Nov. 12, 1963 L. BROCKMAN 3,110,461

CONTROL SYSTEM FOR RAILWAY CAR CLASSIFICATION YARD

Filed Aug. 28, 1958 3 Sheets-Sheet 1

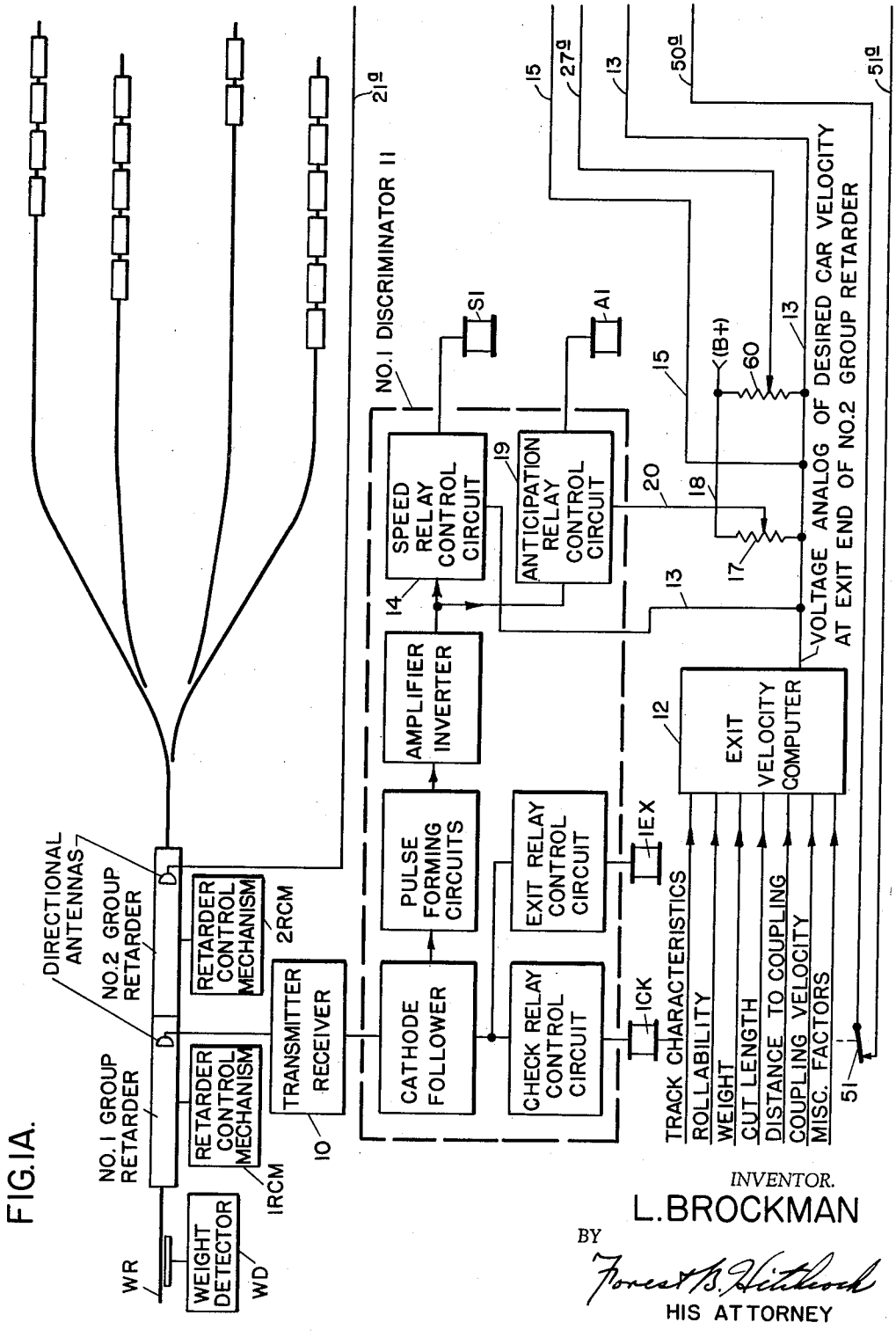


FIG.1A.

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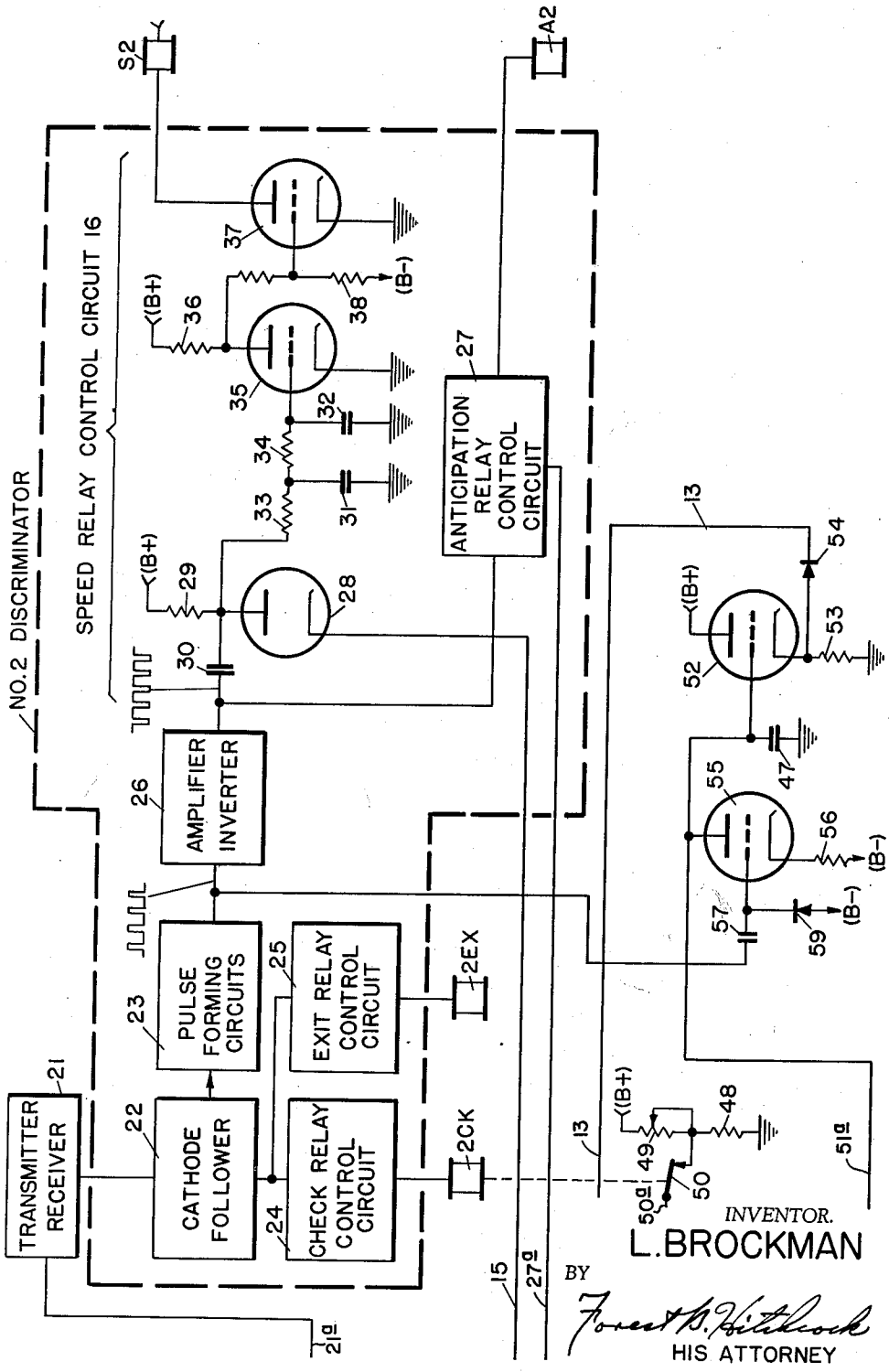


FIG. 1B.

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FIG. 2A.

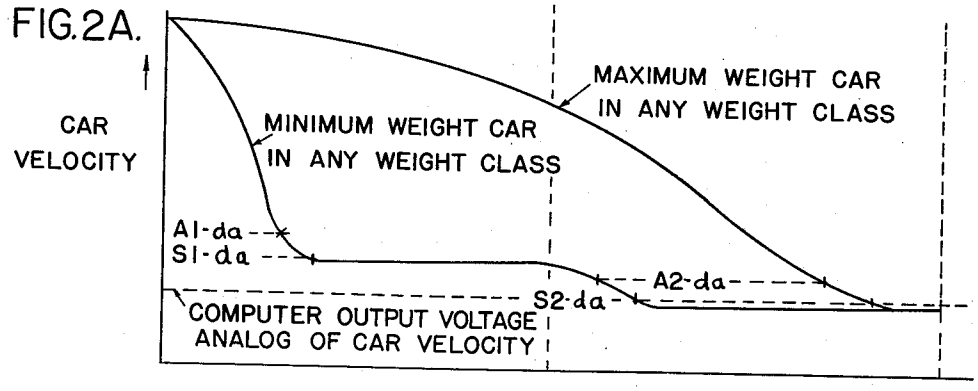


FIG. 2B.

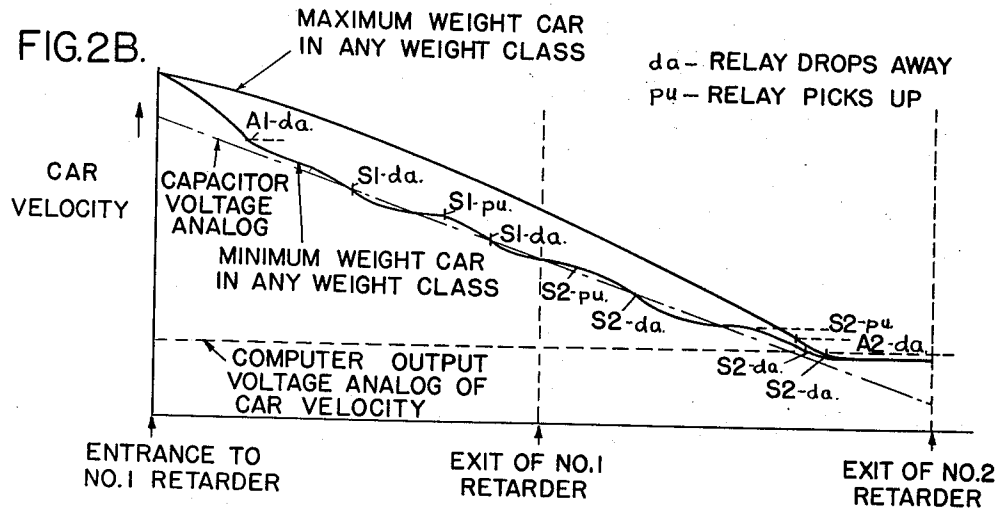
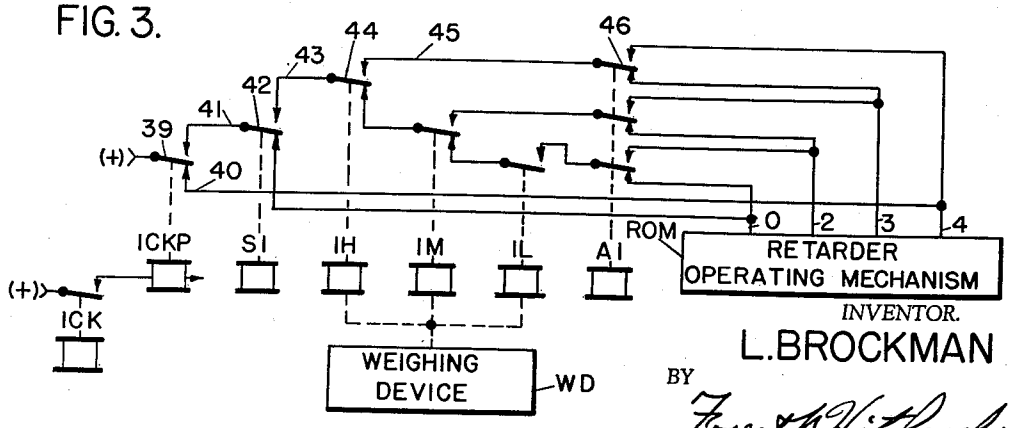


FIG. 3.



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3,110,461

CONTROL SYSTEM FOR RAILWAY CAR CLASSIFICATION YARD

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Filed Aug. 28, 1958, Ser. No. 757,715
5 Claims. (Cl. 246—182)

This invention relates to a railway car classification yard, and more particularly pertains to an organization for controlling the speeds of cars passing through one or more successive car retarders according to a predeterminde retardation pattern.

In a classification yard, a train of railway freight cars is pushed over the crest of a hump, and each car is then allowed to roll by gravity down the hump and over a number of route-selecting switches to a particular one of a number of destination tracks. In this way, the cars of a train can be classified according to their intended destinations.

The grade of the hump is made sufficient so that the car with the hardest rolling characteristics can travel over track providing relatively high rolling resistance and yet reach the most remote destination in the classification yard despite other adverse factors, such as strong headwinds, with sufficient speed to couple onto other cars already in that destination track. Easier rolling cars, must, consequently, be decelerated so that they too may reach their destination tracks with a suitable coupling speed. This deceleration is accomplished by providing car retarders along the track rails whose brake shoe beams apply controllable braking pressure to the rims of the car wheels.

In rolling from the crest of the hump, the cars are switched by an automatic switching system from the main track to a plurality of branch tracks and then over additional switches to their final destination tracks. One or more car retarders are located along the main track, and these are called "hump retarders." Additional car retarders are included in the branch tracks as well so that the speed of each car or cut of cars can be controlled according to the particular conditions relating to the group of tracks it will travel over, and these retarders are called "group retarders."

In modern classification yards, apparatus is provided for automatically controlling the various retarders with the objective of causing each car to reach its intended destination with a preselected coupling speed. The control system determines the car's weight, its rolling characteristics, destination, distance-to-go, and various other factors, and from this data determines the desired release speed for each car from the final retarder. Speed measuring apparatus is also provided that is effective to release each retarder as soon as the car's speed has been reduced to the desired value.

The kinetic energy that a car possesses as it enters a retarder is directly related to its weight so that a greater braking effort must be applied by the retarder to a heavy weight car than to a car of lighter weight. Another limitation in selecting the braking effort to be applied by the retarder results from the fact that a too-heavy retardation applied to a light car will actually squeeze the car wheels out of the brake shoe beams so that the effectiveness of the retarder is greatly diminished. It is, therefore, the practice to determine the weight of each car as being in one of several categories such as the three categories of light, medium, and heavy. The retarder is initially set for each car then in accordance with its weight class, and this setting is made so that the heaviest car likely to be encountered in a particular weight class can have its speed reduced as it passes through the retarder

from the maximum entering speed expected to the lowest probable exit speed. It has also been the practice to continually measure the speed of each car, as by radar speed measuring apparatus, as the car passes through the retarder and to reduce or entirely release the retarder's braking effort when it has been determined that the car speed is at or near the predetermined release speed.

It follows that, according to the above-described manner of operation, the preselected retardation setting of a retarder in accordance with the weight class of a particular car will, nevertheless, act on the car according to whether its weight is at one extreme or the other of its weight class. Specifically, a particular predetermined position of the retarder may be established for a car known to be in the medium weight class, and this setting of the retarder will, it is known, be effective to reduce the speed of the heaviest car in the medium weight class to its desired exit velocity from the highest expected retarder entering speed likely to be possessed by such a car, and substantially the entire length of the retarder will be required in order to effect this amount of deceleration. On the other hand, this same setting of the retarder will produce a considerably higher rate of deceleration on a car that is the lightest of those in the medium weight class. Consequently, this setting of the retarder will cause the lightest of the cars in the medium weight category to have its speed reduced to the desired exit velocity within the first portion of such retarder rather than utilizing all or substantially all of the retarder to accomplish this result.

The above-described mode of operation has been given particularly with respect to cars of the medium weight classification, but it necessarily follows that it applies as well to cars of any of the various classifications. Thus, it may be stated that, in general, a car whose weight is near the maximum for its particular weight classification, regardless of which weight category this is, will have its speed reduced gradually as it moves through the retarder, and will not reach its predetermined release velocity until it is near the exit end of the retarder. On the other hand, a car in any weight category whose weight is at the light end of the range of values for that category will have its speed reduced to substantially the desired exit velocity in the very first portion of the retarder.

It follows from this description, therefore, that whenever a car of light weight in its particular weight classification is followed by another car whose weight is at the heavy end of its weight classification, there will be a tendency for the second car to catch up with the first since the first car will have a considerably lower average velocity while traveling through the retarder than will the second car. If the separation between the two cars is sufficiently reduced in this way, it will be impossible for the two cars to be sent to divergent routes since there will not be sufficient time after the first car has passed over a particular switch for that switch to be operated to the opposite position before the second car passes over such switch. Alternatively, this condition of loss of separation also brings about what is known as "cornering" which results when the two close-together cars are sufficiently spaced to travel over divergent routes but are so close to one another immediately after passing over the particular switch that caused their routes to diverge, that the two car bodies will collide and do considerable damage.

One expedient for overcoming the undesirable characteristics of operation here described is to provide a large number of weight classifications and a correspondingly large number of different retardation settings so that for each car, regardless of its weight, a particular corresponding retarder setting can be established that will result in requiring the substantial entire length of the retarder to reduce the speed of that car from the entrance speed

to the desired exit speed. This expedient, however, requires a considerable increase in complexity in both the weight measuring apparatus and in the car retarder control means.

To overcome these objections, it is proposed, according to the present invention, to provide a system whereby substantially the entire length of a retarder will be utilized in bringing the speed of a car down from its entering speed to the desired leaving speed, irrespective of the weight of the car. In general, this is accomplished by establishing a predetermined retardation pattern for each car. According to this system, there is established a varying quantity which represents the permissible speed of the car at each point in its travel through the retarder. This permissible speed level for the car at each instant takes into account the effectiveness of the remaining portion of the retarder in reducing car speed and thus its magnitude constantly is diminished as the car passes through the retarder. The control system then attempts to control the speed of the car so that the speed will continually correspond to that value represented by the varying analog. In this way, the speed of each car, regardless of weight is reduced gradually to the desired exit velocity so that overtakes are considerably diminished.

It is, accordingly, an object of this invention to provide a control system for a car retarder classification yard wherein each retarder is controlled so as to bring about a gradual reduction of car speed over the length of retarder.

It is a further object of this invention to provide a control system for a car classification yard wherein overtakes of successive cars is reduced to a minimum.

It is another object of this invention to provide a system for the control of the retarders in a car classification yard in which the stored analog of desired car velocity at each point in the progress of the car through the retarder is progressively reduced in response to the successive Doppler frequency pulses provided by the radar speed measuring apparatus.

Other objects, purposes, and characteristic features of this invention will be obvious from the drawings and will be described as the description of the invention progresses.

To describe this invention in detail, certain conventional illustrations and symbols are used. Electromagnetic relays are illustrated diagrammatically, and various electron tubes are shown in a conventional manner and without illustrating the filaments for such tubes. The symbols (B+) and (B−) illustrate connections made to the positive and negative terminals, respectively, of a source of voltage suitable for the operation of various electron tubes, and the symbol for ground connection indicates a connection made to voltage intermediate between the (B+) and (B−) levels. The symbols (+) and (−) indicate connections made to the positive and negative terminals, respectively, of a source of lower voltage suitable for the operation of relays and the like.

In describing this invention in detail, reference will be made to the accompanying drawings which illustrate one specific embodiment of this invention. In these drawings:

FIGS. 1A and 1B, when placed side by side, illustrate one embodiment of this invention;

FIG. 2A illustrates graphically the mode of operation in the control of retarders according to the prior art; and

FIG. 2B illustrates graphically the mode of operation in the control of car retarders according to the present invention;

FIG. 3 illustrates the control circuits for the retarder control mechanism.

Described briefly, it is contemplated that, in the system of the present invention, a voltage analog of car speed will be established which will represent the permissible speed of the car at each point of its travel through the retarder. This quantity is a function of the car's position in the retarder, the desired leaving speed of the car

from the retarder, and the capabilities of the retarder in reducing the speed of the car as it passes through the retarder. More specifically, as each car enters the retarder there is stored in a storage means the voltage analog of maximum permissible car speed for a car entering the retarder. This voltage analog is arrived at by taking into account the approximate desired release speed of the car from the retarder and the capabilities of the retarder in reducing car speed over its entire length. If the speed of the car as it enters the retarder is in excess of this stored voltage analog, then the predetermined braking pressure of the retarder, selected in accordance with the weight class of that car, is applied. As the car progresses through the retarder, the stored voltage analog is progressively reduced in value by successive increments so selected that, just before the car is about to emerge from the retarder, the stored voltage analog will have been reduced to an amount representing a velocity equal to that which has been determined by the computing means as being the proper release speed for that car from the retarder.

As the car progresses through the retarder, the predetermined retarder pressure, selected in accordance with car weight classification, is applied whenever the measured car speed is in excess of that corresponding to the stored voltage analog, but is released whenever the car speed falls below this value. When the stored voltage analog has been reduced to the value representing the computed exit velocity, then the retardation will be selectively applied in accordance with whether the measured car speed is above or below such computed value. In this way, each car, regardless of its weight, has its speed reduced progressively as it passes through the retarder; it is not possible for a light weight car in any particular weight category to have its speed reduced abruptly in the first portion of the retarder and thus bring about the occurrence of overtakes.

FIG. 1A shows a portion of one of the branching tracks referred to above. For the purposes of describing this invention, it is not deemed necessary to illustrate the hump retarder or the control thereof nor the route-selecting switches which are to be found between the hump and group retarders. As is common practice, two successive group retarders are shown in the single stretch of track which diverges, over a number of route-selecting switches, to a plurality of classification tracks. Each of these tracks is diagrammatically illustrated as being occupied by a plurality of freight cars. Each of the group retarders has associated therewith a retarder control mechanism RCM which is selectively controlled in the manner shown in FIG. 3.

In advance of the No. 1 group retarder of FIG. 1A is shown weighing means comprising a floating weighing rail WR which is variously deflected in accordance with the weight upon it, and this acts upon the weight detector WD selectively in such a way that a determination can be made as to whether each car is of the heavy, medium, or light-weight class. Weight measuring means of this kind is shown and fully described in the co-pending application of S. M. Phelps, U.S. Ser. No. 386,095, filed October 14, 1953, now Patent No. 2,868,534, and assigned to the assignee of the present invention.

The speed measuring apparatus is shown as including a directional antenna positioned between the track rails near the exit end of each retarder. The transmitter-receiver such as the transmitter-receiver 10 associated with the directional antenna for the No. 1 group retarder provides a high frequency signal which is directed by the antenna towards approaching cars. The antenna also receives the higher frequency signal that is reflected from such approaching cars. The increase in frequency of the reflected signal is in accordance with the Doppler principle and is directly related to the velocity of the approaching car with respect to the antenna. The transmitter-receiver 10 mixes the two signals of different frequency to obtain a

difference or beat frequency signal which is proportional to car speed. This beat frequency signal is applied to the No. 1 discriminator 11 which controls the operation of both speed and anticipation relays which is used in effecting the release of the retarder and also actuates the check and exit relays 1CK and 1EX to provide certain desired functions as will be explained.

FIG. 1A also shows that an exit velocity computer 12 is provided, and this computer determines for each car or cut of cars that is to pass through the one or more retarders at a group retarder location, the desired leaving speed of the car or cut from the final retarder section. Since the particular type of exit velocity computer used is immaterial to the operation of the present invention, its function will not be described in detail. Briefly, the computer may be assumed to be of the D.C. analog type as is disclosed, for example, in the U.S. patent application of Auer et al., Ser. No. 782,153, filed December 22, 1958, which provides an output signal in the form of a direct-current voltage whose level is proportional to the velocity that a car should have as it emerges from the No. 2 group retarder. The computer 12 is shown as receiving a plurality of inputs, each of which has been found to affect the determination of the desired exit velocity. Among the input factors are the characteristics of the track to be traversed by the car after leaving the retarder, the car's rollability as determined by measuring its performance over a previous stretch of track, car weight, cut length, the distance that the car must travel after emerging from the last retarder until it reaches the point of coupling in the selected classification track, the desired coupling velocity, and other miscellaneous factors which may include a manual adjustment made by an operator.

The output voltage of the computer 12 is applied directly over wires 13 to the speed relay control circuit 14 of the No. 1 discriminator and over wire 15 to the speed relay control circuit 16 of the No. 2 discriminator. It will be noted that the No. 1 and No. 2 discriminators for the two respective group retarders are identical; however, in order to provide for a detailed description of the present invention, the speed relay control circuit 16 of the No. 2 discriminator has been shown in detail whereas the corresponding circuit is shown only in block diagram form in the No. 1 discriminator.

A potentiometer 17 is shown as being connected between the wire 13 on which appears the output voltage of the computer 12 and the wire 18 which is connected to the (B+) terminal. As a result, there appears on the movable tap of the potentiometer 17 a voltage which is applied to the anticipation relay control circuit 19 of the No. 1 discriminator over wire 20 which is a function of the output voltage of computer 12 but is somewhat greater than this voltage in accordance with the position of this tap. As will presently be described, the level of the voltage applied to the speed and anticipation relay control circuits of each discriminator controls the operating point of the respective relays S1 and A1. Since the speed relay control circuit 14 receives a voltage corresponding to the desired release speed as provided by the computer 12, the relay S1 will be actuated when the car speed has been reduced to such level. However, since the anticipation relay control circuit 19 receives a voltage on wire 20 that is somewhat higher, the relay A1 will be actuated as soon as the car speed has been reduced to a level somewhat greater than the desired release speed as determined by the computer 12. This provides for a partial release of the retarder braking effort just prior to the car's speed having been reduced to the desired release speed as will later be more fully explained.

In describing the operation of the discriminator circuits, reference will be made particularly to the No. 2 discriminator of FIG. 1B since it is here that the speed relay control circuit is shown in detail. The beat frequency signal provided by the transmitter-receiver 21, which is connected by wire 21*a* to a directional antenna associated with retarder No. 2, is applied to the cathode follower 22. The cathode follower 22 supplies its output signal, which is still the beat frequency signal proportional to car speed, to the pulse forming circuits 23 and also to the check relay control circuit 24 and the exit relay control circuit 25. The function of the cathode follower is to isolate the output of the transmitter-receiver 21 from the various circuits to which its output beat frequency signal is applied.

The exit relay control circuit 25 controls the relay 2EX in accordace with the amplitude of the beat frequency signal. This circuit organization causes relay 2EX to be picked up whenever the beat frequency signal has an amplitude above some predetermined minimum value and to release when this signal reaches a low value indicating that the car or cut has passed over the directional antenna and is at the point of leaving the respective retarder. The check relay control circuit 24 also operates in accordance with the amplitude of the beat frequency signal but is instead so organized that it causes the picking up of relay 2CK when the weight detector WD is first actuated, provided the beat frequency signal has an amplitude above some minimum value with the result that this relay is actually picked up just prior to the entry of a car or cut into the associated retarder and remains picked up while the car is in the retarder. For a detailed description of the check and exit relay control circuits, reference may be made to the copending application of Kendall and Auer, Jr., Ser. No. 513,364, filed June 6, 1955, and assigned to the assignee of the present invention.

The pulse forming circuits 23 respond to the beat frequency signal by providing an output comprising a square wave of voltage whose frequency equals the frequency of the original beat frequency signal. This square wave of voltage is amplified by the amplifier-inverter 26 and applied to both the speed relay control circuit 16 and the anticipation relay control circuit 27. The square wave pulses have a varying frequency which corresponds continuously to the speed of the approaching car; however, the pulses are all of uniform amplitude and of uniform width. As shown diagrammatically in FIG. 1B, the output of the pulse forming circuits 23 comprises positive-going pulses; whereas, the output of the amplifier-inverter 26 comprises negative-going voltage pulses.

Various relationships between speed, frequency, and voltage may be established. As an aid in describing the operation of this system, it is desirable to assume certain relationships among the different quantities. Thus, in one specific embodiment of this invention, the high frequency signal that was transmitted towards moving vehicles was selected to be of a value which would result in a beat frequency of approximately 7.5 cycles per second for each mile per hour of car speed. A car moving at 8 miles per hour, for example, then causes a beat frequency signal of 60 cycles per second. Furthermore, the relationship between frequency and voltage was established on a one-to-one basis. Thus, the voltage analog relating to a car speed of 8 miles per hour with a resulting beat frequency of 60 cycles per second was a D.C. voltage of 60 volts.

The speed relay control circuit 16 of FIG. 1B controls the actuation of relay S2 in such a manner that this relay is released and thereby opens the retarder at a particular car speed whose value is dependent upon the output voltage of the computer 12 as applied to the cathode of the diode 28. More specifically, in accordance with the relationship described above, if a voltage level of 60 volts is applied to this cathode from the computer 12, the release of relay S2 will occur when the car speed has been reduced to 8 miles per hour.

The manner in which this control of relay S2 is obtained will now be described in detail. Thus, the plate of the diode is connected through resistor 29 to (B+); therefore, the voltage at the plate of this tube tends to rise to

the (B+) level. However, it cannot rise substantially above the level of the control voltage applied to the cathode of diode 28 since any attempt of the plate to rise appreciably above this level results in conduction with an increased voltage drop across the plate resistor 29. Thus, the plate voltage of diode 28 rests normally at a voltage only slightly above that applied to the cathode.

The negative-going rectangularly spaced pulses of constant width and amplitude appearing at the output of the amplifier inverter 26 are applied through capacitor 30 to the plate of diode 29 and cause the voltage at the plate of diode 28 to decrease by a corresponding amount for each negative-going excursion. Thus, negative-going voltage pulses appear at the plate of diode 28. Now, however, the upper level of each pulse is fixed as being just slightly above the level of the voltage at the cathode of diode 28. Although their width and amplitude are still constant, the average value of the pulses is now determined by the control voltage which sets their upper base line. Thus, with a high value of control voltage, the pulses have a high average value since their upper level is then at a high value. Similarly, a low value of the control voltage causes the pulses at the plate of diode 28 to have a low average value since their upper level is then at a lower value.

These negative-going pulses at the plate of diode 28 are applied to an integrating circuit that comprises the capacitors 31 and 32 and the resistors 33 and 34. Under normal conditions, when no car is present to provide a beat frequency signal, triode tube 35 is fully conductive since its grid is connected to the plate of diode 28, and this plate is steadily positive when it is not receiving negative pulses from amplifier-inverter 26. The resultant large voltage drop across plate resistor 36 then results in a relatively low voltage at the plate of this tube. This low voltage is unable to overcome the negative bias provided by the connection of the grid of tube 37 through resistor 38 to (B—) so that tube 37 is cut off and relay S2 included in its plate circuit is dropped away.

The negative-going pulses at the plate of diode 28 charge the integrating capacitors 31 and 32 negatively. The higher their frequency, the less that capacitors 31 and 32 can discharge between successive pulses; consequently these capacitors 31 and 32 become negatively charged to an amount directly dependent on the frequency of these negative going pulses. The reduced charge on capacitors 31 and 32 is, of course, also a function of the average or D.C. level of these pulses. When their average value is high, they are less able to reduce the charge on these capacitors than when they are of low average value. Thus, the smaller the control voltage applied to the cathode of diode 28, the lower the average value of the pulses at the plate of this tube and the greater the charge on capacitors 31 and 32 will be reduced. A more detailed disclosure of the mode of operation of the integrating circuit is found in the prior U.S. patent application of Kendall et al., Ser. No. 359,162, filed June 2, 1953.

Since the charge on the integrating capacitors 31 and 32 is thus dependent on pulse frequency and on the value of the voltage applied to the cathode of tube 28, it is possible to balance the two so that tube 35 will just verge on the condition of conductiveness. In other words, for each value of control voltage directly affecting the average value of the pulses, there is a corresponding frequency of these pulses such that the average charge on capacitors 31 and 32 is just sufficient to allow tube 35 to conduct. When the pulse frequency is increased, but with the control voltage remaining the same as compared to the balance condition, capacitors 31 and 32 receive more negative charging pulses in any given period of time and so assumes a more negative average charge, causing tube 35 to be driven beyond cut off. Similarly, maintaining pulse frequency, but lowering the control voltage causes pulses at the same rate but a lower average value to charge capacitors 31 and 32 so that their average charge again becomes less positive. On the other hand, a reduction in the pulse frequency or, alternatively, an increase in the control voltage causes capacitors 31 and 32 to be more highly charged so that tube 35 then becomes conductive.

Consequently, for any value of control voltage applied to the cathode of diode 28 and representing a corresponding car speed, there is a pulse frequency at which the balanced condition occurs with tube 35 verging on the conductive condition, and it is at this car speed that relay S2 drops away to thereby actuate the retarder mechanism. For higher car speeds, the pulse frequency is greater, capacitors 31 and 32 are more negatively charged, tube 35 is cut off, tube 37 is conductive, and relay S2 is picked up. For lower car speeds, the opposite conditions prevail, and relay S2 is dropped away.

Before describing further the apparatus of FIGS. 1A and 1B, it is believed expedient to describe how control of the retarder is effected, particularly how the factor of weight influences the positioning of the retarder. The manner in which the retarder operating mechanism is selectively controlled is illustrated in FIG. 3. When there is no car in, or immediately in approach either of the group retarders so that the check relay 1CK is dropped away, the repeater relay 1CKP associated with the check relay is dropped away. Consequently, a circuit is then completed from (+), through back contact 39 of relay 1CKP and over wire 40 to the input wire No. 4 of the retarder operating mechanism ROM. The application of electrical energy to this particular wire causes the retarder to assume a fully closed position.

When the car approaches the retarder so that the relay 1CK is picked up, the repeater relay 1CKP also picks up and this results in the application of energy from (+) through front contact 39 of relay 1CKP to wire 41. If the speed relay S1 is picked up at this time, as would normally be the case, indicating that car speed is above the desired car speed, energy is then applied from wire 41, through front contact 42, to wire 43.

The position to which the retarder operating mechanism is operated is dependent upon car weight since a heavy car requires a greater braking effort than does a light car. For a car detected as being of the heavy weight classification by the weighing device, relay 1H is picked up. Under these circumstances, energy is then applied from wire 43, through front contact 44, to wire 45.

Normally, the car speed would, upon entry of the car in the retarder, be above the speed at which the anticipation relay A1 drops away. Therefore, the energy appearing on wire 45 would be applied through front contact 46 to the No. 4 input wire of the retarder operating mechanism so that the retarder is operated for the heavy car to its fully closed position. As the heavy car is decelerated by the retarder, its speed eventually reaches the particular speed at which the anticipation relay A1 is controlled to drop away. When this occurs, front contact 46 of relay A1 opens, thereby removing energy from the input wire No. 4. At this time, the back contact 46 closes to energize the input wire No. 3. This results in the partial opening of the retarder. When the car speed has been further reduced to the level at which the speed relay S1 is to operate, back contact 42 of relay S1 closes and energizes the input wire No. 0 of the retarder operating mechanism. This results in the retarder being operated to its fully released position.

By analogy with this description it is evident that, with car speed above the releasing speeds for the A1 and S1 relays, the retarder operating mechanism is controlled to apply braking pressure in accordance with the weight as determined by the conditions of relays 1H, 1M, and 1L. Upon the operation of the anticipation relay A1, the retarder is partially opened so as to decrease the braking effect on the car. Finally, when car speed has been further reduced to substantiate the desired leaving speed from the retarder, the relay S1 drops away and the retarder is then fully open.

As was previously explained, each of the various retarder settings is originally adjusted to ensure that the application of that particular retarder pressure to all cars of the corresponding weight class will be effective in reducing the speeds of all such cars from the maximum expected retarder entering speed down to the usual levels of release speed. For example, as shown in FIG. 3, the retarder is initially set in the No. 3 retardation position for a car whose weight has been detected as being in the medium class. This particular position of the retarder must then be effective to reduce the speed of the heaviest of the different cars in the medium weight class from its maximum retarder entering speed to the desired leaving speed. This control of the retarder is shown in the upper curve of FIG. 2A which shows how the speed of a maximum weight car in a particular weight class may be varied as it moves through the retarder. The graph shows that the car speed is not reduced while the car is in the No. 1 group retarder to a sufficiently low speed to result in the release of either the A1 or S1 relays. It is not until the car is substantially near the exit end of the No. 2 group retarder that its speed is reduced to the level where the relay A2 will drop away. This level of operation of the relay A2 is shown as being somewhat above that of the relay S2 which, in turn, is shown as operating at the particular car velocity determined by the output of the computer 12. Upon the release of the anticipation relay A2, the retarder braking effort is partially reduced as shown by the decrease in slope of the curve, but some retardation is continually applied until the relay S2 drops away. At this time, the retarder is fully opened and the car speed then remains substantially constant during the remainder of its travel through the retarder.

The particular retarder setting that is established in view of the requirements of the heavier cars in a particular weight class is, according to the systems of the prior art, effective to reduce the speeds of minimum weight cars in any weight class to the desired release speed within the first portion of the No. 1 group retarder. This is shown in the lower of the two curves of FIG. 2A. It is assumed that, as is the usual practice, the various control relays A1, S1, A2 and S2 are governed to be released sequentially in the order given as the car speed is reduced. This sequential operation is obtained by providing a somewhat higher control voltage on wire 27*a* for the anticipation relay control circuit 27 than for the speed relay control circuit 16 by means of potentiometer 60. Still higher control voltages are similarly provided for the speed and anticipation relay control circuits 14 and 19, respectively, by providing potentiometers connected in a manner similar to potentiometer 60.

As shown, the car speed is rapidly reduced until the speed is reached at which the anticipation relay A1 will drop away. The braking effort is then decreased but continues until a lower car speed is reached when the relay S1 drops away. The car then receives no more retardation in the No. 1 group retarder so that its speed may remain substantially constant until it enters the No. 2 group retarder. Of course, if the car were to accelerate further in the No. 1 group retarder after the relay S1 had dropped away, this relay would again pick up when the car speed had become somewhat in excess of the value which produced the release of this relay, and the retarder would then reapply braking pressure to such car.

As the car enters the No. 2 group retarder, its speed is further reduced since the full retarder pressure for the weight class of that car is applied, and this retardation remains in effect until the anticipation relay A2 drops away. The braking effort is then somewhat reduced until the car speed has finally reached the level at which the relay S2 is released. All retardation is then removed and the car will then pass through the rest of the No. 2 group retarder without any further braking, provided that its speed does not rise appreciably above the precomputed release speed.

This prior art mode of operation as illustrated in FIG. 2A results in the fact that a car whose weight is at the lower end of the range of car weights in its particular weight class will have its speed reduced within the first portion of the group retarders and will, therefore, travel through the remainder of the retarder sections at a relatively low speed. This condition greatly increases the possibility of an overtake since the following car will not, unless it is also of minimum weight for its class, have its speed brought down to the precomputed release speed until it is substantially about to emerge from the group retarders.

To overcome these drawbacks of the retarder control systems of the prior art, the system of the present invention has been devised. Thus, a capacitor 47 has been provided, and this capacitor is initially charged for each car to a voltage that represents the analog of the permissible speed the car may have as it enters the No. 1 group retarder. This voltage is selected in accordance with the usual values of release speed for the different cars from the No. 2 group retarder and also in accordance with the capabilities of the retarder in reducing the speeds of cars. As has been stated, the initial retarder position is selected in accordance with car weight so that it might at first appear that the capabilities of the retarder are a function of the weight class of the cars. However, it has been found that the different retarder positions are roughly equally effective on the respective weight classes of cars in reducing the speeds of such cars within the confines of the retarder. In other words, the two successive group retarders are, in their No. 4 retarding position, approximately as effective in reducing their speed of a car falling within the heavy weight class as they are effective in the No. 3 position to reduce the speed of a medium weight car. Consequently, the weight of a car need not be taken into account in determining what the initial voltage on the capacitor should be. Also, although the desired exit velocity varies for different cars, it has been found that satisfactory results may be obtained by using an average value for the exit velocity. In actual practice it has been found desirable, in fact, to charge the capacitor initially with a voltage level that will ensure, under all conditions, that the capacitor will be discharged to the level of the computer output voltage before the car has reached the exit end of the No. 2 group retarder.

As will presently be shown, it is the voltage across the capacitor 47 which is applied to the anticipation and speed relay control circuits of both discriminators, and the result is that the objective of this system is continually to control the speed of the car at each instant in accordance with the level of the voltage on the capacitor, provided only that the capacitor voltage is above the output voltage of the computer 12. When the capacitor voltage becomes discharged to a level where it is below the computer output voltage, it then is the objective of the system to control the car speed in accordance with the computer output.

The capacitor 47 can become charged only in the event that both the check relays associated with the two discriminators are released. This ensures that the capacitor voltage will be effective on the discriminators only when both the No. 1 and No. 2 group retarders are unoccupied for reasons which will later be made clear. The charging voltage for the capacitor 47 is obtained from the junction of resistor 48 and potentiometer 49 connected in series between (B+) and ground. Adjustment of the tap on the potentiometer 49 provides the means for adjusting the level of the charging voltage in accordance with the principles described above. This charging voltage is effective through the back contact 50 of relay 2CK, wire 50*a*, back contact 51 of relay 1CK and wire 51*a* to charge capacitor 47. Upon the picking up of relay 1CK, which occurs when a car actuates the weight detector WD immediately in approach of the No. 1 group retarder, the

above-described charging circuit for capacitor 47 is opened.

The capacitor voltage is applied as the input signal to a cathode follower comprising triode tube 52. The output voltage of this cathode follower appearing across its cathode resistor 53 is somewhat less than the voltage on the capacitor but is, of course, of the same positive polarity and varies in accordance with such capacitor voltage. This output voltage is applied through the rectifier 54 to the wire 13. Initially, this voltage is substantially above the output voltage of the computer 12, and since the output impedance of the cathode follower is relatively low, it is this voltage that appears on the wire 13 rather than the output voltage provided by the higher impedance output of the computer 12.

The upper terminal of capacitor 47 is not only connected to the grid of triode 52 but also to the plate of another triode 55. This tube has its cathode connected through a current limiting resistor 56 to ground, and its control grid is connected through a capacitor 57 to the output of the pulse forming circuits 23. This tube 55 is normally biased to the cut-off condition by having its control grid connected through a rectifier 59 to the (B—) voltage terminal. The output pulses provided by the pulse forming circuit 23 are thus applied to the grid circuit of this tube. The voltage on the grid is prevented from ever becoming more negative than the level of the (B—) voltage supply because of the connection of the grid through the rectifier 59 to this (B—) terminal. However, each positive-going rectangularly shaped pulse obtained from the pulse forming circuits 23 produces a voltage increase on the grid of tube 55 and causes the rectifier 59 to present a high impedance in the grid circuit so that only a very slight charging of the capacitor 57 can occur. Consequently, substantially the full amplitude of each pulse appears on the grid of tube 55 and causes this tube to be conductive throughout the duration of such pulse. Each such occurrence of conduction of tube 55 results in a partial discharge of the capacitor 47.

As is well-known in the art, Doppler speed measuring systems of the radio frequency type employed in this invention provide, in effect, a separate pulse for each uniform increment of travel of the vehicle. Thus, for the micro-wave frequencies employed in one embodiment of this invention, one beat frequency pulse was provided for approximately each 2½ inches of travel of a railway car. Thus, it is known exactly how many pulses will be provided by the pulse forming circuits 23 in the time that it takes for a car to travel over the length of the No. 1 and No. 2 group retarders. With this known number of pulses, the cathode resistor 56 of tube 55 is selected in value such that the known number of pulses will discharge the capacitor 47 from its predetermined initial voltage to a value less than the lowest expected output voltage of the computer 12 by the time the car emerges from the No. 2 group retarder.

Consequently, the cars passing through the retarders have their velocities, according to the present invention, controlled in the manner graphically illustrated in FIG. 2B. A car whose weight is at or near the maximum for its weight class has its speed gradually reduced through the length of the two successive retarders so that it reaches the desired release velocity near the exit end of the No. 2 group retarder. The anticipation relay A2 is dropped away when the car speed is slightly above that precomputed for that car by the computer 12. The retarder becomes fully released only when the car speed has been brought down to the computed release speed so that the speed relay S2 will drop away.

For a car whose weight is toward the lighter end of its particular weight class, its retardation pattern may be substantially as shown by the lower curve of FIG. 2B. Thus, the intial setting of the retarder tends to reduce the car speed quickly as shown by the first portion of this curve. In the meantime, the capacitor 47 is continually being discharged by the pulses received from the pulse forming circuits 23. When the car speed reaches a value slightly above the existing capacitor voltage, the relay A1 will drop away. This point of operation of the relay A1 is fixed by the position of the tap of potentiometer 17. Thus, if this tap were at its lowest point so that the voltage on it were equal to the output of the computer 12, then the relay A1 would not be released until the car speed had been reduced to a level corresponding to the voltage then across the capacitor 47. However, the position of this tap is adjusted to provide for a partial release of the retarder's braking effort so that there will be less tendency for the car speed to be overcontrolled.

With the dropping away of the relay A1, the car is still decelerated but now at a less rapid rate. If the deceleration is such, however, that the voltage analog of the car speed at any instant becomes equal to or less than the voltage across capacitor 47, then the relay S1 will drop away and cause the retarder to be fully opened. Under these circumstances, the car will ordinarily then not decelerate further; it may, in fact, have its speed increased since the group car retarders are actually located on an accelerating grade. However, even if the car speed remains constant, the capacitor 47 is continually being discharged so that eventually the relay S1 may again pick up and cause the retarder to again apply braking force to the car. When the car enters the No. 2 group retarder the same mode of operation applies with respect to the control of the relays A2 and S2 associated with such retarder. The result is that the car speed may fluctuate gradually above and below the value represented by the progressively-discharging capacitor 47.

This action can occur, however, only until the capacitor 47 has discharged to the level where its voltage equals the output voltage of the computer 12. At such time, the rectifier 54 becomes effective in that the high back resistance it provides makes it impossible for the output voltage of the cathode follower tube 52 to be impressed upon the wire 13 when such voltage is less than that provided by computer 12. Therefore, when this condition is reached, the control of the relays S2 and A2 is entirely in accordance with the output voltage provided by the computer 12 so that the car will be released from the retarder at a speed at or very near that predetermined for the car by the computer.

It will be apparent from a comparison of FIGS. 2A and 2B that the conditions which tend to bring about overtakes in the operation according to the prior art are not present when the operation is according to the present invention as particularly illustrated in FIG. 2B. It will be noted from FIG. 2B that cars of either maximum or minimum weight in their particular class will all have their speed reduced gradually throughout their travel in the retarders. There is, therefore, no chance for successive cars to have their respective speeds considerably different as they pass through the group retarders.

As previously mentioned, it is necessary that both the check relays 1CK and 2CK be dropped away in order that the capacitor 47 can receive its initial charge. This condition requires that both retarders be unoccupied at the time a car is about to enter the No. 1 group retarder. If this condition is not met, the capacitor 47 will not be charged as the car enters the No. 1 group retarder and the output voltage of the cathode follower tube 52 will be at a low value, ordinarily below that provided by the computer 12 all the time that the car is passing through the retarders. For such a car, therefore, the principles of operation of this invention will not apply. More specifically, the voltage on wire 13 will then continually be the computer output voltage during the time that the car is moving through the group retarder and, if the car is of relatively light weight for its particular class its speed will be quickly reduced to the computed release speed. It will be evident from this description that this provides a

means for correcting partially for overtake condition that may have occurred before the cars entered the group retarders. If two successive cars are following one another so closely that the second is about to enter the No. 1 group retarder before the first has vacated the No. 2 group retarder, the capacitor cannot be charged and so cannot be effective and the second car will, unless it is of relatively heavy weight, be brought down to the release speed sooner than it ordinarily would, and this will tend to increase its spacing relative to the car ahead.

The control system of this invention has been described particularly in connection with the control of group retarders, but it is evident that it applies equally well to the control of hump retarders. It is also, of course, immaterial as to the location of the directional antenna associated with the speed measuring apparatus for each retarder.

Having thus described a control for car retarders in a railway car classification yard, I desire it to be understood that various modifications and adaptations may be made thereto without in any manner departing from the spirit or scope of this invention.

What I claim is:

1. In a system for controlling the speeds of railway cars rolling by gravity over a stretch of sloping track, a car retarder disposed along said stretch of track and operable selectively from a nonbraking position to a plurality of braking positions, computer means for predetermining a voltage analog of the desired exit speed of said car from the leaving end of said retarder in response to a plurality of factors to cause said car to arrive at a predetermined location beyond said retarder with a selected speed, means for setting up a voltage analog comparable to a velocity approaching the maximum velocity the car may have at the entrance to said retarder and yet have its speed reduced by said retarder over substantially its entire length to said exit speed, means for storing said voltage, radio frequency speed measuring apparatus effective to provide output pulses whose frequency is related to the speed of each car passing through said retarder, circuit means responsive to said pulses for progressively reducing said stored voltage as said car progresses through said retarder to cause said voltage to be reduced to a value representing a velocity for said car not greater than said desired exit speed of said car by the time said car leaves said retarder, and means responsive to said stored voltage when said voltage is greater than the output of said computer means but being responsive to the output of said computer means when said stored voltage is less than the output of said computer means for controlling the braking effect of said retarder on said car.

2. Speed controlling means for railway cars rolling by gravity over a stretch of sloping railway track comprising, at least a single car retarder disposed along said track and operable selectively to open and closed positions for selectively applying controllable braking pressure to the wheels of each car passing through said retarder, means for initially setting up a voltage whose amplitude is proportional to a car speed approaching the maximum speed a car may have at the entrance to said retarder and yet have its speed reduced within said retarder in response to a selected pressure exerted by said retarder to a value that will permit said car to arrive at a predetermined point beyond said retarder with a selected speed, speed measuring means of the radio-frequency type for providing a succession of pulses whose frequency is continuously proportional to the velocity of said car as it passes through said retarder, and means for reducing said voltage by substantially uniform decrements in response to said respective pulses to thereby cause said voltage to be proportional to the desired car speed when the car is at any point within said retarder, and means responsive jointly to said speed measuring means and said stored voltage for causing said retarder to apply said braking pressure as the car progresses through the retarder only when a voltage analog of the measured speed of said car is in excess of the then existing stored voltage.

3. In a system for controlling the speeds of railway cars rolling by gravity over a stretch of sloping railway track, a car retarder located along said stretch of track and selectively operable to open and closed positions for selectively applying controllable braking pressure to the wheels of each car passing through said retarder, computer means for predetermining a desired exit speed of said car from the leaving end of said retarder in response to a plurality of factors to cause said car to arrive at a predetermined location beyond said retarder with a selected speed, means for providing a voltage analog of car speed approaching the maximum velocity the car may have at the entrance to said retarder and yet have its speed reduced by said retarder over substantially its entire length to said exit speed, means for storing said voltage only provided that said retarder is unoccupied, radio-frequency speed measuring apparatus effective to provide output pulses of uniform width and amplitude whose frequency is proportional to the speed of each car passing through said retarder, and means for reducing said voltage in response to each of said pulses by an amount effective to reduce said stored voltage in response to the sum of said pulses received as said car passes through said retarder to a value representing a velocity less than said predetermined exit velocity, control means for said retarder receiving analog voltages representing both said desired exit speed established by said computer means and said stored voltage, means including a rectifier to prevent said stored voltage from being applied to said control means when said stored voltage has been reduced to a value less than the voltage corresponding to said desired exit speed, said control means being responsive jointly to said speed measuring means and to whichever of the speed voltages received by said control means is greater for causing said retarder to apply said braking pressure only when the measured speed of said car is in excess of that corresponding to the then effective speed voltage.

4. In a system for the control of the speeds of railway cars rolling by gravity over a stretch of railway track, at least a single car retarder located along the track rail and being selectively operable to open and a plurality of different braking positions, means for initially setting up a voltage whose amplitude is proportional substantially to the maximum speed a car may have at the entrance to said retarder and yet have its speed reduced within said retarder in response to a selected pressure exerted by said retarder to a value that will permit said car to arrive at a predetermined point beyond said retarder with a selected speed, storage means including a capacitor for storing said voltage weight measuring means for determining the weight classification of a car in advance of said retarder, means for selecting a braking pressure for said retarder in accordance with the measured weight class of said car, speed measuring means of the radio-frequency type for providing a succession of pulses of uniform width and amplitude whose frequency is continuously proportional to the velocity of said car as it passes through said retarder, circuit means including an electron tube associated with said capacitor and being rendered effective in response to each of said pulses to partially discharge said capacitor to thereby cause said voltage to be proportional to the desired leaving speed of said car from said retarder when said car is in substantially the final portion of said retarder, and means responsive jointly to said speed measuring means and said stored voltage for causing said retarder to apply said braking pressure only when the measured speed of said car is in excess of that corresponding to said stored voltage as a car progresses through the retarder.

5. Speed controlling means for railway cars rolling by gravity over a stretch of sloping railway track comprising, at least a single car retarder disposed along said track and capable of applying a controllable braking pressure to the

wheels of each car passing through said retarder, means for providing an analog voltage whose amplitude is substantially proportional to the maximum speed a car may have at the entrance to said retarder and yet have its speed reduced within said retarder to a value that will permit said car to arrive at a predetermined point beyond said retarder with a selected speed, a capacitor for storing said voltage, speed measuring means of the radio-frequency type for providing a succession of pulses whose frequency is continuously proportional to the velocity of said car as it passes through said retarder, circuit means including an electron tube associated with said capacitor and responsive to each of said pulses produced as said car passes through said retarder for rendering said tube momentarily conductive to thereby positively discharge said capacitor, whereby the voltage across said capacitor when said car is in substantially the final portion of said retarder is an analog of the desired leaving speed of said car from said retarder, and means responsive to both said speed measuring means and said voltage stored in said capacitor as a car progresses through the retarder for causing said retarder to apply said braking pressure only when the measured speed of said car is in excess of that corresponding to said stored voltage.

References Cited in the file of this patent

FOREIGN PATENTS

746,443	Great Britain	Mar. 14, 1956
208,415	Australia	May 30, 1957