an implication falls upon the obstinate influences that have stood in the way of an earlier solution of any of the problems involved. As long as eight years ago the Block Signal and Train Control Board, after four years of investigation and service trials, summed up its conclusions in the following language:

"Few, if any, of the mechanical or electrical elements entering into the construction of automatic train-control systems involve any new principles, nor are they materially different from the elements used by the railroads in the everyday operation of their interlocking and block signals, train brakes, and other devices. The ingenuity and initiative which have been manifested by railroad engineers in the development of much of the apparatus used in the conduct of railroad business greatly exceeds, in the opinion of the Board, that required to produce apparatus which can be super-imposed upon existing signal systems adequately to compel obedience to the signal indications.

"Further, the Board has no hesitancy in saying that had the railroads directed the same effort toward the development of automatic train-control apparatus that has been devoted to the development of interlocking and block-signaling apparatus, we should now have adequate installations of automatic train-control devices which would permit an engineman to handle his train without interference as long as he did it properly, but would intervene to stop his train if he disregarded a stop signal or ran at excessive speed where speed restriction was prescribed."

The old line of defense that a practical system of automatic train control has not been developed no longer holds true, nor is it, at this day, even plausible. A few far-seeing managements, largely with the assistance of ingenuity from outside of railroad employees or officials, having gone ahead and done something, it is now timely that more initiative should proceed from within the railroad corporations. The present status of the art will amply justify laying out programs for beginning installation in all general situations, for circuit layouts and designs of apparatus can now be followed that are practical and safe.

It hardly need be added that appliances developed fully to the point of meeting every essential condition of operation await installation under service conditions, and the more numerous and extensive the installations the more rapid will be the progress. The elaborations of modern automatic block signaling have come from small beginnings, and automatic train control devices fall so nearly into the same class, and the solution of the problem has progressed so near to a satisfactory state that no such record of "trial and error" as has been true of the history of automatic block signaling need follow from further progress with train control.

It is unreasonable to expect that a system of train control, or any other railroad equipment that is equally intricate, could be thought out full-fledged and designed to a finality in advance of service experience. No great improvement in railroad operation or railroad engineering has come about in that way, but, rather, as the outgrowth of trial and modification under operating conditions. Any broad-minded conception of the problem must concede this truth to be equally applicable to automatic train control; and it is now the decided feeling of many railroad officials who have looked into the subject that such automatic control is bound to come.

It remains to be said that the expense of installation and maintenance is the only real question which confronts the railroads in this matter of automatic control of trains. What the first cost of installation would be in typical cases, not to consider special situations, has not, for lack of experience, been worked out to close estimation, as yet; but it seems likely that it might reach a figure somewhere between $800 and $2,000 per mile of road, according to local conditions, in addition to the cost of the wayside signals. At any rate it is certain that the cost would not be prohibitive.

In some installations that have been made, with ramps, and with signals already installed, the cost (war-price basis) has been as low as $200 per ramp, or $200 per mile for the track appliances. In certain installations now in service the cost of installing the appliances on the locomotives has been around $600 per set.

The halt in railroad extensions, and the diminishing rate of improvement of existing lines, for some years past, have brought the transportation business of the country into a spell which must soon be broken if our industrial life is to prosper. Much new capital will be necessary to provide for sorely needed second track, yard and terminal additions, new buildings and other facilities. What would be needed to equip the heavy traffic lines for automatic train control is only a trifle compared with capital that will have to be raised for the construction of new roadbed and track. Now is the time to decide the question, while the country, railroads and all, is in a state of flux. In the years of high prices that seem bound to follow the present period of unrest the cost of installing train control, which must, in the end, fall upon the "ultimate consumer," will seem less of a burden than to try to add it on after rates shall once more become stabilized.

What is now needed in the automatic train control situation is to make some kind of a start, with the most promising types or systems, beginning with train-stopping devices as the foundation, aim at gradual development, adding speed control features and such other refinements, step by step, as may be studied out. By the time that experience with the ordinary situations shall have become general the more difficult of the problems relating to terminal conditions will doubtless have been worked out. The fact is that the majority of serious train collisions have not occurred where the track conditions were complicated with interlocking, or with switches and crossings and crossovers, but out on the straight-away line, at a distance from terminals, where high speed is usually made, and where enginemen, as a rule, are not as alert as when passing through terminals. It is therefore entirely logical and fitting to take the simplest situations first.