A. G. WILLIAMSON AND S. V. HUBER.

TRAIN CONTROL SYSTEM.

APPLICATION FILED OCT. 20, 1917.

1,351,822.

Patented Sept. 7, 1920.

2 SHEETS—SHEET 1.

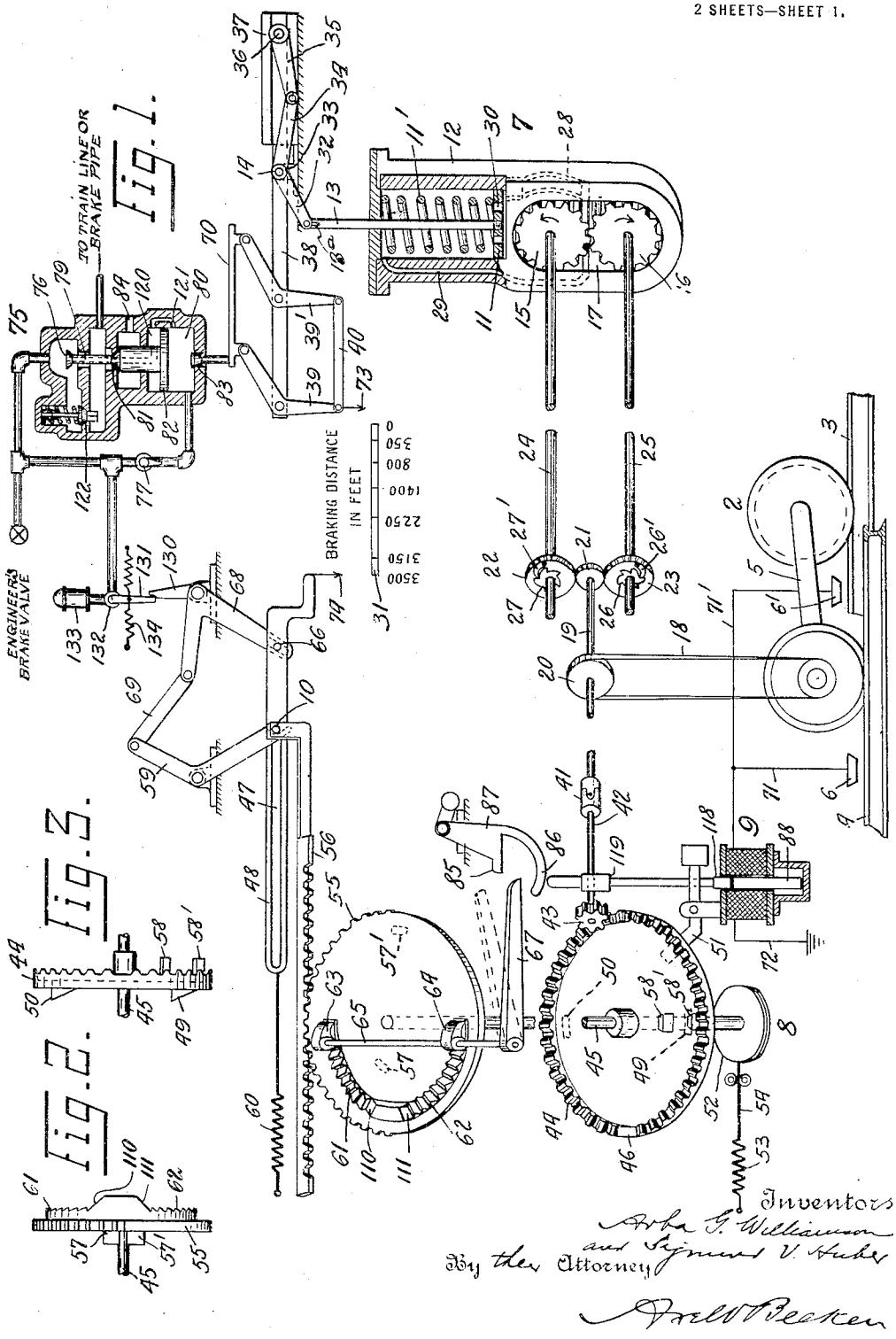



Fig. 1.

Fig. 2.

Fig. 3.

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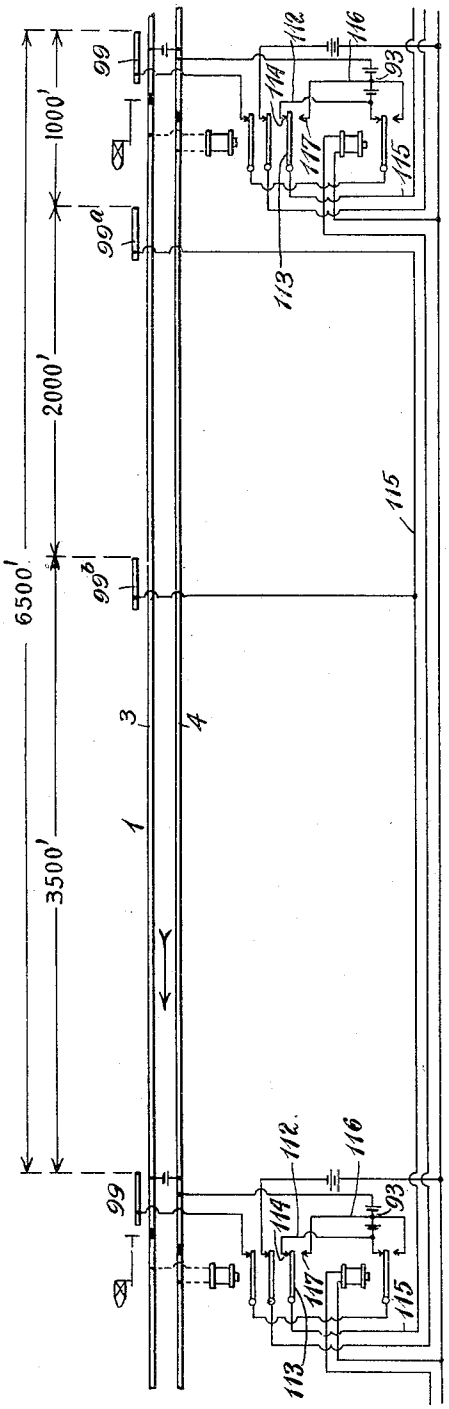



Fig. 5

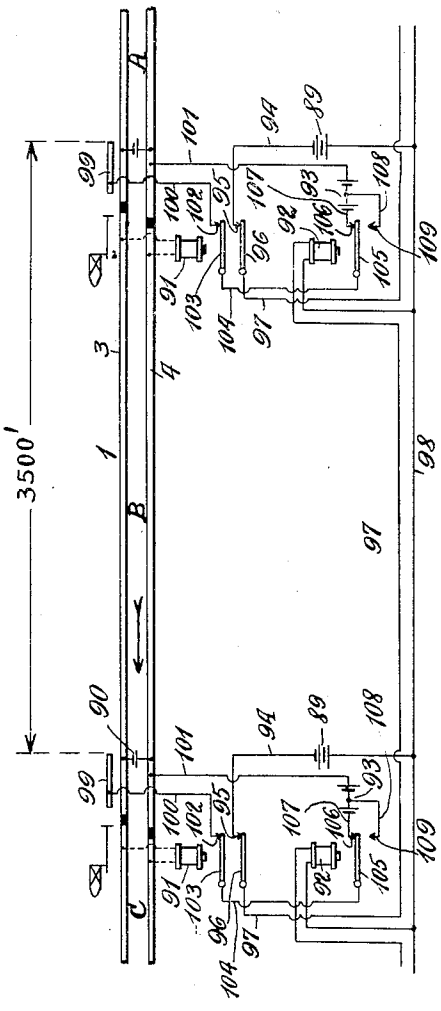



Fig. 4.

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# UNITED STATES PATENT OFFICE.

ARBA G. WILLIAMSON, OF PITTSBURGH, PENNSYLVANIA, AND SIGMUND V. HUBER, OF LOS ANGELES, CALIFORNIA.

## TRAIN-CONTROL SYSTEM.

1,351,822. Specification of Letters Patent. Patented Sept. 7, 1920.

Application filed October 20, 1917. Serial No. 197,528.

*To all whom it may concern:*

Be it known that we, ARBA G. WILLIAMSON, a resident of the city of Pittsburgh, county of Allegheny, and State of Pennsylvania, and SIGMUND V. HUBER, a resident of Los Angeles, in the county of Los Angeles and State of California, citizens of the United States of America, have invented certain new and useful Improvements in Train-Control Systems, of which the following is a specification.

The present invention relates generally to train controlling systems and has for its main object the control of a train so that it will at all times be running at a safe speed under a given set of traffic conditions.

In working out this problem, it will be seen that if a train has at all times sufficient available braking distance between itself and the point of danger the train will always be safe. Obviously, however, the required braking distance for each train will vary according to the speed, equipment, weather, load, etc., so that it is almost impossible to determine the exact required braking distance for any given train. The best that can be done is to ascertain the required braking distance under the most adverse conditions, when using a medium application of brakes, and adopt that as a standard; that is to say, the factors of load, weather, grade, etc., are considered uniform in calculating the required braking distance, the only variable factor then remaining being that of speed. It will be evident that a slowly moving train requires less braking distance than a fast moving train; and that the slowly moving train therefore can traverse a greater part of a caution zone before it needs to be "slowed down" than would be the case of a train running at a higher rate of speed. It is an important point in the automatic control of trains not to "slow down" a train before it is necessary to do so, because to unnecessarily retard the advance of trains hampers traffic along the line of way.

One feature of the invention resides in the use of two measuring devices carried by the train, one of which measures available braking distance for the train within a given block length; and the other of which measures required braking distance for the train when traveling at a given speed. It will be understood that these two devices are so arranged that, when they occupy a certain predetermined relation with respect to each other, automatic means are brought into play to control the train.

For instance, when a train is traveling in say a caution zone and the measuring device indicates that there is a thousand feet of available braking distance left in the zone, then if the braking distance required should exceed or approach that figure, the automatic train control would be brought into action.

Other factors being equal, the required braking distance of a train varies as the square of its velocity and in accordance with this, one of the measuring devices utilized has a movement with respect to the other measuring device that is substantially proportionate to the square of the velocity of the train. The other measuring device is given a movement in accordance with the distance of a train from a given point; and, when these two devices approach each other, or assume a given relation, the train will be brought under the automatic controlling means.

Another feature of the invention resides in means whereby two measuring elements, whatever may be their nature, will eventually, during the running of the train, assume the active train control relation when unaffected by traffic conditions, so that should wayside indicating means become inoperative or disarranged, the train will have an inherent capacity for bringing itself to a stop; or, at least, of reducing its speed, to, say, ten miles an hour at which danger is negligible. In connection with this, there is employed means, extraneous of the train, that will effect a resetting of the two devices with relation to each other when traffic conditions are favorable, the absence of said resetting means or their disarrangement permitting the train to bring itself to a stop or to a safe running speed.

It will be understood that it is not always feasible to adhere to a given standard of block length and that, since the measuring device that indicates available braking distance necessarily is predicated upon a given block length, means must be provided for automatically expanding the capacity of the measuring device when the train is entering a block longer than one of normal length. This feature of the invention is applicable to measuring devices of a character differ-

ent from those herein disclosed but it is not intended to include a selective device comprising a plurality of means any one of which may be selected. It is, however, intended to include any device that, so to speak, automatically expands its own capacity without having recourse to a group of elements any one of which may be selected. When used in connection with a measuring device of a certain type, this feature practically amounts to a diminishing, under certain conditions, of the normal ratio of movement of one of said devices with respect to the other measuring device. Such a diminution of the normal ratio of movement may be constant, or nearly so; or, as here disclosed, it may be intermittent in its action and may interrupt the movement of a member of one of said measuring devices without, however, interfering with the measuring operation.

Other features of the invention will appear as the specification proceeds.

In the embodiment of the invention disclosed in the drawings:—

Figure 1 is a more or less diagrammatic view of the train carried mechanism:

Fig. 2 is an edge view of the member 55:

Fig. 3 is an edge view of the member 44:

Fig. 4 is a diagrammatic view illustrating a controlling means extraneous of the train in connection with a block of normal length: and

Fig. 5 is a diagrammatic view showing the same means as in Fig. 4 when applied to a block length greater than a normal one together with means for automatically expanding the action of the train carried means.

Suitable train controlling means, normally inoperative and here represented by the train controlling valve 75, is utilized, said valve being rendered operative by the interaction of two devices, one of which is represented by bar 48 and the other of which may be designated as the member 38. Bar 48 measures available braking distance and is given, in the drawing, a movement to the right in accordance with the distance traversed by a train in a caution zone. The member 38 measures required braking distance and is moved to the left in the drawing at a speed substantially proportionate to the square of the velocity of the train. When the members 48 and 38 encounter each other, plate 70 is raised and the brake valve 75 actuated.

A detail description of the device that measures or indicates required braking distance is as follows: 2 designates the train which, of course, may comprise one or more cars provided with the usual wheels running on rails 3 and 4 and having an axle 5 connecting said wheels. 19 indicates a shaft driven from the axle 5 by any suitable means, such as the spring belt 18 and pulley 20. On the end of shaft 19 is a pinion 21 which meshes continually with two gears 22 and 23 running loosely on shafts 24 and 25 and carrying the pawls 27′ and 26′. 24 and 25 are two shafts to which are keyed respectively the ratchets 27 and 26. The relation of ratchets 27 and 26 and their coöperating pawls is such that if shaft 19 is rotated clockwise, then pawl 27′ will drive ratchet 27, and hence shaft 24, while pawl 26′ will slide idly over ratchet 26. If, however, the rotation of shaft 19 is counter-clockwise pawl 26′ will drive ratchet 26, and hence shaft 25, while pawl 27′ is sliding idly over ratchet 27. On the ends of shafts 24 and 25 are keyed two gears 15 and 16 enmeshed with each other; and it will therefore be seen that irrespective of the direction of movement of the train the gears 15 and 16 will rotate in the same direction, one gear being the driver in one instance and the other gear being the driver under reverse circumstances. What it is meant here to convey is that regardless of whether or not the train is traveling in one direction on one track or in the other direction on the other track, the gears 15 and 16 will always rotate in the same direction. These gears rotate in a casing 17 above which is a cylinder 12 in which works a plunger 11 that is subjected to pressure by a spring 11′. A passage 28 extends from a point intermediate the gears 15 and 16 to the bottom of cylinder 12, while another passage 29 extends from the top of the cylinder to a point intermediate the gears 15 and 16 but on the other side from that at which the passage 28 is located. 30 indicates passages, extending through plunger 11, of less capacity than that of passages 28 and 29. Casing 17 and cylinder 12 are filled with oil and rotation of gears 15 and 16 will establish circulation of the oil through the passages above mentioned. Owing to the fact, however, that passages 30 have less capacity than 28 and 29, a choking effect will be produced, the extent of which will depend upon the rate of rotation of gears 15 and 16. The oil will therefore move the plunger upwardly against the action of spring 11′ and will thereby actuate the stem 13. 38 indicates a member having a pin 36 moving in a slide 37. 14 is a crank mounted on the fixed center 33 and connected by means of an arm 32 having pin-and-slot connections $13^a$ to the stem 13 and by means of arm 34 to a link 35 that is secured to pin 36. The position of arm 34, at zero speed, with respect to the straight line in which bar 38 travels is such that the cosine of movement of arm 34, when amplified by link 35, is substantially as the square of the speed of the train. Bar 38 carries on its outer end two cranks 39 and 39′ con-

nected by means of a link 40 and having at their upper ends a plate 70. It will be apparent that if cranks 39 and 39′ are given a movement to the right in Fig. 1, plate 70 will be elevated and valve 83 lifted. 31 indicates a scale that may be used in connection with the device, said scale indicating a predetermined number of feet of a standard block, say thirty-five hundred. By providing a pointer 73 on crank 39, said pointer will indicate the required braking distance at the speed at which the train travels. It will be understood that pointer 73 will move unequal distances for equal increases in speed: that is to say, if there is an increase in the speed of the train of from ten to twenty miles per hour, the pointer will move a much smaller distance than when the increase is from forty to fifty miles per hour. Thus bar 38 and pointer 73 will move, not in accordance with the speed of the train or in proportion to the speed, but substantially as the square of its velocity thereby indicating at all times the required braking distance, since the greater the speed, the greater the braking distance required. If desired, scale 31 may be divided into equal spaces to indicate units of feet or may have arbitrary indications showing various braking distances, as 350, 800, 1400, etc.

The device for measuring or indicating the available braking distance is preferably constructed as follows: 44 indicates a rotatable member, here shown in the form of a gear keyed to a shaft 45 with which normally meshes a pinion 43 carried by a shaft 42 and connected by suitable reduction gears, not shown, with shaft 19 and, also, having interposed a universal joint 41. The ratio of the reduction gears is such that gear 44 will make one quarter of a revolution while the train is traveling one block length, here arbitrarily fixed at thirty-five hundred feet. The direction of rotation of gear 44 will depend on the direction of travel of the train but, due to a mutilated portion 46 of gear 44, it will be understood that when it has made one-half of a revolution in either direction,—that is to say, when the train has traveled two block lengths,—pinion 43 will reach the mutilated portion 46 and further rotation of gear 44 will not be possible beyond that point. The parts will be held in this position by reason of spring 53, one end of which is connected by means of a flexible band 54 to a pulley 52 carried by shaft 45. If, however, pinion 43 is lifted out of engagement with gear 44, in a manner to be hereinafter described, the action of spring 53 will restore gear 44 to its original position. On the underside of gear 44 are two dogs 49 and 50 so spaced with relation to latch 51 that, whenever 44 is rotated one-quarter of a revolution, either dog 49 or 50, depending upon the direction of rotation, will have slipped over latch 51; and, if pinion 43 should then be lifted out of engagement with gear 44, it would not be possible for the latter to be restored to its original position. The dogs 49 and 50 are oppositely beveled with relation to each other so that each will slip over latch 51 in its forward movement but not in its reverse direction. 55 indicates another rotatable member, here taking the form of a gear in mesh with a rack 56. This gear 55 is loose on shaft 45 but is adapted to be coupled to, and driven by, gear 44 under certain conditions. In order to effect this, gear 55 is provided with two abutments 57 and 57′ on its under side, so positioned that they are in the path of the drivers 58 and 58′ on the upper side of gear 44. It will be understood that gears 44 and 55 are mounted directly one above the other but that they are shown in the drawing as separated and in perspective for the sake of clearness of illustration. The drivers 58 and 58′ are positioned mid-way between the pinion 43 and the mutilated portion 46 so that when gear 44 has made a quarter of a revolution,—that is to say, when the train has traversed one block length,—gear 55 will commence its rotation and will move rack 56 so that during the second quarter of a revolution of gear 44, *i. e.* during the travel of the train through the second block, the member 48 will be carried to the right in Fig. 1 and will indicate by its relation to scale 31 the braking distance available or still remaining in that block;—that is from the home signal. In order that bar 48 may be moved to the right, regardless of the direction of rotation of gear 55 and regardless of direction of movement of rack 56, the following means are provided: Rack 56 is provided with a pin 10 that works in slot 47 of member 48 and has also secured to it one end of a crank 59. The member 48 is provided with a pin 66 that works in the slot of a crank 68. Cranks 59 and 68 are connected by means of a link 69. A spring 60 constantly urges member 48 to the left in Fig. 1. If rack 56 is moved to the right in Fig. 1, then pin 10, being at the end of slot 47, will move member 48 to the right; but if rack 56 is moved to the left, then pin 10 will slide in slot 47, will rotate crank 59 clockwise and, through link 69 will move crank 68 counter-clockwise thereby moving the member 48 to the right. Therefore, irrespective of the direction of rotation of gear 55 and of the direction of movement of rack 56, the member 48, and consequently the pointer 74, will always move to the right in Fig. 1. Carried by gear 55 are two ratchets 61 and 62, there being an incline 110 at the end of ratchet 61 and an incline 111 at the end of ratchet 62. 63 and 64 are pawls keyed to shaft 65 mounted independently of

gear 55. When gear 55 turns in either direction, one pawl, by engaging its ratchet, will normally prevent retrograde movement; and, when a quarter of a revolution of gear 55 has been effected either incline 110, or incline 111, will raise one of the pawls thereby turning shaft 65 and elevating arm 67. Suitable means are provided for elevating arm 67 thereby freeing pawls 63 and 64 from engagement with ratchets 61 and 62, such means taking, in the present instance, the following form: 87 is a latch having two projections, a lower one 86, normally beneath arm 67, and an upper and shorter one 85 normally above said arm 67. 88 indicates a plunger, controlled by magnet 9 having a stem 118 that passes through the weighted end of latch 51 and that also carries a bearing 119 for shaft 42. Magnet 9 is normally deenergized and is so designed that its plunger 88 will be lifted when a minimum amount of voltage—here arbitrarily taken as six volts—is applied to its coil. The six volts will lift plunger 88 until it comes in contact with the weighted arm of latch 51, but will not have sufficient power to lift said weight. The movement imparted by the six volts, however, is sufficient to lift pinion 43 out of mesh with gear 44 so that spring 53 will restore said gear to its initial position provided the dogs 49 and 50 have not passed latch 51. The movement of plunger 88, when the coil is actuated by a six-volt current, will also lift latch 87 by engaging the member 86 thereof, moving the latter a sufficient distance to bring it in contact with, but without lifting, arm 67 provided said arm has not been previously lifted by a movement of shaft 65. If shaft 65 has previously been turned and arm 67 elevated thereby, then the end 85 of the latch will be brought under arm 67, and will hold the pawls 63 and 64 out of engagement with the ratchets while spring 60 restores the gear 55. If a maximum voltage—here arbitrarily chosen as twelve volts—is applied to the coil of magnet 9, it will be so powerfully energized that plunger 88 will be lifted its full stroke thereby not merely lifting pinion 43 out of mesh with gear 44 but also elevating latch 51 to admit of spring 53 restoring gear 44 to its original position. In these circumstances plunger 88 will also act to lift arm 67 so as to release either pawl 63 or 64 from its ratchet thereby permitting gear 55 to be restored to its original position by spring 60. It will be noted that if arm 67 is in its lower position member 86 will lift the arm, while if the arm 67 has already been lifted by the incline 110 or 111 the member 85 will lift the arm 67.

Any suitable means may be utilized for controlling magnet 9. In the present instance, the coil of this magnet is connected by conductors 71 and 71′ to shoes 6 and 6′, either one of which is adapted to ride upon a third rail or ramp 99, the other end of the coil of magnet 9 being grounded on the engine frame by means of conductor 72. The object in having two shoes, as 6 and 6′, is to insure contact with a track ramp regardless of the direction in which the train is facing. Each block of the track 1 is provided with the usual track circuit consisting of a battery 90 and a relay 91 connected to opposed rails 3 and 4 of said track. In addition, there may be employed the usual line circuits consisting here of battery 89, conductor 94, contact point 95, armature 96, conductor 97, line relay 92 and common return conductor 98. At the entrance of each block and adjacent to one of the running rails 3 or 4 is a short third rail 99 leading from which is a partial circuit consisting of conductor 100, contact point 102, armature 103, conductor 104, armature 105, contact point 106, conductor 107, battery 93 and conductor 101 to one of the track rails. From the center of battery 93 leads conductor 108 to the back contact 109. Therefore, with both track relay 91 and line relay 92 closed, the partial circuit just described is charged with the voltage of battery 93, in this instance twelve volts; but, when line relay 92 is deenergized and only track relay 91 is energized, the partial circuit previously described is charged with only one-half of the volts of battery 93,—that is, six volts. This is caused by the armature 105 under the influence of line relay 92 moving out of engagement with contact 106 and into engagement with back contact 109. If relay 91 is deenergized, the amount of voltage in the partial circuit is zero.

The train controlling means in the present instance takes the following form: In the pipe leading from the engineer's brake valve to the train line, there is interposed a valve generally designated as 75. Normally, air pressure flows through the passage 79 to chamber 120 and thence by passage 121 to chamber 80 thereby holding valves 81 and 83 in their closed position, and also holding valve 76 in its open position. If valve 83 is now unseated by plate 70, air will escape past valve 83, and the reduction of pressure in chamber 80 will cause the brake pipe pressure to unseat valve 81 thereby permitting air to exhaust through port 84. At the same time, valve 76 will be seated to close the passage of flow of pressure from the main reservoir to the brake pipe and to the atmosphere. Inasmuch as the piston 82 is forced down past port 121, valve 81 will remain unseated even after valve 83 has been seated. To release the brakes, cut-out valve 77 must be opened so that pressure will flow from the main reservoir to chamber 80. Cut-out valve 77 is under seal and is preferably accessible only from the ground

so that once the automatic train controlling means are rendered operative, it is not possible for the engineer to intervene and prevent them from acting; but, while the engineer can not charge the brake pipe during automatic application of the brakes, he can nevertheless make a further reduction in the brake pipe by means of the engineer's valve. In order that the operator may have an audible caution indication, an arm 130 is attached to crank 68 so that, when the latter is rotated, lever 131 will be moved to open valve 132. Air pressure now flows from the main reservoir to whistle 133 thereby giving the required caution indication. In order that this signal may not be unduly prolonged, springs 134 are employed which will tend to restore arm 131 to its mid-position as soon as arm 130 has moved past arm 131. If desired, the parts may be so arranged that when member 48 is reset, whistle 133 will again blow momentarily.

It is a characteristic feature of this invention that both measuring devices are active whether the train is running in a clear block or in a caution block; but, when a clear block has been traversed, the traffic conditions will determine whether the devices shall be re-set with respect to each other or whether the measuring shall continue until the train is brought under control. It will, therefore, be seen that the system is normally predicated upon use of two blocks, or zones a given distance from the point of danger, such as the home signal, and that all operations are based on this calculation. In order that it may be understood how the device acts under different traffic conditions, the following statement of operation is made:

A train traveling through the clear block A will, at the time the shoe 6 or 6′ reaches the rail 99, have revolved gear 44 through its first one quarter turn; either dog 49, or 50, will have passed over latch 51 and either driver 58, or 58′, will just have come in contact with lug 57, or 57′, thereby starting rotation of gear 55. Now, if block B is clear and the relays 91 and 92 are closed, rail 99 of block A will be charged with twelve volts; and, when shoe 6, or 6′, comes in contact with rail 99, the following circuit is established: battery 93, conductor 107, contact point 106, armature 105, conductor 104, armature 103, contact point 102, conductor 100, rail 99, shoe 6, conductor 71, coil of magnet 9, conductor 72, frame of engine, traffic rail 4 and conductor 101 back to battery 93. Under the influence of the twelve volt current, plunger 88 will be lifted its full stroke thereby bringing pinion 43 out of mesh with gear 44, and lifting latch 51 and also causing member 86 to lift arm 67. This will permit springs 53 and 60 to restore gears 44 and 55 to initial position. This action will be repeated every time the train passes from a clear block into a clear block.

If a train traveling through block A encounters a caution zone in block B, that is to say that there is another train in block C, then the following conditions will be present: relay 92 will have become deënergized thereby dropping armature 105 into engagement with back contact 109. Consequently, when shoe 6 comes in contact with rail 99, the following circuit will be established. Battery 93, conductor 108, contact point 109, armature 105, conductor 104, armature 103, contact point 102, conductor 100, rail 99, contact shoe 6, conductor 71, coil of magnet 9, conductor 72, frame of engine, traffic rail 4, conductor 101 back to battery 93. In this instance, only 6 volts will flow in the circuit just described and the coil of magnet 9 will accordingly be less powerfully energized than under the conditions previously described. The movement of plunger 88, however, will be sufficient to throw pinion 43 momentarily out of mesh with gear 44 but latch 51 will not be lifted and gear 44 will therefore not be returned under the influence of spring 53 since it will be prevented by reason of dogs 49, or 50, coming against latch 51. Likewise arm 67 will not be lifted. In these circumstances, as the train enters block B rack 56 will be driven either to the right or to the left depending upon the direction of rotation. This movement on the part of rack 56 in either case will cause a movement of the member 48 to the right in Fig. 1 and pointer 74 will travel over scale 31. The position of pointer 73 will, of course, at all times indicate the braking distance required and this pointer will constantly shift back and forth in proportion to the square of the velocity of the train. The engineer must now so control the train that the member 48 is prevented from coming in contact with the member 39 to lift plate 70 to apply the brakes. In other words, the available braking distance must always be at least slightly greater than the required braking distance. By the time the train has traversed block B, gear 44 will have revolved through its second quarter of a turn and pinion 43 will have reached the mutilated portion 46. Likewise, gear 55 has been driven through its quarter turn, and rack 56, and therefore the member 48 and pointer 74, will have reached their full travel. If the block in advance,—*i. e.* block C,—is still occupied, then track relay 91 of block C will be deënergized and the rail 99 at the end of block B will not be charged with current. When the shoe 6, therefore, comes in contact with this rail, the coil of magnet 9 will not be energized so that neither gear 44 nor gear 55 is reset. Therefore, the train cannot enter block C except at such minimum speed as the device may be set for,—or, indeed, if desired it may be

stopped altogether. It will be observed that if at any time rail 99 should be removed, or the circuit thereof destroyed, the result would be that the coil of magnet 9 would not be energized and no resetting of the parts would take place and subsequent travel of the train would eventually cause, in due time, an automatic application of the brakes.

Again, if the train has passed out of block C into the next adjacent block by the time the train traveling in block B under caution conditions reaches rail 99 at the end of block B, then the coil of magnet 9 will receive a current of six volts in the manner previously described. This will cause pinion 43 to be moved out of mesh with gear 44 but will not raise latch 51. Therefore, spring 53 will be permitted to reset gear 44 only a quarter of a revolution, or until dog 49, or 50, encounters latch 51. Inasmuch as gear 55 will by this time have made its quarter of a revolution, either pawl 63 or 64 will have been tilted by surface 110, or 111, and shaft 65 will have been rotated sufficiently to lift arm 67 into the dotted position indicated in Fig. 1. The six volt lift of plunger 88, will, therefore, in these circumstances, tilt latch 87 to bring the projection 85 under arm 67, which is now in its raised position, thereby permitting spring 60 to reset the member 48, rack 56 and gear 55.

Under the conditions given, if a train in block B should now enter block C under caution, the member 48 will begin its traveling movement to the right (Fig. 1) and the train will again be subjected to the predetermined relative position of members 48 and 38. It is clear that the action of resetting the member 48 will be continued as often as the train moves out of one caution block into another caution block.

Once more, if a train traveling through block B should, when it encounters rail 99 at the end of block B, find that a train in block C had passed two blocks beyond and that therefore block C is clear, then said rail 99 will be charged with twelve volts thereby energizing the coil of magnet 9, fully lifting latch 51, and permitting spring 53 to reset gear 44 and, by lifting latch 87 cause member 85 to lift and hold arm 67 while spring 60 resets member 48, rack 56 and gear 55.

In the description so far given it has been considered that the blocks will have a normal length of substantially thirty-five hundred feet. It will be evident, however, that owing to present location of stations, junctions, and conditions of grade, it is not always practicable to make the blocks of a uniform length. Under certain conditions, we will say that it would be desirable to make the block length sixty-five hundred feet; or, of course, any other length, may be selected. It is clear, that since the measuring of available braking distance is predicated upon a given block length, of say thirty-five hundred feet, provision must be made for expanding the capacity of the measuring device, as it were, and this is accomplished in the following mannner:

In Fig. 5 there is shown a block having a length of sixty-five hundred feet and the circuit arrangements in connection with this block are substantially the same as that previously described, the chief difference being that two intermediate rails $99^a$ and $99^b$ are interposed in the block, the first one a thousand feet inside the block and the second one three thousand feet inside the block. The rails $99^a$ and $99^b$ are normally charged with twelve volts from battery 93 at the outgoing end of the block by conductor 112, contact 114, armature 113 and conductor 115 when the track relay 91 is closed; but when it is open, said rails $99^a$ and $99^b$, are charged with only six volts by means of a circuit established from battery 93, conductor 116, contact 117, armature 113, conductor 115. Now let us assume, that the block shown in Fig. 5 is clear and that a train is about to enter from the preceding block to the right. As the shoe 6 of this train comes in contact with rail 99, it will receive a current of twelve volts and the measuring devices will be reset in initial position in accordance with the description previously given. When the train reaches rail $99^a$, it will again receive twelve volts, the magnet 9 will be energized and pinion 43 will be lifted out of mesh with gear 44 and spring 53 will return gear 44 to its initial position. Again, when rail $99^b$ is encountered by shoe 6, this action will be repeated and gear 44 will be restored to its original position. During the time that the train travels over the remaining thirty-five hundred feet of the block, gear 44 will have been revolved one quarter of a turn so that the position of this gear will be the same as when it has passed through a block having a normal length of thirty-five hundred feet.

If the train, however, when it reached rail 99 before entering the block shown in Fig. 5, received a caution indication—that is a current of six volts—then gear 44 would not be reset owing to the fact that latch 51 would prevent a backward rotation of the gear by engaging either dog 49, or 50. In these circumstances, continued rotation of gear 44 will drive gear 55 and will move rack 56 and member 48. However, when the train has advanced a thousand feet into the block, shoe 6 will encounter rail $99^a$ and will receive six volts thereby energizing magnet 9 sufficiently to throw pinion 43 out of mesh with gear 44 and thus admit of gear 44 being reset back to the point where either dog 49, or 50, will come in contact with latch 51. The movement of plunger

88, however, under the influence of a six volt current will not be such as to raise latch 87 sufficiently to cause member 86 to lift arm 67; and hence either pawl 63 or pawl 64 will remain in the tooth to which it is advanced and will prevent backward rotation of gear 55. Consequently, the member 48 will remain in the position to which it has been advanced. It is clear that during the next one thousand feet of the advance of the train, gear 55 will not be driven having already previously been advanced to that extent: but as soon as the drivers 58 or 58′ again reach lug 57 or 57′, as the case may be, rotation of gear 55 will take place and rack 56 and member 48, together with pointer 74, will be correspondingly advanced. Therefore, when the train reaches 99ᵇ, gear 55 will have been turned a distance equal to two thousand feet of travel due to the previously described resetting of the devices. At this point, magnet 9 is again energized with six volts and gear 44 is consequently restored to its mid-position,—that is, until dog 49, or 50, encounters latch 51; but, as before, 67 will not be lifted by 86 and pawl 63, or 64, will prevent backward rotation of gear 55 by engaging with the tooth to which it has been advanced. Thus, during the next two thousand feet of advance by the train, the member 48, rack 56 and gear 55 will remain stationary. This will bring the train to a point within fifteen hundred feet of the end of the block and, at this point, it is clear that gear 44 will again begin to drive gear 55 so that when the end of the block is reached the member 48 will have completed its movement to the right and will have moved a distance equal to the distance that it ordinarily would have moved in a block of normal length, *i. e.* thirty-five hundred feet. At the same time, it will be clear that pointer 74 has always indicated a safe available braking distance although not necessarily the actual available braking distance. If after traversing the block in question under the conditions just described a stop indication is received, then the member 48 and pointer 74 are retained in extreme right hand position and the automatic control is effected unless the speed of the train is reduced to a predetermined maximum permissible under all circumstances. If, however, the train, after passing through the block, received a caution indication, then the partial elevation of plunger 88 will reset gear 44 one quarter of a revolution or until dog 49, or 50, encounters latch 51; and arm 67, having been elevated by pawl 63, or 64, encountering incline 110, or 111, will be held by projection 85 of latch 87 coming in engagement therewith and spring 60 will restore gear 55 to its original position and, with it, rack 56 and the member 48. It is also clear that if, at the end of the block, a clear indication is received then both gears 44 and 55 will be restored to their initial positions.

The rails 99ᵃ and 99ᵇ perform another function which will be understood from the following: Assume that the block shown in Fig. 5 is a caution zone so that when the train reaches the rail 99, it will receive a six volt impulse. If, when the train arrives at rail 99ᵃ, the block is still a caution zone, it will again receive a six volt impulse with the result previously described. If, now, the block changes from a caution zone to a clear zone while the train is traveling from rail 99ᵃ to rail 99ᵇ, then it will be understood that magnet 9 will receive a twelve volt impulse which will raise plunger 88 to its full stroke thereby resetting gear 44 to its initial position and also resetting gear 55 from its partially advanced position to its initial position. In these circumstances, the pointer 74 will indicate an increased available braking distance and hence the engine man can accelerate the speed of the train. The advantage of this is obvious since it admits of an increase in the speed of the train in response to traffic conditions which, in train control is, from a traffic point of view, as important as the stopping of the train under danger conditions. It will be obvious that rails, such as 99ᵃ and 99ᵇ, may be disposed in blocks of ordinary length to give the same indications.

We claim:

1. A train controlling system including: a train, train controlling means normally inoperative, a device measuring required braking distance, a device measuring available braking distance, both carried by the train, and means whereby, when the two devices occupy a predetermined relation with respect to each other, the train controlling means are rendered operative.

2. A train controlling system including: a train, train controlling means normally inoperative, a device, carried by the train and operated from the running gear thereof, measuring required braking distance, a device, carried by the train and operated from the running gear thereof, measuring available braking distance and means whereby, when the two devices occupy a predetermined relation with respect to each other, the train controlling means are rendered operative.

3. A train controlling system including: a train, train controlling means normally inoperative, a device moving substantially in accordance with the square of the velocity of the train, a device moving in accordance with the distance traversed from a given point, both devices being carried by the train, and means whereby, when the two devices occupy a predetermined relation

with respect to each other, the train controlling means are rendered operative.

4. A train controlling system including: a train, train controlling means normally inoperative, a device carried by the train and operated from the running gear thereof and moving substantially in accordance with the square of the velocity of the train, a device carried by the train and operated from the running gear thereof and moving in accordance with the distance traversed from a given point, and means whereby, when the two devices occupy a predetermined relation with respect to each other, the train controlling means are rendered operative.

5. A train controlling system including: a train, train controlling means normally inoperative, a device carried by the train and operated from the running gear thereof in a given direction, irrespective of the direction of movement of the train, and measuring required braking distance, a device carried by the train and operated from the running gear thereof in a given direction, irrespective of the direction of movement of the train, and measuring available braking distance, and means whereby, when the two devices occupy a predetermined relation with respect to each other, the train controlling means are rendered operative.

6. A train controlling system including: a train, train controlling means normally inoperative, a device carried by the train and operated from the running gear thereof and moving in a given direction, regardless of the direction of movement of the train, substantially in accordance with the square of the velocity of the train, a device carried by the train and operated from the running gear thereof and moving in a given direction, regardless of the direction of movement of the train, in accordance with the distance traversed by the train, and means whereby, when the two devices occupy a predetermined relation with respect to each other, the train controlling means are rendered operative.

7. A train controlling system including: a train, train controlling means normally inoperative, two devices representing elements determining the control of the train which, when they occupy a predetermined relative position, render the controlling means operative, means for operating said devices from the running gear of the train so that the travel of the train wil leventually move said devices to said predetermined position when uninfluenced by traffic conditions, and means extraneous of the train and controlled by traffic conditions for effecting, undere ceertain conditions, a resetting of the devices.

8. A train controlling system including: a train, train controlling means normally inoperative, two devices representing elements determining the control of the train which, when they occupy a predetermined relative position render the train controlling means operative, means for operating said devices from the running gear of the train so that the travel of the train in either direction will eventually move said devices to said predetermined relative position when uninfluenced by traffic conditions, and means extraneous of the train and controlled by traffic conditions for effecting, under certain conditions, a resetting of the devices.

9. A train controlling system including: a train, train controlling means normally inoperative, two devices one measuring required braking distance and the other available braking distance which, when they occupy a predetermined relative position, render the train controlling means operative, means for operating said devices from the running gear of the train so that the travel of the train will eventually move said devices to said predetermined position when uninfluenced by traffic conditions, and means extraneous of the train and controlled by traffic conditions for effecting, under certain conditions, a resetting of the device measuring available braking distance.

10. A train controlling system including: a train, train controlling means normally inoperative, two devices, one moving in accordance with the square of the velocity of the train and another moving in accordance with the distance traversed by the train from a given point which, when they occupy a predetermined relative position, render the train controlling means operative, means for operating said devices from the running gear of the train so that the travel of the train will eventually move said devices to said predetermined position when uninfluenced by traffic conditions, and means extraneous of the train and controlled by traffic conditions for effecting, under certain conditions, a resetting of the device for measuring available braking distance.

11. A train controlling system including: a train, train controlling means normally inoperative, two devices one measuring required braking distance and the other available braking distance which, when they occupy a predetermined relative position, render the train controlling means operative, means for operating said devices from the running gear of the train so that the travel of the train in either direction will eventually move said devices to said predetermined position when uninfluenced by traffic conditions, and means extraneous of the train and controlled by traffic conditions for effecting, under certain conditions, a resetting of the device measuring available braking distance.

12. A train controlling system including:

a train, train controlling means normally inoperative, two devices, one moving in accordance with the square of the velocity of the train and another moving in accordance with the distance traversed by the train from a given point which, when they occupy a predetermined relative position, render the train controlling means operative, means for operating said devices from the running gear of the train so that the travel in either direction of the train will eventually move said devices to said predetermined position when uninfluenced by traffic conditions, and means extraneous of the train and controlled by traffic conditions for effecting, under certain conditions, a resetting of the device for measuring available braking distance.

13. A train controlling system including: a train, train controlling means normally inoperative, a device measuring required braking distance, a device measuring available braking distance, both carried by the train, means whereby, when the two devices occupy a predetermined relation with respect to each other the train controlling means are rendered operative, and means, whereby, under certain conditions, the occurrence of the predetermined relation, with respect to each other, of the two measuring devices may be deferred.

14. A train controlling system including: a train, train controlling means normally inoperative, a device, carried by the train and operated from the running gear thereof, measuring required braking distance, a device, carried by the train and operated from the running gear thereof, measuring available braking distance, means whereby, when the two devices occupy a predetermined relation with respect to each other, the train controlling means are rendered operative, and means, whereby, under certain conditions, the occurrence of the predetermined relation, with respect to each other, of the two measuring devices may be deferred.

15. A train controlling system including: a train, train controlling means normally inoperative, a device carried by the train and operated from the running gear thereof in a given direction, irrespective of the direction of movement of the train, and measuring required braking distance, a device carried by the train and operated from the running gear thereof in a given direction, irrespective of the direction of movement of the train and measuring available braking distance, means whereby, when the two devices occupy a predetermined relation with respect to each other, the train controlling means are rendered operative, and means, whereby, under certain conditions, the occurrence of the predetermined relation, with respect to each other, of the two measuring devices may be deferred.

16. A train controlling system including: a train, train controlling means normally inoperative, a device carried by the train and operated from the running gear thereof and moving in a given direction, regardless of the direction of movement of the train, substantially in accordance with the square of the velocity of the train, a device carried by the train and operated from the running gear thereof in a given direction, regardless of the direction of movement of the train, in accordance with the distance traversed by the train, means whereby, when the two devices occupy a predetermined relation with respect to each other, the train controlling means are rendered operative, and means, whereby, under certain conditions, the occurrence of the predetermined relation, with respect to each other, of the two measuring devices may be deferred.

17. A train controlling system including: a train, train controlling means normally inoperative, two devices representing elements determining the control of the train which, when they occupy a predetermined relative position, render the controlling means operative, means for operating said devices from the running gear of the train so that the travel of the train will eventually move said devices to said predetermined position when uninfluenced by traffic conditions, means extraneous of the train and controlled by traffic conditions for effecting, under certain conditions, a resetting of the devices, and means, whereby, under certain conditions, the relative predetermined position, with respect to each other, of the two measuring devices may be deferred.

18. A train controlling system including: a train, train controlling means normally inoperative, two devices representing elements determining the control of the train which, when they occupy a predetermined relative position render the train controlling means operative, means for operating said devices from the running gear of the train so that the travel of the train in either direction will eventually move said devices to said predetermined relative position when uninfluenced by traffic conditions, means extraneous of the train and controlled by traffic conditions for effecting, under certain conditions, a resetting of the devices, and means, whereby, under certain conditions, the relative predetermined position, with respect to each other, of the two measuring devices may be deferred.

19. A train controlling system including: a train, train controlling means normally inoperative, two devices one measuring required braking distance and the other available braking distance which, when they occupy a predetermined relative position, render the train controlling means operative means for operating said devices from the running gear of the train so that the travel

of the train will eventually move said devices to said predetermined position when uninfluenced by traffic condition, means extraneous of the train and controlled by traffic conditions for effecting, under certain conditions, a resetting of the device measuring available braking distance, and means, whereby, under certain conditions, the relative predetermined position, with respect to each other, of the two measuring devices may be deferred.

20. A train controlling system including: a train, train controlling means normally inoperative, two devices one measuring required braking distance and the other available braking distance which, when they occupy a predetermined relative position, render the train controlling means operative, means for operating said devices from the running gear of the train so that the travel of the train in either direction will eventually move said devices in said predetermined position when uninfluenced by traffic conditions, means extraneous of the train and controlled by traffic conditions for effecting, under certain conditions, a resetting of the device measuring available braking distance, and means, whereby, under certain conditions, the relative predetermined position, with respect to each other, of the two measuring devices may be deferred.

21. A train controlling system including: a train, train controlling means normally inoperative, two measuring devices driven from the running gear of the train representing elements determining the control of the train and which, when they occupy a certain predetermined relation with respect to each other, render the controlling means operative, and means, whereby, under certain conditions, the occurrence of the predetermined relation, with respect to each other, of the two measuring devices may be deferred.

22. A train controlling system including: a train, train controlling means normally inoperative, two measuring devices driven from the running gear on the train representing elements determining the control of the train and which, when they occupy a certain predetermined relation with respect to each other, render the train controlling means operative, and means, whereby, under certain conditions, the occurrence of the predetermined relation, with respect to each other, of the two measuring devices may be deferred.

23. A train controlling system including: a train, train controlling means normally inoperative, two measuring devices driven from the running gear on the train representing elements determining the control of the train and which, when they occupy a certain predetermined relation with respect to each other, render the train controlling means operative, one of said devices being predicated upon a given block length, and means whereby, under certain conditions, the occurrence of said predetermined relation, with respect to each other, of the two measuring devices may be deferred to accord with a change in block length.

24. A train controlling system including: a train, train controlling means normally inoperative, two measuring devices driven from the running gear of the train representing elements determining the control of the train, which, when they occupy a certain predetermined relation with respect to each other, render the train controlling means operative, one of said devices being predicated upon a given block length, and means whereby, under certain conditions, the occurrence of said predetermined relation, with respect to each other, of the two measuring devices may be deferred to accord with a change in block length.

25. A train controlling system including: a train, train controlling means normally inoperative; two measuring devices which, when they occupy a predetermined relation with respect to each other, render the train controlling means operative, one of said devices being predicated upon a given block length, and means whereby, under certain conditions, the occurrence of said predetermined relation, with respect to each other, of the two measuring devices may be deferred to accord with a change in block length.

26. A train controlling system including: a train, train controlling means normally inoperative, a device measuring required braking distance, a device measuring available braking distance predicated upon a given block length, both carried by the train, means whereby, when the two devices occupy a predetermined relation with respect to each other, the train controlling means are rendered operative, and means whereby, under certain conditions, the occurrence of said predetermined relation, with respect to each other, of the two measuring devices may be deferred to accord with a change in block length.

27. A train controlling system including: a train, train controlling means normally inoperative, two devices representing elements determining the control of the train which, when they occupy a relative predetermined position, render the train controlling means operative, one of said devices comprising a member movable from the running gear of the train whether the train is in a clear zone or in a caution zone, another member automatically coupled to the first member and driven by it when so coupled when the train has traversed a clear zone, means for restoring said first member when passing from one clear zone to another clear zone, means for resetting said second member and par-

tially resetting the first member when passing from one caution zone into another caution zone, means for resetting both members when passing from a caution zone to a clear zone, and means for operating the other of said two devices from the running gear of the train.

28. A train controlling system including: a train, train controlling means normally inoperative, two devices representing elements determining the control of the train which, when they occupy a relative predetermined position, render the train controlling means operative, one of said devices comprising a member movable from the running gear of the train whether the train is in a clear zone or in a caution zone, another member automatically coupled to the first member and driven by it when so coupled when the train has traversed a clear zone, means for restoring said first member when passing from one clear zone to another clear zone, means for resetting said second member and partially resetting the first member when passing from one caution zone into another caution zone, and means for resetting both members when passing from a caution zone to a clear zone, means for resetting the first member while retaining the second member in the position it occupies when the train is in caution zone of greater length than a normal one, and means for operating the other of said two devices from the running gear of the train.

29. In a train controlling system, a measuring device including two members, one movable from the running gear of the train and the other automatically coupled to the first member after the latter is advanced a predetermined distance and driven by it when so coupled.

30. In a train controlling system, a measuring device including two members, one movable from the running gear of the train and the other automatically coupled to the first member after the latter is advanced a predetermined distance and driven by it when so coupled, and means for resetting said first member independently of the second member or jointly therewith.

31. In a train controlling system, a measuring device including two members, one movable from the running gear of the train and the other automatically coupled to the first member after the latter is advanced a predetermined distance and driven by it when so coupled, means for resetting the first member under certain traffic conditions before it is brought into driving relation with the second member and under certain other traffic conditions after it is brought into driving relation with the second member, and means for resetting said second member under certain traffic conditions after it has been advanced by the first member.

32. In a train controlling system, a measuring device including two members, one movable from the running gear of the train and the other automatically coupled to the first member after the latter is advanced a predetermined distance and driven by it when so coupled, means for resetting the first member under certain traffic conditions before it is brought into driving relation with the second member and for resetting it under certain other traffic conditions, in whole or in part, and means for resetting said second member under certain traffic conditions after it has been advanced by the first member, and for retaining it in the position to which it has been advanced under certain other traffic conditions when the first member is partially reset.

33. In a train controlling system, a measuring device including two rotatable members one capacitated to make one-half of a revolution and driven from the running gear of the train and the other automatically coupled to the first member after the latter is advanced a quarter of a revolution and driven by it when so coupled during the next quarter revolution.

34. In a train controlling system, a measuring device including two rotatable members one capacitated to make one-half of a revolution and driven from the running gear of the train and the other automatically coupled to the first member after the latter is advanced a quarter of a revolution and driven by it when so coupled during the next quarter revolution, means for resetting said first member under certain traffic conditions when it has made a quarter of a revolution and under certain other traffic conditions when it has made a half revolution, and means for resetting said second member under certain traffic conditions when it has made a quarter of a revolution.

35. In a train controlling system, a measuring device including two rotatable members one capacitated to make one-half of a revolution and driven from the running gear of the train and the other automatically coupled to the first member after the latter is advanced a quarter of a revolution and driven by it when so coupled during the next quarter revolution, means for resetting said first member under certain traffic conditions when it has made a quarter of a revolution and under certain other traffic conditions when it has made a half revolution either back to its quarter revolution position or to its initial position, and means for resetting said second member under certain traffic conditions when it has made a quarter of a revolution.

36. In a train controlling system, a measuring device including two rotatable members one capacitated to make one-half of a revolution and driven from the running gear

of the train and the other automatically coupled to the first member after the latter is advanced a quarter of a revolution and driven by it when so coupled during the next quarter revolution, means for resetting said first member under certain traffic conditions when it has made a quarter of a revolution and for resetting it under certain other traffic conditions either to its quarter revolution position or to its initial position when it has made one-half of a revolution and for resetting it under certain other traffic conditions to its quarter revolution point after it has made less than a half revolution, and means for resetting said second member under certain traffic conditions when it has made a quarter revolution and for retaining it in its advanced position under certain traffic conditions when it has made less than a quarter of a revolution while the first member is being reset to its quarter revolution position.

37. In a train controlling system, a measuring device including two rotatable members one capacitated to make one half of a revolution and driven from the running gear of the train and the other automatically coupled to the first member after the latter has advanced a quarter of a revolution and driven by it when so coupled during the next quarter revolution, means for resetting said first member under certain traffic conditions when it has made a quarter of a revolution and under certain other traffic conditions after it has made a quarter of a revolution, and means for resetting said second member under certain traffic conditions after it has been advanced by the first member.

38. In a train controlling system, a measuring device including two rotatable members one capacitated to make one half of a revolution and driven from the running gear of the train and the other automatically coupled to the first member after the last has advanced a quarter of a revolution and driven by it when so coupled during the next quarter revolution, means for resetting said first member under certain traffic conditions when it has made a quarter of a revolution and under certain other traffic conditions when it has made more than a quarter revolution either back to its quarter revolution position or to its initial position, and means for resetting said second member under certain traffic conditions after it has been advanced by the first member.

39. In a train controlling system, a measuring device including two rotatable members one capacitated to make one half of a revolution and driven from the running gear of the train and the other automatically coupled to the first member after the latter has advanced a quarter of a revolution and driven by it during the next quarter revolution, means for resetting said first member under certain traffic conditions when it has made a quarter of a revolution and for resetting it under certain other traffic conditions either to its quarter revolution position or to its initial position when it has made one half of a revolution and for resetting it under certain other traffic conditions to its quarter revolution point after it has made less than a half revolution, and means for resetting said second member under certain traffic conditions when it has made a quarter revolution and for retaining it in its advanced position under certain traffic conditions when it has made less than a quarter of a revolution while the first member is being reset to its quarter revolution position and for resetting it to its initial position under certain other traffic conditions before it has made a quarter of a revolution simultaneously with the resetting of the first member to its original position after the last has made more than a quarter of a revolution.

Signed at Pittsburgh, in the county of Allegheny and State of Pennsylvania, this 27th day of September, 1917.

ARBA G. WILLIAMSON.

Signed at Los Angeles, in the county of Los Angeles and State of California, this 3d day of October, 1917.

SIGMUND V. HUBER.