March 2, 1926. 1,575,579

W. K. HOWE

TRAIN CONTROL

Filed Jan. 4, 1924 2 Sheets-Sheet 1

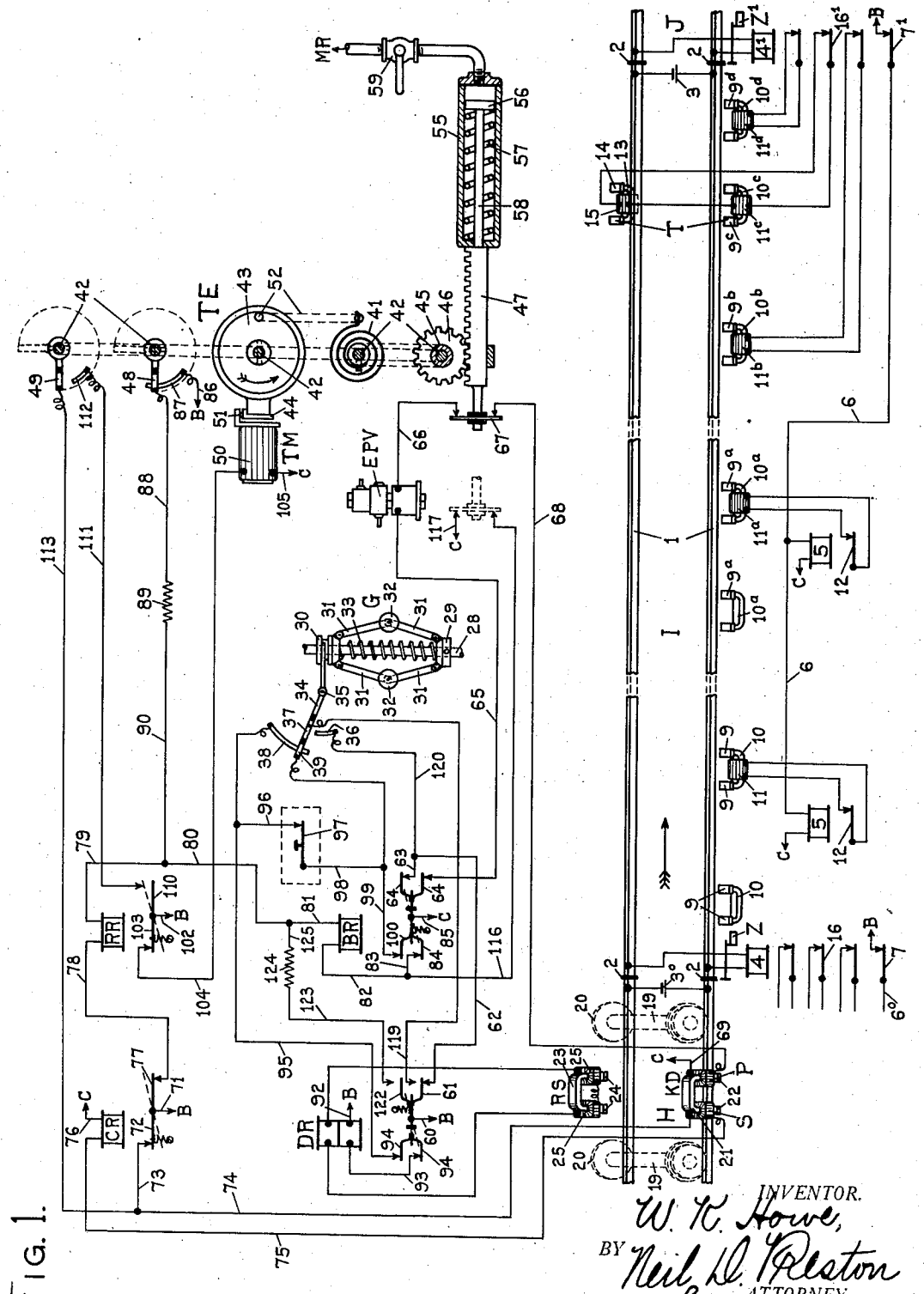

FIG. 1.

INVENTOR.
W. K. Howe,
BY Neil D. Preston
his ATTORNEY

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W. K. HOWE

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FIG. 2.

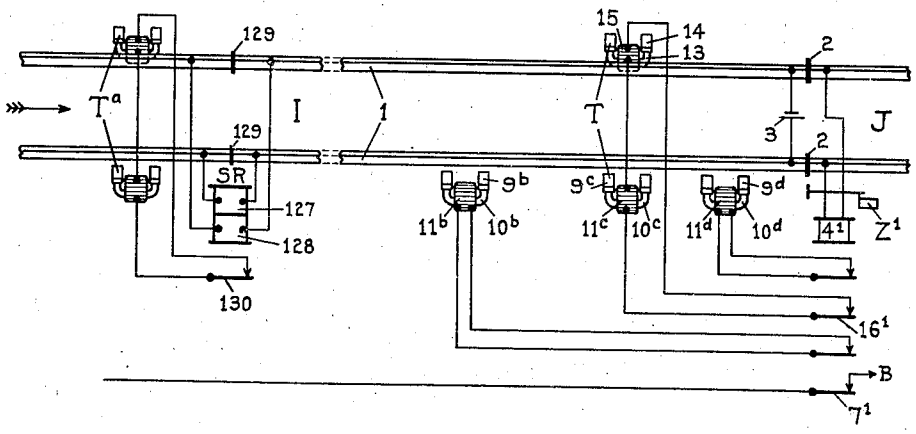
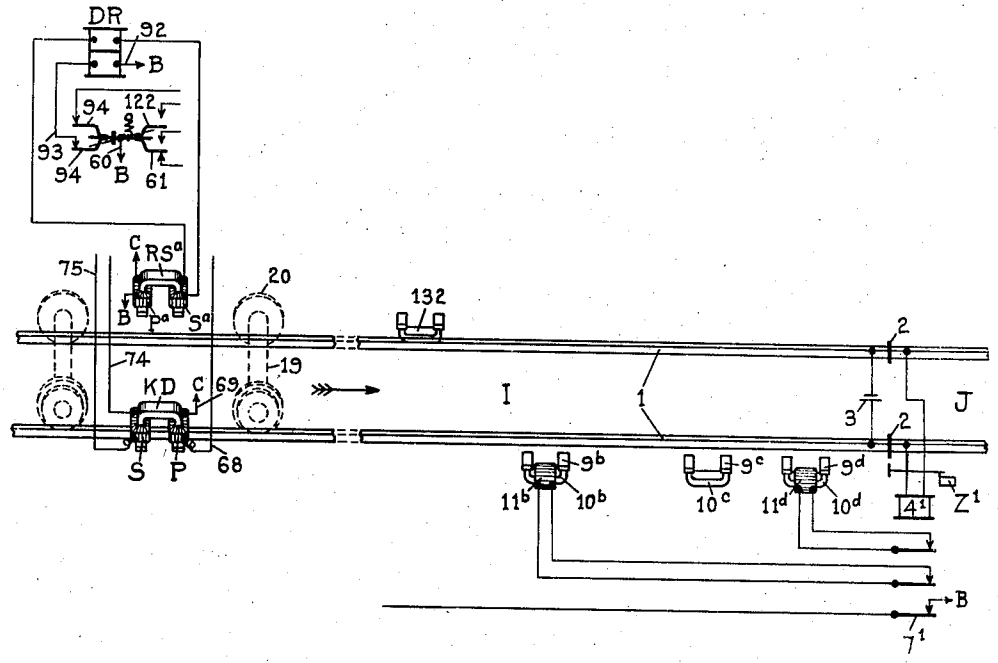


FIG. 3.



INVENTOR.
W. K. Howe,
BY Neil D. Preston
his ATTORNEY

Patented Mar. 2, 1926. 1,575,579

UNITED STATES PATENT OFFICE.

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

TRAIN CONTROL.

Application filed January 4, 1924. Serial No. 684,357.

To all whom it may concern:

Be it known that I, WINTHROP K. HOWE, a citizen of the United States of America, residing at Rochester, in the county of Monroe and State of New York, have invented certain new and useful Improvements in Train Controls, of which the following is a specification.

This invention relates to train control systems of the intermittent inductive type.

In applying automatic train control to railways with the idea of controlling the speed of the train in accordance with traffic conditions ahead, it has been found that the speed limits at various points of caution blocks vary considerably depending on the type of train used, the grade of the track, the length of a particular block and various other conditions; whereas the permissive speed which a train may attain in a danger block is some predetermined low value constant for any block regardless of grade, or the like. It therefore appears to be expedient to set up speed limits along the track in caution territory dependent on the trackway conditions (length of the block, grade of the trackway, etc.), and to set up a predetermined continuing speed limit for the train when moving in a danger block which persists throughout the entire length of such block.

With the above and other considerations in mind it is proposed in accordance with the present invention to apply apparatus which enforces predetermined speed limits at predetermined points in a caution block in accordance with the time-distance interval principle, that is, automatically apply the brakes if the train consumes less than a predetermined time in running a predetermined distance at certain points in such caution block; and to provide additional apparatus on the car, including a speed-responsive device, which is automatically rendered active upon the entrance of the train into a danger or occupied block to apply the brakes if the train during its travel through such danger block exceeds a predetermined minimum speed, and which is automatically rendered inactive so as to remove the minimum speed restriction upon entering a clear or caution block.

More specifically, it is proposed to provide inductive influence communicating means of the intermittent type which cooperates with suitable relays and a time element device on the railway vehicle to apply the brakes of the vehicle if two successive control influences are transmitted from the trackway in less than a predetermined period of time; to provide penalizing means which requires the engineer to manipulate certain resetting apparatus, which is only accessible from the ground, each time an automatic brake application has been inflicted by this time-distance interval mechanism, the operation of this resetting mechanism restoring the automatic brake control device and the time-distance interval mechanism but not restoring all of the car-carried mechanism so that a certain continuing speed limit will still be imposed after such penalty has been inflicted; to provide suitable resetting or restoring means which is entirely automatically operated only under clear or caution traffic conditions ahead which is also accompanied by transmitting an inductive control influence from the trackway to the moving vehicle, this automatic restoring operation putting the car-carried apparatus back in its original clear traffic condition. It is thus apparent that if an automatic brake application has taken place in a caution block and the engineer has stepped to the ground and operated the manually operable restoring or resetting device that a certain predetermined speed limit imposed by a speed-responsive device or governor driven by the wheels of the vehicle is still effective and that this speed limit cannot be exceeded until an automatic restoring control influence has been transmitted from the trackway which is only possible under clear or caution traffic conditions ahead. It is thus seen that the speed control apparatus effective in a danger block is initiated by the reception of two control influences in less than a predetermined time in a caution block. In order to make it very difficult for a train to pass entirely through a caution block without receiving two control influences from the trackway in less than a predetermined time, the devices of the last pair of trackway devices for trans-

mitting such influences are spaced very closely together so that the engineer is required to reduce his speed below, say, three miles per hour. To further assure the initiation of the danger control apparatus in danger territory a suitable acknowledging device has been provided. This acknowledging device cooperates with the various elements of the car-carried apparatus in a manner so that the penalty (manual resetting operation) is not inflicted if the acknowledging device is operated but the danger territory speed restricting apparatus is initiated by such operation of this acknowledging device. In other words, the engineer is encouraged to operate an acknowledging device because it removes the penalty heretofore mentioned, but by such operation he himself initiates the danger speed control apparatus. The combined effect of the spaced trackway devices which require the train to be moving at less than three miles per hour to initiate the danger control apparatus, and the provision of the acknowledging device, the operation of which also initiates this danger control apparatus, is believed to substantially assure initiation of this apparatus upon the entrance to a danger block.

Another object of the present invention relates to the provision of automatic restoring trackway devices located at an intermediate point in a block, so that, if the train enters a danger block and this block changes to a caution or clear block while the train is moving therein and before it reaches such intermediate point, a restoring control influence is transmitted to the train at such point, so that it may again proceed at either a caution or a clear speed depending on traffic conditions in the next block in advance.

In describing the invention in detail reference will be had to the accompanying drawings in which:—

Fig. 1 is a circuit diagram of the car-carried apparatus and the trackway apparatus illustrating one embodiment of the present invention, in which the various elements have been shown conventionally;

Fig. 2 shows the major portion and exit end of a block, direction of traffic being as indicated by the arrow and illustrates the trackway restoring apparatus which is controlled by a relay connected in series with the trackway; and

Fig. 3 illustrates a portion of the system as shown in Fig. 1 in which a modified form of restoring influence communicating means is employed.

Trackway apparatus.

Referring more particularly to the lower part of Fig. 1 of the drawings, there has been shown in a conventional manner a railway track having rails 1 divided by insulating joints 2 into blocks in the usual manner, the block I and the adjacent ends of two other blocks H and J being shown. Since the various blocks are the same, like parts of each block have like reference characters with distinctive exponents assigned thereto. The block I is provided with a suitable source of energy at the exit end, which has been shown conventionaly as comprising a battery 3, and a track relay 4 of the usual construction at the entrance end to this block. Although wayside signals of any one of the various commercial types, such as color light signals, position light signals, semaphore signals or the like may be used, semaphore signals Z have for convenience been shown conventionally, without illustrating their well-known circuits and devices.

As heretofore mentioned, the car-carried apparatus is constructed on the principle that the reception of two control influences from the trackway in less than a predetermined time causes an automatic brake application as a result of excessive speed. In order to transmit such control influences pairs of suitable trackway devices are provided, and the devices of the respective pairs are spaced along the track distances depending on the speed to be enforced at such points. In order to control such trackway devices in accordance with traffic conditions in the block ahead, a line relay 5 is provided for each pair of devices. These line relays 5 for each block are connected in multiple across a line wire 6 and a common wire, not shown but having a connection thereto designated C. The line wire 6 of each block is connected to a suitable source of energy, designated B, through a front contact 7′ of the track relay of the block in advance.

Each of the trackway devices comprises a core 10 of magnetic material preferably laminated and of general U-shape, the legs of which terminate in enlarged pole pieces 9. The second device of each of these pairs of trackway devices is provided with a winding 11 on the back yoke thereof. This winding 11 is connected in a closed deenergized circuit of low resistance including the front contact 12 of the corresponding line relay 5, for purposes more clearly described in connection with the operation hereinafter. Since these trackway devices are the same, the trackway devices which have a coil are designated by like reference characters having distinctive exponents "a", "b", "c" and "d". Near the exit end of the block are provided three such trackway cores 10 each of which is provided with a winding 11. These three trackway elements are so spaced that the first two enforce a speed limit by the time-distance interval principle of say 20 miles per hour; whereas the second two

elements are spaced to enforce a speed limit of say three miles per hour, heretofore mentioned. These last three elements are spaced in the manner just mentioned so that they will serve as two separate pairs and also as part of the restoring track apparatus to be presently described. The middle element of these three trackway devices comprises one element of a so-called "transformer scheme" restoring device T for transmitting inductive restoring influences. The other element of this transformer scheme comprises a core 13 having pole pieces 14 and a coil 15 on the back yoke thereof which is substantially identical in construction to that of the other trackway elements or devices. The trackway apparatus comprising the trackway cores 10^c and 13 for transmitting a restoring control influence by the "transformer scheme" have their windings 11^c and 15 connected in series through the front contact 16' of the track relay 4 of the block J in advance. It is thus noted the trackway elements of this restoring trackway apparatus are operatively connected through a closed electric circuit only under clear traffic conditions of the block in advance. These trackway elements are preferably mounted to project a certain distance above the top of the track rails.

Car-carried apparatus.

Car elements.—On the railway vehicle, which has been shown conventionally by the axles 19 and wheels 20, are mounted a knockdown car element KD which is adapted to receive control influences to restrict the movement of the vehicle and a restoring element RS for receiving favorable proceed or restoring influences. These elements are preferably mounted on the railway vehicle in suitable non-magnetic casings spring supported from the track of such vehicle in a manner so as to cause them to pass directly over the right hand and left hand trackway elements heretofore described, so that they may communicate through an intervening air gap, say, from 1½ to 3 inches.

This knockdown element KD comprises a core 21 of general inverted U shape preferably constructed of a high grade of laminated magnetic material terminating in enlarged pole pieces 22. On one of the legs of this core 21 is supported a primary coil P, which is adapted to set up a certain magneto-motive-force in the core when energized. On the other leg of this core 21 is provided a secondary coil S for purposes more clearly described hereinafter. The restoring influence receiving car-element RS comprises a similar core 23 terminating in pole pieces 24. On the legs of this core 23 are provided coils 25 connected in series for purposes pointed out hereinafter.

Relays.—The car-carried apparatus includes suitable sensitive and quick acting relays CR, RR, BR, and DR, and a time element device hereinafter described. Certain of these relays are connected in circuits and assume certain positions depending on the sequence of operation of certain other relays. Although these relays may take any one of the various well-known forms, they preferably are relays of the tractive armature type, in which the armature is pivotally mounted for movement about a vertical axis and in which the armature is well-balanced so as not to be responsive to vibrations in either a vertical or a horizontal plane. The armatures of these relays are preferably very light so as to reduce the moment of inertia to a minimum, thereby causing them to be quick acting in response to a slight change of current in their energizing circuits. The contacts operated by these relays can more conveniently be described in connection with the circuits which they control and will be mentioned more particularly hereinafter.

Brake control device.—On the railway vehicle is provided a suitable device for automatically applying the usual air brakes of the train, which in the particular instance has been conventionally illustrated as an electro-pneumatic valve EPV. This brake control device EPV is of the normally energized type and is adapted to vent the brake pipe in any desired manner if deenergized. This device EPV may control suitable actuating means which moves the usual engineer's brake valve to the service brake applying position when the device EPV is deenergized; it may vent the brake pipe directly and simultaneously therewith cut off main reservoir pressure from the engineer's brake valve, so that the engineer cannot prevent an automatic brake application by recharging the brake pipe; or it may operate certain brake applying means which vents the brake pipe to a predetermined extent only, and simultaneously therewith cut air pressure off of the engineer's brake valve so that he cannot recharge the train line.

Speed indicator or governor.—Another element of the car-carried apparatus comprises a speed responsive device for continuously indicating the speed of the train and for convenience a governor G of the centrifugal type has been shown. This governor G consists of a shaft 28 operatively connected to the wheels 20 or axles 19 of the vehicle. To this governor shaft 28 is pinned a bushing 29 which is connected to a circumferentially grooved sleeve 30 slidably mounted on the shaft by links 31 having a weight 32 at the junction of these links. The sleeve 30 is normally maintained in its highest position by a compression coil spring 33 contained about the shaft 28. It is thus noted that the sleeve 30 will assume its

highest position when the shaft 28 is at rest, but will gradually assume lower positions by reason of the centrifugal force acting on the weights 32 pulling the sleeve 30 down against the opposition of the compression coil spring 33 in response to rotation of the shaft 28. A contact arm 34 pivotally secured on a pin 35 has a forked end projecting therefrom engaging the grooves in the sleeve 30, so that this contact arm 34 moves about its pivot in response to a change in speed of the vehicle. A stationary contact 36 is provided which is in contacting relation with the portion 37 of the contact arm for all speeds of less than, say, 20 miles per hour. A similar stationary contact 38 is provided which is in contacting relation with the portion 39 of the contact arm at speeds above 20 miles per hour, for purposes more clearly described in connection with the operation of the system.

Time element device.—In order to automatically apply the brakes if two successive control influences are received in less than a predetermined time a time element device TE is employed. This time element device TE operates on the principle of acceleration and deceleration of a given mass similar to the principle employed in watches of the usual construction. This device TE comprises a shaft 42 having a fly wheel 43 of non-magnetic material pinned thereto which has an armature 44 of the usual tractive iron type fastened to the periphery thereof. This fly wheel or balance wheel 43 is biased by a spiral spring 41 in a counterclockwise direction as indicated by the arrow on this balance wheel. This spiral spring has its one end anchored to a sleeve 45 of a pinion 46 which is held in a predetermined position under normal conditions by a rack 47. On the shaft 42 are provided a normally closed contact 48 and a normally open contact 49 which make and break certain circuits in a certain sequence each time the time element device TE performs a cycle of operation. Adjacent the balance wheel 43 is supported an electromagnet comprising two coils 50 (only one of which has been shown) which when energized maintain the armature 44 in engagement with the residual pin 51 of this timing magnet TM.

By looking at the time element device TE it will be noted that the balance wheel 43 rotates in a counterclockwise direction by reason of the spiral spring 41 acting on the pin 52 fastened in the balance wheel 43 as soon as this timing magnet TM is deenergized. The inertia of the balance wheel 43 carries the rotation of this wheel beyond the point of zero tension of the spiral spring 41 through an angle of substantially 135°, so that the total arc of movement is substantially 270° as shown by the dotted position of the contacts 48 and 49. This particular arc of movement is of course not necessary, but has been shown to illustrate the functioning of the system. With the spiral spring 41 biased in the opposite direction it urges the balance wheel in a clockwise direction, and causes it to almost return to its original position. If now the timing magnet has again been energized in the meantime it attracts the armature 44 and again holds the time element device TE in its normal position. If for any reason this time element device assumes its biased or intermediate position it may be restored to its normal position by rotation of the pinion 46 in a clockwise direction far enough to carry the balance wheel back to its initial position. In order to restore this time element device TE to its normal position by rotating the pinion 46, a cylinder 55 having a piston 56 therein, which is maintained in its normal position by a compression coil spring 57, is provided. This piston 56 is connected to the rack 47 by a piston rod 58. In order to permit the engineer to restore the time element device, and certain of the relays, to their normal positions a suitable resetting valve 59, only accessible from the ground is employed. Operation of this resetting valve 59 causes main reservoir air pressure to flow into the cylinder 55 actuating the pinion 46 to its resetting position. It should be noted that if the armature 44 of the time element device assumes a position intermediate its extreme positions that the pinion 45 must be rotated in the clockwise direction substantially 135° before the armature gets back to a position where it may be attracted by the timing magnet. If the timing magnet is energized, as it would be under ordinary conditions, the balance wheel will be held in its normal position, as shown in the drawings. Upon return of this valve to its normal position compressed air again flows from the cylinder 55 to atmosphere through a suitable exhaust port (not shown).

Operation.

Normal condition of apparatus.—In order to simplify the wiring diagram of the car-carried apparatus one terminal of a suitable source of energy has been designated B, the other terminal being connected to a common return wire C (not shown). The terminals B may of course be the terminals of different sources of energy or any one of several different taps of a common source of energy, such as a battery. Under normal clear traffic conditions as shown in Fig. 1 of the drawings the electro-pneumatic device EPV and the primary coil P are connected in series in an energized circuit which may be traced as follows:—beginning at the terminal B of a suitable source of energy, wire 60, front contact 61 of the danger relay DR, wires 62 and 63, front contacts 64 of the brake control

relay BR, wire 65, winding of the brake control device EPV, wire 66, contact 67 on the rack 47, wire 68, primary coil P, wire 69, back to the common return wire C.

The flow of current in this circuit, as heretofore mentioned produces a certain magneto-motive-force in the knock-down car element KD which sets up a certain leakage of magnetic flux around the primary coil P, a certain part of the flux however passing through the secondary coil S.

The control relay CR is energized through the following stick circuit:—beginning at the terminal B of a suitable source of energy, wire 71, front contact 72 of the control relay CR, wires 73 and 74, secondary coil S of the car element KD, wires 75, winding of the control relay CR, wire 76, back to common return wire C.

With the control relay CR in its energized position, an energizing circuit including the relays RR and BR in series is completed which may be traced as follows:—beginning at the terminal B, wire 71, front contact 77 of the control relay CR, wire 78, winding of the repeater relay RR, wires 79, 80 and 81, winding of the brake control relay BR, wires 82 and 83, front contact 84 of the brake control relay BR, wire 85, back to the common return wire C.

Part of the current for energizing the brake control relay BR under normal clear traffic conditions, as shown, does not flow through the repeater relay RR but is derived from the normally closed contacts of the time element device TE and flows through the following circuit:—beginning at the terminal B of a suitable source of energy, wire 86, contacts 87 and 48 of the time element device TE, wire 88, resistance unit 89, wires 90, 80 and 81, winding of the brake control relay BR, wires 82 and 83, front contact 84 of brake control relay BR, wire 85, back to common return wire C.

Thus, opening of the front contact 77 of the control relay CR merely deenergizes the repeater relay RR but not necessarily deenergizes the relay BR, because this relay BR may be held up by the current flowing in the last traced circuit.

With the brake control relay BR in its energized position, the danger relay DR may be maintained energized through the following stick circuit:—beginning at the terminal B of a suitable source of energy, wire 92, lower winding of the danger relay DR, wire 93, front contact 94, wires 95 and 96, acknowledging push button switch 97, wires 98 and 99, front contact 100 of the brake control relay BR, wire 85 back to the common return wire C.

In connection with the stick circuit just traced it should be noted that operation of the acknowledging push button 97 will interrupt this circuit, providing the speed of the train is less than 20 miles per hour; but if the speed is above 20 miles per hour, the acknowledging push button contact 97 is shunted by the contacts 38 and 39 of the governor G, and therefore these governor contacts will prevent interruption of the stick circuit at speeds above this limit, even though the push button is depressed.

With the repeater relay RR in its energized position, a circuit is completed for the timing magnet TM as follows:—beginning at the terminal B, wire 102, front contact 103 of the repeater relay RR, wire 104, winding 50 of the timing magnet TM, wire 105, back to the common return wire C, the completion of which causes the armature 44 and the balance wheel 43 to be held in their normal position as shown.

The upper winding of the danger relay DR is connected in a closed deenergized circuit in series with the coils 25 of the restoring car element RS which may readily be traced in the drawings.

Caution condition (*speed not excessive*).—Let us assume that the vehicle with the associated car-carried apparatus as shown in Fig. 1 is moving in the block H in the normal direction of traffic, as indicated by the arrow, when the block J is occupied by another train. With the block J occupied by another train, current is shunted from the track relay 4', thereby causing deenergization of the line relays 5, and opening of the normally deenergized circuits for the coils 11 and 11^a of the pairs of trackway elements. Also, with the track relay 4' deenergized, the windings 11^b, 11^c and 11^d of the last three track elements in a caution block are in an open circuit, so that all of the track elements function like a U-shaped core of unmagnetized material.

As the train in question passes into the block I a distance to cause the knock-down element KD to come into communicating relationship with the first track element of the first pair of elements, the reluctance of the magnetic circuit including the car-carried core 21 is momentarily reduced. This reduction in the reluctance of his magnetic circuit causes a sudden increase of flux to take place through the secondary coil S on one leg of this core 21. This sudden increase of flux through the secondary coil S is due to a large extent, it is believed, to the diversion of flux from leakage paths and to a certain extent to the increase in the total flux passing through the primary coil P. As the car-carried element KD recedes from this track element the flux passing through the secondary coil S again rapidly decreases to the original and normal value. This rapid increase and decrease of flux through the secondary coil S causes a voltage to be induced, first in one direction and then in the other, in the circuit including the winding

of the control relay CR, substantially the same as a single cycle of alternating current potential. The secondary coil S is so connected in this circuit that the first wave of this cycle of voltage is in a direction to oppose the voltage of the source normally maintaining the control relay CR energized, thereby causing a momentary reduction in the flow of current in the control relay CR. This momentary reduction in the flow of current in this control relay CR causes it to assume its deenergized position; and since it is connected in a stick circuit, it assumes its deenergized position permanently until it is restored by some other means.

With the control relay CR deenergized, the repeater relay RR assumes its deenergized position, but the brake control relay BR is not deenergized because another energizing circuit, including the contacts 48 and 87 of the time element device TE, is still intact.

Deenergization of the timing magnet TM of the time element device TE, as a result of the deenergization of the repeater relay RR, causes the balance wheel 43 of this time element device and its associated contacts 48 and 49 to start on their oscillating cycle of operation. After a short arc of movement of the time element shaft 42, the contact 49 on this shaft completes a pick up circuit for the control relay CR which may be traced as follows:—beginning at the terminal B of a suitable source of energy, wire 102, back contact 110 of the repeater relay RR, wire 111, contacts 112 and 49 of the time element device TE, wires 113 and 74, secondary coil S of car element KD, wire 75, winding of the control relay CR, wire 76 back to the common return wire C. Momentary closure of this circuit energizes the control relay CR which is thereafter maintained energized through its stick circuit heretofore traced. Reenergization of the control relay CR causes the repeater relay RR to be picked up, which again energizes the timing magnet TM. Also, the completion of the circuit for the repeater relay RR through the front contact 77 of the control relay CR furnishes current for the brake control relay BR connected in series therewith. During the time that the contacts 49 and 112 of the time element device close a pick-up circuit for the control relay CR which in turn energizes the repeater relay RR, the brake control relay BR is maintained energized through the contacts 48 and 87 of the time element device TE. The time element device continues to rotate in a counterclockwise direction until it reaches its other dotted position, as shown, and then again returns practically to its initial position, from whence it is attracted to its normal position by the timing magnet TM acting on the armature 44. It is assumed that the train is running slow enough so that the time element device has reached its normal position after performing the cycle of operation just explained before the car element KD gets into communicating relation with the second track element of this first pair of trackway devices. When the car element KD passes over this second track element, having its coil 11 open-circuited, the same cycle of operation takes place, no brake application being effected because the time element device returns to its normal position without the reception of an intervening knock-down control influence.

Briefly reviewing this cycle of operation, it should be remembered that the brake control relay BR is maintained energized by the time element device during the time that this time element device again picks up the control relay CR and the repeater relay RR, after which the brake control relay BR is maintained energized by the control relay CR but is not independently maintained energized by the time element TE as it is under normal conditions, so that, if a second control influence is received while the time element device is performing its cycle and the contact 48 is not in contacting relation with the contact 87, the reception of a control influence causes deenergization of the brake control relay BR and interruption of its stick circuit permanently. There is, however, still another way of maintaining the brake control relay BR energized which is effective if the danger relay DR is deenergized under predetermined limited speeds as more clearly described hereinafter.

Caution condition (speed excessive).—Let us assume that the train continues to move through the block I while this block is in the caution condition, and that it passes by the second pair of elements at excessive speed. As the car element KD passes over the first track element of the second pair the time element device TE is again initiated. This time element device again picks up the control relay CR and is still in motion at some point at which contacts 48 and 87 are out of contacting relation when the car element KD passes over the second element of this pair. The reception of a control influence by the control relay CR at this time causes deenergization of the brake control relay BR as well as deenergization of the repeater relay RR, this, for the reason that no current can now flow through the circuit including resistance unit 89, so that the brake control relay BR assumes its deenergized position. With the brake control relay BR deenergized, the energizing circuit for the brake control device EPV is interrupted, thus causing an unpreventable application of the brakes and stoppage of the train.

Reset from ground (permitting a speed of 15 miles per hour, only).—In order that the engineer may continue to move the train along the trackway after an automatic brake application has taken place, he is required to alight and operate the resetting valve 59 which is only accessible from the ground. If the engineer operates this valve air pressure is admitted into the cylinder 55, thereby causing the rack 47 and associated contacts 67 to move to the left or dotted position. Movement of the rack to such position causes the balance wheel 43 when in its unbiased condition with respect to the pinion 46 to assume the same position as when this wheel is in its normal position as shown in the drawings, so that with the timing magnet TM energized it may again hold the armature 44 against the residual pin 51. It should be noted that the return of the balance wheel 43 to its normal position causes the control relay CR to again be picked up. With the contact disk 67 on the rack 47 in its dotted position, a pick up circuit is completed for the brake control relay BR which includes the repeater relay RR and may be traced as follows:—beginning at the terminal B, wire 71, front contact 77 of the control relay CR, wire 78, winding of the repeater relay RR, wires 79, 80, and 81, winding of the brake control relay BR, wires 82 and 116, contacts 67, wire 117, back to common return wire C. This relay BR after being picked up is again stuck up through its stick circuit heretofore mentioned.

After the engineer had held the resetting or the restoring valve 59 into its active position for a short period he may again return it to its normal position, thereby releasing pressure from the cylinder 55 and allowing the spring 57 to return the piston 56. When the contact disk 67 reaches its normal position, the brake control device EPV is again energized which allows the engineer to remove the brakes by recharging the brake pipe and proceed along the trackway. It should be noted that the energizing stick circuit for the lower winding of the danger relay DR was interrupted during the time that the brake control relay BR assumed its deenergized position, by reason of the contact 100 of the brake control relay BR. Since the danger relay DR was energized through a stick circuit, it assumes its deenergized position until again restored by suitable other means. With the danger relay DR in its deenergized position, and the brake control relay BR again energized as a result of manual operation of the valve 59 and the infliction of the penalty associated therewith, the train is again permitted to proceed at a continuing limited speed of, say, 20 miles per hour by reason of energization of the EPV through the following circuit:—beginning at the terminal B wire 60, contact 61 of the danger relay DR, wire 119, contacts 37 and 36 of the speed governor G, wires 120 and 63, contacts 64 of the brake control relay BR, wire 65, winding of the EPV, wire 66, contacts 67, wire 68, primary coil P, wire 69, back to the common return wire C, the contacts 36 and 37 only being in contacting relation at speeds below 20 miles per hour.

If the train at any time under this condition of the apparatus assumes a speed greater than 20 miles per hour, the brake control device EPV is deenergized, but is again energized as soon as the speed comes below this value, so that the engineer may remove the brakes by charging the brake pipe in the usual manner as soon as the train speed is below this value.

Automatic reset.—Let us assume that traffic conditions ahead have cleared up and that the track relay 4′ assumes its energized position and completes a circuit including the coils 11ᵉ and 15 of the restoring trackway elements, and that the train is just passing over these devices so that one of these track elements is in cooperation with the knock-down element KD and the other track element is in cooperation with the restoring car element RS. As the train moves by these track elements forming transformer portions, the element KD by reason of the strong magnetic field produced by the primary coil P, induces a current in the circuit including the two coils 11ᵉ and 15 thereby producing an alternating flux emanating from the pole pieces 14 of the core 13. A large part of this alternating flux passes through the core 23 of the restoring car element RS and induces a similar single cycle of alternating current in the coils 25 of this restoring car element RS and in the upper winding of the danger relay DR, so that this danger relay DR assumes its energized position momentarily. With the danger relay DR momentarily energized its stick circuit through the lower winding of this relay is again completed, thereby permanently restoring it to its normal position. With the danger relay DR again energized, the train may proceed at a speed dependent on traffic conditions ahead and the spacing of active pairs of track elements.

Caution condition with acknowledgment (speed excessive).—Let us assume that the train in question is moving through the block I under caution traffic conditions and has reached the last pair of elements, namely the pair spaced at 3 miles per hour, without exceeding the speed limit as enforced by any of the previous pairs of track elements located in this block, and that the speed of the train is somewhere above 3 miles per hour and below 20 miles per hour. Under this condition, the engineer presses the ac-

knowledging button 97 for the purpose of avoiding the penalty associated with an automatic brake application inflicted as a result of excessive speed by reason of the reception of two control influences in less than a predetermined time. Pressing of the acknowledging button 97 momentarily deenergizes the stick circuit for the danger relay DR, thereby permanently putting this relay in its deenergized position. As the car element KD passes over the first track element of this last pair of track elements the time element device TE is again initiated upon its cycle of operation. Since the speed, as has been assumed, is excessive a second impulse is received by the last element of this pair before the time element device TE causes closure of the contacts 48 and 87. Deenergization of the control relay CR and repeater relay RR, however, does not deenergize the brake control relay BR because this relay BR is maintained energized through the following circuit:—beginning at the terminal B, wire 60, back contact 122 of the danger relay DR, wire 123, resistance unit 124, wires 125 and 81, winding of the brake control relay BR, wires 82 and 83, front contact 84 of the relay BR, wire 85, back to common return wire C, so that this brake control relay BR is maintained energized entirely independently of the time element device TE and the relays CR and RR controlling the same. The resistance unit 124 as well as the resistance unit 89 have a resistance substantially equal to the resistance of the relay RR, so that the relay BR may be held up by current flowing in any one of the three circuits for this relay which have been traced.

The engineer, by pressing the acknowledging push button 97, has not only prevented the infliction of a penalty, but has also prevented an automatic brake application since the train is moving at less than 20 miles per hour, as has been assumed, and the contacts 36—37 are closed. It is thus noted that the engineer is encouraged to operate the acknowledging push button 97 if he is traveling at a speed less than 20 miles per hour, because such operation will prevent an automatic brake application as well as the penalty associated therewith to restore the same, and that he will probably operate this acknowledging button each time he passes a pair of track elements spaced to enforce a speed of less than 20 miles per hour. The operation of this acknowledging push button will of course set up a continuing speed limit heretofore fixed at 20 miles per hour imposed by the governor G which will persist until an automatic restoring control influence has been received from the trackway, so that the train in entering a danger block will be restricted to this speed until it passes trackway restoring apparatus such as the trackway devices having coils 11c and 15, as shown. Further, by this arrangement, since it is very difficult for the engineer to ascertain whether or not he is running his train at less than three miles per hour, the speed limit set up by the last pair of track elements in the block, when he is actually running at less than this speed, he will be encouraged to operate the acknowledging push button 97 to avoid the penalty heretofore mentioned, and in so doing will set up a continuing permissive speed limit.

Clear traffic conditions.—Let us now assume that the car-carried apparatus is in its normal condition on a train passing through a block, such as the block I, under clear traffic conditions ahead, and at a speed in excess of the speed for which the track elements of a pair in the block are spaced. As the car-carried element KD passes over the first element of such a pair the time element device is initiated upon its cycle of operation as heretofore described. If this element passes over the second element of this first pair the time element device will of course not yet have returned to its normal position, it having been assumed that the speed of the train is in excess of that enforced by this pair of elements. This is, however, immaterial, since no control influence is transmitted from this second track element, because the core of this element has its coil 11 closed in a circuit of low resistance. One theory by which the failure of transmission of a control influence under these conditions may be accounted for is, that the passage of a few lines of flux through the track element causes a current to be set up in the coil 11 which is in a direction to oppose further increase of flux through this element, so that very little flux is permitted to pass through this track element by reason of the bucking action of the current produced by it, and consequently very little flux is diverted from leakage paths through the secondary coil S. With very little change of flux through the secondary coil only a slight voltage is induced therein and a correspondingly small change of current flow takes place in the control relay CR. In other words, the coil 11 on the track element acts as a bucking coil, so to speak, and prevents to a large extent the passage of flux through the track element, so that no control influence is transmitted by a track element having its coil closed in a deenergized circuit of low resistance.

Automatic reset at intermediate points in block.—It may very well happen that a danger block changes to a caution or a clear block shortly after a train has entered such block, and in order to provide means for restoring the car-carried apparatus at an intermediate point, trackway restoring apparatus has been shown in Fig. 2 of the draw-

ings located at such point in a block for restoring the car apparatus providing this block is not occupied by another train ahead.

In order to ascertain whether there is a train in the same block in advance of the train in question it is necessary to determine whether or not there is a flow of current in the track rails directly ahead of the train in question, and in order to ascertain such flow of current a series two winding track relay SR has been connected in series with the track rails by placing the two windings 127 and 128 around insulated joints 129 in the track rails 1. This series track relay SR is provided with a front contact 130 which connects the windings of two restoring track elements T^a in series. It will thus be noted that if there is no train ahead of the train in question in the same block that this relay SR will assume its energized position and transmit a restoring control influence to car-carried apparatus such as shown in Fig. 1.

Modified form automatic reset.—In Fig. 3 has been illustrated the automatic restoring portion of car-carried apparatus such as shown in Fig. 1. Those parts of the car-carried apparatus shown which are also shown in Fig. 1 have been assigned the same reference characters. This restoring apparatus is not traffic controlled and is always effective regardless of traffic conditions ahead. It should however be borne in mind that a pair of closely spaced track elements is located on the right side of the trackway so that in spite of the reception of a restoring control influence by the car-carried element RS^a the speed of the train is restricted in accordance with the traffic condition of the block in advance by reason of the track elements just beyond the restoring track element 132.

In this embodiment of the invention the restoring car-carried element RS^a comprises a primary coil P^a and a secondary coil S^a which are designed substantially the same as are the coils of the knock-down element KD. An alternating current is induced in this secondary coil S^a similar to a single cycle of alternating current by reason of the passage of this car element over an effective track element such as the element 132 for reasons explained in connection with the operation of the element KD when passing over an active track element. This induced current flows through the upper winding of the danger relay DR to restore this relay in a manner already explained.

The car-carried apparatus of this modified system is the same as that shown in Fig. 1, except that the car elements provided are of substantially identical construction the right hand one of which controls the control relay CR and the left hand one of which is adapted to momentarily energize the danger relay DR. In this system a restoring control influence is transmitted each time the restoring car element RS^a passes by an active track element, which of course must be located on the left side of the track and in the arrangement shown is always active. The proper control of the train as it enters the next block is however assured by reason of the active track elements of the right side of the track under danger traffic conditions of the next block, so that the train after being released will immediately be restricted under danger traffic conditions.

Conclusion.—A train control system has thus been proposed in which speed limits are enforced in a caution block by mechanism which permits extreme flexibility in regard to the particular speed restriction enforced at various points in such block, this flexibility being facilitated by the employment of the time-distance interval principle of enforcing speed restrictions. The proposed system is one wherein a governor is employed to continually restrict the speed of the train in an occupied block as a result of the reception of two successive control influences in less than a predetermined time previously, and without the reception of an intervening restoring influence. The transmission of two such influences is substantially assured by spaced track elements so close together that the speed of the train must be very low, and probably so low that the train is unable to avoid exceeding it. This system also includes an acknowledging means, whereby the engineer may avoid a penalty but in so doing sets up a permanent restriction in the movement of his train, which restriction can only be removed by the reception of a control influence from the trackway if traffic conditions ahead are clear.

Having thus shown one specific embodiment of the invention with a single modified form of restoring mechanism, it is desired to be understood that the specific arrangement shown has been selected for illustrative purposes rather than with the view of showing the scope of this invention, and it is desired to be understood that various changes and modifications may be made to adapt the invention to various types of systems having various kinds of means for transmitting control influences from the trackway without departing from the scope of the idea of means underlying the present invention.

What I desire to secure by Letters Patent of the United States is:—

1. An automatic train control system comprising, normally inactive means which when initiated sets up a restricted speed limit and effects an automatic brake application if this speed limit is exceeded, and means

including a device which responds to the reception of two successive control influences if received in less than a predetermined time for initiating said means.

2. In an automatic train control system, the combination of normally inactive means for continuously restricting the speed of a train to a predetermined low speed limit which the train cannot exceed without incurring a brake application for controlling the train in an occupied block, and apparatus for automatically applying the brakes responsive to the reception of two successive control influences in less than a predetermined time as a result of excessive speed in passing over spaced trackway elements in a caution block, said first mentioned means being initiated if two successive control influences are received in less than said predetermined time.

3. In an automatic train control system, the combination of normally inactive means for continuously restricting the speed of a train to a predetermined low speed limit which the train cannot exceed without incurring a brake application for controlling the train in an occupied block, and apparatus for automatically applying the brakes responsive to the reception of two successive control influences in less than a predetermined time as a result of excessive speed in passing over spaced trackway elements, said means being initiated if two successive control influences are received in less than said predetermined time, and means for restoring said apparatus to normal.

4. In an automatic train control system, the combination of normally inactive means for continuously restricting the speed of a train to a predetermined low speed limit which the train cannot exceed without incurring a brake application for controlling the train in an occupied block, apparatus for automatically applying the brakes responsive to the reception of two successive control influences in less than a predetermined time as a result of excessive speed in passing over spaced trackway elements, and automatic means controlled by influences received from the trackway under clear traffic conditions ahead for restoring said means to normal.

5. In an automatic train control system, the combination of a device for controlling a train by the time-distance interval principle in a caution block and by a continuing restricted speed limit in an occupied block comprising, a brake control device which if deenergized applies the brakes of the usual air brake system, means for deenergizing said device by control influences transmitted from the trackway as a result of passing over a pair of spaced trackway devices in less than a predetermined interval of time, and means initiated upon the reception of two control influences in less than a predetermined time for continuously restricting the speed of the train to a certain value.

6. In an automatic train control system, the combination of a track divided into blocks in the usual manner, pairs of spaced track elements in each block for transmitting control influences to a passing vehicle, a brake control device on the vehicle, a caution speed restricting apparatus for actuating said brake control device if two successive control influences are received in less than a predetermined time, a danger speed restricting means which when active restricts the speed of the train to a predetermined low value, said danger speed restricting means also being initiated upon the reception of two successive control influences in less than said time interval, and means responsive to a clearing influence transmitted from the trackway under clear traffic conditions ahead for restoring said danger speed restricting means to normal only.

7. An automatic train control system comprising, a brake control device, means partly on the vehicle and partly along the track for actuating said brake control device and thereafter continuing to restrict the speed of the train to a low limiting speed until a clearing control influence is received from the trackway if the speed of the train is excessive as evidenced by the transmission of two successive control influences in less than a predetermined time, and means accessible only from the ground which if actuated restores said brake control device but does not remove the continuing restrictive speed limit.

8. An automatic train control system comprising, trackway apparatus including spaced trackway devices having their spacing fixed to correspond to speed limits at corresponding points and adapted to transmit control influences to the train when the next block in advance is occupied, and car-carried apparatus including, a brake control device, means for deenergizing said device if two successive control influences are received in less than a predetermined time, another means also initiated if two control influences are received in less than a predetermined time which if initiated requires the train to remain below a certain low speed limit to avoid an automatic brake application, means only accessible from the ground for restoring said first mentioned means to normal, and means for restoring said another means to normal comprising, means partly on the vehicle and partly along the track and adapted to transmit a restoring control influence providing traffic conditions ahead are clear.

9. An automatic train control system comprising, trackway apparatus including spaced trackway devices at points along the trackway having their spacing fixed to cor-

respond to speed limits to be enforced at such points; and car-carried apparatus including, a brake control device, means for actuating said brake control device if two successive control influences are received from the spaced trackway device in less than a predetermined time, another means responsive to the reception of two control influences in less than a predetermined time and continually restricting the speed of the train to a certain limiting value which if exceeded causes automatic actuation of said brake control device, and means manually operable by the engineer for initiating said another means, whereby an automatic brake application may be avoided if the speed of the train is less than said limiting value but is more than would be enforced by the spacing of a pair of active elements which is being passed.

10. An automatic train control system comprising, a brake control device, means carried on the vehicle for restricting the speed of the vehicle to a certain value which if exceeded causes said means to actuate said device, means partly on the vehicle and partly along the trackway for initiating said speed restricting means responsive to the transmission of two successive influences and including spaced trackway devices, and means for restoring said speed restricting means to normal including two trackway elements of magnetic material each having a coil thereon, and means for transmitting a control influence from the vehicle to one of said elements and for detecting an influence transmitted from the other element to the vehicle, whereby if the two track elements are coupled together a control influence may be transmitted to the restoring means.

11. An automatic train control system comprising, a brake control device, normally inactive means for setting up a prescribed speed limit which if exceeded causes automatic actuation of said device, means partly on the vehicle and partly along the trackway and acting through an intervening air gap for initiating said normally inactive means, and means for restoring said normally inactive means to normal including a car-carried element having a primary and a secondary coil thereon and a trackway device adapted to cooperate with said car-carried element comprising an unmagnetized core of magnetic material.

12. An automatic train control system comprising, a brake control device, means for actuating said brake control device if the train exceeds a certain speed limit as determined by the reception of two control influences from the trackway in less than a predetermined time, means for penalizing the engineer if the brake control device is automatically actuated, and manually operable means which if operated permits the engineer to avoid such penalty and which if actuated sets up a continuing restrictive speed limit which will persist until a restoring control influence is transmitted from the trackway.

13. An automatic train control system comprising, trackway apparatus including spaced trackway devices at points along the trackway having their spacing fixed to correspond to speed limits to be enforced at such points; and car-carried apparatus including, a brake control device, means for actuating said brake control device if two successive control influences are received from the spaced trackway device in less than a predetermined time, another means responsive to the reception of two control influences in less than a predetermined time and continually restricting the speed of the train to a certain limiting value which if exceeded causes automatic actuation of said brake control device as long as the restricted speed limit is exceeded, and means manually operable by the engineer for initiating said another means, whereby an automatic brake application and a resulting penalty may be avoided under certain conditions of speed.

14. An automatic train control system comprising, a brake control device, means partly on the vehicle and partly along the track for actuating said brake control device and thereafter continuing to restrict the speed of the train to a low limiting speed until a clearing control influence is received from the trackway if the speed of the train is excessive as evidenced by the transmission of two successive control influences in less than a predetermined time, and means controlled by influences transmitted from the trackway for removing the continuing restricted speed limit.

15. In an automatic train control system, the combination of means partly on the vehicle and partly along the trackway for transmitting control influences from the trackway to the vehicle through an intervening air-gap by inducing a potential of a predetermined value in a car-carried coil and which means is unable to induce such potential if the speed of the vehicle is extremely low, normally inactive means on the vehicle rendered active upon the reception of a control influence from the trackway and which if active restricts the speed of the vehicle by initiating a brake application if the vehicle exceeds a predetermined speed limit, another means for effecting a brake application upon the reception of such influence from the trackway, and manually operable means for preventing a brake application by said another means which if operated renders said normally inactive means active, and means responsive to restoring control influences transmitted from the trackway under clear traffic conditions ahead for re-

storing said normally inactive means to normal.

16. An automatic train control system comprising, apparatus partly on the vehicle and partly along the trackway for transmitting control influences from the trackway to the vehicle through an intervening air-gap by inducing a potential in a car-carried coil due to movement of the vehicle by a trackway device and by which insufficient potential is induced to transmit such control influence if the speed of the vehicle is extremely low, normally inactive means rendered active upon the reception of a control influence and which if active restricts the speed of the vehicle by causing an automatic application of the brakes of the vehicle if the speed of the vehicle exceeds a predetermined speed limit, means for penalizing the engineer if said normally inactive means is rendered active by the reception of a control influence, manually operable acknowledging means which if operated before said normally inactive means is rendered active renders said normally inactive means active and thereby avoids such penalty, and means effective upon the reception of a restoring influence from the trackway for restoring said normally inactive means to normal.

17. An automatic train control system comprising, apparatus partly on the vehicle and partly along the trackway for transmitting control influences from the trackway to the vehicle through an intervening air-gap by inducing a potential in a car-carried coil due to movement of the vehicle by a trackway device and by which insufficient potential is induced to transmit such control influence if the speed of the vehicle is extremely low, normally inactive means rendered active upon the reception of a control influence and which if active restructs the speed of the vehicle by causing an automatic application of the brakes of the vehicle if the speed of the vehicle exceeds a predetermined speed limit, manually operable acknowledging means which if operated before said normally inactive means is rendered active renders said normally inactive means active, and means effective upon the reception of a restoring influence from the trackway for restoring said normally inactive means to normal.

18. An automatic train control system comprising, apparatus partly on the vehicle and partly along the trackway for transmitting control influences from the trackway to the vehicle through an intervening air-gap by inducing a potential in a car-carried coil due to movement of the vehicle by a trackway device and by which insufficient potential is induced to transmit such control influence if the speed of the vehicle is extremely low, normally inactive means rendered active upon the reception of a control influence and which if active restricts the speed of the vehicle by causing an automatic application of the brakes of the vehicle if the speed of the vehicle exceeds a predetermined speed limit, means for penalizing the engineer if said normally inactive means is rendered active by the reception of a control influence, and manually operable acknowledging means which if operated before said normally inactive means is rendered active renders said normally inactive means active and thereby avoids such penalty.

19. An automatic train control system comprising, apparatus partly on the vehicle and partly along the trackway for transmitting control influences from the trackway to the vehicle through an intervening air-gap by inducing a potential in a car-carried coil due to movement of the vehicle by a trackway device and by which insufficient potential is induced to transmit such control influence if the speed of the vehicle is extremely low, normally inactive means rendered active upon the reception of a control influence and which if active restricts the speed of the vehicle by causing an automatic application of the brakes of the vehicle if the speed thereof exceeds a predetermined speed limit, and manually operable acknowledging means which if operated before said normally inactive means is rendered active renders said normally inactive means active.

20. An automatic train control system comprising, apparatus partly on the vehicle and partly along the track for transmitting control influences from the trackway to the vehicle, a normally inactive device which if active restricts the speed of the vehicle and which is rendered active upon the reception of a control influence, means for penalizing the engineer if said device is rendered active by the reception of a control influence, and manually operable means for rendering said device active.

21. An automatic train control system comprising, apparatus partly on the vehicle and partly along the track for transmitting control influences from the trackway to the vehicle, a normally inactive device which if active restricts the speed of the vehicle and which is rendered active upon the reception of a control influence, means for penalizing the engineer if said device is rendered active and manually operable means effective only if operated prior to the reception of a control influence for rendering the penalizing means ineffective which if operated renders said device active.

22. An automatic train control system comprising, apparatus partly on the vehicle and partly along the track for transmitting control influences from the trackway to the vehicle, a normally inactive device which if

active restricts the speed of the vehicle and which is rendered active upon the reception of a control influence, means for penalizing the engineer if said device is automatically rendered active, manually operable means for rendering said device active, and means responsive to the reception of restoring control influences transmitted from the trackway for restoring said device to normal.

In testimony whereof I hereby affix my signature.

WINTHROP K. HOWE.