June 1, 1943. C. S. SNAVELY 2,320,802

RAILWAY BRAKING APPARATUS

Filed Dec. 24, 1941 5 Sheets-Sheet 1

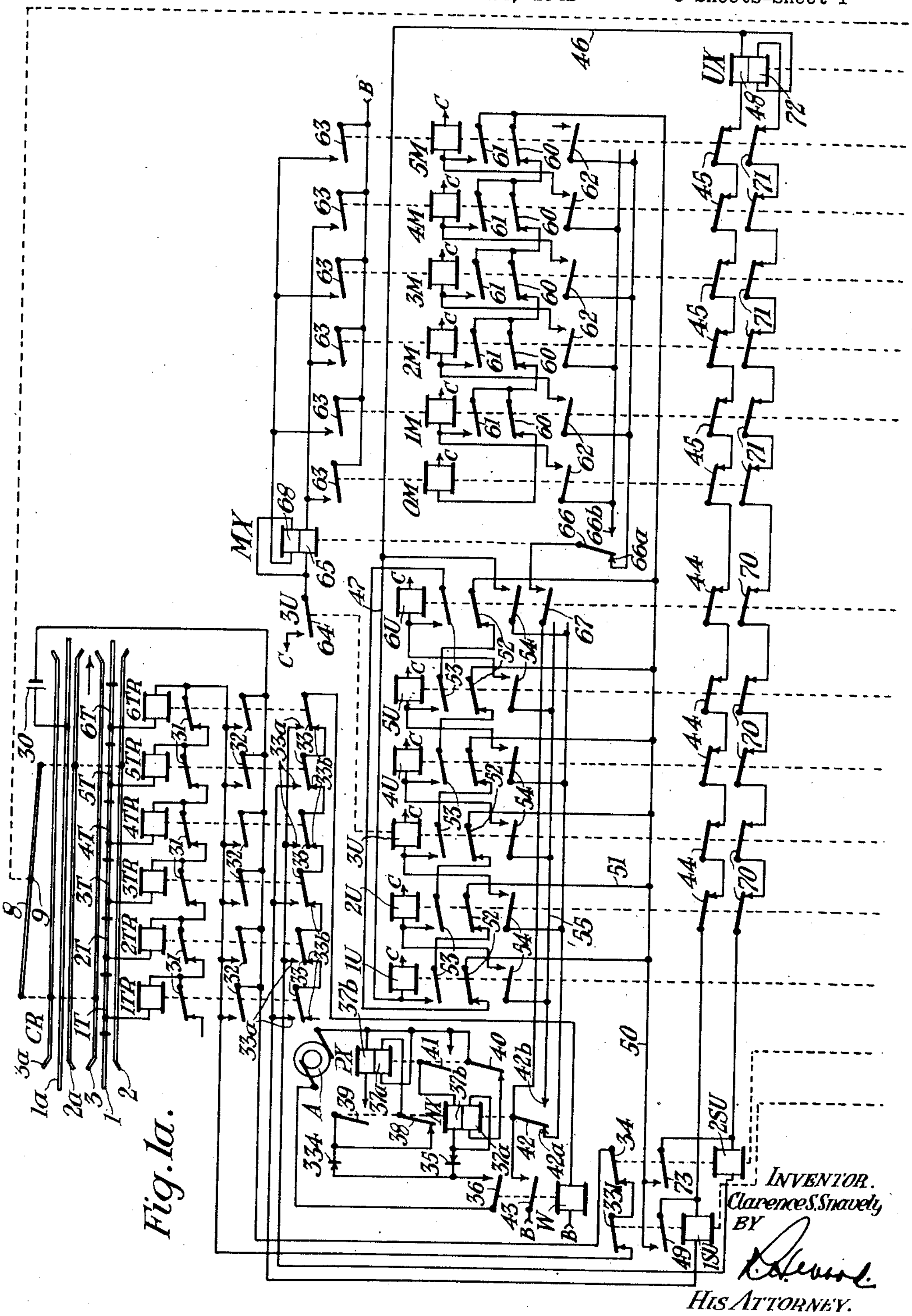

Fig. 1a.

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RAILWAY BRAKING APPARATUS

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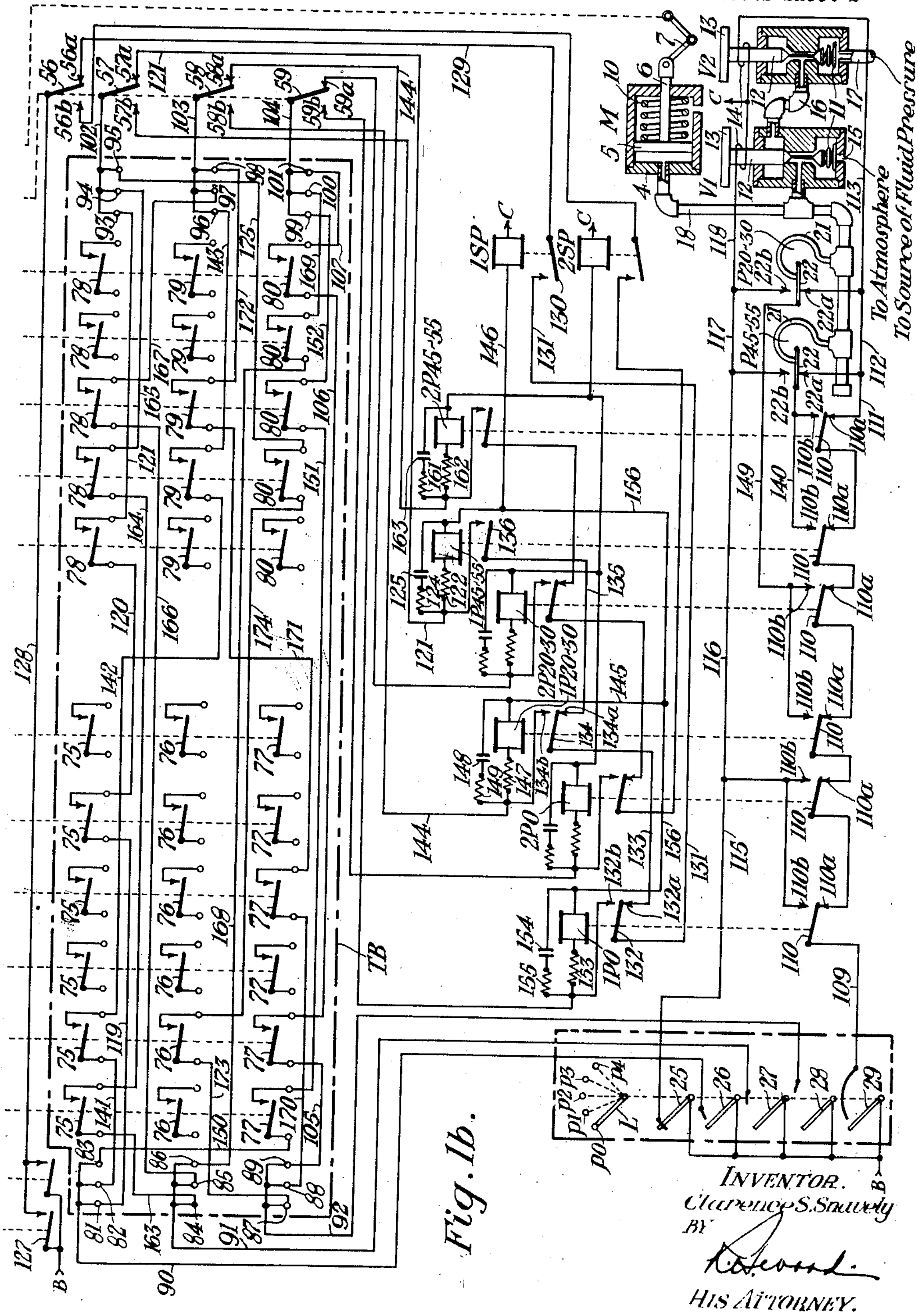

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RAILWAY BRAKING APPARATUS

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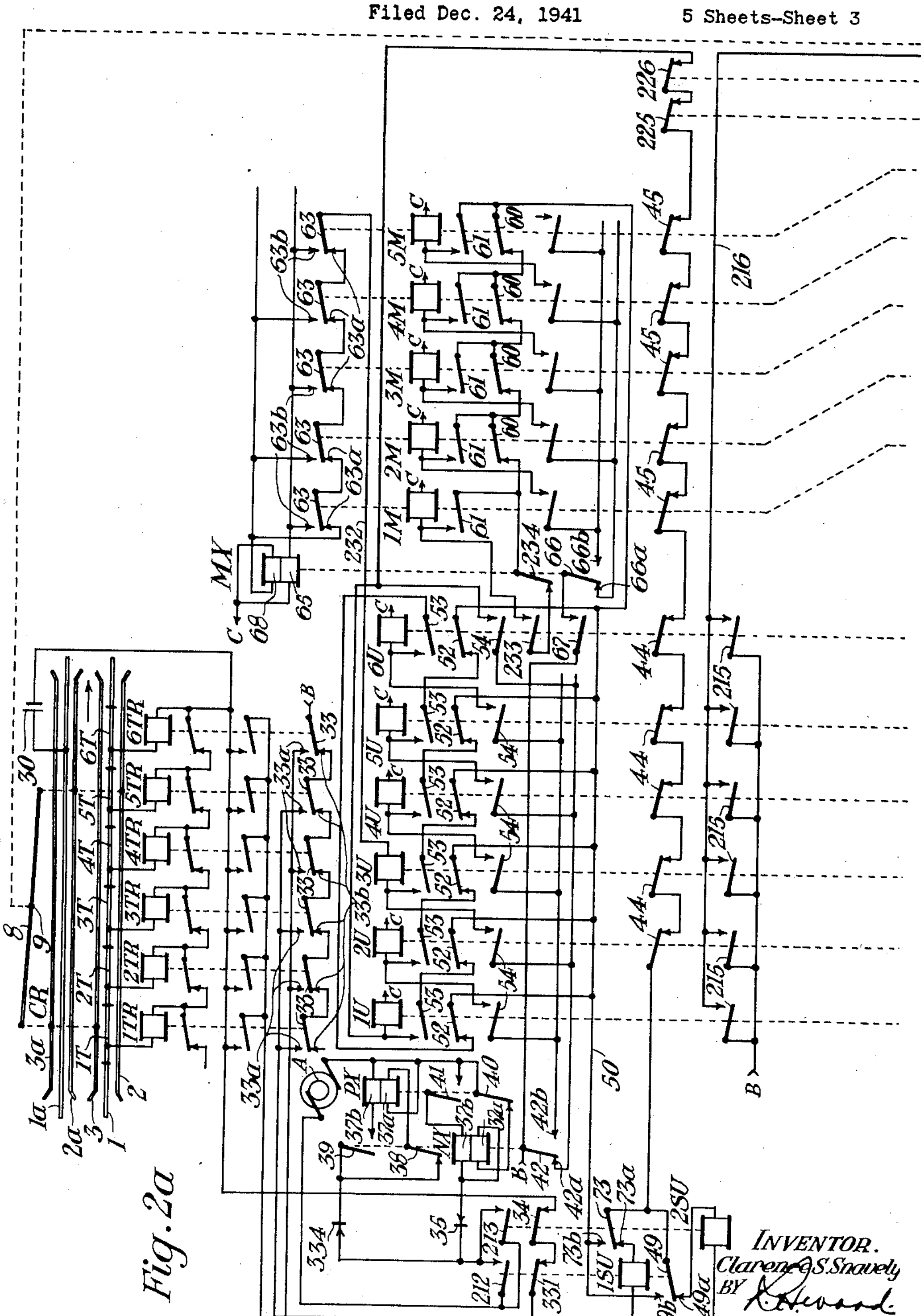

Fig. 2a

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RAILWAY BRAKING APPARATUS

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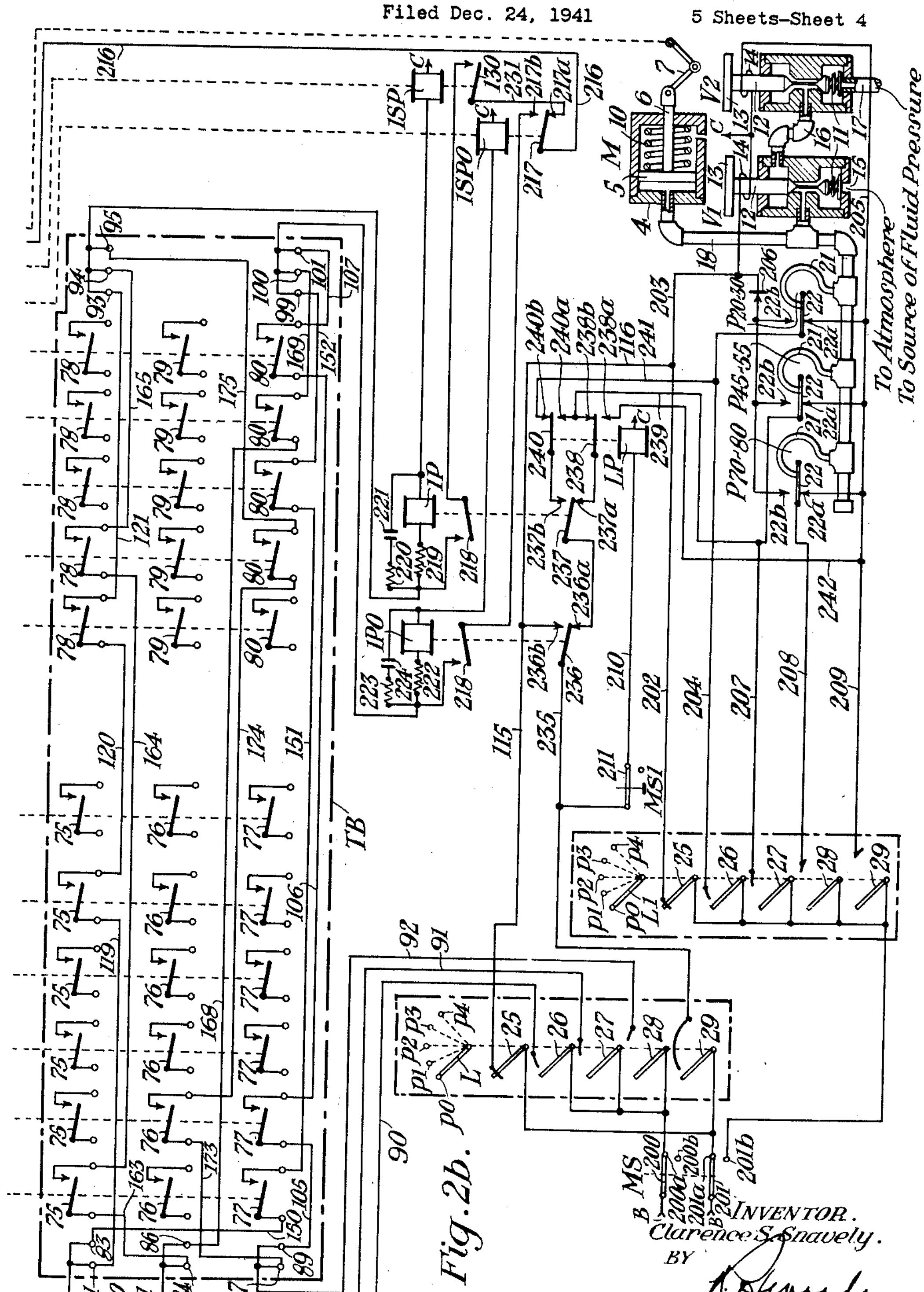

Fig. 2b.

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RAILWAY BRAKING APPARATUS

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SPEED SELECTING CONNECTIONS

Connect Front Contacts of Relay Combinations shown to obtain speed indicated.

Fig 3

Relay Combination	Speed in M.P.H.
1M + 2U	16.0
1M + 3U	14.2
1M + 4U	12.8
1M + 5U	11.6
2M	10.6
2M + 1U	9.8
2M + 2U	9.1
2M + 3U	8.6
2M + 4U	8.0
2M + 5U	7.5
3M	7.1
3M + 1U	6.7
3M + 2U	6.4
3M + 3U	6.1
3M + 4U	5.8
3M + 5U	5.6
4M	5.3
4M + 1U	5.1
4M + 2U	4.9
4M + 3U	4.7
4M + 4U	4.6
4M + 5U	4.5
5M	4.3
5M + 1U	4.2
5M + 2U	4.0
5M + 3U	3.9
5M + 4U	3.8
5M + 5U	3.7

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Patented June 1, 1943

2,320,802

UNITED STATES PATENT OFFICE

2,320,802

RAILWAY BRAKING APPARATUS

Clarence S. Snavely, Churchill Borough, Pa., assignor to The Union Switch & Signal Company, Swissvale, Pa., a corporation of Pennsylvania

Application December 24, 1941, Serial No. 424,338

34 Claims. (Cl. 303—21)

My invention relates to railway braking apparatus, and particularly to car retarders of the type comprising wheel engaging braking bars located beside a track rail and movable toward and away from the rail into braking and non-braking positions. More particularly, my invention relates to apparatus of the type described wherein the braking bars are arranged to be moved to their braking positions by means of one or more fluid pressure motors, and to be restored to their non-braking positions by suitable biasing means.

One object of my invention is the provision of improved means for automatically controlling the braking action of a car retarder in accordance with the speed of a car passing therethrough.

Another object of my invention is the provision of improved timing means for measuring the speed of a car passing through a car retarder.

Another object of my invention is the provision of improved means for progressively decreasing the braking force exerted by a car retarder as the speed of a car being retarded by the retarder approaches a selected one of a plurality of predetermined control speeds, and for releasing the retarder when the selected control speed is reached.

A further object of my invention is the provision of means whereby the braking action of a car retarder may be controlled automatically in accordance with the speed of a car passing through the retarder, or manually at the will of an operator.

A still further object of my invention is the provision of means for providing improved flexibility of operation of a fluid pressure operated car retarder by enabling the pressure which is supplied to the retarder to operate it to be graduated into manually selected levels.

According to my invention the stretch of track with which the retarder is associated is provided with a series of single rail track circuits each of which includes an insulated rail section which is sufficiently short so that two wheels of a car cannot occupy the section at any one time. Each track circuit includes a track relay, and a back contact of all of the track relays in advance, whereby only one track relay will be energized at a time. When any track relay is energized, it sets into operation time measuring means comprising a source of constant frequency alternating current, and means for counting the cycles of this source.

The means for counting the cycles of the source includes a pair of half-step relays which respond to alternate half cycles of the current, whereby each relay operates once during each cycle of the alternating current, and a unit chain of counting relays which pick up successively one each time a selected one of the half-step relays operates. The counting relays are arranged to continue to operate as long as the track relay which initiated their operation remains energized. Assuming that the frequency of the constant frequency source is 60 cycles, and that the unit chain includes 6 relays, it will be seen that successive relays of the unit chain will pick up at intervals of 16⅔ milliseconds, and the chain will complete a full cycle of operation every 100 milliseconds.

The time measuring means also includes a multiple chain of counting relays so arranged that the relays of this latter chain will advance progressively one each time the unit chain completes a round trip of operation.

The time measuring means further includes means for restoring the counting chain to starting position to initiate a new timing period each time a new track relay picks up.

The relays of the unit and multiple chains control other relays for effecting a graduated reduction in the pressure of the fluid applied to the operating cylinder of a fluid pressure operated car retarder in accordance with the setting of a manually operable lever to cause the retarder to release when the speed of a car has been reduced to a selected speed.

The apparatus also includes means whereby the retarder can be controlled manually independently of the manually operable lever.

Other objects and characteristic features of my invention will become apparent as the description proceeds.

I shall describe two forms of railway braking apparatus embodying my invention, and shall then point out the novel features thereof in claims.

In the accompanying drawings, Figs. 1*a* and 1*b* are views which, when placed one above the other with Fig. 1*a* on top in such manner that the dotted lines leading to the bottom of Fig. 1*a* align with the dotted lines leading to the top of Fig. 1*b*, together constitute a view partly sectioned and partly diagrammatic illustrating one form of apparatus embodying my invention. Figs. 2*a* and 2*b* are views similar to Figs. 1*a* and 1*b* illustrating another form of apparatus embodying my invention. Fig. 3 is a table showing the method of connecting the front contacts of certain ones of the relays forming part of the apparatus illustrated in Figs. 1*a*, 1*b*, 2*a* and 2*b* to obtain predetermined control speeds.

Similar reference characters refer to similar parts in all three views.

Referring first to Figs. 1*a* and 1*b*, the reference characters 1 and 1*a* designate the track rails of a stretch of railway track over which cars normally move in the direction indicated by the arrow under such conditions that it is desirable to at times control the speed of the cars automatically. For example, the stretch of track here shown might be in a classification yard of the hump type through which cars move under the influence of gravity. It is obvious that in service of this kind the speed of individual cars or strings of cars will vary through wide limits depending among other things on the speed at which they go over the hump, the temperature, the weight of the car and its contents, and the condition of the car as to whether it is a free running car or otherwise.

In order to control the speed of the cars, the stretch of track illustrated in the drawings is provided with a car retarder CR which in the form here shown comprises two braking bars 2 and 3 extending parallel with, and located on opposite sides of rail 1, and two similar braking bars 2*a* and 3*a* extending parallel with and located on opposite sides of rail 1*a*.

The braking bars 2, 3, 2*a* and 3*a* are operated by a fluid pressure motor M (Fig. 1*b*) comprising a cylinder 4 containing a reciprocable piston 5 attached to one end of a piston rod 6. The braking bars 2, 3, 2*a* and 3*a* are operatively connected with the piston rod 6 through a suitable linkwork here shown as comprising a bell crank 7 and a lever 8 pivotally supported at point 9. When piston 5 occupies its extreme left-hand position, in which it is illustrated in the drawings, the braking bars occupy their non-braking or ineffective positions in which they are out of engagement with the wheels of a car traversing the rails 1 and 1*a*. When piston 5 is moved to its right-hand position, however, as when fluid pressure is admitted to the left-hand end of cylinder 4, the braking bars 2, 3, 2*a* and 3*a* are moved toward the associated rails to their effective or braking positions in which they will engage the wheels of a car traversing the rails 1 and 1*a*, to retard the speed of the car.

The braking bars 2, 3, 2*a* and 3*a* are constantly biased to their non-braking positions by any suitable means, here shown as a spring 10 which is interposed in the cylinder 4 between the right-hand end of the cylinder and the piston 5.

The motor M is controlled by two magnet valves V1 and V2, each comprising a valve stem 12 biased to an upper position by means of a spring 11, and provided with an armature 13 and a winding 14. When valve V1 is energized, as shown in the drawings, valve stem 12 of this valve is moved downwardly against the bias of spring 11, and a pipe 18 which communicates with the left-hand end of motor M is then connected with atmosphere through a port 15. When valve V1 is deenergized, however, pipe 18 is disconnected from atmosphere, and is connected with a pipe 16 leading to valve V2. When valve V2 is energized, valve stem 12 of this valve moves downwardly, and connects pipe 16 with pipe 17 which is constantly supplied with fluid pressure, usually air, from a suitable source not shown in the drawings, but when valve V2 is deenergized, as shown in the drawings, pipe 16 is then disconnected from pipe 17. It will be apparent, therefore, that when valve V1 is energized, the region of the cylinder 4 of motor M between the piston 5 and the left-hand end of the cylinder is connected with atmosphere, so that the braking bars of the car retarder will then be held in their ineffective or non-braking positions by the spring 10. When, however, valve V1 is deenergized and valve V2 is energized, fluid pressure will be supplied to the left-hand end of cylinder 4 of motor M, thus causing the braking bars to move to their effective or braking positions. It will be obvious that when the braking bars are moved to their braking positions, they will exert a braking force which is proportional to the pressure of the fluid which is then supplied to the left-hand end of motor M.

The valves V are controlled in part by a plurality of pressure responsive devices P20—30 and P45—55, each comprising a Bourdon tube 21 connected to pipe 18 and hence subjected to the pressure of the fluid in the left-hand end of motor M. Each Bourdon tube controls two contacts 22—22*a* and 22—22*b*. The pressure responsive devices P20—30 and P45—55 are so constructed and so adjusted that they will operate successively as the pressure in the region of cylinder 4 between the piston 5 and the left-hand end of the cylinder increases. For example, for all pressures below 20 pounds per square inch, the contact 22—22*a* of each of these devices is closed. If the pressure exceeds 20 pounds per square inch, however, the contact 22—22*a* of device P20—30 opens, and if the pressure exceeds 30 pounds per square inch, contact 22—22*b* of device P20—30 closes. In similar manner, the pressure responsive device P45—55 is adjusted to open its contact 22—22*a* at 45 pounds per square inch, and to close its contact 22—22*b* at 55 pounds per square inch. Of course, these specific pressures are not essential but are only mentioned for purposes of explanation.

The valves V are also controlled in part by a plurality of relays 1PO, 2PO, 1P20—30, 2P20—30, 1P45—55 and 2P45—55 which relays, in turn, are controlled by speed responsive apparatus in a manner which will be described in detail hereinafter.

The valves V are further controlled by means of a manually operable lever L which, as here shown, is capable of assuming five positions, indicated by dotted lines in the drawings, and designated by the reference characters *p*0 to *p*4, inclusive. Operatively connected with the lever L are a plurality of contacts 25, 26, 27, 28 and 29. Contacts 25, 26, 27 and 28 are closed, respectively, in the *p*0, *p*1, *p*2 and *p*3 positions of lever L, while contact 29 is closed in the *p*1 position, the *p*4 position, or any position intermediate these two positions.

The lever L will usually be located at a point remote from the braking apparatus, as in the control cabin of a classification yard car retarder system, and will be connected with the braking apparatus by means of line wires extending from the control cabin to the braking apparatus.

The previously mentioned speed responsive apparatus for controlling relays 1P0, 2P0, 1P20—30, 2P20—30, 1P45—55 and 2P45—55 comprises a series of relatively short insulated control sections 1T, 2T, 3T, 4T, 5T and 6T, which control sections are formed in the rail 1. These control sections will usually be of uniform lengths, and their lengths may be varied as conditions require, but the lengths of these sections will preferably be such that two wheels of a car cannot occupy the same section at any one time. A preferred length for these sections is 3 ft. 1½ in.

Associated with each control section is a track relay designated by the reference character R with a prefix corresponding to the reference character for the associated section. These track relays are sensitive quick acting relays, and each relay is connected in a track circuit which, when all of the track relays are initially deenergized and a pair of wheels moves onto any one of the track sections T, includes a suitable source of current here shown as a battery **30**, a back contact **34** of a relay 2SU, a back contact **331** of a relay 1SU, a back contact **31** of each of the track relays in advance of the occupied section, the winding of the track relay of the occupied section T, the wheels and axle of the pair of wheels on the occupied section T, and the rail **1a**.

When a track relay picks up due to the energy supplied over any one of the track circuits just described, if the track relay is an even-numbered relay, relay 2SU will pick up by virtue of a circuit which I shall describe presently and will open its back contact **34**, and if the track relay is an odd-numbered relay, relay 1SU will pick up by virtue of a circuit which I shall also describe presently and will open its back contact **331**. However, when either back contact **34** of relay 2SU or back contact **331** of relay 1SU opens, the front contact **32** of the picked-up track relay will then be closed and will have completed a branch circuit in multiple with the contacts **331** and **34** in series, which branch circuit will maintain energy on the picked-up track relay as long as the pair of wheels which caused the track relay to pick up remain on the associated section. For example, if track relay 1TR picks up due to a pair of car wheels entering section 1T, relay 1SU will pick up and will open its front contact **331**, but track relay 1TR will be maintained in its energized condition after front contact **331** opens until the pair of wheels leaves section 1T, by virtue of a branch circuit including front contact **32** of track relay 1TR.

When any one of the track relays is energized, and a pair of wheels W enters any section in rear of the section for the energized relay, the track circuit for such rear section will be held open at the back contact **31** of the picked-up track relay, and the track relay for such rear section will remain deenergized.

When a track relay is energized, and the pair of wheels which caused it to become energized enters the section next in advance, the front contact **32** of the energized track relay will remain closed long enough to complete a track circuit for the advance relay which track circuit will be similar to the circuit described above except that this circuit will include the front contact **32** of the picked-up relay in place of the back contact **34** of relay 2SU and the back contact **331** of relay 1SU in series. The reason why a track relay remains energized until the relay next in advance picks up when the pair of wheels which caused the relay to become energized passes from the associated section to the section next in advance is that the wheels will always engage the advance section for a brief interval of time before they will break contact with the rear section.

It will be seen, therefore, that when no car is traversing the track circuited territory through the retarder, the track relays T will all be deenergized. When, however, a car traverses the track circuited territory, as the forward pair of wheels enters each track section, the track relay for such section will pick up, and the track relay for the section next in rear will release. As soon as the forward pair of wheels passes out of section **6T**, relay **6TR** will release and will cause relay 1SU or **2SU** to release. As soon as these relays are both released, the track circuit for each relay whose associated section is then occupied by a pair of wheels will become completed at the back contacts **331** and **34** of these relays. However, only the track relay for the section which is then occupied by the leading pair of wheels in the track circuited territory will complete its pick-up stroke since the opening of the back contact of this relay will interrupt the track circuits for all of the relays in the rear.

The speed responsive apparatus also comprises means for measuring the time during which any of the track relays is energized to thereby provide a measurement of the speed of the car.

In the particular form illustrated, this time measuring means comprises a suitable source of constant frequency alternating current, illustrated in the drawing as an alternator A, and means for counting the cycles of this source. In actual practice, the source of alternating current will generally comprise the usual commercial power source.

The means for counting the cycles of alternating current includes two half-step relays PX and NX of the quick acting two winding polar magnetic stick type and two oppositely poled half wave rectifiers **334** and **35**. The one winding **37a** of relay PX is connected with alternator A over a front contact **36** of a relay W, the rectifier **334** and a normal contact **38** of relay NX, while the other winding **37b** of relay PX is connected with the alternator A over front contact **36** of relay W, rectifier **334**, and reverse contact **39** of relay NX. In a similar manner, the winding **37a** of relay NX is connected with alternator A over front contact **36** of relay W, rectifier **35**, and a normal contact **40** of relay PX, while the other winding **37b** of relay NX is connected with alternator A over front contact **36** of relay W, rectifier **35** and reverse contact **41** of relay PX. The rectifier **334** is poled to pass current during positive half cycles only, while the rectifier **35** is poled to permit current to flow during negative half cycles only.

With the relays PX and NX connected with alternator A in the manner just described, it will be apparent that when front contact **36** of relay W is open, both relays PX and NX will be deenergized. When, however, front contact **36** of relay W becomes closed, during the first half cycle of current which flows from alternator A winding **37a** of relay PX or winding **37a** of relay NX will become energized depending upon whether the half cycle is a positive or a negative half cycle. Assuming for purposes of illustration that the first half cycle is positive, the resultant energization of winding **37a** of relay PX will cause this relay to open its normal contact **40** and close its reverse contact **41**. The closing of contact **41** will complete the circuit for winding **37b** of relay NX, and as a result, the first negative half cycle will cause winding **37b** of relay NX to become energized, whereupon this relay will open its normal contact **38** and will close its reverse contact **39**. The closing of reverse contact **39** will complete the circuit for winding **37b** of relay PX, and during the next positive half cycle winding 37*b* of relay PX will become energized and will cause reverse contact 41 of relay PX to open and normal contact 40 to close. Contact 40 now being closed, the next negative half cycle will energize winding 37*a* of relay NX, with the result that reverse contact 39 will open and normal contact 38 will close. The above described cycle of operation will then start to repeat itself, and the relays PX and NX will continue to alternately close their normal and reverse contacts as long as the contact 36 remains closed.

The relay W is controlled by the track relays R in such manner that this relay will be energized whenever any one of these track relays is energized, by virtue of circuits which I shall describe shortly.

The relay NX is provided, in addition to the previously mentioned normal and reverse contacts 38 and 39, with a normal contact 42—42*a* and a reverse contact 42—42*b*. Assuming for purposes of illustration that the alternator A has a frequency of 60 cycles, it will be apparent that when the relay NX is operating, these contacts will become alternately closed at intervals of 1/60 of a second or 16⅔ milliseconds. This rate will vary only to the extent that the frequency of the alternator A varies, which variation will be extremely small, particularly if the alternator A comprises a commercial source of power.

The cycle counting means also comprises a unit chain of counting relays 1U to 6U arranged to pick up successively in response to the alternate operation of the contacts 42—42*a* and 42—42*b* of relay NX, and a multiple chain of counting relays 0M to 5M arranged to advance progressively one each time the unit chain completes a round trip of operation. The relays of both chains are of the quick acting neutral type.

Associated with the unit and multiple counting chains is a relay MX of the two winding polar magnetic stick type which serves to make the selection of the circuits for the relays of the multiple group necessary to cause them to pick up in succession in response to each round trip of operation of the unit chain, and a similar relay UX, the function of which will be made clear presently.

The operation of the timing means as a whole is as follows: When the track relays T are all deenergized, as is the case when no car is traversing the stretch of track shown in the drawing, the relays of both timing chains, and the associated relays W, 1SU, 2SU, NX, PX, MX and UX are all deenergized. When a car starts to traverse the stretch of track shown in the drawing, relay 1TR will pick up first for reasons which will be apparent from the foregoing description, and the picking up of this relay will complete a circuit for relays W, 1SU, 1U and the winding 48 of relay UX in series, which circuit may be traced from the terminal B of a suitable source of direct current not shown in the drawings, through the winding of relay W, a back contact 33—33*b* of each of the track relays 6TR, 5TR, 4TR, 3TR and 2TR, front contact 33—33*a* of track relay 1TR, the winding of relay 1SU, a back contact 44 of each of the relays 2U to 6U, inclusive, of the unit counting chain, a back contact 45 of each of the relays 0M to 5M of the multiple counting chain, winding 48 of relay UX, wires 46 and 47, and the winding of relay 1U to the other terminal C of the source. Relays W, 1SU and 1U will therefore pick up immediately, and relay UX will reverse its armature to open its normal contacts and close its reverse contacts.

The picking up of relays 1U and 1SU completes a stick or holding circuit for these relays passing from terminal B through the winding of relay W, a back contact 33—33*b* of each of the track relays 6TR, 5TR, 4TR, 3TR and 2TR, front contact 33—33*a* of track relay 1TR, the winding of relay 1SU, front contact 49 of relay 1SU, wires 50 and 51, back contact 52 of relay 2U, front contact 53 of relay 1U, and the winding of relay 1U to terminal C. The function of these stick circuits will be made clear presently.

The picking up of relay W completes at its front contact 36 the previously described operating circuits for the relays PX and NX, and these relays therefore start to alternately operate on alternate half cycles of the alternator A in the manner described hereinbefore.

Since relays W and 1U are both picked up when the relays NX and PX start to operate, the first time reverse contact 42—42*b* of relay NX becomes closed, it completes a pick-up circuit for relay 2U passing from terminal B through front contact 43 of relay W, reverse contact 42—42*b* of relay NX, wire 55, front contact 54 of relay 1U, and the winding of relay 2U to terminal C. Relay 2U therefore picks up and interrupts at its back contacts 44 and 52, respectively, the previously described pick-up and stick circuits for relay 1U, and completes at its front contact 53 a stick or holding circuit which is similar to the previously traced stick circuit for relays 1SU and 1U with the exception that this latter circuit includes a back contact 52 of relay 3U, front contact 53 of relay 2U and the winding of relay 2U in place of a back contact 52 of relay 2U, front contact 53 of relay 1U, and the winding of relay 1U. Relay 1U, therefore, now becomes deenergized, while relay 2U remains energized as long as relay 3U remains deenergized.

When normal contact 42—42*a* of relay NX again closes, it completes a pick-up circuit for relay 3U which is similar to the corresponding pick-up circuit just traced for relay 2U, and which will therefore be apparent from an inspection of the drawing. Relay 3U therefore picks up and interrupts both the pick-up and stick circuits for relay 2U which causes relay 2U to release. The picking up of relay 3U also completes a pickup or holding circuit for this relay similar to the previously traced pick-up or holding circuit for relays 1U and 2U.

When relay NX next closes its reverse contact, relay 4U will pick up and relay 3U will release, and when relay NX next closes its normal contact, relay 5U will pick up and relay 4U will release and so on, until a complete cycle of operation of the unit chain is completed. When this happens, if section 1T is then still occupied, relay 1U will again pick up by virtue of circuit connections between the 6U and 1U relays similar to those between any two succeeding relays of the chain, and will start the operation of the chain over again. It will be seen, therefore, that the relays 1U to 6U will continue to climb around and around as long as track relay 1TR remains energized. It will also be apparent that if the frequency of the alternator A is 60 cycles, so that the contacts 42—42*a* and 42—42*b* become alternately closed at intervals of 16⅔ milliseconds, the time spacing between the picking up of successive relays U will be 16⅔ milliseconds, and the chain will complete a round trip of operation in exactly 100 milliseconds.

The front contact 49 of relay 1SU, in addition to being included in the previously described stick circuits for the relays 1U to 6U, is also included in a pick-up circuit for the starting relay OM of the multiple chain, which latter circuit may be traced from battery B through the winding of relay W, back contact 33—33b of each of the track relays 6TR, 5TR, 4TR, 3TR and 2TR, front contact 33—33a of track relay 1TR, the winding of relay 1SU, front contact 49 of relay 1SU, wire 50, a back contact 60 of each of the relays 5M, 4M, 3M, 2M and 1M of the multiple chain, and the winding of relay OM to terminal C. It will be seen, therefore, that as soon as relay 1SU becomes energized following the energization of track relay 1TR, relay OM of the multiple chain will pick up.

With relay OM picked up, when relay 3U picks up during the first round trip of operation of the unit chain, it will complete at its front contact 64 a circuit for the one winding 65 of the transfer relay MX, and this relay will thereupon open its normal contact 66—66a and will close its reverse contact 66—66b. This circuit includes in addition to front contact 64 of relay 3U, front contact 63 of relay OM, as will be obvious from an inspection of the drawings. The circuit will become opened as soon as relay 3U releases, but since relay MX is of the magnetic stick type, contact 66—66b will remain closed until this relay is again energized in the direction to close its normal contact.

As a result, when relay 6U of the unit chain picks up during the first round trip of operation, a pick-up circuit is completed for relay 1M passing from terminal B through front contact 43 of relay W, front contact 67 of relay 6U, reverse contact 66—66b of relay MX, front contact 62 of relay OM, and the winding of relay 1M to terminal C. Relay 1M thereupon picks up, and completes a stick circuit passing from terminal B through the winding of relay W, back contact 33—33b of each of the track relays 6TR, 5TR, 4TR, 3TR and 2TR, front contact 33—33a of track relay 1TR, the winding of relay 1SU, front contact 49 of relay 1SU, wire 50, a back contact 60 of each of the relays 5M, 4M, 3M and 2M, a front contact 61 of relay 1M and the winding of relay 1M to terminal C. This stick circuit serves to retain relay 1M energized after relay 6U releases as will be obvious.

The picking up of relay 1M in addition to completing its own stick circuit also interrupts at its back contact 60 the pick-up circuit for relay OM, and this latter relay therefore releases.

When relay 3U picks up during the second round trip of operation of the unit chain, the resultant closing of contact 64 completes a circuit for the other winding 68 of relay MX including front contact 63 of relay 1M, and relay MX then opens its reverse contact 66—66b and closes its normal contact 66—66a.

With normal contact 66—66a of relay MX closed, when relay 6U of the unit chain picks up during the second round trip of operation of this chain, the resultant closing of its front contact 67 completes a pick-up circuit for relay 2M including front contact 62 of relay 1M. This latter circuit will be apparent from an inspection of the drawing without further detailed description. Relay 2M thereupon picks up and interrupts the previously traced stick circuit for relay 1M and completes a stick circuit for itself similar to the previously traced stick circuit for relay 1M.

On the third round trip of the unit chain since front contact 63 of relay 2M is now closed, the resulting closing of front contact 64 of relay 3U will complete another circuit for winding 65 of relay MX which will cause this relay to again open its normal contact 66—66a and close its reverse contact 66—66b, and when relay 6U picks up, the closing of its front contact 67 will complete a pick-up circuit for relay 3M. Relay 3M will thereupon pick up and relay 2M will release.

In a similar manner if track section 1T remains occupied long enough on the fourth and fifth round trips of the unit chain, relays 4M and 5M will pick up and relays 3M and 4M will release.

It will be seen, therefore, that each time the unit chain progresses to and including the 6U relay, the multiple chain will advance its action by one relay. Accordingly, assuming that the frequency of the alternator A is 60 cycles so that the unit chain completes a round trip of operation each 100 milliseconds, the picking up of each progressive relay of the multiple chain represents a period of 100 milliseconds. In the particular embodiment of my invention shown provision is made for counting up to 500 milliseconds by the picking up of the M relays, after which, of course, another 100 milliseconds may be counted by permitting another round trip of the unit chain, making a total of 600 milliseconds with the circuits as shown.

It will also be seen that the relay MX merely serves to make the necessary circuit selection of the M group of relays so that each pick-up action of the 6U relay of the unit chain will advance the multiple group of relays by one relay.

The function of the hereinbefore referred to stick circuit for relay 1U, and of the stick circuits for each of the other U relays of the unit chain is to maintain these relays energized during the interval of time which elapses between the opening, at contact 42—42a or 42—42b of relay NX, of the pick-up circuit for the relay whose stick circuit is then closed and the picking up of the relay next in advance in the chain.

The stick circuits for the relays of the multiple chain similarly serve to maintain the M relay which last became energized in its energized condition during the interval which elapses between the opening of its pick-up circuit at contact 66—66a or 66—66b of relay MX, and the picking up of the relay next in advance. In other words, the stick circuits for both chains function to keep the chains in operation as long as the track relay which started the operation remains energized.

When the car which caused track relay 1TR to pick up advances to the point where relay 2TR picks up, the resultant opening of back contact 33—33b of track relay 2TR interrupts any of the stick circuits which then happens to be closed for any of the relays of either the unit and multiple chains, and relays W and 1SU therefore immediately become deenergized. As soon as relay W becomes deenergized, it opens the pick-up circuits for each of the relays of both chains, and since the pick-up and stick circuits for the relays of both chains are then all open, these relays all become deenergized. The deenergization of relay W also momentarily stops the operation of the PX and NX relays.

As soon as the back contacts of all of the U relays and the back contacts of all of the M relays all become closed, thereby checking that these relays are all deenergized, a pick-up circuit for relay 1U is completed at front contact 33—33a of track relay 2TR and current flows from battery B through the winding of relay W, a back contact 33—33b of each of the track relays 6TR, 5TR, 4TR and 3TR, front contact 33—33a of track relay 2TR, the winding of relay 2SU, back contact 70 of each of the relays 2U to 6U, inclusive, a back contact 71 of each of the relays OM to 5M, inclusive, the winding 72 of relay UX, wire 46, and the winding of relay 1U to terminal C. Since relays 1SU and W are both included in this circuit, these relays and relay 1U all pick up. Furthermore, since the winding 72 of relay UX is included in this circuit, this relay reverses its armature, thereby opening its normal contacts and closing its reverse contacts.

When relay 2SU picks up, it completes a stick circut for relay 1U, and a pick-up circuit for relay OM which circuits are similar to the circuits which were completed by relay 1SU following the picking up of track relay 1TR with the exception that these latter circuits each include a front contact 33—33a of track relay 2TR, the winding of relay 2SU, and front contact 73 of relay 2SU in place of front contact 33—33a of track relay 1TR, the winding of relay 1SU, and front contact 49 of relay 1SU.

When relay W picks up, it sets the counting chains into operation, and these chains then function to measure the time required for the pair of wheels of the car to traverse section 2TR in the same manner as these chains functioned to measure the time for the forward pair of wheels of the car to traverse section 1T. The circuits for the various relays of the two counting chains will all be similar to those previously described except for the fact that each stick circuit will now include front contact 33—33a of track relay 2TR, the winding of relay 2SU and front contact 73 of relay 2SU in place of front contact 33—33a of track relay 1TR, the winding of relay 1SU and front contact 49 of relay 1SU.

When track relays 3TR and 5TR subsequently pick up, the relay 1SU will be picked up and the apparatus will function in the same manner as when relay 1TR was picked up. Similarly, when the relays 4TR and 6TR pick up the apparatus will function in the same manner as when relay 2TR is picked up. It will be seen, therefore, that as a car advances through the track circuited territory, the relays 1SU and 2SU alternate in their action depending upon whether an odd or an even-numbered track relay is then picked up. Each SU relay checks that all relays of both counting chains have become deenergized before it can pick up after which the 1U relay of the unit chain picks up for the beginning of a new timing period.

The back contacts 331 and 34 of the 1SU and 2SU relays are included in the pick-up circuits for the track relays for check purposes. As long as the track relays become successively energized, the multiple front contacts of the track relays by-pass the back contacts of the SU relays and accordingly freely permit the relay next in advance to pick up. After the leading car axle leaves section 6T, it will be apparent that the relay 6TR will have to release before any of the other track relays in the rear can pick up. Accordingly, all other multiple front contacts of the track relays are then opened, and it is then necessary that both SU relays be released in order that their back contacts 331 and 34 may close and permit another track relay in rear of track relay 6TR to pick up. This check is provided in order to prevent the counting relays from doubling back to another section without first having been reset to the starting point.

The function of the W relay is to provide the necessary separate contacts for supplying operating energy to the NX and PX relays and to the counting chain during the energized periods of the track circuits.

It should be pointed out that while I prefer to provide a source of alternating current controlling the energization of the half-step relays PX and NX to effect the energization of the successive relays of the timing chains, the alternating current source and associated half-step relays may be replaced by any suitable motor means which will alternately close the contacts 42—42a and 42—42b at a known fixed rate.

It will be obvious that the particular relays of the unit and multiple chains which are picked up at any one time are a measure of the time that any section which is then functioning as a measuring section has been occupied. It will also be obvious that since the sections have a known fixed length, the speed of a car passing through the car retarder can be determined from the time during which a section is occupied by a pair of wheels. It follows, therefore, that the relays of the counting chains which are picked up when a pair of wheels vacates a section which is then functioning as a measuring section serve as a measure of the average car speed while the car is traversing a length equal to the lengths of the measuring sections. For example, assuming that the track sections T are all 3 ft. 1½ in. long, and that the alternator A has a frequency of 60 cycles per second, if a track section remains occupied for 266 milliseconds, which is the time it will remain occupied with an average car speed of 8 miles per hour, when the section becomes vacated, relays 2M and 4U will be picked up, and it follows that if these relays are picked up when a measuring section becomes vacated, it is an indication that the car which caused them to pick up was traveling at an average speed of 8 miles per hour. Similarly, if a track section which is serving as a measuring section is occupied for 600 milliseconds, which corresponds to a car speed of 3.1 miles per hour, relays 6U and 5M will be picked up to indicate that the car speed is 3.1 miles per hour. The car speeds corresponding to various relay combinations are shown in tabular form in Fig. 3, and by reference to this table the car speed for any particular relay combination can be determined.

The previously referred to relays 1P45—55, 1P20—30 and 1PO constitute one group of relays, and the previously referred to relays 2P45—55, 2P20—30 and 2PO constitute another group of relays, for so controlling the valves V1 and V2 as to effect an automatic stepped reduction in the pressure of the fluid supplied to the motor M as the speed of a car passing through the car retarder approaches a predetermined control speed which depends upon the setting of lever L, and for effecting the full release of the retarder when this particular control speed is reached. These two groups of relays are caused to function alternately, according as an odd or an even-numbered track section is acting as a speed measuring section, by means of the UX relay which it will be remembered closes its normal contacts 56—56a, 57—57a, 58—58a and 59—59a or its reverse contacts 56—56b, 57—57b, 58—58b and 59—59b according as an odd-numbered track relay 1TR, 3TR or 5TR, or an even-numbered track relay 2TR, 4TR or 6TR is picked up, and each P relay is provided with a plurality of control circuits controlled by different contact combinations of the relays of the unit and multiple counting chains.

In the particular form of my invention illustrated in the drawings, each P relay is provided with a different control circuit for each of the *p1*, *p2* and *p3* positions of the lever L, making three control circuits for each relay. The control circuits for the 1P and 2P relays are similar except for the fact that each control circuit for each of the 1P relays includes a normal contact of the UX relay, whereas each control circuit for each of the 2P relays includes a corresponding reverse contact of the UX relay. These control circuits may be varied as conditions require, but as shown in the drawing they are so arranged that when lever L occupies its *p1* position, which position I shall term for convenience its high speed position, relay 1P45—55 or 2P45—55 will pick up when relays 1M and 5U are simultaneously picked up, the relay 1P25—30 or 2P25—30 will pick up when the relays 2M and 2U are simultaneously picked up, and the relay 1P0 or 2P0 will pick up when the relays 3M and 1U are simultaneously picked up. When, however, lever L occupies its *p2* position, which I shall term its medium speed position, relay 1P45—55 or 2P45—55 will pick up when relays 2M and 1U are simultaneously picked up, relay 1P20—30 or 2P20—30 will pick up when relay 3M is picked up and relay 1P0 or 2P0 will pick up when relay 4M is picked up. Similarly, when lever L occupies its *p3* position, which I shall term its low speed position, relay 1P45—55 or 2P45—55 will pick up when relays 2M and 4U are both picked up, relay 1P20—30 or 2P20—30 will pick up when relays 3M and 4U are simultaneously picked up, and relay 1P0 or 2P0 will pick up when relays 5M and 2U are simultaneously picked up.

By virtue of circuits which will be described in detail hereinafter, when lever L is first moved to its *p1*, *p2* or *p3* position, the fluid pressure motor M will be supplied with fluid at full line pressure, which I shall assume for purposes of explanation to be 100 pounds per square inch. If the relay 1P45—55 or 2P45—55 subsequently picks up, the pressure in motor M will be automatically reduced to a pressure of between 45 and 55 pounds per square inch, if relay 1P20—30 or 2P20—30 picks up, the pressure in motor M will be automatically reduced to a pressure of between 20 and 30 pounds per square inch, and if the relay 1P0 or 2P0 picks up, motor M will be vented to atmosphere to effect the automatic release of the car retarder.

The *p0* position of lever L is its "off" position and is the position to which the lever is moved when it is desired to manually release the retarder.

The *p4* position of lever L is provided to obtain the full braking force available irrespective of the speed of a car which is being retarded, and when the lever occupies this position, the speed control apparatus is ineffective to control the retarder as will appear presently.

Associated with the relays 1P45—55, 1P20—30 and 1P0 is a stick relay 1SP which is picked up whenever any one of these pressure control relays is picked up, and associated with the pressure control relays 2P45—55, 2P20—30 and 2P0 is a stick relay 2SP which is picked up whenever any one of these last mentioned speed control relays is picked up.

Since a time element is involved from the time a pair of car wheels enters a track circuit which is then functioning as a measuring section until a speed determination can be made, it is necessary that any pressure control that is obtained by the picking up of any one of the P relays in response to an immediately preceding speed determination be maintained for a sufficient length of time to overlap the interval required to make the new speed measurement. Thus, once a given pressure control has been obtained by means of one of the P relays, it should be maintained as long as successive speed measurements indicate the need for that particular pressure. It is for the purpose of obtaining this overlap action that the two groups of pressure control relays are provided, and this overlap is obtained by the use of energy stored in a condenser which is shunted around each pressure control relay P in series with one or more resistances, and which renders the relay slow releasing. A condenser is used because it guarantees a definite time element in a shorter space of time than is possible with schemes utilizing the saturation of the relay to obtain the time element.

The stick relays 1SP and 2SP are provided to prevent the pressure control relays from starting their timing period at the time of their pickup instead of waiting until the track section the occupancy of which caused them to pick up is vacated. Thus the SP relays on each successive speed measurement will maintain energy on any pressure control relay which is then energized until such time as the next track circuit becomes operated, in which event the reversing of the UX relay will release the SP relay which was previously energized and will thereby permit the condenser associated with the energized pressure control relay to function to delay the release of the pressure control relay until a new speed measurement is completed.

Due to the fact that conditions change from time to time in a car retarder yard due, for example, to weather changes, seasonal difference in the lading of the cars, etc., it is desirable to be able to readily vary the car speeds at which the P relays function, and to this end, I permanently connect each of the contacts of the timing relays of the unit and multiple chains which are provided for controlling the P relays to a different pair of terminal posts mounted on a terminal board TB (Fig. 1*b*). This terminal board is also provided with a plurality of terminal posts 81, 82 and 83 which are permanently connected to a wire 90 leading to contact 26 of lever L, with a plurality of terminal posts 84, 85 and 86 which are permanently connected to a wire 91 leading to contact 27 of lever L, and with a plurality of terminal posts 87, 88 and 89 which are permanently connected to a wire 92 leading to contact 29 of lever L. This terminal board is further provided with a plurality of terminal posts 93, 94 and 95 which are permanently connected to a wire 102 leading to the movable contact finger 57 of relay UX, with a plurality of terminal posts 96, 97 and 98 which are permanently connected to a wire 103 leading to the movable finger 58 of relay UX, and with a plurality of terminal posts 99, 100 and 101 which are permanently connected to a wire 104 leading to the movable finger 59 of relay UX.

With the terminal board B arranged in this manner, when it is desired to effect the operation of one of the P relays at any particular car speed for a particular lever setting, reference is first made to the chart shown in Fig. 3 to determine which combination of contacts of the unit and multiple groups come closest to the desired speed, and the contacts of this combination are then connected in series by means of jumpers, between one of the terminal posts which is permanently connected to the lever contact which is closed for the particular lever setting, and one of the terminal posts which is permanently connected to the wire 102, 103 or 104 leading to the contact of the UX relay which is included in the particular control circuit for the desired P relay. For example, if it is desired to cause the 1P0 and 2P0 relays to operate at a speed of 4 miles per hour when lever L occupies its *p3* or low speed position, it is necessary to connect a contact of the 5M relay and a contact of the 2U relay in the circuit for these relays, and this is accomplished by connecting a jumper 105 from the terminal post 89 to the one terminal post which is connected with front contact 77 of relay 2U, a jumper 106 from the other terminal post which is permanently connected with front contact 77 of relay 2U to the one terminal post which is permanently connected with the contact 80 of relay 5M, and a jumper 107 from the other terminal post which is permanently connected with the terminal post 80 of relay 2U to terminal post 101. In actual practice the relay contact which is connected to each terminal post will be indicated by suitable marking means associated with the terminal post and the other terminal posts which are not connected with relay contacts will be properly identified by suitable markings to indicate the proper circuit with which they are associated.

As shown in the drawings, all parts occupy the positions which they normally occupy when no car is passing through the retarder, that is to say, all relays are deenergized, lever L occupies its *p0* or off position, and valve V2 is deenergized. Valve V1, however, is energized over a circuit which may be traced from terminal B of the source through contact 25 of lever L, line wire 115, wires 116, 117 and 118, and the winding of valve V1 to terminal C. As was pointed out hereinbefore, when valve V2 is deenergized and valve V1 is energized, cylinder 4 of motor M is disconnected from the source of fluid pressure and is connected with atmosphere, and the braking bars are held in their ineffective or non-braking positions by the spring 10. The contact 22—22*a* of each of the pressure responsive devices P is closed, and the contact 22—22*b* of each of these devices is open.

In explaining the operation of the apparatus as a whole, I shall assume that a car which is to be retarded is approaching the retarder, and the operator wishing to cause the car to leave the retarder at the highest speed for which the apparatus is designed moves lever L from its *p0* or off position to its *p1* or high speed position. The movement of the lever L from its *p0* to its *p1* position will interrupt at its contact 25 the circuit which was previously closed for valve V1, and will complete at its contact 29 a circuit for valve V2 which may be traced from battery B through contact 29 of lever L, wire 109, back contact 110—110*a* of relay 1P0, back contact 110—110*a* of relay 2P0, back contact 110—110*a* of relay 1P20—30, back contact 110—110*a* of relay 2P20—30, back contact 110—110*a* of relay 1P45—55, back contact 110—110*a* of relay 2P45—55, wires 111, 112 and 113, and the winding of valve V2 to terminal C. Valve V1 will therefore become deenergized and will disconnect cylinder 4 of motor M from atmosphere, and valve V2 will become energized and will connect cylinder 4 with pipe 11, thereby admitting fluid to cylinder 4 at full line pressure. The braking bars will therefore immediately move from their ineffective or non-braking positions to their effective or braking positions.

When the first axle of the car enters track section 1T, track relay 1TR will pick up and will cause the W, 1SU and 1U relays to immediately pick up. The picking up of track relay 1TR will also cause the winding 48 of relay UX to become energized, but since the normal contacts of this relay are already closed, the energization of this relay will not cause any operation of the relay contacts. The picking up of the W relay immediately starts the operation of the half-step relays PX and NX, and since relay 1SU is then energized, the counting chain starts to function to measure the speed of the car. If the speed of the car is sufficiently slow to cause the 1M and 5U relays to pick up, a circuit will become closed for pressure control relay 1P45—55 and stick relay 1SP passing from terminal B through contact 26 of lever L, wire 90, terminal post 81, jumper 119, front contact 75 of relay 5U, jumper 120, front contact 78 of relay 1M, jumper 121, terminal post 93, wire 102, normal contact 57—57*a* of relay UX, wire 121, resistor 122, the winding of relay 1P45—55, wire 146, and the winding of relay 1SP to terminal C. This circuit includes a resistor 124 and a condenser 125 in series connected in multiple with the resistor 122 and the winding of relay 1P45—55 in series. Relay 1P45—55 and stick relay 1SP will therefore pickup and will complete a stick circuit passing from terminal B of the source through front contact 127 of relay 1SU, wire 128, normal contact 56—56*a* of relay UX, wire 129, back contact 130 of relay 1SP, wire 131, back contact 132—132*a* of relay 1P0, wire 133, back contact 134—134*a* of relay 1P20—30, wire 135, front contact 136 of relay 1P45—55, the resistor 122, the winding of relay 1P45—55, wire 146, and the winding of relay 1SP to terminal C. This stick circuit also includes the condenser 125 and resistor 124 referred to hereinbefore. It should be noted that since this stick circuit includes front contact 127 of relay 1SU, back contact 134—134*a* of relay 1P20—30 and back contact 132—132*a* of relay 1P0, when relay 1P45—55 becomes energized under the conditions just described, it will subsequently remain energized until relay 1P20—30 or relay 1P0 picks up or section 1T becomes vacated even though the relays 5U and 1M of the counting chain which caused it to become energized subsequently release.

The picking up of relay 1P45—55 interrupts at its back contact 110—110*a* the circuit which was previously closed for valve V2 and completes at its front contact 110—110*b* a circuit for valve V1 passing from battery B through contact 29 of lever L, wire 109, back contact 110—110*a* of relay 1P0, back contact 110—110*a* of relay 2P0, back contact 110—110*a* of relay 1P20—30, back contact 110—110*a* of relay 2P20—30, front contact 110—110*b* of relay 1P45—55, wire 140, contact 22—22*b* of pressure responsive device P45—55, wires 117 and 118, and the winding of valve V1 to terminal C. Valve V2 therefore becomes deenergized and disconnects motor M from the source of fluid pressure, and valve V1 becomes energized and vents motor M to atmosphere. Valve V1 will continue to vent motor M to atmosphere until the pressure in the cylinder 4 decreases to 55 pounds per square inch, at which time contact 22—22b of pressure responsive device P45—55 will open and will deenergize valve V1. If the pressure in the cylinder 4 decreases below 45 pounds per square inch, the resultant closing of contact 22—22b of pressure responsive device P45—55 will complete another circuit for valve V2, and current will flow from battery B through contact 29 of lever L, line wire 109, back contact 110—110a of relay 1P0, back contact 110—110a of relay 2P0, back contact 110—110a of relay 1P20—30, back contact 110—110a of relay 2P20—30, front contact 110—110b of relay 1P45—55, wire 140, contact 22—22a of pressure responsive device P45—55, wires 112 and 113, and the winding of valve V2 to terminal C. Valve V2 will therefore become energized and will connect motor M with the source of fluid pressure until the pressure increases to 45 pounds per square inch at which time contact 22—22b of pressure responsive device P45—55 will open and will deenergize valve V2. It will be seen, therefore, that when relay 1P45—55 becomes energized, the fluid in the cylinder 4 of motor M will be reduced to a pressure of between 45 and 55 pounds per square inch, and will be subsequently maintained at this pressure as long as relay 1P45—55 remains energized.

If the speed of the car is sufficiently slow while the leading pair of wheels is traversing section 1TR to cause relays 2M and 2U of the multiple and unit counting chains to both become picked up, a circuit will then be completed for relay 1P20—30 passing from terminal B of the source through contact 26 of lever L, wire 90, terminal post 82, jumper 141, front contact 75 of relay 2U, jumper 142, front contact 79 of relay 2M, jumper 143, terminal post 96, wire 103, normal contact 58—58a of relay UX, wire 144, resistor 147, the winding of relay 1P20—30, wires 145, 156 and 146, and the winding of relay 1SP to terminal C. This latter circuit also includes a condenser 148 and a resistor 149 in series connected in multiple with the resistor 147 and the winding of the relay 1P20—30 in series. Relay 1P20—30 will therefore pick up, and relay 1SP will remain picked up. When relay 1P20—30 picks up, it completes a stick circuit passing from terminal B through front contact 127 of relay 1SU, wire 128, normal contact 56—56a of relay UX, wire 129, front contact 130 of relay 1SP, wire 131, back contact 132—132a of relay 1PO, wire 133, front contact 134—134b of relay 1P20—30, resistor 147, the winding of relay 1P20—30, wires 145, 156 and 146, and the winding of relay 1SP to terminal C. This stick circuit includes the condenser 148 and resistor 147 referred to hereinbefore. This stick circuit for relay 1P20—30 will maintain this latter relay energized until relay 1SU releases or relay 1P0 picks up.

The picking up of relay 1P20—30 interrupts at its back contact 110—110a any circuit which was previously closed for either valve V2 or valve V1, and completes at its front contact 110—110b another circuit for valve V1 passing from terminal B through contact 29 of lever L, line wire 109, back contact 110—110a of relay 1P0, back contact 110—110a of relay 2P0, front contact 110—110b of relay 1P20—30, wire 149, contact 22—22b of pressure responsive device P20—30, wire 113, and the winding of valve V1 to terminal C. Valve V2 if it is not already deenergized when this circuit becomes closed will become deenergized, and valve V1 will become energized to thereby again vent fluid from motor M. When the pressure of the fluid in cylinder 4 of motor M decreases to 30 pounds per square inch, contact 22—22b of pressure responsive device P20—30 will open and will deenergize valve V1, and if the pressure in the cylinder of motor M decreases to 20 pounds per square inch, contact 22—22a of pressure responsive device P20—30 will close and will complete another circuit for valve V2 which is similar to the circuit just traced for valve V1 with the exception that this latter circuit includes contact 22—22a of pressure responsive device P20—30, wire 113, and the winding of valve V2 in place of contact 22—22b of pressure responsive device P20—30, wire 118 and the winding of valve V1. It will be seen, therefore, that when relay 1P20—30 becomes energized under the conditions just described the pressure responsive device P20—30 will function to reduce the pressure of the fluid in cylinder M to a pressure of between 20 and 30 pounds per square inch.

If the car which is traversing the stretch of track shown in the drawing has been slowed down by the car retarder sufficiently to permit relays 3M and 1U to pick up while the leading pair of wheels is traversing section 1TR, relay 1P0 will become energized by virtue of a circuit passing from terminal B of the source through contact 26 of lever L, wire 90, terminal post 83, jumper 150, front contact 77 of relay 1U, jumper 151, front contact 80 of relay 3M, jumper 152, terminal post 99, wire 104, normal contact 59—59a of relay UX, resistor 153, the winding of relay 1P0, wires 156 and 146, and the winding of relay 1SP to terminal C. This latter circuit includes a condenser 154 and a resistor 155 in series connected in multiple with the resistor 153 and the winding of relay 1P0 in series. Relay 1P0 will therefore pick up and since this pick-up circuit includes relay 1SP, relay 1SP will remain energized. When relay 1P0 becomes energized, it completes a stick circuit passing from terminal B through front contact 127 of relay 1SU, wire 128, normal contact 56—56a of relay UX, wire 129, front contact 130 of relay 1SP, wire 131, front contact 132—132b of relay 1P0, resistor 153, the winding of relay 1P0, wires 156 and 146, and the winding of relay 1SP to terminal C. This stick circuit also includes the condenser 154 and the resistor 155 which are included in the pick-up circuit for relay 1P0. This stick circuit will maintain relay 1P0 energized until the leading pair of wheels vacates track section 1TR.

The opening of back contact 110—110a of relay 1P0 interrupts all circuits which were previously closed for either valve V1 or valve V2, while the closing of front contact 110—110b of this relay completes a circuit for the valve V1 passing from terminal B through contact 29 of lever L, line wire 109, front contact 110—110b of relay 1P0, wires 116, 117 and 118, and the winding of relay V1 to terminal C. Valve V1 therefore becomes energized and vents the fluid in cylinder M to atmosphere to thereby effect the release of the retarder.

I shall now assume that with lever L in its *p1* position, the leading pair of wheels of a car pass out of section 1TR and into section 2TR while relay 1P45—55 is energized. When this happens relay 1SU will release and relay 2SU will pick up to initiate a new timing period in the manner previously described. When relay 1SU releases, it will interrupt at its front contact 127 the stick circuit which was previously closed for relay 1P45—55 and relays 1P45—55 and 1SP will therefore both become deenergized. Due, however, to the condenser 125 and resistor 124 associated with relay 1P45—55, this relay will not release for a sufficient interval of time to permit a new time measurement to be made.

The picking up of relay 2SU will cause relay UX to open its normal contacts and close its reverse contacts, and as soon as a new time measurement has been made, the relay 2P45—55 will pick up by virtue of a circuit which is similar to that previously traced for relay 1P45—55 with the exception that this latter circuit includes reverse contact 57—57b of relay UX and the winding of relay 2P45—55 together with the associated condenser 161 and associated resistors 161 and 162 in place of the contact 57—57a of relay UX and the winding of relay 1P45—55 together with the associated condenser 125 and resistors 124 and 122. As soon after relay 2P45—55 picks up as relay 1P45—55 releases, the relay 2P45—55 will become effective to control the valves V1 and V2 in the same manner that these valves were previously controlled by the relay 1P45—55.

If when lever L occupies its $p1$ position, the leading pair of wheels of a car which is being retarded passes from section 1TR to 2TR when either the pressure control relay 1P20—30 or 1PO is energized, the pressure control relay 2P20—30 or 2PO will subsequently be rendered effective to control the valves V1 and V2 as soon as a new measurement of speed can be made if the speed of the car has not changed until the new measurement is completed.

It will be apparent that a new speed measurement will be made each time the leading pair of wheels enters a new track section, and if the car speeds up between two speed measurements, when the next speed measurement is made, the pressure control relays will automatically function to increase the braking pressure. It is believed that this operation will be apparent from an inspection of the drawings without the necessity for describing it in detail.

When lever L is moved to its $p2$ position, the apparatus functions in the same manner as when it is moved to its $p1$ position with the exception that under these conditions the pressure control relays are provided with different control circuits to cause the pressure of the fluid supplied to motor M to be reduced in graduated steps as the speed of a car approaches the control speed corresponding to this lever position and the retarder to be automatically released when the speed of the car reaches this control speed. The control circuit for the 1P45—55 relay under these conditions passes from terminal B of the source through contact 27 of lever L, wire 91, terminal post 84, jumper 163, front contact 75 of relay 1U, jumper 164, front contact 78 of relay 2M, jumper 165, terminal post 94, wire 102, normal contact 57—57a of relay UX, wire 121, resistor 122, the winding of relay 1P45—55, wire 146, and the winding of relay 1SP to terminal C. This circuit includes the condenser 125 and the resistor 124. The circuit for the relay 2P45—55 is the same as that just traced for the relay 1P45—55 except for the differences which will be apparent from an inspection of the drawings and from the foregoing description.

The circuit for relay 1P20—30 when lever L occupies its $p3$ position passes from terminal B through front contact 27 of lever L, wire 91, terminal post 85, jumper 166, front contact 78 of relay 3M, jumper 167, terminal post 97, wire 103, normal contact 58—58a of relay UX, wire 144, resistor 147, the winding of relay 1P20—30, wires 145, 156 and 146, and the winding of relay 1SP to terminal C. This circuit includes the condenser 148 and resistor 149 as will be obvious.

The circuit for the relay 1PO when lever L occupies its $p2$ position passes from terminal B through contact 27 of lever L, wire 91, terminal post 86, jumper 168, front contact 80 of relay 4M, jumper 169, wire 104, normal contact 59—59a of relay UX, resistor 153 and the winding of relay 1PO in series in multiple with condenser 154 and resistor 155, wires 156 and 146, and the winding of relay 1SP to terminal C.

When lever L occupies its $p3$ position, the circuit for relay 1P45—55 passes from terminal B through contact 28 of lever L, wire 92, terminal post 87, jumper 173, front contact 76 of relay 2U, jumper 174, front contact 80 of relay 2M, jumper 175, terminal post 95, wire 102, normal contact 57—57a of relay UX, wire 121, resistor 122 and the winding of relay 1P45—55 in series in multiple with condenser 125 and resistor 124, wire 146, and the winding of relay 1SP to terminal B.

The circuit for relay 1P20—30 when lever L occupies its $p3$ position passes from terminal B of the source through contact 28 of lever L, wire 92, terminal post 88, jumper 170, front contact 77 of relay 4U, jumper 171, front contact 79 of relay 3M, wire 172, terminal post 98, wire 103, normal contact 58—58a of relay UX, wire 144, resistor 147 in series with the winding of relay 1P20—30 in multiple with condenser 148 and resistor 149 in series, wires 145, 156 and 146 and the winding of relay 1SP to terminal C.

The circuit for relay 1PO when lever L occupies its $p3$ position passes from battery B through contact 28 of lever L, wire 92, terminal post 89, jumper 105, front contact 77 of relay 2U, jumper 106, front contact 80 of relay 5M, jumper 107, terminal post 101, wire 104, normal contact 59—59a of relay UX, resistance 153 and the winding of relay 1PO connected in multiple with the condenser 154 and the resistor 155 in series, wire 156, and the winding of relay 1SP to terminal C.

The circuits for each of the relays 2P45—55, 2P20—30 and 2PO when lever L occupies its $p2$ and $p3$ positions differ from the circuits just traced for the relays 1P45—55, 1P20—30 and 1PO in the same manner that the circuits for the relays 2P45—55, 2P20—30 and 2PO differ from the circuits for the relays 1P45—55, 1P20—30 and 1PO when lever L occupies its $p1$ position, and will be apparent from an inspection of the drawing without further description.

If the operator moves lever L to its $p4$ position, the speed responsive apparatus is rendered ineffective to control the retarder and under these conditions the valve V2 becomes energized and remains energized by virtue of a circuit which passes from battery B through contact 29 of lever L, line wire 109, back contact 110—110a of relay 1PO, back contact 110—110a of relay 2PO, back contact 110—110a of relay 1P20—30, back contact 110—110a of relay 2P20—30, back contact 110—110a of relay 1P45—55, back contact 110—110a of relay 2P45—55, wires 111, 112 and 113, and the winding of valve V2 to terminal C. Since valve V2 remains energized under these conditions the braking bars are held in their braking positions by fluid at full line pressure, and the retarder is effective to exert its maximum braking force during the entire time the car is passing through the retarder.

It will be apparent from the foregoing that with railway braking apparatus constructed in the manner shown in Fig. 1 the operator by proper operation of the lever L may cause the braking bars to become automatically released when the speed of a car which is being retarded by the retarder decreases to any one of a plurality of selected speeds, which speeds may be varied as conditions require. It will also be apparent that when the speed of a car is being reduced by the retarder, the pressure of the fluid supplied to the fluid pressure motor of the retarder will be reduced in two stages prior to the actual release of the retarder, thereby providing a more effective control of the car retarder than would otherwise be possible. It should be particularly pointed out that the track circuit lengths as well as the alternating current frequency of the alternator A can be varied depending upon the condition obtaining and the accuracy desired. Ordinarily 60 cycle alternating current would be used since this is the usual commercial frequency available and one that can be accurately controlled in view of its general use for operating electric clocks. If desired an entirely independent source or any desired source of frequency may be used.

It will also be apparent that the counting chain combinations and the number of steps involved in each chain is merely a matter of choice depending upon the conditions to be served. If desired, in cases where longer timing is needed it would be feasible to introduce three groups of multipliers instead of restricting the apparatus to the two groups shown. For such an arrangement the second group would of course rotate in a manner similar to the first group, and the third group would then be used to total the number of revolutions made by the second group. This principle could be carried on as far as is necessary.

It should further be pointed out that the number of speeds that may be selected by the operator from the lever L is purely a matter of design. The attached drawings show a high, medium and low speed. This may be amplified to any desired number of speeds that may be needed. Furthermore, the number of pressure reductions is dependent only on the amount of the equipment which is provided. Moreover there is no necessary or essential relationship between the number of speed controls and the number of pressure reductions that may be provided.

Referring now to Fig. 2, the apparatus here illustrated is generally similar to that shown in Fig. 1. However, the apparatus shown in Fig. 2 includes certain additions that have been made to permit it to perform additional functions, and embodies certain circuit changes which permit a reduction in the number of relays required and the number of contacts which are necessary on other relays, as will be made clear.

As shown in Fig. 2, an additional pressure responsive device P70—80 is provided to provide an additional braking pressure. The device P70—80 is similar to the previously described devices P20—30 and P45—55 except for the fact that its contact 22—22*a* is adjusted to open at 70 pounds per square inch, and its contact 22—22*b* is adjusted to close at 80 pounds per square inch.

Furthermore, as shown in Fig. 2, a standard control lever L1 similar to the lever L has been provided to permit the car retarder CR to be manually controlled wholly independently of the speed responsive apparatus, together with a manually operable switch MS which functions to shift the control of the car retarder from one lever to the other.

As shown in the drawing, the switch MS occupies the position in which the lever L is effective to control the retarder, and in which its contacts 200—200*a* and 201—201*a* are closed, and its contacts 200—200*b* and 201—201*b* are open. When it is desired to control the retarder by means of the lever L1, this switch is reversed to open its contacts 200—200*a* and 201—201*a* and to close its contacts 200—200*b* and 201—201*b*.

The control of the car retarder by means of lever L1 is as follows. When this lever occupies its *p0* or "off" position in which it is shown in the drawings, all contacts of the lever with the exception of the contact 25 are open, and under these conditions valve V2 is deenergized and valve V1 is energized over a circuit which passes from terminal B through contact 201—201*b* of switch MS, contact 25 of lever L1, wire 202, wire 203, and the winding of valve V1 to terminal C. Since valve V2 is deenergized, pipe 17 is disconnected from pipe 16, and the supply of fluid pressure to cylinder 4 of motor M is therefore cut off, and since valve V1 is energized, cylinder 4 is connected with atmosphere. The braking bars are therefore held in their ineffective or non-braking positions by the spring 10. The contact 22—22*a* of each of the pressure responsive devices P is closed, and the contact 22—22*b* of each of these devices is open.

I shall now assume that the operator wishes to make a comparatively light brake application. To do this he moves lever L1 from its *p0* to its *p1* position, thereby opening contact 25 and closing contact 26. The opening of contact 25 interrups the circuit which was previously closed for valve V1 at this contact, and valve V1 therefore now becomes deenergized and disconnects pipe 18 from port 15. The closing of contact 26 completes a circuit for valve V2, and current flows from battery B through contact 201—201*b* of switch MS, contact 26 of lever L1, line wire 204, contact 22—22*a* of pressure responsive device P20—30, wire 205, and the winding 14 of valve V2 to terminal C. Valve V2 therefore becomes energized and connects pipe 17 with pipe 16, so that fluid at full line pressure is now supplied to cylinder 4, thus causing the braking bars to move to their effective or braking positions. As soon as the fluid in cylinder 4 reaches 20 pounds per square inch, contact 22—22*a* of pressure responsive device P20—30 will open and will interrupt the circuit just traced for valve V2. Valve V2 will then become deenergized and will cut off the supply of fluid to cylinder 4 of motor M until the pressure in the motor again decreases below 20 pounds per square inch at which time valve V2 will again become energized and will again admit fluid to the cylinder. If the fluid in the cylinder 4 of motor M increases to a pressure of 30 pounds per square inch for any reason, contact 22—22*b* of pressure responsive device P20—30 will become closed and will complete a circuit for valve V1 which passes from terminal B through contact 201—201*b* of switch MS, contact 26 of lever L1, line wire 204, contact 22—22*b* of pressure responsive device P20—30, an asymmetric unit 206 in its low resistance direction, and the winding 14 of valve V1 to terminal C. Valve V1 will therefore become energized and will vent fluid from cylinder 4 until the pressure again decreases to

30 pounds per square inch and permits contact 220—22b to be open. It will be seen, therefore, that when lever L1 occupies its p1 position, the braking bars will be held in their braking positions by a pressure of between 20 and 30 pounds per square inch.

If the operator desires to make a more powerful brake application, he will move lever L1 to its p2 position in which contact 27 is closed. Under these conditions, valve V1 will be deenergized and valve V2 will become energized over a circuit which passes from battery B through contact 201—201b of switch MS, contact 27 of lever L1, line wire 207, contact 22—22a of pressure responsive device P45—55, wire 205, and the winding 14 of valve V2 to terminal C. Fluid pressure will therefore now be admitted to cylinder 4 of motor M until the pressure of the fluid in the cylinder increases to 45 pounds per square inch, at which time control 22—22a of pressure responsive device P45—55 will open and will deenergize valve V2. If the pressure in cylinder 4 now increases to 55 pounds per square inch, contact 22—22b of pressure responsive device P45—55 will become closed and will complete another circuit for valve V1, this latter circuit passing from battery B through contact 201—201b of switch MS, contact 27 of lever L1, line wire 207, contact 22—22b of pressure responsive device P45—55, asymmetric unit 206 in its low resistance direction, and winding 14 of valve V1 to terminal C. Valve V1 will therefore become energized and will exhaust fluid from cylinder 4 until the pressure decreases to that at which contact 22—22b of pressure responsive device P45—55 opens. It will be apparent, therefore, that when lever L1 occupies its p2 position, the braking bars will be held in their braking positions by a pressure of between 45 and 55 pounds per square inch.

If the operator moves lever L1 to its p3 position, valve V2 will then become energized over a circuit which passes from battery B through contact 201—201b of switch MS, contact 28 of lever L1, line wire 208, contact 22—22a of pressure responsive device P70—80, wire 205, and the winding 14 of valve V2 to terminal C. Under these conditions, fluid will be supplied to cylinder 4 of motor M until the pressure in the cylinder reaches 70 pounds per square inch which is the pressure at which contact 22—22a of pressure responsive device P70—80 opens. If the pressure in cylinder 4 now increases to 80 pounds per square inch, contact 22—22b of pressure responsive device P70—80 will become closed and will complete still another circuit for valve V1. This latter circuit for valve V1 may be traced from battery B through contact 201—201b of switch MS, contact 28 of lever L1, line wire 208, contact 22—22b of pressure responsive device P70—80, asymmetric unit 206 in its low resistance direction, and the winding 14 of valve V1 to terminal B. Valve V1 will therefore become energized until the pressure in cylinder 4 of motor M again decreases to 80 pounds per square inch. It will be seen, therefore, that when lever L1 is moved to its p3 position, cylinder 4 is supplied with fluid at a pressure of between 70 and 80 pounds per square inch, so that the braking bars exert a corresponding braking force.

If the operator desires to cause the braking bars to exert their maximum braking force, he will move lever L1 to its p4 position. Under these conditions, valve V2 will become energized and will subsequently remain energized by virtue of a circuit which passes from battery B through contact 201—201b of switch MS, contact 29 of lever L1, line wire 209, wire 205, and the winding of valve V2 to terminal C. It will be apparent, therefore, that under these conditions the braking bars will be held in their braking positions by fluid at full line pressure.

It should be observed that if the operator moves lever L1 from a position corresponding to a higher braking force to a position corresponding to a lower braking force, the apparatus immediately and automatically reduces the braking pressure to a value corresponding to the new position of the lever in a manner which will be apparent from the drawings without tracing the sequence of operation in detail.

When lever L1 occupies any one of its p1, p2, p3 or p4 positions, so that the braking bars occupy their braking positions and the operator wishes to restore the braking bars to their non-braking positions in which they are illustrated in the drawing, he will restore lever L1 to its p0 or off position. When he does this, all circuits previously traced for valve V2 will be interrupted, and the circuits previously described for valve V1 including contact 25 of lever L1 will become closed. Valve V2 will therefore become deenergized and valve V1 will become energized. As a result, the supply of fluid pressure to the cylinder 4 of motor M will be cut off and the fluid which was previously supplied to the cylinder will be vented to atmosphere. The braking bars will therefore move under the influence of the spring 10 to their ineffective or non-braking positions. When the braking bars reach their non-braking positions, all parts are restored to the positions in which they are shown in the drawings.

Associated with lever L is a relay LP which provides a means for decreasing the general level of the braking pressure at the will of the operator when the car retarder is being controlled by the speed responsive apparatus. The relay LP is provided with a control circuit which passes from terminal B through contact 201—201a of manually operable switch MS, contact 29 of lever L, contact 211 of a manually operable switch MS1, line wire 210, and the winding of relay LP to terminal C. With relay LP controlled over this circuit it will be apparent that when the car retarder is being controlled by lever L, if contact 211 of switch MS1 is then closed, relay LP will be picked up in all positions of lever L except the p0 position. It will also be apparent that relay LP can be released at any time by operating the switch MS1 to open the contact 211.

In actual practice the switch MS1 will usually be a push button of the stick type which is built into lever L, and which is arranged to be retained in either of its two positions by suitable detent means.

Only two pressure control relays 1P and 1PO are provided in Fig. 2. The relay 1P has associated therewith a stick relay 1SP and is provided with three pick-up circuits one for each of the p1, p2 and p3 positions of lever L.

When lever L occupies its p1 position, the pick-up circuit for relay 1SP passes from battery B through contact 200—200a of manually operable switch MS, contact 26 of lever L, wire 90, terminal post 81, jumper 119, front contact 75 of relay 5U, jumper 120, front contact 78 of relay 1M, jumper 121, terminal post 93, a resistor 219 in series with the winding of relay 1P connected in multiple with a condenser 221 in series with resistor 220, and the winding of relay 1SP to terminal C. It will be noted that this circuit includes front contact 75 of relay 5U and front contact 78 of relay 1M in series, and it will be apparent, therefore, that when lever L occupies its p1 position, relay 1P will pick up if the speed of a car passing through the retarder becomes less than that at which the relays 5U and 1M pick up, namely 11.6 miles per hour.

When lever L occupies its p2 position, the pick-up circuit for relay 1P then passes from terminal B of the source through contact 200—200a of manually operable switch MS, contact 27 of lever L, wire 91, terminal post 84, jumper 163, front contact 75 of relay 1U, jumper 164, front contact 78 of relay 2M, jumper 165, terminal post 94, resistor 219 in series with the winding of relay 1P connected in multiple with a condenser 221 in series with a resistor 220, and the winding of relay 1SP to terminal C. This circuit includes front contact 75 of relay 1U in series with front contact 78 of relay 2M, and it follows that when lever L occupies its p2 position, relay 1SP will pick up if the speed of a car passing through the retarder becomes less than 9.8 miles per hour.

When lever L occupies its p3 position, the pick-up circuit for relay 1P then passes from terminal B through contact 200—200a of manually operable switch MS, contact 28 of lever L, wire 92, terminal post 87, jumper 173, front contact 76 of relay 2U, jumper 174, front contact 80 of relay 2M, jumper 175, terminal post 95, resistor 219 in series with the winding of relay 1P connected in multiple with the condenser 221 in series with a resistor 220, and the winding of relay 1SP to terminal C. This circuit includes front contact 76 of relay 2U in series with front contact 80 of relay 2M, and it will be seen that when lever L occupies its p3 position, relay 1P will become picked up if the speed of the car passing through the retarder becomes less than 9.1 miles per hour.

Relay 1P is also provided with a plurality of stick circuits each of which includes terminal B of the source, a front contact 215 of a different one of the U relays, wire 216, back contact 217—217a of relay 1SPO, wire 231, front contact 130 of relay 1SP, front contact 218 of relay 1P, resistance 219 in series with the winding of relay 1P connected in multiple with condenser 221 in series with resistor 220, and the winding of relay 1SP to terminal C. The front contact 215 of at least one of the U relays is always closed when the unit counting chain is operating and it will be seen, therefore, that when relay 1P once picks up it will remain picked up either until the unit chain stops operating, or until relay 1SPO picks up.

The relay 1PO likewise has associated therewith a stick relay 1SPO and is provided with three pick-up circuits one for each of the p1, p2 and p3 positions of lever L. When lever L occupies its p1 position, the pick-up circuit for relay 1PO passes from terminal B through contact 200—200a of manually operable switch MS, contact 26 of lever L, wire 90, terminal post 83, jumper 150, front contact 77 of relay 1U, wire 151, front contact 80 of relay 3M, jumper 152, terminal post 99, the resistor 222 in series with the winding of relay 1PO connected in multiple with a condenser 224 in series with a resistor 223, and the winding 1SPO to terminal C of the source. Since relays 1U and 3M pick up whenever the speed of a car traversing the stretch of track shown in the drawing is less than 6.7 miles per hour, it will be apparent that when lever L occupies its p1 position, the relay 1PO will pick up if the speed of a car traversing the stretch of track shown in the drawing decreases to a speed of less than 6.7 miles per hour.

When lever L occupies its p2 position, relay 1PO will then become energized if the speed of a car traversing the stretch of track in the drawing decreases below a speed of 5.3 miles per hour by virtue of a circuit which passes from terminal B through contact 200—200a of manually operable switch MS, contact 27 of lever L, wire 91, terminal post 86, jumper 168, front contact 80 of relay 4M, jumper 169, terminal post 100, resistor 222 in series with the winding of relay 1PO connected in multiple with a condenser 224 in series with a resistor 223, and the winding of relay 1SPO to terminal C.

When lever L occupies its p3 position, relay 1PO will then become energized if the speed of a car traversing the stretch of track in the drawing decreases below a speed of 4 miles per hour by virtue of a circuit which passes from terminal B through contact 200—200a of manually operable switch MS, contact 28 of lever L, wire 92, terminal post 89, jumper 105, front contact 77 of relay 2U, wire 106, front contact 80 of relay 5M, jumper 107, terminal post 101, resistor 222 in series with the winding of relay 1PO connected in multiple with a condenser 224 in series with resistor 223, and the winding of relay 1SPO to terminal C.

Relay 1PO is further provided with a plurality of stick circuits each of which passes from terminal B through front contact 215 of a different one of the U relays, wire 216, front contact 217—217b of relay 1SPO, front contact 218 of relay 1PO, resistor 222 in series with the winding of relay 1PO connected in multiple with condenser 224 in series with resistor 223, and the winding of relay 1SPO to terminal C.

Referring now particularly to the speed responsive portion of the apparatus shown in Fig. 2, relay W has been eliminated, and the energizing circuits for the half-step relays PX and NX previously described in connection with Fig. 1 have been modified to include a front contact 212 of relay 1SU or a front contact 213 of relay 2SU in place of front contact 36 of relay W. It will be apparent, therefore, that when either relay 1SU or relay 2SU picks up, the half-step relays PX and NX will immediately start to operate and will continue to operate as long as the relay which initiated the operation remains energized.

Relay UX has also been eliminated in Fig. 2, and the initial pick-up circuit for the 1U relay which becomes closed when the operation of the unit counting chain is initiated by the picking up of any one of the odd-numbered track relays 1TR, 3TR or 5TR has been modified to include a back contact 73—73a of relay 2SU in place of the winding of the W relay, and a back contact 255 of relay 1SPO and a back contact 226 of relay 1SP in place of the winding 48 of the relay UX. Tracing this circuit in detail for the condition when track relay 5TR is picked up, for example, this circuit passes from terminal B through back contact 33—33b of track relay 6TR, front contact 33—33a of track relay 5TR, the winding of relay 1SU, back contact 73—73a of relay 2SU, a back contact 44 of each of the relays 2U to 6U, inclusive, a back contact 45 of each of the M relays, back contact 225 of relay 1SPO, back contact 226 of relay 1SP, and the winding of relay 1U to terminal C.

The initial pick-up circuit for the 1U relay which becomes closed when the operation of the counting chain is initiated by the picking up of any of the even-numbered track relays 2TR, 4TR and 6TR in Fig. 2 has been modified in a manner similar to the circuit controlled by the odd-numbered track relays, and will be apparent from the above and from an inspection of the drawing without further detailed description.

It should be pointed out that since the initial pick-up circuits for relay 1U each include a back contact 225 of relay 1SPO and a back contact 226 of relay 1SP, the relay 1SU or 2SU will not pick up in Fig. 2 unless relays 1SP and 1SPO are both deenergized. This check insures that the SP relays have released between counting operations and permits the elimination of the alternate series of pressure control relays shown in Fig. 1.

It should also be pointed out that this change makes possible the elimination of the UX relay, and reduces the pick-up circuits for the 1U relay to a single series of back contacts instead of a double set as shown in Fig. 1.

The OM relay has been eliminated in Fig. 2, and the stick circuits for the remaining M relays and for the U relays have been modified to include in addition to the front contact 49—49b of the 1SU relay or a front contact 73—73b of the relay 2SU depending upon whether the 1SU or 2SU relay is then energized, a back contact of the SU relay which is deenergized. That is to say, when the relay 1SU is energized, the stick circuits for each of the M or U relays includes in addition to the front contact 49—49b of relay 1SU, back contact 73—73a of relay 2SU, and when relay 2SU is energized, the stick circuits for each of the U or M relays includes in addition to the front contact 73—73b of relay 2SU, back contact 49—49a of relay 1SU. Except for the modification just noted, and a modification of the stick circuit for the relay 3U which I shall describe presently, these stick circuits are otherwise identical with the circuits previously described in connection with Fig. 1.

The pick-up circuits for the U and M relays in Fig. 2, with the exception of the pick-up circuit for relay 3U and the pick-up circuit for the 1M relay, are identical with the corresponding circuits shown in Fig. 1 except for the fact that front contact 43 of relay W has been omitted from these circuits. This contact has been omitted because the stick circuits for the U relays include the windings of the SU relays which insures proper operation of the U chain.

The pick-up circuit for relay 3U when all of the M relays of the multiple chain are deenergized passes from battery B through a normal contact 42—42a of relay NX, front contact 54 of relay 2U, the winding of relay 3U, wire 232, back contact 63—63a of each of the relays 5M, 4M, 3M, 2M and 1M, and winding 68 of relay MX to terminal C of the source. When relay 1M is picked up, the pick-up circuit for relay 3U on the next round trip of operation of the unit chain will pass from battery B through contact 42—42a of relay NX, front contact 54 of relay 2U, the winding of relay 3U, wire 232, back contact 63—63a of relays 5M, 4M, 3M and 2M, front contact 63—63b of relay 1M, and the winding 65 of relay MX to terminal C. Each time a succeeding one of the M relays of the multiple chain picks up, its front contact will be included in the pick-up circuit which next becomes closed for relay 3U, as will be obvious.

It should be noted that with the pick-up circuits for relay 3U arranged in this manner, the windings 65 and 68 of relay MX will be alternately energized in response to successive energizations of the relay 3U, whereby the relay MX is caused to alternately open and close its polar contacts to effect the successive energization of the relays of the multiple chain in the same manner as in Fig. 1.

The pick-up circuit for relay 1M in Fig. 2 is closed by the picking up of relay 6U, and when this circuit becomes closed if an odd-numbered track relay is then picked up, this circuit passes from terminal B through back contact 33—33b of each of the track relays in advance of the picked-up track relay, front contact 33—33a of the picked-up track relay, the winding of relay 1SU, back contact 73—73a of relay 2SU, front contact 49—49b of relay 1SU, wire 50, back contact 60 of each of the relays 5M, 4M, 3M and 2M, normal contact 234 of relay MX, front contact 233 of relay 6U and the winding of relay 1M to terminal C.

The pick-up circuit for relay 1M when any of the even-numbered track relays 2TR, 4TR or 6TR is then picked up passes from terminal B through back contact 33—33b of each track relay in advance of the picked-up track relay, front contact 33—33a of the picked-up track relay, the winding of relay 2SU, back contact 49—49a of relay 1SU, front contact 73—73b of relay 2SU, wire 50, a back contact 60 of each of the relays 5M, 4M, 3M and 2M, normal contact 234 of relay MX, front contact 233 of relay 6U, and the winding of relay 1M to terminal C.

The stick circuits for relay 3U in Fig. 2 differ from the stick circuits for relay 3U in Fig. 1 in the same manner that the pick-up circuits for relay 3U in Fig. 2 differ from the pick-up circuits for relay 3U in Fig. 1. It is believed, therefore, that these stick circuits will be obvious from an inspection of the drawing without further detailed description.

The operation of the time measuring means as a whole with the apparatus constructed as shown in Fig. 2a is essentially the same as the operation of the apparatus shown in Fig. 1a, it being noted that with the apparatus shown in Fig. 2a the NX and PX relays are set into operation by the picking up of the 1SU or 2SU relay in response to the picking up of a track relay and are subsequently maintained in operation until such track relay releases. With the relays NX and PX in operation, the relays of the unit and multiple chains will function to register the time the relays NX and PX remain in operation to thereby measure the speed of a car traversing the track circuited stretch through the retarder. Since the operation of the time measuring apparatus shown in Fig. 2a is essentially the same as that shown in Fig. 1a, a detailed description of the operation of this portion of the apparatus is believed to be unnecessary.

The operation as a whole of the apparatus shown in Figs. 2 and 2a is as follows: When the manually operable switch MS occupies the position shown, the apparatus is conditioned for the control of the car retarder by the lever L. Lever L is shown in its p0 position and when the lever occupies this position, all circuits for valve V2 are open and valve V1 is energized over a circuit which passes from terminal B through contact 201—201a of manually operable switch MS, contact 25 of lever L, line wire 115, wires 116 and 203, and the winding 14 of valve V1 to terminal C. Since valve V2 is deenergized and valve V1 is energized, the braking bars are held in their non-braking positions by the spring 10.

I shall now assume that with the apparatus conditioned to be controlled by the lever L, the operator moves the lever from its *p0* to its *p1* position to slow down a car which is approaching the retarder to the maximum control speed for which the apparatus is designed. The movement of lever L from its *p0* to its *p1* position interrupts the circuit which was previously closed for valve V1 and completes one or the other of two circuits for valve V2 depending upon whether relay LP is then energized or deenergized. Assuming that relay LP is energized as shown in the drawing, the circuit for valve V2 passes from terminal B through contact 201—201*a* of switch MS, contact 29 of lever L, wire 235, back contact 236—236*a* of relay 1P0, back contact 237—237*a* of relay 1P, front contact 238—238*b* of relay LP, wire 239, contact 22—22*a* of pressure responsive device P45—55, wire 205, and the winding 14 of valve V2 to terminal C. Valve V2 will therefore become energized and will admit fluid pressure to cylinder 4 of motor M until the pressure in the cylinder increases to 45 pounds per square inch, whereupon the pressure responsive device P45—55 will function to maintain the pressure in the motor at a pressure of between 45 and 55 pounds per square inch.

If now with lever L in its *p1* position and with relay LP picked up, relay 1P becomes picked up due to the speed of the car passing through the retarder decreasing to the value at which relay 1P becomes picked up, the circuit which was previously closed for valve V2 will become interrupted at back contact 237—237*a* of relay 1P, and a circuit will become closed for valve V1 passing from terminal B through contact 201—201*a* of manually operable switch MS, contact 29 of lever L, wire 235, back contact 236—236*a* of relay 1P0, front contact 237—237*b* of relay 1P, front contact 240—240*b* of relay LP, wire 241, contact 22—22*b* of pressure responsive device P20—30, asymmetric unit 206 in its low resistance direction and the winding of valve V1 to terminal C. Valve V1 will therefore become energized and will vent fluid pressure from cylinder 4 of motor M until the pressure decreases to 20 pounds per square inch whereupon pressure responsive device P20—30 will then function to maintain the pressure of the fluid in motor M at a pressure of between 20 and 30 pounds per square inch.

If when lever L was moved to its *p1* position relay LP had then been deenergized, valve V2 would then have become energized over a circuit which passes from battery B through contact 201—201*a* of manually operable switch MS, contact 29 of lever L, wire 235, back contact 236—236*a* of relay 1P0, back contact 237—237*a* of relay 1P, back contact 238—238*a* of relay LP, wire 242, and the winding 14 of valve V2 to terminal C. Under these conditions, none of the pressure responsive devices is included in the control of the valve V2, and it will be apparent therefore that the resultant energization of the valve V2 would cause fluid at full line pressure to be supplied to motor M.

If, with lever L in its *p1* position and relay LP deenergized, relay 1P becomes energized due to the speed of the car decreasing to the proper speed, the circuit previously traced for valve V2 would then become interrupted at back contact 237—237*a* of relay 1P and a circuit would become closed for valve V1 at front contact 237—237*b* of relay 1P which latter circuit may be traced from battery B through contact 201—201*a* of manually operable switch MS, contact 29 of lever L, wire 235, back contact 236—236*a* of relay 1P0, front contact 237—237*b* of relay 1P, back contact 240—240*a* of relay LP, wire 239, contact 22—22*b* of pressure responsive device P45—55, asymmetric unit 206 in its low resistance direction, and the winding 14 of valve V1 to terminal C. Valve V1 will therefore become energized and will vent fluid from cylinder 4 of motor M until the pressure decreases to 45 pounds per square inch at which time the pressure responsive device P45—55 will function to subsequently maintain the pressure of the fluid in cylinder 4 of motor M at the pressure of between 45 and 55 pounds per square inch.

If, when lever L occupies its *p1* position, the speed of the car decreases sufficiently to cause relay 1P0 to pick up, all circuits previously traced for valve V and V1 will become interrupted and a circuit for valve V1 will become closed passing from battery B through contact 201—201a of manually operable switch MS, contact 29 of lever L, wire 235, front contact 236—236*b* of pressure responsive device 1P0, wire 116, and the winding of valve V1 to terminal C. Valve V1 will therefore become energized and will vent the fluid which was previously supplied to the motor M to atmosphere to thereby permit the spring 10 to move the braking bars to their non-braking or released positions.

It will be seen, therefore, that when lever L is moved to its *p1* position, cylinder 4 of motor M will be supplied with fluid at full line pressure or at approximately half full line pressure according as relay LP is then released or is picked up. It will also be apparent that if relay LP is picked up when relay 1P becomes deenergized, the pressure will be decreased from a pressure of between 45 and 55 pounds to a pressure of between 20 and 30 pounds, whereas if relay 1P becomes picked up when relay LP is released, the pressure of the fluid in motor M will be decreased from full line pressure to a pressure of between 45 and 55 pounds.

It should be noted that relay LP can be picked up or released at the will of the operator by merely operating the switch MS1, and it follows, therefore, that when the lever occupies its *p1* position, the operator can change the base pressure at which the retarder operates from the full line pressure to half line pressure or vice versa at will. This feature is particularly desirable in yards where some of the cars are heavy cars and other cars are light weight cars, and permits the operator to make the desired selection between the braking force which will be applied to the heavy cars and the braking force which will be applied to the light cars to thereby prevent derailment of the light cars.

The operation of the apparatus when lever L is moved to its *p2* or *p3* position is similar in all respects to that just described for the operation of the apparatus when lever L is moved to its *p1* position with the exception that under these latter conditions the speed at which the 1P relay picks up will be different from the speeds at which this relay picked up when the lever occupied its *p1* position. It is believed, therefore, that this operation will be understood from the drawings without further detailed description. When lever L is moved to its p4 position, the speed responsive apparatus is rendered ineffective to control the relays 1P and 1PO, and the apparatus will therefore exert either the full braking pressure or half the full braking pressure depending upon whether relay LP is then released or picked up as will readily be understood.

If the operator wishes to render the speed control lever L ineffective to control the retarder and to control the retarder by means of the standard control lever L1, he will operate the switch MS to open the contacts 201—201a and 200—200a and close its contacts 201—201b and 200—200b. The control of the retarder by the lever L1 was explained in detail hereinbefore and need not be repeated.

One advantage of speed responsive apparatus embodying my invention is that since it employs a counting chain in which the units of time between the operation of the successive relays of the chain are the alternating current cycles, it is apparent that the accuracy will be dependent primarily upon the accuracy of the alternating current power source. In view of the close regulation which is available for alternating current power sources there can be very little error in this portion of the apparatus. As long as the relays function as intended there remains only the error that may result depending upon how the first cycle of the counting operation is split in getting the relays of the counting chain into action, and also where the cut-off point comes in stopping of the chain. Accordingly, thereoretically there can be a maximum possible error of two cycles in a given timing operation. In the case of a control speed of 4 miles per hour using a track circuit 3 ft. 1½ in. long, a timing of approximately 500 milliseconds is involved. If the maximum error which can occur is an error of two cycles, this would represent an error of only six and a half per cent for this speed.

Another advantage of apparatus embodying my invention is that the timing is entirely independent of the variables ordinarily caused by temperature, voltage, etc.

Another advantage of apparatus embodying my invention is that it possesses a high degree of flexibility. The track circuit lengths as well as the frequency of the alternating current for operation of the system can be selected depending upon the conditions obtaining and the accuracy desired. Since the system is designed primarily for operation on 60 cycle current, it can be operated on the current which is commercially available. If desired, an entirely independent source or any desired source of constant frequency current may be used.

It is also apparent that the counting chain combinations including the number of steps involved in each chain is merely a matter of choice depending upon the conditions to be served. If desirable, in cases where longer timing is needed, more groups of multipliers may be employed. For such an arrangement the second group would of course rotate in similar fashion to the first group and the third group would total the number of complete cycles of operation made by the second group. This principle may of course be carried as far as it is found desirable.

It is further apparent that the number of speeds that may be selected by the operator from the controller is purely a matter of choice. The attached disclosure shows three speeds. This may be amplified as desired to any number of speeds that may be needed. It is also apparent that the number of pressure reductions is dependent only upon the design and the amount of equipment provided. Also there is no necessary or essential relationship between the number of speed controls and the number of pressures provided.

Although I have herein shown and described only two forms of railway braking apparatus embodying my invention, it is understood that various changes and modifications may be made therein within the scope of the appended claims without departing from the spirit and scope of my invention.

Having thus described my invention, what I claim is:

1. Apparatus for measuring the speed of a vehicle comprising a chain of counting relays, a source of controlled frequency alternating current, and means effective while said vehicle is traversing a fixed distance for successively energizing said relays at the rate of one for each cycle of said source.

2. Apparatus for measuring the speed of a vehicle comprising a relay, means for energizing said relay while said vehicle is traversing a fixed distance, a pair of contacts which are alternately operated at a fixed rate when said relay is energized, and means for counting the number of operations of said contacts while said relay is energized.

3. Apparatus for measuring the speed of a vehicle comprising a unit chain and a multiple chain of counting relays, means for energizing the relays of said unit chain one during each cycle of a constant frequency source of alternating current while said vehicle is traversing a fixed distance, and means for successively energizing the relays of said multiple chain one during each complete cycle of operation of said unit chain to totalize the number of complete cycles of operation of said unit chain.

4. Apparatus for measuring the speed of a vehicle comprising, a source of controlled frequency alternating current, a first relay, means for energizing said first relay while said vehicle is traversing a fixed distance, a source of constant frequency alternating current, a pair of half-step relays, means controlled by said first relay and effective when said first relay is energized for connecting said half-step relays with said source in such manner that said half-step relays will become alternately energized on alternate half cycles of said source, and time measuring means responsive to the number of operations of one of said half-step relays.

5. In combination, a source of controlled frequency alternating current, a pair of half-step relays of the two winding polar magnetic stick type, means including a first rectifier poled to pass current during positive half cycles only of said source and a normal contact of the one relay for connecting the one winding of the other relay with said source, means including said first rectifier and a reverse contact of said one relay for connecting the other winding of said other relay with said source, said other relay being so constructed that it will close its normal or its reverse contacts according as its one or its other winding is energized, means including a second rectifier poled to pass current during negative half cycles only of said source and a normal contact of said other relay for connecting the one

winding of said one relay with said source, means including said second rectifier and a reverse contact of said other relay for connecting the other winding of said one relay with said source, said one relay being so constructed that it will close its normal or its reverse contacts according as its one or its other winding is energized, whereby said relays will alternately operate on alternate half cycles of said source, and means controlled by one of said relays for counting the number of operations of said one relay.

6. In combination, a source of controlled frequency alternating current, a pair of half-step relays of the polar magnetic stick type each connected with said source over circuit means controlled by the other in such manner that said relays will alternately operate on alternate half cycles of current supplied by said source, and means controlled by one of said relays for counting the number of operations of said one relay.

7. In combination, a stretch of railway track, an insulated section formed in one rail of said stretch; a track circuit including the winding of a track relay, said section, and the opposite rail of said stretch; a source of controlled frequency alternating current, and means controlled by said track relay for counting the cycles of said source when said track relay is energized to measure the speed of a car traversing said stretch.

8. In combination, a stretch of railway track, an insulated section formed in one rail of said stretch, said section being of such length that it cannot be occupied by more than one wheel of a car at any one time, a track relay connected with said section and arranged to be energized when said section is occupied by a car wheel, a source of constant frequency alternating current, and means including a chain of counting relays set into operation by energization of said relay for counting the cycles of said source while said relay is energized to measure the speed of a car traversing said stretch.

9. Apparatus for repeatedly measuring the speed of a car traversing a stretch of track comprising a series of track sections formed in said stretch, said sections being of such lengths that only one wheel of a car can occupy a section at a time, a track circuit for each section including the section, a source of current, the winding of an associated track relay and a back contact of each of the track relays in advance, whereby the track relays will become successively energized and deenergized as the car traverses said stretch, and time measuring means set into operation by the energization of each relay.

10. Apparatus for repeatedly measuring the speed of a car traversing a stretch of track comprising a series of track sections formed in said stretch, said sections being of such lengths that only one wheel of a car can occupy a section at a time, a track circuit for each section including the section, a source of current, the winding of an associated track relay and a back contact of each of the track relays in advance, whereby the track relays will become successively energized and deenergized as the car traverses said stretch, time measuring means set into operation by the energization of each relay, said time measuring means comprising a source of controlled frequency alternating current, a pair of half-step relays which alternately operate on alternate half cycles of the current supplied by said source when any one of said track relays is energized, and a chain of counting relays which pick up successively in response to the operation of a particular one of said half step relays.

11. Apparatus for repeatedly measuring the speed of a car traversing a stretch of track comprising a series of track sections formed in said stretch, said sections being of such lengths that only one wheel of a car can occupy a section at a time, a track circuit for each section including the section, a source of current, the winding of an associated track relay and a back contact of each of the track relays in advance, whereby the track relays will become successively energized and deenergized as the car traverses said stretch, and time measuring means set into operation by the energization of each relay, said time measuring means comprising a source of constant frequency alternating current, and means for counting the cycles of said source.

12. Apparatus for measuring time comprising a pair of contacts, means for alternately closing said contacts at a constant frequency, a chain of counting relays, means for energizing the first relay of the chain and simultaneously energizing said first mentioned means to set said chain into operation, and means controlled by said contacts for thereafter consecutively energizing the relays of the chain as long as said contacts continue to operate.

13. Apparatus for measuring time comprising a pair of contacts, means for alternately closing said contacts at a constant frequency, a chain of counting relays, means for energizing the first relay of the chain and simultaneously energizing said first mentioned means to set said chain into operation, and means controlled by said contacts for thereafter consecutively energizing the relays of the chain as long as said contacts continue to operate over a series of pick-up circuits each of which includes a front contact of the relay next in rear and a series of stick circuits each of which includes a back contact of the relay next in advance.

14. Apparatus for measuring time comprising a pair of contacts, means for alternately closing said contacts at a constant frequency, a chain of counting relays, means for setting said first mentioned means in operation and for simultaneously energizing the first relay of the chain, and means for subsequently consecutively energizing the relays of said chain one each time one of said contacts becomes closed and for releasing the relay in rear of the energized relay.

15. Apparatus for measuring the speed of a car traversing a stretch of track comprising a series of relatively short track sections formed in said stretch, a series of track relays one for each track section, a track circuit for each section including the rails of the section, a source of current, the winding of the associated track relay and a back contact of each of the track relays in advance, a chain of counting relays, and means for setting said chain into operation each time one of said track relays picks up.

16. Apparatus for measuring the speed of a car traversing a stretch of track comprising a series of relays and means for operating them consecutively when a car traverses said stretch for time intervals which depend upon the speed of the car, a source of constant frequency alternating current, a chain of counting relays, and means controlled by each relay of said series of relays and effective when any relay of the series becomes operated for consecutively energizing the relays of said chain one for each cycle of said source.

17. Apparatus for measuring the speed of a car

traversing a stretch of track comprising a source of constant frequency alternating current, a series of contacts, means for consecutively operating said contacts when a car traverses said stretch for time intervals which depend upon the speed of the car, and means for counting the cycles of said source newly set into operation by the operation of each successive contact of the series.

18. Apparatus for measuring the speed of a car traversing a stretch of track comprising a series of relatively short insulated track sections formed in one rail of said stretch, a series of track relays one for each track section, two checking relays; a track circuit for each track relay including a source of current, the associated section, the opposite rail of the stretch, a back contact of each track relay of the series in advance, and a back contact of each of said checking relays in series connected in multiple with a front contact of each of said track relays; time measuring means, means for energizing the one check relay when any one of the alternate relays of the series starting with the first relay picks up provided said time measuring means then occupies a starting position and for simultaneously setting said time measuring means into operation, means for energizing the other check relay when any one of the alternate relays of the series starting with the second relay picks up provided said time measuring means then occupies its starting position and for simultaneously setting said time measuring means into operation, means for maintaining either check relay energized when it once becomes energized until said time measuring means returns to its starting position, and means for causing said timing means to return to its starting position each time a different track relay picks up.

19. Apparatus for measuring the speed of a car traversing a stretch of track comprising a series of insulated track sections formed in one rail of said stretch, said sections being of such lengths that only one wheel of a car can occupy any one section at a time, a series of track relays one associated with each track section; a track circuit for each track relay including a source of current, the associated section, the opposite rail of said stretch and a back contact of each track relay in advance; whereby each track relay will pick up when and only when the associated track section is the leading occupied section, a chain of counting relays adapted to pick up and release progressively when said chain is in operation, means effective when all of said track relays are deenergized for preventing any track relay from subsequently picking up unless all of the relays of said chain are deenergized, and means effective when any track relay picks up for causing said chain to operate until the relay next in advance picks up.

20. Apparatus for measuring the speed of a car traversing a stretch of track comprising a series of relays, means for successively picking up and releasing the relays of said series in response to a car traversing said stretch, each said relay being picked up for a time interval which is proportional to the average speed of a car over a fixed distance individual to the relay, a source of constant frequency alternating current, a pair of half-step relays, means effective when any one of the relays of said series picks up for connecting said half-step relays with said source in such manner that they will alternately operate on alternate half cycles of the current supplied by said source, the one half-step relay being provided with two contacts which are alternately operated when said relay is operating, a chain of counting relays; a plurality of pick-up circuits for the first relay of said chain each including a front contact of a different alternate one of the relays of said series beginning with the first relay, the winding of a first checking relay and a back contact of each relay of the chain except said first relay; a plurality of other pick-up circuits for the first relay of said chain each including a front contact of a different one of the relays of said series beginning with the second relay, the winding of a second checking relay and a back contact of each relay of the chain except said first relay; a pick-up circuit for each relay of said chain including a front contact of the relay next in rear and one or the other of the contacts of said one half-step relay according as the relay is an odd or even-numbered relay, whereby said relays will pick up in succession as long as said one-half step relay is operating, a plurality of stick circuits two for each relay of said chain and each including a front contact of the associated relay, a back contact of the relay next in advance, the winding of the checking relay which was included in the starting circuit for the first relay of the chain and a front contact of such checking relay, and means controlled by said checking relays for preventing any relay of said series of relays from picking up when the relays of said series are all deenergized unless both said checking relays are then deenergized.

21. Apparatus for measuring the speed of a car traversing a stretch of track comprising a series of insulated track sections formed in one rail of said stretch, said sections being of such lengths that only one wheel of a car can occupy any one section at a time, a series of track relays one associated with each track section, two checking relays, a track circuit for each track relay including a source of current, the associated section, the opposite rail of said stretch, and a back contact of each track relay in advance and a back contact of each of said checking relays, whereby each track relay will pick up when and only when the associated track section is the leading occupied section and then only if said checking relays are both deenergized or the track relay next in rear was previously picked up, a chain of counting relays, a pair of contacts, means for alternately operating said contacts at a constant frequency when any one of said track relays is picked up, a first series of starting circuits for the first relay of said chain each including a front contact of a different alternate one of said track relays beginning with the first track relay, the winding of said first checking relay, and a back contact of each relay of said chain except said first relay; a second series of starting circuits for the first relay of said chain each including a front contact of a different alternate one of said track relays beginning with the second track relay, the winding of said second checking relay, and a track circuit of each relay of the series except said first relay, a pick-up circuit for each relay of the chain each including a front contact of the relay next in rear and one or the other of the contacts of said pair according as the relay is an odd or an even-numbered relay, whereby the relays of said chain will pick up in succession as long as said pair of contacts are alternately operated, and a plurality of stick circuits two for each relay of said chain and each including a front contact of the associated relay, a back contact of the relay next in advance, the winding of the checking relay which was included in the starting circuit for the first relay

of the chain and a front contact of such checking relay.

22. In combination, a stretch of railway track, a fluid pressure operated car retarder associated with said stretch for retarding the speed of a car traversing said stretch, a series of relatively short insulated control sections formed in one rail of said stretch, a series of track relays one associated with each track section, a track circuit for each track relay including a source of current, the associated section, the opposite rail of said stretch, and a back contact of each track relay in advance, whereby each track relay will pick up when and only when the associated track section is the leading occupied section, time measuring means comprising a source of constant frequency alternating current and a counting chain for counting the cycles of said source, means controlled by each track relay for setting said time measuring means into operation, and means controlled by said time measuring means for controlling the pressure of the fluid supplied to said car retarder.

23. In combination, a stretch of railway track, a fluid pressure operated car retarder associated with said stretch for retarding the speed of a car traversing said stretch, a series of insulated track sections formed in one rail of said stretch, a series of track relays one associated with each section; a track circuit for each track relay closed to pick up the associated relay by the occupancy of the associated section if and only if all of the sections in advance are unoccupied, a unit chain of counting relays, means for energizing the relays of said chain in succession when any one of said track relays is picked up, a multiple chain of counting relays, means for energizing the relays of said multiple chain one each time said unit chain completes a round trip of operation, a plurality of pressure control relays, means controlled by the relays of said unit and multiple chains for selectively energizing said pressure control relays in accordance with the speed of a car traversing said stretch, and means controlled by said pressure control relays for controlling the pressure of the fluid supplied to said car retarder.

24. In combination, a stretch of railway track, a car retarder associated with said stretch, a chain of counting relays, means for energizing the relays of said chain in succession when a car is traversing said stretch for successive intervals of time the duration of which intervals depends upon the speed of the car during the interval, and means controlled by said relays for controlling the braking action of said car retarder.

25. In combination, a stretch of railway track, a car retarder associated with said stretch, means for measuring the speed of a vehicle passing through said car retarder comprising a source of controlled frequency alternating current and means for counting the cycles of said source while the car is traversing a fixed distance, and means controlled by said speed measuring means for controlling the braking action of said car retarder to cause the braking force to decrease as the speed of the car decreases and to cause the retarder to automatically release when a predetermined control speed is reached.

26. In combination, a stretch of railway track, a car retarder associated with said stretch, means for measuring the speed of a vehicle passing through said car retarder comprising a source of controlled frequency alternating current and means for counting the cycles of said source while the car is traversing a fixed distance, and means controlled by said speed measuring means for controlling the braking action of said car retarder.

27. In combination, a stretch of railway track, a car retarder associated with said stretch, means for repeatedly measuring the speed of a car traversing said stretch comprising a source of constant frequency alternating current and a chain of counting relays for counting the cycles of said source each time the car advances a fixed distance, and means selectively controlled by the relays of said chain for controlling the braking action of said car retarder.

28. In combination, a stretch of railway track, a car retarder associated with said stretch, means for measuring the speed of a car traversing said stretch, a speed control lever, means controlled jointly by said lever and by said speed measuring means for causing said car retarder to exert a braking force which depends upon the speed of the car, a manually operable switch associated with said lever, and means controlled by said switch for changing the general level of the braking force exerted by said car retarder.

29. In combination, a stretch of railway track, a braking bar extending parallel to a track rail, a fluid pressure motor for moving said braking bar toward the track rail to a braking position, a source of fluid pressure, a first magnet valve effective when energized for connecting said motor with a source of fluid pressure, a second magnet valve effective when energized for connecting said motor with atmosphere, a relay, a lever having an "off" and an "on" position, means effective when said lever occupies its "off" position for energizing said second magnet valve, a first contact which becomes opened when the pressure of the fluid in said motor increases to a predetermined pressure and a second contact which becomes closed when the pressure of the fluid in said motor increases to a pressure which is somewhat higher than the pressure at which said first contact opens, means effective when said lever occupies its "on" position and said relay is deenergized for energizing said first magnet valve to supply said motor with pressure from said source at the full pressure of said source, means effective when said lever occupies its "on" position and said relay is energized for energizing said first magnet valve in series with said first contact to supply said motor with pressure from said source until the pressure increases to the pressure at which said first contact becomes opened, and means effective when said lever occupies its "on" position and said second contact becomes closed for energizing said second magnet valve to prevent the pressure of the fluid in said motor from increasing beyond the pressure at which said second contact closes.

30. In combination, a stretch of railway track, a fluid pressure operated car retarder for retarding the speed of a car traversing said stretch, a plurality of relays, means for progressively energizing said relays as the speed of a car traversing said stretch progressively decreases, means effective when all of said relays are deenergized for supplying said car retarder with fluid at a predetermined pressure, and means for decreasing the pressure of the fluid supplied to said retarder progressively in response to the progressive energization of said relays.

31. In combination, a stretch of railway track, a fluid pressure operated car retarder associated with said stretch, two sets of pressure control

relays, means effective when a car is traversing said stretch for alternately controlling the relays of the two sets in accordance with the speed of the car in such manner that none of the relays will become operated if the speed is above a predetermined speed, one of the relays will become operated if the speed drops below a first predetermined speed, two of the relays will operate in succession if the speed drops below a second predetermined speed, etc., means controlled by the relays of either set which is then responsive to the speed of a car traversing said stretch for selectively controlling the pressure of the fluid supplied to said car retarder, and means effective when either set of relays is effective to control the pressure of the fluid supplied to said car retarder for maintaining its control until the other set subsequently becomes effective to control said retarder.

32. In combination, a stretch of railway track, a fluid pressure operated car retarder associated with said stretch, two sets of pressure control relays, means for controlling the relays of the two sets in accordance with the speed of a car traversing said stretch in such manner that the relays of one set or the other alternatively will pick up and release in succession to an extent which depends upon the car speed at the time, means controlled by the relays of the other set for selectively controlling the pressure of the fluid supplied to said retarder, and means effective when either set of relays is controlling the retarder for continuing the control of the retarder by such set until the other set becomes effective to control the retarder.

33. In combination, a stretch of railway track, a fluid pressure operated car retarder associated with said stretch, a first lever, means controlled by said first lever for supplying said car retarder with fluid at different pressures for different lever settings, a second lever, means controlled by said second lever for initially supplying said retarder with fluid at a predetermined pressure and for decreasing said pressure in graduated steps as the speed of a car traversing said stretch decreases, and manually operable means for rendering one lever or the other effective to control the supply of fluid pressure to said car retarder.

34. In combination, a stretch of railway track, a fluid pressure operated car retarder associated with said stretch, a first lever, means controlled by said first lever for supplying said car retarder with fluid at different pressures for different lever settings, a second lever, means controlled by said second lever for initially supplying said retarder with fluid at a predetermined pressure and for decreasing said pressure in graduated steps as the speed of a car traversing said stretch decreases until the pressure supplied to said motor decreases to a pressure which depends upon the lever setting and for subsequently releasing the retarder automatically, and manually operable means for rendering one lever or the other effective to control the supply of fluid pressure to said car retarder.

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