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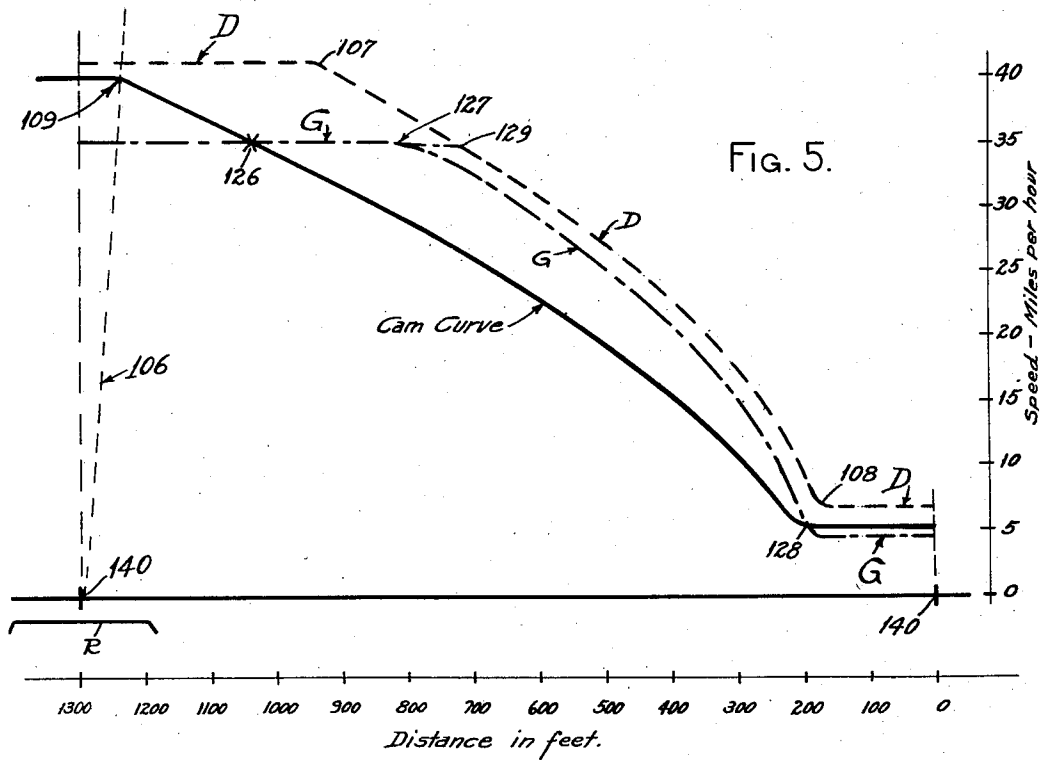
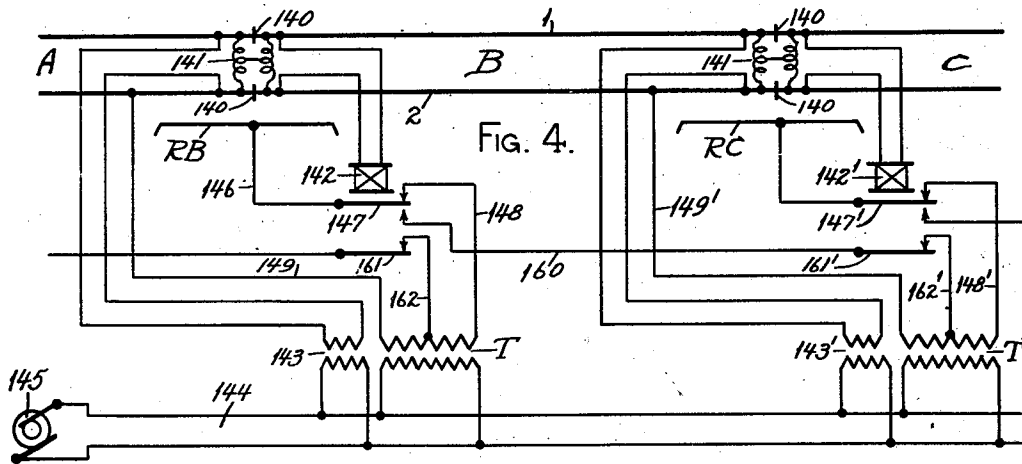
W. K. HOWE

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AUTOMATIC TRAIN CONTROL SYSTEM

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INVENTOR
Winthrop K. Howe.
BY
Neil C. Preston
ATTORNEY

UNITED STATES PATENT OFFICE

WINTHROP K. HOWE, OF ROCHESTER, NEW YORK, ASSIGNOR TO GENERAL RAILWAY SIGNAL COMPANY, OF GATES, NEW YORK, A CORPORATION OF NEW YORK

AUTOMATIC TRAIN-CONTROL SYSTEM

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This invention relates to systems for automatically controlling the movement of railway trains or vehicles, and more particularly to such systems in which signals for the guidance of the engineer or motorman of the train are operated or displayed in his cab, and in which suitable provisions are made for automatically controlling the movement of the train whenever the engineer fails to properly observe the signals and control his train in a way consistent with safety.

It has heretofore been recognized that the well known block signaling systems using fixed signals do not afford all the safety and protection desired, because actual trial has demonstrated that serious accidents sometimes occur because the engineer is unable to read these signals correctly, or negligently fails to do so, or for some reason fails to obey these signals. It has been proposed to provide mechanical devices for automatically governing the movement of a train under dangerous conditions, in order that an accident may be prevented in case the engineer fails for any reason to properly control his train himself. It is appreciated, however, that mechanical devices, as well as the human element, are liable to failure at critical times, and in order to obtain the best and most effective results, it is preferable to use the automatic mechanical devices more to supplement the vigilance of the engineer, than as the principal and only safeguard, so that before accident can occur, it is necessary for both the engineer and the mechanical devices to fail to perform their proper duties. To attain this end, it is necessary as a practical consideration to adopt some way of preventing the engineer from becoming careless or negligent and relying upon the mechanical devices with which his train is equipped, otherwise safety would in reality be dependent on the reliability of the mechanical devices. This may be accomplished by making it a practice to impose severe penalties upon the engineer in every instance where he has been so careless or negligent that the automatic mechanical devices have acted to control the train because of his failure to do so. Before such penalties can be imposed, how-

ever, it is necessary to furnish the engineer with ample information as to when and how he should control his train and also to provide a reliable and accurate recording device or similar mechanism which will detect the failure of the engineer to perform his duties properly.

With these considerations in view, one of the objects of this invention is to provide a reliable and accurate warning signal in connection with automatic train control apparatus, which will give to the engineer a readily recognized signal, warning him of the existence of danger and further advising him that unless he shall promptly slow down his train by his own initiative, the automatic train control apparatus will operate.

A further object of the invention is to provide suitable means whereby the warning signal will be given for a time prior to the automatic application of the brakes by the train control apparatus which is sufficient to permit the engineer to take appropriate action toward slowing down the train himself, and further to provide suitable means so that when the engineer acts properly in obedience to the warning signal, and there is no necessity for the automatic train control apparatus to operate, the operation of this apparatus will be automatically prevented.

A still further object of this invention is to provide for the giving of a warning signal prior to an automatic application of the brakes by the operation of the train control apparatus in such a way and under such circumstances as will govern the train with the necessary safety and without unnecessarily delaying its movements, thereby affording not only the greatest safety but also the greatest facility in the movement of trains.

A still further object of the invention is to provide a reliable and accurate recording device which will make a permanent record in some suitable way whenever the engineer fails to properly control his train in obedience to the warning signal, but which will not make a record when an automatic application of the brakes occurs due to the failure of any part of the system, so that a record will be made when and only when the en-

gineer has failed to properly perform his duties.

Further objects and advantages of the invention will be readily apparent as the description of the invention progresses.

In describing the invention in detail, reference will be made to the accompanying drawing, in which is illustrated a preferred embodiment of my invention, in which like reference characters designate corresponding parts in the several views, and in which:

Fig. 1 is a diagrammatic view, partly in the nature of a wiring diagram, which illustrates in a simplified form the parts and circuits on the vehicle which constitute one specific embodiment of this invention, said parts and circuits being illustrated more with the view of making their functions and operations more readily understood than with regard to their exact construction and arrangement;

Figs. 2 and 3 are schematic diagrams showing the closed position of certain contacts used in the embodiment of the invention shown;

Fig. 4 is a diagrammatic view showing one arrangement of the parts and circuits of the system along the track; and

Fig. 5 is a diagrammatic view showing speed and distance curves for illustrating the performance of trains governed by the train control system embodying this invention.

Referring first to the apparatus on the vehicle shown in Fig. 1, the numerals 1 and 2 designate portions of the track rails of an ordinary railway track. The vehicle is illustrated in a simplified and conventional manner as comprising two pairs of wheels 3—3 and 4—4 connected by the usual axles 5 and 6. The frame of the vehicle or train is shown in a simplified manner as formed of two side bars 7.

According to the specific embodiment of the invention illustrated, communication between the track and the vehicle, necessary for the control of the automatic apparatus on the vehicle in accordance with traffic conditions, is obtained by means of ramps and contact shoes. These contact shoes may be of any suitable construction, but in the accompanying drawing there is shown a simplified type which comprises a vertically movable plunger 8 slidably mounted in one of the side bars 7, this side bar for simplicity being assumed to be made of wood or other similar material, in order that the plunger 8 of the contact shoe may be insulated. The plunger 8 is pressed downward toward its lower position (shown in Fig. 1) by a compression spring 9 interposed between the side bar 7 and a collar 10 fixed to said plunger. The plunger 8 is intended to open a circuit when lifted by its engagement with a ramp, and while this function may be accomplished in various ways, this plunger is shown as pro-

vided with a button 11 of insulating material, which is larger than the plunger so as to form a stop for limiting the downward movement thereof. This button 11 is arranged to lift a contact spring 12 out of electrical contact with a contact piece 13, said spring 12 and contact piece 13 being secured to the side bar 7. In order to avoid complication, only one contact shoe on one side of the vehicle has been illustrated, but it is contemplated that in practice a contact shoe will be located on each side of the vehicle so that the desired cooperation of a contact shoe with the ramps along the track will occur regardless of which way the vehicle is headed.

The ramps may be of any suitable construction and in general comprise metallic contacting portions having sloping ends which are fixed in any suitable manner adjacent to one of the track rails but insulated therefrom so as to be in position to be engaged by the plunger 8 of the contact shoe of each train or vehicle. These ramps, being well known in the art, are illustrated conventionally in the drawing and are designated by the reference character R. Associated with each ramp R is a source of electrical energy and circuits for at times establishing differences of potential between the ramp and a track rail. One suitable arrangement of these trackway circuits is shown in Fig. 4, and will be described hereinafter; but in Fig. 1, the source of current is shown as a transformer T, having one terminal of its secondary connected to the ramp R. The secondary of this transformer is provided with two taps, giving different voltages, and by means of a switch 14 either of these two taps may be connected to the track rail 2. It is apparent that the simplified arrangement shown in Fig. 1 provides for connecting the entire voltage of the secondary of the transformer T across the track rail 2 of the ramp R, for connecting the voltage of only a part of this secondary across the track rail and ramp, and for disconnecting the secondary entirely. For convenience, these different electrical conditions of the ramp R will be hereinafter termed high voltage on the ramp, low voltage on the ramp, and zero voltage on the ramp, respectively. While in some instances the voltage applied to a ramp R may be controlled manually by a switch 14, ordinarily in practice the electrical connections for these different voltages are governed automatically in accordance with traffic conditions, as shown in Fig. 4.

The simplified form of a train control apparatus shown in Fig. 1 comprises a worm 15 fixed to the axle 6 and meshing with the worm wheel 16 secured to the lower end of a shaft 17 which is supported by suitable fixed supports 18. The shaft 17 drives a suitable speed responsive device which serves to indicate or establish, by the degree of

movement given to a movable part or member, the actual speed at which the train is traveling at any time. As illustrated, this speed responsive device comprises a block 19 fastened to the shaft 17, and a movable block 20 loosely mounted on said shaft so as to slide lengthwise thereon. Arms 21 carrying weights at their lower ends are pivotally connected to the fixed block 19 at their upper ends, and links 22 are connected between these arms and the lower movable block 20. Between the blocks 19 and 20 is interposed a compression spring 23. The block 20 is formed with flanges 24, between which are disposed rollers 25 carried by the bifurcated end of a lever 26, only one of said rollers being shown. The operation of this speed responsive device is similar to that of the well known centrifugal governor and will be fully understood without further explanation.

To the upper end of the shaft 17 is secured a bevel gear 27 which meshes with two other bevel gears 28 loosely mounted on a shaft 29 and disposed diametrically opposite to each other with relation to the gear 27. Each of the gears 28 is provided with clutch teeth adapted to engage corresponding teeth formed in the ends of a slidable sleeve 30, which is mounted on the shaft 29 between the two bevel gears 28 and which is connected to the shaft 29 by a pin and slot connection 31. The construction of parts just described constitutes one form of an automatic reversing gearing. The operation of this reversing gearing will be apparent without further explanation and is used for the purpose of causing the shaft 29 to rotate in the same direction regardless of which direction the shaft 17 is rotated, so that whichever way the vehicle is headed, the shaft 29 is always rotated in the same direction.

The shaft 29 is supported in suitable fixed supports 32 and is connected by a universal coupling 33 to another shaft 34. Disposed above the outer or free end of the shaft 34, is a cam control solenoid 35, having a core 36 which is pivotally connected to a sleeve 37 loosely mounted on the shaft 34. Secured to the shaft 34 is a worm 38 which is adapted to mesh with a worm wheel 39 fixed to a cam shaft 40 supported in suitable bearings 41. Part of the teeth of the worm wheel 39 are cut away, as clearly shown, for the purpose hereinafter explained. Fastened to the shaft 40 is a cam-shaped plate K, hereinafter referred to as the cam. The cam-shaft 40 and the cam K are biased to a predetermined initial position by some suitable device, which is shown in the simplified form of the invention illustrated, as a counterweight 42 fastened to the cam K. A fixed stop 43 is used for limiting the movement of the cam K under the influence of the counterweight 42. When the shaft 34 is allowed to drop by its

own weight, upon deenergization of the solenoid 35, the worm 38 is brought into mesh with the worm gear 39, and the cam-shaft 40 and the cam K are gradually turned in accordance with the distance traveled by the vehicle.

From the construction so far described, it can be seen that a movable part, namely the block 20 of the speed responsive device, is caused to assume different positions in accordance with variations in the actual speed of the vehicle, and that another movable part, namely, the cam K, is caused to be gradually moved at times in accordance with the distance traveled by the vehicle so that its follower is moved to establish varying permissive speeds for the vehicle at different points in its travel, the variation in the permissive speeds being determined by the shape of this cam. Thus, there is provided automatic means for determining the desired permissive speed for the vehicle and also its actual speed, and in order to obtain the automatic control desired, it remains to compare the actual speed with the existant permissive speed by suitable mechanical devices and arrange to control the movement of the vehicle when its actual speed exceeds the desired permissive speed. In the simplified construction illustrated, the floating lever 26 is connected at one end by the rollers 25 and the flanges 24 to the block 20 of the speed permissive device, and this lever carries at its other end a freely revoluble roller 44 which bears against the edge of the cam K. Pivotally connected to the lever 26 between its ends is a link or member 45 which is pulled downward by a spring 46, this spring serving to press the roller 44 against the edge of the cam K. Fastened to the link 45 is a piece of insulating material 47 which is arranged, when the link 45 has been raised to a predetermined extent, to move a contact member 48 upward away from one contact (indicated conventionally by an arrow) against another contact, thereby controlling circuits for the purpose hereinafter explained.

The train control apparatus hereinbefore described is controlled so as to have its operation initiated when dangerous traffic conditions exist ahead, and to be restored to its normal conditions when traffic conditions ahead become safe. The appropriate control of this train control apparatus is attained by the cooperation of the trackway circuits shown in Fig. 4 and hereinafter described with suitable control devices on the vehicle. In the particular embodiment of the invention illustrated, these control devices comprise a speed control relay SC, responsive to direct current, and a pick-up relay CP, responsive to alternating current only. These relays SC and CP are provided with contact fingers and associated contacts which are illustrated conventionally. The circuits com-

trolling these relays will be pointed out hereinafter in the description of the operation.

The information furnished to the engineer or motorman for guiding him in controlling his train properly, is given by suitable cab signals which are preferably located in the engineer's cab and which are so constructed as to give arrestive and readily distinguishable indications. As illustrated, these cab signals comprise a proceed signal, shown as a green light G; a caution signal, shown as a yellow light Y; and a warning signal, shown as a whistle W. The whistle W is operated by air pressure derived from a suitable source, as the main reservoir 49, and the operation of this whistle W is controlled by a piston valve 50, having a casing 51. This casing 51 is connected to the supply reservoir 49 by a pipe 52, and to the whistle W by a passage-way 53. The valve 50 is operated by a solenoid 54. In the construction illustrated, this solenoid 54 is normally deenergized, and the valve 50 is maintained by its own weight (aided by a spring, if necessary) in the lower position, thereby cutting off the supply of air from the reservoir 49 to the whistle W. When the solenoid 54 is energized, its core is attracted and the valve 50 is raised to open communications from the reservoir 49 to the passage 53, thereby sounding the whistle W. Fastened to but insulated from the core of the solenoid 54 is a contact disk 55 which is adapted to electrically connect cooperating contacts (illustrated conventionally by arrows) when the core is attracted, for the purpose hereinafter explained.

Associated with the train control apparatus and forming an important part of this invention, is a slow-acting circuit controlling device P, adapted to be operated electrically. According to the embodiment of the invention illustrated, this device P is shown in a simplified form as controlled in accordance with time, and comprises a solenoid M having two windings 57 and 58 and a vertically movable core 59. Secured to the core 59 and insulated therefrom are two contact disks 60 and 61. The contact disk 60 is arranged to establish an electrical connection between its cooperating contacts (illustrated conventionally as arrows) after the core 59 has moved downward to its lowermost position. The contact disk 61 is arranged to establish electrical connection between its cooperating contacts, when the core 59 is in its upper position and during the movement of said core nearly to its lower position, the contact disk 61 breaking circuit at the same time or slightly after the contact disk 60 makes circuit. The downward movement of the core 59 is retarded gradually in accordance with time by a suitable time controlled device. In the particular simplified construction illustrated, a piston 62 with a flexible packing is fastened to the lower end of the core 59, and this piston

fits in a dash-pot cylinder 63 having a restricted exhaust opening 64 in the bottom thereof. This dash-pot device permits the core 59 to be raised quickly by an energization of either winding 57 or 58 of the solenoid M, but acts to cause the core 59, when moving downward under its own weight, to move gradually in accordance with time. Obviously, other forms of time controlled devices may be used in place of the dash-pot device illustrated.

According to the embodiment of the invention illustrated, it is contemplated that the movement of the train or vehicle will be retarded by the well-known system of air brakes, and since this system of brakes is well known, it is only necessary to illustrate generally how the parts of the train control system act to cause an automatic application of the brakes. A portion of the train pipe forming part of the air brake system is shown and designated 65. As is well understood, the venting of this train pipe causes an automatic application of the brakes, either a service or an emergency application, depending upon the rapidity with which the air is vented. For automatically venting this train pipe so as to cause an automatic application of the brakes, an electro-pneumatic valve E. P. V. is connected to this train pipe. As shown, this valve E. P. V. comprises a casing 66, and a valve proper 67, which is urged by a spring 68 to its open position and which is held against the opposition of said spring in its closed position by a normally energized solenoid 69.

The instrument for recording or indicating when the train control apparatus has acted automatically to cause an application of the brakes, because of the failure of the engineer to properly control his train, may take various forms. This instrument is illustrated conventionally in the drawing as a recorder or counter I which is adapted to be operated upon energization of an electro-magnet or solenoid 70. It is contemplated that in practice this recorder I will be encased and sealed in some appropriate manner, so that it may be inspected by authorized persons but cannot be maliciously manipulated by the engineer.

According to the embodiment of the invention illustrated, it is assumed that the power used to propel the vehicle is electricity, which is controlled in the usual way by a controller L (shown diagrammatically). It should be understood, however, that by modifications readily apparent to the ordinary mechanic, this invention may be applied to trains which are propelled by steam. The controller L is provided with a suitable circuit controlling device, adapted to close a break in a circuit when the controller is in its "off" position and also to close a break

Operation

Operation of speed control apparatus.—

Prior to describing the operation of the system as a whole, including the trackway circuits, a brief explanation will be given of the operation of the apparatus on the vehicle which occurs when the vehicle passes a ramp at the entrance to a block when said ramp is deenergized on account of the block ahead being occupied by another train. Normally the parts of the train control apparatus are in the position shown in Fig. 1, and except for the limitation upon the maximum speed at which the train may travel as explained hereinafter, the train may travel at any speed. With the parts in the normal position the speed control relay SC is energized by a circuit which may be traced as follows: Commencing at the battery O, conductors 84 and 85, relay SC, conductors 86 and 87, contact finger 88 raised, conductor 89, contact spring 12, contact piece 13, and conductors 90, 91 and 92 back to the battery O.

When the vehicle passes a deenergized ramp the plunger 8 of the contact shoe is raised, and moves the contact spring 12 out of contact with the contact piece 13, thereby interrupting the circuit just traced for normally energizing the speed control relay SC. Since the ramp is assumed to be deenergized, no current is supplied to the pick-up relay CP, and consequently all of the contact fingers of the speed control relay SC drop to their lower position.

The dropping of the contact finger 93 interrupts the circuit which normally energizes the cam control solenoid 35, said circuit being traced as follows: Commencing at the battery O, conductors 84, 94 and 95, contact finger 93 raised, conductor 96, solenoid 35, and conductors 97, 98, 91 and 92 back to the battery O.

The dropping of the contact finger 99 interrupts the circuit for lighting the green lamp G, this circuit being traced as follows: Commencing at the battery O, conductors 84, 94 and 100, contact finger 99 raised, conductor 101, lamp G, conductor 102, 103, 98, 91 and 92 back to the battery O. At the same time, contact finger 99 in its lower position establishes a circuit for lighting the yellow lamp Y, said circuit being traced as follows: commencing at the battery O, conductors 84, 94 and 100, contact finger 99 in its lower position, conductor 104, lamp Y and conductors 105, 103, 98, 91 and 92 back to the battery O.

In this way, when the speed control relay SC is deenergized, the proceed signal given by the green lamp G is extinguished, and the caution signal given by the yellow light Y is displayed. Also, the solenoid 35 is deenergized and permits the shaft 34 to drop by its own weight and bring the worm 38 into mesh with the worm gear 39, thereby com-

in another circuit when the controller is in any one of its several positions in which the power is on. As shown, this circuit controller comprises a drum 71 of suitable insulating material, which is operatively connected to the handle 72 of the controller. This drum 71 carries a contact strip 73, and carried by suitable insulating supports are two pairs of contact fingers *c* and *d*. The construction and arrangement of these parts is such that when the controller handle 72 is in its "off" position the contact fingers *c* are bridged by contact strip 73, whereas the contact fingers *d* are bridged by the contact strip 73 when the controller is moved to any one of its power positions. This range of control of these pairs of contacts is shown diagrammatically in Fig. 3.

The usual engineer's brake valve by means of which he controls the automatic application and release of the air brakes is shown diagrammatically and designated H. Operatively connected to this brake valve is a drum 74 of suitable insulating material to which is fastened a contact strip 75. As is well known, the handle of the engineer's brake valve has several different positions, commonly termed release, running, lap, service and emergency. Associated with the contact strip 75 is a pair of contact fingers *a* which are arranged to be electrically connected by this contact strip when the handle of the engineer's brake valve is in either the release or running position; and in a similar way a pair of contact fingers *b* are electrically connected when the handle is in either the service or emergency positions. The range of contact of the contact fingers *a* and *b* is shown diagrammatically in Fig. 2.

In connection with this invention it is desirable to provide an automatic circuit controller which will be closed whenever the air brakes on the vehicle are actually applied. This circuit controller may be connected in various ways to the brake rigging; but as shown, this circuit controller comprises a pair of contact springs 76 secured to blocks of insulating material 77 fastened to a cylinder 78. Within this cylinder 78 is an air-tight piston 79 which is pressed by a spring 80 toward the left (as viewed in the drawing) and which carries a contact piece 81, said contact piece being adapted to electrically connect the springs 76 when the piston 79 is urged outward to the right against the opposition of the spring 80. The cylinder 78 is connected by a pipe 82 to the usual brake cylinder 83. It will be readily apparent that when the air brakes are applied, air under pressure from the brake cylinder 83 will cause the piston 79 to move to the right and establish an electrical connection between the contact springs 76 for the purpose hereinafter explained.

mencing a gradual turning of the cam K in a clockwise direction in accordance with the distance traveled by the vehicle.

When the speed control relay SC is deenergized, its contact finger 88 opens and makes an additional break in its normally closed energizing circuit, so that after the shoe leaves the ramp and the shoe contacts close, nevertheless, the speed control relay will not be reenergized.

With the cam K connected to the wheels of the vehicle and gradually turned as the vehicle travels through the block, there commences a gradual reduction in the permissive speed for the vehicle; and unless the actual speed of the vehicle is maintained less than this prescribed permissive speed, the train control apparatus acts automatically to first sound the warning signal, and then after an interval of delay, unless the engineer himself acts to control the train, to cause an automatic application of the brakes, as will be more fully explained hereinafter. The shape of the cam K determines the way in which the permissive speed is gradually decreased, and in general, this gradual decrease in permissive speed is preferably determined in accordance with the actual braking curve of the vehicle. In the particular type of cam illustrated, the radii correspond to speed and the angular displacement of the cam from its initial position (shown in Fig. 1) corresponds to the distance traveled by the vehicle after the cam K has commenced to move. In short, the cam K acts mechanically to reproduce on the train, so to speak, a certain prescribed speed-distance curve which it is desired that the vehicle should observe in travelling through the block.

In order to explain more clearly the factors of speed and distance which determine the preferable shape of the cam K and also to point out the features of the construction and operation of the system embodying this invention, a number of curves are shown in Fig. 5 which are drawn with regard to a certain assumed length of block and braking equipment, together with certain other assumed conditions. These curves are drawn according to the well known method of plotting curves to rectangular coordinates, the horizontal spaces or distances representing the distance along the track, and the vertical spaces various speeds. The length of the block in Fig. 5 is indicated as the space between the insulated joints 140. The curve drawn as a heavy line and marked "cam curve" in Fig. 5 is the curve from which the shape of the cam K, suitable for governing a vehicle in this block, would be determined; and this curve shows the different permissive speeds for the different points in the block which would satisfy the conditions assumed. It should be understood that the "cam curve" illustrated, as well as the other curves shown

in Fig. 5, are drawn for illustrative purposes and while effort has been made to show such curves as would be true of practical working conditions, these curves should not be considered as precisely correct, or as the only curves which can be employed, since the various assumptions on which these curves are based may be varied according to the desire or volition of the one practicing the invention.

According to the preferred method of determining the shape of the "cam curve" there is first obtained the braking data for the braking equipment of the vehicle or train to be governed. There is a substantially uniform distance within which a train or vehicle having a given braking equipment can be brought to a stop by its brakes when traveling at a given speed at the time the brakes are first applied. These different braking distances for different speeds may be determined by tests; and when such data has been collected, the different braking distances for the different speeds may be plotted to form a speed-distance curve which may be termed the braking curve for the vehicle in question. Such a braking curve is shown in Fig. 5 between the points 107 and 108 by the heavy dash line curve marked D. This curve D indicates the speeds at the different points in the block at which the brakes should be applied in order that the vehicle may be brought to a predetermined low speed before it reaches the end of the block. While this curve D may be based upon either an emergency or a service application of the brakes, with suitable margins or modifications as desired, this curve is shown as corresponding substantially with the braking curve for the vehicle under a normal service application of the brakes. The distance between the point 108 and the actual end of the block, indicated by the insulated joint 140, is adopted as a margin of safety to take care of slight variations in the braking power of the vehicle under different conditions and slight variations in the exact point and speed at which the brakes are applied. The portion of the curve D from this point 108 to the end of the block, is horizontal and indicates some arbitrary assumed low speed, such as 8 or 10 miles per hour, which is considered to be a safe low speed for the vehicle. The horizontal portion of the curve D from the point 107 to the entrance end of the block represents the maximum speed at which the vehicle may enter the block in question and be safely controlled by its brakes within the limits of that block. This maximum speed is selected with due regard to the length of the block and with reference to trackway conditions and factors affecting train capacity.

Having assumed the desired braking curve D, the "cam curve" is determined from this curve by making the portion of the "cam

curve" from the point 109 to the point 128 such that the horizontal distances between the two curves represent a substantially fixed interval of time at the different speeds. This interval of time is selected so as to afford the engineer ample opportunity to recognize the warning signal, shut off the power and move his brake handle to the service braking position; and this interval of time corresponds to that for which the time control device P is adjusted to break circuit at the contact disk 61. It will be appreciated that this interval of time selected should be made as short as practicable, if it is desired to obtain the best train capacity, because it is evident that the block may be made shorter as this time interval is decreased.

The horizontal portion of the "cam curve" from the point 109 to the vertical line indicating the actual entrance end of the block indicates the maximum permissive speed prescribed by the cam K in its normal or initial position. It will be noted that this portion of the "cam curve" extends a short distance into the block, indicating that the cam K does not actually commence to move until after the vehicle has traveled a short distance into the block. This delay in the beginning of the movement of the cam K is due to the fact that the speed control relay SC is not deenergized until after the first pair of wheels of the vehicle enter the block (as explained more fully hereinafter), and also because there is a slight time required for the operation of the parts which result in causing the cam to commence to move. The delay from the instant the wheels of the vehicle first enter the block to the instant when the cam K first starts to move is very short when measured as time, but is appreciable when measured as distance, especially at high speeds. This interval of delay, measured as distance, is indicated by the dotted line 106.

It will also be noted that the horizontal portion of the "cam curve" at the beginning end of the block is below the horizontal portion of the curve D. This difference between the maximum permissive speed indicated by the "cam curve" and the maximum speed indicated by the curve D is selected with due regard to the maximum rate of acceleration of the train at this speed, so that, even if the vehicle were accelerating at its maximum rate when it exceeds the maximum permissive speed prescribed by the cam, (shown as about 38 miles per hour) the brakes would be automatically applied after a lapse of an interval of time before the train could accelerate to a speed higher than that represented by the curve D. In other words, the maximum permissive speed established by the cam is selected such that the vehicle cannot overrun the safe braking curve D, under the most adverse conditions, thereby assuring that under no circumstances will the vehicle be traveling

so fast at the beginning of the block that it cannot be automatically stopped in accordance with the curve D before reaching the end of the block. In the same way and for the same reason the lower portion of the "cam curve" from the point 128 to the end of the block is at a lower speed than the curve D, a greater difference in the speeds being shown because of the fact that as a rule vehicles can accelerate to higher speeds in a given time while traveling at a low speed than while traveling at a high speed.

From the foregoing, it can be seen that the "cam curve" indicates for all points in the travel of the vehicle a limiting permissive speed at which the time control device P will be set into operation, and that the curve D indicates the speeds at which the automatic application of the brakes will occur when the time control device has run out. Strictly speaking, the curve D only approximately represents the speed at which the automatic application of the brakes will occur, because the exact speed and the distance will depend upon the rate of acceleration or deceleration during the time elapsing from the instant the train exceeds the speed prescribed by the "cam curve". In this connection, the "cam curve" is preferably shaped such that an automatic application of the brakes will never occur at a higher speed for a given point than indicated by the curve D, even though the vehicle is accelerating during the time interval at its maximum rate, but this assumption is not compulsory, since the margin of safety at the end of the block may be depended upon to take care of such variations as would occur.

Referring now to the operation of the train control apparatus on the vehicle and referring to Fig. 1 it can be seen that after the cam K is connected to the wheels, as previously described, and commences to turn gradually in accordance with the distance traveled by the vehicle, the right hand end of the floating lever 26 will be gradually raised. The left hand end of this floating lever is raised by the speed responsive device to higher positions as the actual speed of the train increases. The parts are so proportioned that, with the cam K in a given position, corresponding to the permissive speed it is desired to enforce at that instant, the lefthand end of the lever 26 will be raised by the speed responsive device, provided the actual speed of the vehicle is greater than this permissive speed, to a point where the link 45 will be moved upward far enough to cause the insulated piece 47 to lift the contact member 48, thereby initiating the operation of the devices, as hereinafter explained, which act to compel a reduction in speed of the vehicle. This action will take place regardless of the speed at which the train en-

tered the block and at the proper point in the block.

The raising of the contact member 48 establishes a circuit for sounding the warning whistle. For convenience, some of the circuits have been shown as extending from one grounded point (shown conventionally) to another, with a separate battery in each circuit; but it is to be understood that in practice ordinarily only one battery would be used, and consequently the batteries have been given the same reference character O with distinctive exponents added. It will be evident that these circuits which extend from one grounded point to another grounded point are completed by the frame or body of the vehicle. The circuit for the warning signal may be traced as follows: from ground through the battery O¹, conductor 110, contact member 48, conductor 111, solenoid 54, and conductor 112 to ground.

At the same time, a normally closed circuit for energizing the winding 58 of the solenoid M is interrupted, said circuit being traced as follows: from ground to the battery O¹, conductor 110, contact member 48, conductor 114, winding 58, and conductor 115 to ground. The solenoid M being de-energized, its core 59 commences to move gradually downward in accordance with time.

Upon sounding of the warning whistle W, the engineer is expected to immediately shut off the power and move his brake handle to the service position. Assuming that the engineer properly performs his duties in this way, a circuit is established for energizing the winding 57 of the solenoid M, said circuit being traced as follows: from ground through the battery O², conductor 116, contact fingers c, conductor 117, contact fingers b, conductors 118 and 119, winding 57, and conductor 120 to ground. The establishing of this circuit restores the core 59 to its upper or normal position. In practice, it is necessary for the engineer to keep his brake valve in the service position for only a short time in order to cause a service application of the brakes, whereupon he may move it back to the lap position. This would open the circuit just traced at the contact fingers b. In the meantime, however, a shunt for these contact fingers b, comprising conductors 121 and 122, is established at the contact springs 76 by the contact piece 81, providing the brakes have properly operated and air pressure actually exists in the brake cylinder 83. In this way, although the engineer puts his brake valve back to the lap position, the winding 57 of the solenoid M is maintained energized, so as to prevent an automatic application of the brakes. If the engineer should release the brakes, or attempt to move the controller handle 72 to a power position, the winding 57 would become deenergized, and

in time an automatic application of the brakes would occur. Consequently, not only must the engineer observe the warning signal by shutting off the power and actually applying the brakes, but he must maintain the brakes applied and the power off. Another feature of this construction and arrangement is that after an automatic application of the brakes by an opening of the electro-pneumatic valve assuming that the power has been shut off, this electro-pneumatic valve is automatically restored to its closed position when the brakes are acting, because the contact springs 76 are bridged by the contact piece 81 and serve to automatically restore the core 59 to the upper position and reenergize the solenoid 69.

To illustrate this operation just described, referring to Fig. 5, assume the train enters the block at the speed represented by the dot and dash line G, and after receiving the caution signal Y continues at this speed. At the point 126 where this dot and dash line G intersects the "cam curve", the contact member 48 will be raised. If the engineer properly performs his duties, the train will continue at substantially a uniform speed, as illustrated in Fig. 5 by the dot and dash line G extending from the point 126 to the point 127 horizontally, for a distance representing the travel of the train while the engineer is shutting off the power and applying the brakes. At or about the point 127, the brakes will be fully acting. The portion of the dot and dash curve G just to the left of the dash line D from point 127 down represents the speed-distance curve of the train under the manual service application of the brakes.

In this connection, it is noted that Fig. 5 and the foregoing description have been made on the assumption that as much facility as possible is desired, the "cam curve" and the dash curve D being caused to correspond substantially with the speed-distance curve of the train under a full service application. In other words, the curves in Fig. 5 are drawn with the idea that after the train has once exceeded its permissive speed, the brakes must be continually applied until the end of the block is nearly reached. After the train has gradually reduced its speed in accordance with the dot and dash line curve G to the point 128 where this curve intersects the "cam curve", the actual speed of the train is then below the permissive speed, so that the contact member 48 is permitted to move to its lower position. This stops the sounding of the warning whistle W and advises the engineer that he has succeeded in controlling his train to a safe speed. When the warning signal W stops sounding, the engineer is expected to release the brakes and continue at a speed slightly less than the minimum permissive speed, as indicated by

the lower horizontal portion of the dot and dash curve G. After having brought his train to a predetermined low speed, the engineer may bring his train to a stop at the end of the block, with the contact shoe of the engine or first motor car of the train in engagement with the ramp R at the entrance to the next block in advance, so that when traffic conditions ahead become safe, the speed control relay SC will be automatically re-energized, as explained hereinafter in describing the operation of the trackway circuits, thereby reenergizing the cam control solenoid 35 and permitting the cam K to return automatically to its normal or initial maximum speed position under the influence of the counterweight 42, ready for its next operation when required. This permits the engineer to accelerate without delay. If, however, conditions require, the engineer need not wait for the speed control relay SC to be re-energized, but may enter the next block at the low minimum speed prescribed by the cam. The mutilated portion of the gear 39 provides for this continuing movement of the vehicle without causing further movement of the cam K and without injuring the parts. If, while his train is traveling through this next block at the minimum speed, the engineer should attempt to exceed this minimum speed, the warning signal would be sounded and in time an automatic application of the brakes would result unless the engineer should reduce speed. In this way, the train may be allowed to enter a block even though the ramp at the entrance to that block is in the condition indicating that the block in question is occupied by another train.

Assume that the engineer, after having received the warning signal, is incapacitated or through negligence or carelessness fails to promptly shut off the power and manually apply the brakes. After the lapse of the time for which the time mechanism P is set, the brakes will be automatically applied by reason of the fact that the contact disk 61 moves downward far enough to break circuit with its cooperating contacts, thereby interrupting the normally closed circuit for energizing the solenoid 69 controlling the electro-pneumatic brake valve E. P. V. said circuit being traced as follows: from ground to battery O³, conductor 123, contact disk 61, conductor 124, solenoid 69, and conductor 125 to ground. Since the time interval for which the time control mechanism is set corresponds at any given speed with the distance between the "cam curve" and the curve D, this automatic application of the brakes takes place at about the point to cause the vehicle to decelerate along the curve D, and the speed of the train is reduced in accordance with the curve D. In this way, the train is automatically brought to a safe low speed before it

reaches the end of the block, regardless of the speed at which it entered that block.

The performance of the vehicle just described is illustrated in Fig. 5 by the horizontal dot and dash line between points 127 and 129, it being assumed as before that the vehicle enters the block at the speed represented by the horizontal portion of the dot and dash curve G and that the engineer receives the warning signal at the point 126 and continues at the same speed without any effort to shut off the power or apply the brakes, the automatic application of the brakes taking place at the point 129.

In connection with the operation of the train control apparatus described, one important feature of this invention is the provision for preventing the automatic application of the brakes by the running out of the slow acting device P when the engineer obeys the warning signal by shutting off the power and manually applying the brakes. This feature is of importance, because it is impracticable to obtain the desired facility of train movement by depending upon the closing of the circuit at the contact arm 48 to re-energize the solenoid M, so as to arrest further operation of the device P, since this would occur only after the vehicle had reduced its speed below the limiting speeds prescribed by the cam curve; and it can be seen that if this reduction in speed is to be accomplished by a manual application of the brakes after the sounding of the warning signal, the rate of deceleration indicated by the "cam curve" must be much less than that of the service application of the brakes. Otherwise, with the "cam curve" determined from the service breaking curve (as described and shown in Fig. 5), the very best reduction in speed which the engineer could accomplish by a manual application of the brakes would be indicated by the dot and dash curve G, and it can be seen that this curve does not again cross the "cam curve" until the lowest speed is reached. In other words, unless the "cam curve" is made so flat as regards the actual service braking curve, as to greatly lengthen the blocks beyond that required for safety, thereby seriously interfering with the train capacity, the engineer could never in spite of his best efforts prevent an automatic application of the brakes by the running out of the device P, unless some other expedient than the reclosing of the energizing circuit of this device P by the cam controlled contacts is adapted to prevent an automatic application by the running out of the device P.

Maximum speed limitation.—Even when the cam K is in its normal or initial position there is imposed a limitation on the maximum speed at which the vehicle may travel, this maximum limiting speed being determined by the radius of the cam in its normal position. This maximum speed is indicated in

Fig. 5 by the horizontal portion of the "cam curve" at the left of the point 109. This limitation upon the maximum speed of the vehicle prevents the vehicle from entering a given block at too high a speed and may also be used to limit the speed of the vehicle over certain sections of the railroad, such as over cross-overs, around sharp corners, through yard limits, and the like.

Recording mechanism.—The circuit for energizing the solenoid 70 of the recording mechanism so as to make a permanent record may be traced as follows: from ground to the battery O⁴, conductor 130, solenoid 70, conductor 131, contact disk 60, conductor 132, and thence along either of two multiple paths, one through the contact fingers *a*, conductor 133, to conductor 135, or along conductor 134 through the contact fingers *d* to the conductor 135, thence through the contact disk 55, and conductor 136 to ground. The above traced circuit for operating the recording mechanism is normally open, and consequently any failure of a part of this circuit results in a failure to make a record rather than in making an improper record. The operation of the recording mechanism depends: first, upon the core 59 of the solenoid M being in its lower position, second, upon either the controller handle 72 being in a power position, or the engineer's brake valve in the release or running position; and finally upon the solenoid 54 being energized. When the solenoid 54 is energized, then the warning signal is sounding, and if the engineer fails to either shut off the power or manually apply the brakes, and the brakes are automatically applied by the dropping of the core 59, a record is made against the engineer. By reason of this control of the recording mechanism, it is assured that a record will never be made unless the engineer is at fault; and when a record is made, it is possible to justly penalize the engineer; because it is positively assured that this record is not due to any failure of the train control apparatus to operate properly. If the brakes are improperly applied by the electro-pneumatic valve E. P. V., due to a failure in its circuit, a record will not be made because the circuit controlling the recorder will be broken at the contact disk 60. If the solenoid M should be improperly deenergized because of a failure in its circuits, no record would be made because the circuit operating the recorder would be broken at the contact disk 55. If, for any reason, current is not actually applied to the solenoid 54 controlling the warning signal, so that the warning signal in fact does not operate when it should, a record will not be made, because the contact disk 55 will not then close the circuit. It will also be noted that the engineer is not required to actually slow down his train but is only required to shut off the power and move his brake valve

to the brake applying position; and if he properly performs these movements a record will not be made against him. If, for any reason, the braking equipment of the train is defective, so that even though the engineer moves his brake valve to the service position, the brakes do not actually operate, the engineer will not have a record made against him although the time controlled device P may continue in operation and open the electro-pneumatic valve E. P. V., for the reason that the recorder circuit will be broken at the contacts *a* while the engineer is trying to apply the brakes.

Trackway circuits.—From a consideration of the operation of the apparatus carried on the vehicle it can be seen that when the speed control relay SC is energized, the cam K is in its maximum speed position, when this relay is deenergized the cam K is operated to impose a gradually decreasing limitation upon the speed of the vehicle, and when this relay is reenergized, it having once been deenergized, the cam is automatically restored to its maximum speed position. The speed control relay SC may be controlled at the proper times and in the proper way to accord with traffic conditions ahead by various arrangements of trackway circuits; and one such arrangement is illustrated in Fig. 4. Referring to Fig. 4, the track rails 1 and 2 are divided by insulating joints 140 into blocks A, B and C in the usual way, only the block B being entirely shown. In this connection, it should be understood that when the invention is applied to electrically propelled roads, the usual impedance bonds will be used to render the track rails electrically continuous for the propulsion current and yet electrically isolated for signaling current. Such impedance bonds are shown diagrammatically in Fig. 4 and are designated generally 141. The circuits and apparatus associated with each block are the same and for convenience corresponding parts and conductors are given the same reference characters with distinctive exponents added.

Each block is provided with a track relay 142 connected across the track rails at one end of the corresponding block in the usual way. Each block is also provided with a track transformer 143, the secondary of which is connected across the track rails in the usual way and the primary of which is connected to a transmission line 144 which is supplied with alternating current from a suitable generator 145. The transformer T for supplying energy to the ramp R at the entrance to each block also has its primary connected to the transmission line 144. Referring to the electric condition of the ramp RB at the entrance to the block B, this ramp will be supplied with high voltage when the block B is not occupied, by reason of the circuit comprising conductors 146, relay armature 147 raised,

conductor 148, secondary of transformer T, and conductor 149. Consequently, when the vehicle approaches the block B and its contact shoe engages the ramp RB, high voltage is supplied to the ramp RB until the first pair of wheels enters the block B. The pick up relay CP on the vehicle has one terminal connected by the conductor 150 to the contact shoe. Its other terminal is connected by conductor 151 through impedance 152 and conductor 153 to the wheels and axles of the vehicle. The impedance 152 is shunted by a partial circuit of low resistance when the contact finger 155 of the speed control relay SC is raised, this shunt comprising conductor 154, contact finger 155 in its raised position and conductor 156. The impedance 152 is so adjusted that when high voltage is applied to a ramp, and this impedance is in circuit with the relay CP, sufficient current will be supplied to cause the relay to raise its contact finger 157. The raising of the contact finger 157 energizes the speed control relay SC by establishing a circuit which may be traced as follows: commencing at the battery O, conductors 84 and 85, relay SC, conductors 86 and 158, contact finger 157 raised, and conductors 159 and 92 back to the battery O. When low voltage is applied to a ramp, if the impedance 152, is included in circuit with the relay CP, its contact finger 157 will not be raised, but if this impedance 152 is shunted, the contact finger 157 will be raised.

In order to explain clearly the different controlling effects produced upon the speed control relay SC under different traffic conditions occurring in different practice, it is convenient to explain the operation of the relay SC under certain assumptions of traffic conditions. For the first assumed condition, suppose that the vehicle under consideration has been traveling along the track without being under the dominance of its speed control apparatus, except for the maximum speed limitation, and suppose that this vehicle approaches the block B when neither the block B nor the block C is occupied by another train. Upon engagement of the shoe of the vehicle with the ramp RB, the stick circuit for the speed control relay SC will be interrupted, as hereinbefore explained, but at the same time the high voltage applied to this ramp will cause the relay CP to raise its contact finger 157, thereby maintaining the speed control relay SC energized independently of its stick circuit. As the vehicle progresses and its first pair of wheels enter the block B, the track relay 142 associated with this block is shunted and its contact finger 147 drops. With the block C unoccupied as assumed, another partial circuit is established for supplying low voltage to the ramp RB, said partial circuit comprising conductors 146, contact finger 147 in its lower position, conductor 160, contact finger 161¹

of the track relay 142¹ in its upper position, conductor 162¹, low voltage tap of the transformer T¹, and conductor 149¹ to the track rail 2. Since the contact finger 155 of the speed control relay SC is at this time in its upper position so as to shunt the impedance 152, this low voltage is sufficient to maintain the contact finger 157 of the relay CP raised, thereby maintaining the energization of the relay SC until shoe leaves electrical contact with the ramp RB, whereupon the stick circuit for the relay SC is established. In this way, when the vehicle passes the entrance to a block when the next block in advance is not occupied, the speed control relay SC is maintained energized.

For the next traffic condition, assume that the vehicle approaches the block B while another train occupies the block C. Before the first pair of wheels of the vehicle enter the block B, the same operation occurs as hereinbefore explained; but when the vehicle in question enters the block B and shunts the track relay 142, the speed control relay SC is deenergized by reason of the fact that its stick circuit is interrupted and the relay CP is deenergized, the circuit supplying low voltage to said relay CP being interrupted at the contact finger 161¹ of the track relay 142¹. In this way, when a train enters the block, as the block B, and the block next in advance, as the block C, is occupied by another train, the speed control relay SC on the following vehicle is deenergized and the speed control apparatus on the vehicle set into operation.

Assume that the speed control apparatus has been set into operation when the vehicle enters the block B, and that by the time this vehicle reaches the end of the block B, the train ahead formerly occupying the block C has moved out of that block. Then, the ramp RC will be supplied with high voltage since the contact finger 147¹ of the track relay 142¹ is in its upper position. Consequently, even though the speed control relay SC is at that time deenergized and the impedance 152 included in the circuit with the relay CP, sufficient current is supplied to the relay CP to raise its contact finger 157, thereby reenergizing the speed control relay SC. If the train ahead is in the block next in advance of the block C, upon entrance of the vehicle in question into the block C, the speed control relay SC will be deenergized in the same way as previously explained.

Assume, however, that after the speed control apparatus on the vehicle has been set into operation at the entrance to the block B due to the presence of the train ahead in the block C, that this train ahead still occupies the block C at the time the vehicle reaches the end of the block B. Under these conditions either low voltage or zero voltage will be applied to the ramp RC, depending upon

whether or not the block next in advance of the block C is occupied or unoccupied. In either case, the relay CP will not be reenergized, since the impedance 152 is then included in circuit with it and low voltage is insufficient to raise the contact finger 157. Consequently, the following vehicle is not released from the dominance of its speed control apparatus, and if it enters the block C at all, it must do so at the minimum speed to which it is restricted by the cam K in its minimum permissive speed position. In this connection it will be noted that the worm gear 39 is provided with a cut away portion, so that after the cam K and the shaft 40 have rotated to the minimum speed position, further movement of the vehicle will not cause further rotation of the shaft 40, since the teeth of the worm 38 rotate idly in the cut away portion of the worm gear 39.

In describing the combination and arrangement of parts and circuits embodying this invention, no attempt has been made to show and describe all of the various and obvious modifications, and it should be understood that the specific embodiment of my invention shown and described is susceptible of change to accord with the varying requirements of railroads and varying conditions. For example, it may be found desirable in some instances to omit the contacts *d* on the controller L. This change would enable the motorman or engineer of the vehicle to reverse his motors or engine in obedience to the warning signal, without having a record made against him. To illustrate, suppose that the vehicle exceeds the prescribed permissive speed and the warning whistle W is sounded. The operator of the vehicle may shut off his power and give a service application of the brakes, which as previously described, would energize the winding 57 of the solenoid M and prevent an automatic application of the brakes. There might be occasions, however, where the brakes would not retard the train sufficiently, due to slippery rails or other causes, so that for the sake of safety the operator of the vehicle should reverse his motors or engine. This reversal would include moving the power controller to a position supplying power, thereby breaking the circuit for energizing said winding 57, so as to permit the time controller device P to operate and after the lapse of an interval of time apply the brakes automatically. Obviously the operator of the vehicle should not be penalized in such cases, and for this reason, the contacts *d*, above referred to, may be omitted or combined in circuit with auxiliary contacts connected with the reversing lever. It will be observed that the contact *b* on the brake valve is closed when this brake valve is in the emergency position. This is an optional arrangement, and in some respects, greater safety might be obtained by con-

structing these contacts so as to be closed only in the service position of the brake valve. As an illustration, suppose that the brake valve for some reason should not operate properly when moved to the service position. Then, the operator of the vehicle upon receiving the warning signal and failing to obtain the desired retardation of his train by a service application of the brakes, would naturally move his brake valve to the emergency position. This would keep the contacts *b* still closed and prevent possible action of the electrically operated brake controlling valve E. P. V. From the standpoint of safety, however, it might be considered desirable to have this automatic brake controlling device E. P. V. operated as quickly as the time control device P would permit, since the defect preventing proper operation of the service application of the brakes might also apply to the emergency application of the brakes.

Also, no attempt has been made to illustrate and describe all of the various devices which may be essential to constitute a complete system for practical use, since the way in which these various other devices, which are disclosed in other of my applications, may be incorporated with the features of the system herein shown and described, will be readily apparent to one skilled in the art.

Consequently, although I have particularly described the construction of one physical embodiment of my invention, and explained the operation and principle thereof; nevertheless, I desire to have it understood that the form selected is merely illustrative, but does not exhaust the possible physical embodiments of the idea of means underlying my invention.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. In an automatic train control system, the combination with a vehicle, of automatic train control apparatus therefor adapted to be conditioned for operation from the trackway and acting when thus conditioned to cause automatic application of the brakes of the vehicle whenever it thereafter exceeds certain prescribed limiting speeds during its progress along the track, trackway means for conditioning and restoring said apparatus, a warning signal adapted to attract the attention of the operator of the vehicle and operated prior to the automatic application of the brakes, and means acting when the brakes of the vehicle have been applied manually by the operator of the vehicle for preventing such automatic brake application by the action of said apparatus.

2. In an automatic train control system, the combination with a vehicle, of automatic train control apparatus therefor adapted to cause an automatic application of the brakes whenever the vehicle exceeds certain prescribed limiting speeds during its progress

along the track, a warning signal adapted to attract the attention of the operator of the vehicle and given prior to the automatic application of the brakes, power and brake control devices for the vehicle adapted to be actuated manually by the operator, and means dependent upon said control devices being in position to retard the movement of the vehicle for preventing the automatic application of the brakes by the action of said apparatus.

3. In an automatic train control system, the combination with a vehicle, of automatic train control apparatus therefor comprising means adapted to prescribe limiting speeds for the vehicle during its progress along the track, a slow acting device having a tendency to assume an active condition and governed by said apparatus, said device being set into operation when the vehicle exceeds the limiting speed prescribed therefor, means controlled by said slow acting device for automatically applying the brakes of the vehicle after an interval of delay, a warning signal arranged to attract the attention of the operator of the vehicle and simultaneously operated automatically when said slow acting device is set into operation, and automatic means for preventing the automatic application of the brakes by the action of said slow acting device when the brakes of the vehicle are applied manually by the operator in obedience to the warning signal.

4. In an automatic train control system, the combination with a vehicle, of automatic train control apparatus therefor comprising means adapted to prescribe limiting speeds for the vehicle during its progress along the track, a warning signal in the cab, a normally energized brake setting appliance, means tending to assume its active condition and governed by said train control apparatus for operating the warning signal when the vehicle exceeds the prescribed limiting speed and for operating the brake setting appliance after an interval of delay, control devices adapted to be operated manually by the operator of the vehicle to retard its movement, and means dependent upon said control devices being operated to cause retardation of the vehicle for preventing said automatic application of the brakes.

5. In an automatic train control system, the combination with a vehicle, of a warning signal arranged to attract the attention of the operator of the vehicle, a slow acting device, a brake setting appliance operated when said slow acting device attains its ultimate condition, automatic train control apparatus for simultaneously giving the warning signal and setting said slow acting device into operation when the vehicle exceeds certain prescribed limiting speeds during its travel, and means for restoring said slow

acting device to its initial condition when the brakes of the vehicle are acting.

6. In an automatic train control system, the combination with a vehicle, of automatic train control apparatus therefor comprising a normally energized slow acting device having a tendency to assume its active condition and adapted when set into operation to cause an automatic application of the brakes after an interval of delay, a warning signal arranged to attract the attention of the operator of the vehicle and operated at the same time said slow acting device is set into operation, and means adapted to be controlled manually by the operator of the vehicle for preventing such automatic application of the brakes by the action of said slow action device.

7. In an automatic train control system, the combination with a vehicle, of a slow acting device thereon having a tendency to assume an ultimate condition and cause an automatic application of the brakes of the vehicle after an interval of delay, means for normally maintaining said slow acting device in its initial condition, a warning signal on the vehicle, means responsive to the speed of the vehicle and its location along the track for simultaneously giving the warning signal and controlling said means to set the slow acting device into operation, and means on the vehicle adapted to be operated manually by the operator thereof for preventing said slow acting device from attaining its ultimate condition.

8. In an automatic train control system, the combination with a vehicle, of a permissive speed device thereon adapted to establish safe permissive speeds for the vehicle during its progress along the track, a speed responsive device operated in accordance with the actual speed of the vehicle, a warning signal on the vehicle arranged to attract the attention of the operator thereof, a brake setting appliance, slow acting means adapted when set into operation to cause actuation of said brake setting appliance after an interval of delay, means responding jointly to said permissive speed device and said speed responsive device for simultaneously giving the warning signal and setting said slow acting means into operation whenever the actual speed of the vehicle exceeds the prescribed permissive speed, and means adapted to be operated manually by the operator for preventing the actuation of the brake setting appliance when the operator acts in obedience to said warning signal.

9. In an automatic train control system, the combination with automatic train control apparatus on a vehicle comprising normally energized devices tending to assume an active condition in which the brakes of the vehicle are automatically applied, said apparatus including a normally deenergized warning sig-

nal and means for causing operation of said warning signal prior to the automatic brake application, of an electrically operable recorder, a normally open circuit for operating the recorder, and means dependent jointly on the operation of the warning signal and said devices causing an automatic brake application for closing said circuit, whereby the recorder will not be operated by accidental failure of the said normally energized devices.

10. In an automatic train control system the combination with a vehicle, of automatic train control apparatus therefor comprising devices having a tendency to assume an active condition and adapted to automatically apply the brakes of the vehicle whenever it exceeds certain prescribed limiting speeds during its progress along the track, a recorder, control means adapted to be operated manually by the operator of the vehicle for governing the movement thereof, and a normally open circuit for actuating the recorder which includes in series circuit controllers which are separately closed when said automatic train control apparatus acts to apply the brakes and said control means is in position permitting unretarded movement of the vehicle.

11. In an automatic train control system, the combination with a vehicle, of automatic train control apparatus therefor adapted to give a warning signal and then automatically apply the brakes after an interval of delay when the vehicle exceeds certain limiting speeds during its progress along the track, a recorder, control means on the vehicle adapted to be actuated manually by the operator for governing the movement of the vehicle, and means for actuating the recorder, and a normally open circuit for actuating the recorder, said circuit including in series three circuit controllers which are closed respectively when the warning signal is given, the brakes are automatically applied, and said control means are in position permitting unretarded movement of the vehicle.

12. In an automatic train control system, the combination with a vehicle, of slow acting means adapted to cause an automatic application of the brakes of the vehicle after an interval of delay, automatic train control apparatus for setting said slow acting means into operation, braking equipment for the vehicle including a brake cylinder, and means effective when pressure exists in said brake cylinder for preventing operation of said slow acting means.

13. In an automatic train control system, the combination with train control apparatus on a vehicle comprising a warning signal adapted to attract the attention of the operator, time-controlled means for automatically applying the brakes at the expiration of a predetermined time following the initiation of its operation, and means for simultaneous-

ly actuating the warning signal and initiating the operation of said time-controlled means, of means operable manually by the operator for rendering said time-controlled means inactive and thereby preventing an automatic brake application.

14. Automatic train control apparatus for railway vehicles comprising, in combination: a brake controlling valve, slow-acting means for operating said valve after an interval of delay, train control apparatus for initiating the operation of said slow-acting means, and means under the control of the operator for maintaining said slow-acting means in its normal condition.

15. Automatic train control apparatus for railway vehicles comprising, in combination: a normally energized slow-acting brake control device adapted to apply the brakes after an interval of delay when deenergized, train control apparatus for deenergizing said device, an engineer's brake valve, and means effective while said brake valve is in a brake applying position for maintaining said device energized.

16. Automatic train control apparatus for railway vehicles comprising, in combination: an electrically operated brake setting appliance, a centrifuge driven by the wheels of the vehicle and responsive to the speed of the vehicle for maintaining said appliance normally energized, and a normally open auxiliary energizing circuit for said appliance, and normally open contacts in said circuit closed when the brakes of the vehicle are acting.

17. In an automatic train control system, train control means on a vehicle governed from the trackway in accordance with traffic conditions, and adapted to cause an automatic brake application when operated, power control and brake control devices manually operable by the operator of the vehicle, and means effective while said devices are in the power off position and brake applying position respectively for preventing such brake application by the operation of said train control means independently of its control from the trackway.

18. In an automatic train control system for railway vehicles, the combination with speed control apparatus on a vehicle adapted when set into operation to enforce decreasing limitations upon the speed of said vehicle, said apparatus including a brake setting appliance, of means whereby the operator of the vehicle may prevent such automatic brake application by shutting off the power and manually applying the brakes.

19. Train control equipment for railway vehicles comprising, in combination: a power controller, an engineer's brake valve, pairs of contacts controlled by the power controller and the engineer's brake valve and closed when they are in positions corresponding respectively to power off and

brakes applied, automatic train control means for the vehicle including a normally inactive brake setting appliance, and a circuit including said pairs of contacts in multiple for maintaining said appliance inactive.

20. In an automatic train control system for railroads, having tracks divided into blocks each provided with a normally closed track circuit, train control apparatus on a vehicle normally tending to assume its active condition and including a brake setting appliance operated when the speed of the vehicle is excessive, traffic controlled impulse transmitting means partly on the vehicle and partly along the track for rendering said train control apparatus active near the entrance to a block when the next block in advance is occupied, and for restoring said apparatus to normal at the end of the block when said next block in advance is not occupied, and means effective while the brakes of the vehicle are acting for maintaining said brake setting appliance in its normal condition independently of the control thereof by said apparatus.

21. Automatic train control equipment for railway vehicles comprising, train control means for automatically applying the brakes of the vehicle dependent upon traffic conditions, an engineer's brake valve, a recorder, and means acting to operate said recorder when said train control means acts to apply the brakes and the engineer's brake valve is in its normal running position, whereby a record is made when the engineer fails to apply the brakes.

22. Automatic train control equipment for railway vehicles comprising, a power controller, an engineer's brake valve, traffic controlled means for applying the brakes automatically if the engineer fails to shut off power and operate his brake valve to apply the brakes, a recorder, and means governed by said traffic controlled means and also dependent upon the position of the power controller and the engineer's brake valve for actuating said recorder.

23. Automatic train control equipment for railway vehicles comprising, a power controller, an engineer's brake valve, an electrically operable recorder, pairs of contacts closed when the power controller and engineer's brake valve are in position corresponding to power on and brakes off, and a controlling circuit for the recorder including said pairs of contacts in multiple.

24. Automatic train control equipment for railway vehicles comprising, slow-acting means adapted to apply the brakes of the vehicle, traffic controlled means for governing said slow-acting means, manually operable means under the control of the operator for maintaining said slow-acting means in its normal condition, and a recorder having its operation controlled jointly by said man-

ually operable means and said slow-acting means.

25. Automatic train control equipment for railway vehicles comprising, train control apparatus including normally energized devices having a tendency to apply the brakes of the vehicle and control means therefor, a normally deenergized magnet, said control means acting to energize said magnet at the same time it deenergizes said devices, and a recorder controlled by said magnet and said devices and operated when all have assumed their active condition, whereby no record will be made by accidental failure of one of the normally energized devices.

26. Automatic train control equipment for railway vehicles comprising, train control apparatus including a primary control device, normally open and normally closed contacts simultaneously actuated when said train control device is operated, biased brake control means governed by the normally closed contacts, an electrically operable recorder, a normally open circuit for actuating said recorder, and separated means dependent respectively upon the operation of said brake control means and said normally open contacts for governing said recorder circuit, whereby no record will be made by an accidental failure of the brake control means.

27. Automatic train control equipment for railway vehicles comprising, speed control apparatus on the vehicle including permissive speed means and a speed responsive device governed in accordance with the actual speed of the vehicle, circuit controlling means governed by said apparatus and including normally open contacts and normally closed contacts operated simultaneously, biased brake control means governed by said normally closed contacts, and a recorder having its operation dependent upon the operation of said brake control means and the closing of said normally open contacts, whereby accidental failure of said brake control means will not make a record.

28. Automatic train control apparatus for railway vehicles comprising a normally energized electrically operable time-controlled device adapted when set into operation to cause an automatic brake application after the lapse of a predetermined time, a warning signal arranged to attract the attention of the operator, and means having its operation dependent on the speed of the vehicle for simultaneously actuating the warning signal and setting said time-controlled device into operation.

29. Automatic train control apparatus for railway vehicles comprising a time-controlled device having a tendency to assume an ultimate condition, a brake setting appliance actuated when said device attains such ultimate condition, a warning signal, and per-

missive speed means and actual speed means cooperating to operate the warning signal and simultaneously initiate the operation of the time-controlled device when the vehicle exceeds predetermined limiting speeds.

30. In a train control system for railroads having tracks divided into blocks, the combination with traffic controlled trackway means, of speed control apparatus on a vehicle including changeable permissive speed means conditioned for operation by said trackway means near the entrance to a block when the next block in advance is occupied, actual speed means, said apparatus comprising a time-controlled device electrically controlled by the cooperation of said permissive speed means and said actual speed means, a brake setting appliance operated by the time-controlled device after the lapse of a predetermined time, and a warning signal actuated when the operation of said time-controlled device is initiated.

31. In a train control system for railroads having tracks divided into blocks, the combination with traffic controlled trackway means, of car-carried apparatus conditioned for operation by said trackway means in a block in the rear of an occupied block, said apparatus comprising a time element device tending to assume an ultimate condition, a brake setting appliance operated by said device when it attains its ultimate condition, a warning signal, and speed-responsive means cooperating with permissive speed means to simultaneously actuate the warning signal and initiate the operation of said time element device.

32. In an automatic train control system, car apparatus comprising a warning signal and an electrically operated slow-acting device adapted to cause an automatic brake application after an interval of time, said apparatus when conditioned for operation continuing in operation until restored and acting while in operation to actuate the warning signal and simultaneously initiate the operation of said slow-acting device dependent upon the speed of the car, and means partly on the car and partly on the track for conditioning and restoring said apparatus in accordance with traffic conditions in advance.

33. In an automatic train control system, apparatus on a vehicle adapted when conditioned for operation to enforce a reduction in speed to a predetermined minimum and to maintain that minimum speed limit until the apparatus is restored, said apparatus comprising an electro-responsive time-controlled device governing the brakes of the vehicle and a warning signal actuated when the time-controlled device is set into operation, and trackway means for conditioning and restoring said apparatus in accordance with traffic conditions.

34. Automatic train control apparatus for

railway vehicles comprising, an electro-magnet, a circuit for normally maintaining said magnet energized, means governed in accordance with traffic conditions for interrupting said circuit, an auxiliary circuit for said magnet, and a fluid pressure operated contact operated by fluid pressure of the braking system for closing said auxiliary circuit when the brakes are actually applied.

35. Automatic train control apparatus for railway vehicles comprising a normally energized electrically operable brake setting appliance adapted when deenergized to cause an automatic brake application, apparatus including a speed-responsive device driven from the wheels of the vehicle for governing said appliance, and means acting to maintain the brake setting appliance energized independently of its control by said apparatus when the brakes of the vehicle are acting.

36. In a train control system, the combination with apparatus on a vehicle for automatically applying the brakes thereof, of means associated with the brake equipment of the vehicle and including biased circuit controlling means actuated by pressure as the brakes are applied or released, and a circuit governed by said means for preventing operation of said apparatus to apply the brakes.

37. A train control system for railroads having tracks divided into blocks, comprising automatic apparatus on a vehicle including a permissive speed device driven from the wheels of the vehicle and an actual speed device driven from the wheels of the vehicle and adapted when set into operation to apply the brakes of the vehicle automatically when it exceeds predetermined limiting speeds during its progress through a block, means partly on the vehicle and partly along the track for setting said apparatus into operation near the entrance to a block when the next block in advance is occupied, and means associated with the brake equipment of the vehicle and acting when the brakes are applied to prevent an automatic brake application by the operation of said apparatus.

38. In a train control system according to claim 37, speed control apparatus comprising a permissive speed device and adapted when set into operation to continue the operation until restored, together with means partly on the track and partly on the vehicle for restoring said apparatus at the end of each block when the next block in advance is not occupied.

39. In a train control system, traffic controlled trackway means, car equipment comprising a circuit, means controlled by said trackway means for opening and closing said circuit as the car exceeds or falls below predetermined speed limits during its progress, slow acting means set into operation by the opening of said circuit and acting to automatically apply the brakes after an interval

of delay, and means under the control of the operator for preventing such automatic brake application.

40. Train control apparatus for railway vehicles comprising a movable element shifted to different positions in accordance with the actual speed of the train, a normally energized brake controlling electro-magnet, a circuit for said electro-magnet, circuit controlling means associated with said element for opening and closing said circuit, and another circuit for maintaining said electro-magnet energized while the brakes of the train are applied.

41. Train control apparatus for railway vehicles comprising, a brake control electro-magnet, a circuit for normally maintaining said magnet energized, speed responsive means driven from the wheels of the vehicle for causing interruption of said circuit, and means for preventing deenergization of said electro-magnet while the brakes of the train are applied due to a manual application of the brakes.

42. In combination, a railway vehicle provided with a braking system, automatic apparatus for causing an automatic application of the brakes when said vehicle exceeds certain prescribed limit speeds during its progress along the track, and means for preventing operation of said automatic apparatus, said means being effective only when the brakes have been applied manually by the operator of the vehicle.

43. In combination, a railway vehicle provided with a braking system including a manually operable control device for causing a brake application, automatic apparatus for causing automatic application of the brakes when said vehicle exceeds certain prescribed limit speeds during its progress along the track, and means responsive only to an actual application of the brakes by operation of said control device for preventing operation of said automatic apparatus.

44. In combination, a railway vehicle provided with a braking system, automatic apparatus for causing an automatic application of the brakes upon a prescribed change in traffic conditions if the speed of the vehicle exceeds a prescribed value, and manually operable means for preventing such automatic application of the brakes, said means being effective only when the brakes have been applied manually by the operator of the vehicle.

45. An automatic train control apparatus, comprising brake control mechanism, electrically operable automatic means for actuating said mechanism, a circuit adapted when closed to prevent said automatic means from being actuated, and pressure responsive means for closing a break in said circuit when the brakes are manually applied.

46. Automatic train control equipment for

railway vehicles comprising a normally energized electrically operable brake-setting appliance adapted when deenergized to cause an automatic brake application, apparatus including a speed responsive device driven from the wheels of the vehicle for governing said appliance, and means acting to maintain the brake-setting appliance energized independently of its control by said apparatus when the brakes of the vehicle are acting.

47. In combination, a railway vehicle provided with a braking system, automatic apparatus for causing an automatic application of the brakes when said vehicle exceeds certain prescribed limit speeds during its progress along the track, governing means under the control of the operator for governing the speed of the vehicle, and means dependent upon the operation of said governing means to a degree sufficient to cause retardation of the vehicle for preventing operation of said automatic apparatus.

48. In combination, a railway vehicle provided with a braking system including a manually operable control device for causing a brake application, automatic apparatus for causing automatic application of the brakes when said vehicle exceeds certain prescribed limit speeds during its progress along the track, and means dependent upon a brake application of predetermined value by the action of said manually operable control device for preventing operation of said automatic apparatus.

49. In combination, a railway vehicle provided with a braking system including a manually operable brake control device, automatic means for causing an application of the brakes, and means for preventing operation of said automatic means while said brake control device is in brake-applying position and for continuing to prevent operation of said automatic means after said device is subsequently restored away from brake-applying position if and while a brake application of predetermined value is in effect due to operation of said device.

50. In combination, a railway vehicle provided with a braking system including a manually operable device for causing application of the brakes, automatic apparatus for also causing application of the brakes under certain traffic conditions, and means for preventing operation of said automatic apparatus while said device is in position to initiate a brake application and also after said device has been restored away from initiating position if and while a brake application of at least predetermined value is in effect due to said device having been in initiating position.

51. In combination, a railway vehicle provided with a braking system, means on the vehicle for establishing several permissive speeds, speed responsive means on the vehi-

cle, automatic apparatus controlled jointly by said two means for causing an application of the brakes if the actual speed exceeds the permissive speed at any given instant, and means for preventing operation of said automatic apparatus, said means being effective only when the brakes have been applied by the operator of the vehicle to cause retardation of the vehicle.

52. In combination, a railway vehicle provided with a braking system including a manually operable brake valve, automatic means for stopping the vehicle if certain prescribed limit speeds are exceeded by said vehicle in its progress along the track, and means controlled by said manually operable valve and effective only if the valve is held in brake applying position long enough to actually apply the brakes, for preventing said action of said automatic means.

53. Railway traffic controlling apparatus comprising means on a train controlled from the trackway for imposing a continuously effective speed limit under one given condition of traffic in advance of the train, means for automatically applying the brakes of the train if such speed limit is exceeded, and apparatus under the control of the engineer effective if operated previous to the initiation of such automatic brake application to prevent an automatic application when such speed limit is exceeded.

54. The method of controlling railway traffic which consists in establishing a continuously effective speed limit on a train determined by traffic conditions in advance of the train, applying the brakes automatically if the established speed limit is exceeded at any moment, and preventing such automatic application if the engineer takes suitable action prior to exceeding the established speed limit.

55. The method of controlling railway traffic which consists in establishing a continuously effective speed limit on a train determined by traffic conditions in advance of the train, applying the brakes automatically if the established speed limit is exceeded at any moment, and preventing such automatic application if the engineer applies the brakes manually prior to exceeding the established speed limit and keeps them applied as long as the speed limit is exceeded.

56. In an automatic train control system, the combination with an air brake system on the vehicle including an engineer's brake valve having a brake applying and a lap position, automatic brake control means on the vehicle governed in accordance with traffic conditions for applying the brakes of said air brake system, means responsive to the braking of the vehicle for preventing said automatic brake control means applying the brakes when the brakes are already applied, and means effective to prevent said auto-

matic brake control means applying the brakes when said engineer's brake valve is in the brake applying position, whereby the engineer's brake valve may be moved to the lap position when the brakes have been manually applied without rendering said automatic brake control means effective to apply the brakes.

57. An automatic train control system comprising, a vehicle equipped with air brakes and including a suitable engineer's brake valve for applying the brakes, an electrically operated brake control valve, a circuit for maintaining said brake control valve energized and inactive, means for controlling said circuit in accordance with traffic conditions ahead, and an auxiliary energizing circuit for said electrically operated brake control valve including a pneumatically operated contact closed only when the brakes are actually applied.

58. Automatic train control apparatus for railway vehicles comprising a normally energized electrically operable brake setting appliance adapted when deenergized to cause an automatic brake application, an engineer's brake valve, means for controlling said appliance in accordance with traffic conditions in advance, and two independent devices for maintaining said appliance energized irrespective of traffic conditions ahead one of which is controlled by said engineer's brake valve and the other of which is effective if an automatic brake application has already taken place.

WINTHROP K. HOWE.