

United States Patent

Murato et al.

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[54] **CONTROLLING SYSTEM FOR MEANS FOR ADJUSTING SPEEDS OF FREIGHT CARS IN A YARD**

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[51] Int. Cl.....B61j 3/12

[58] Field of Search.....104/26 R; 246/182 A; 105/1 A, 105/7

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Assistant Examiner—George H. Libman
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[57] **ABSTRACT**

A controlling system for means for adjusting speeds of freight cars in a yard, which is designed such that self-powered freight car speed adjusting means having arms to catch a thrust freight car, in catching said freight car, detects the freight car at a point a predetermined distance ahead of said arms, whereby it is preliminarily accelerated to make the speed differential between it and the freight car small.

11 Claims, 10 Drawing Figures

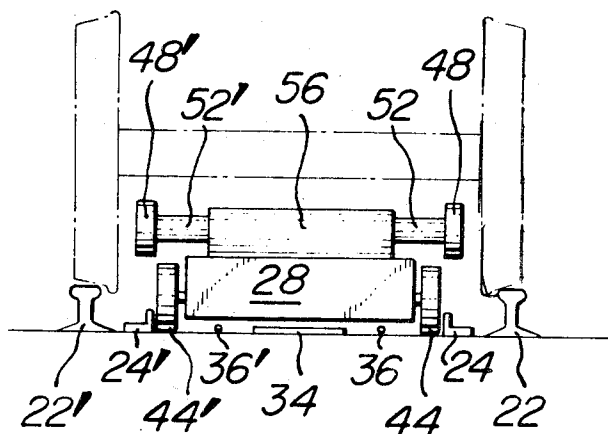


FIG. 1

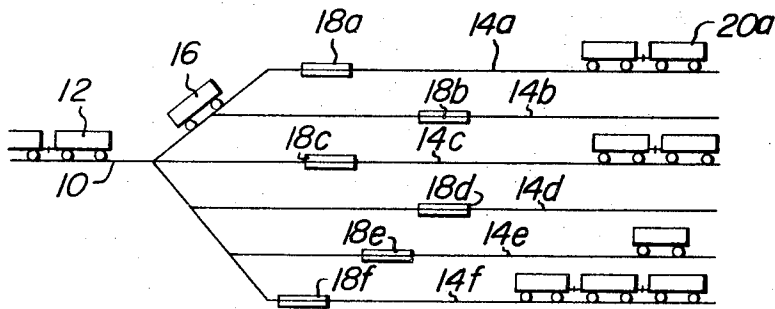
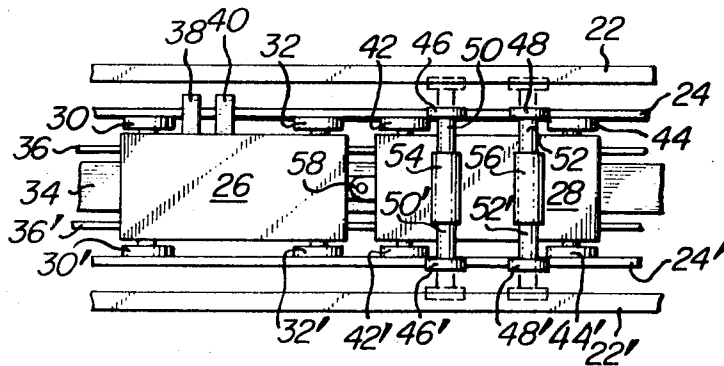


FIG. 2a



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FIG. 2b

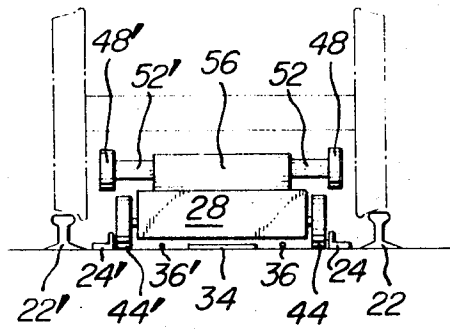


FIG. 2c

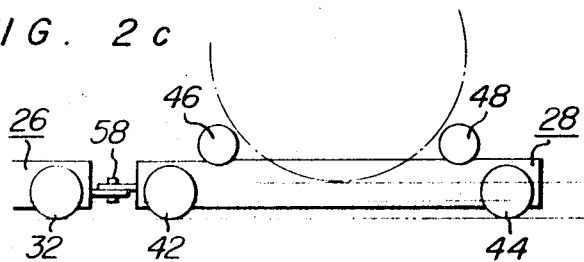
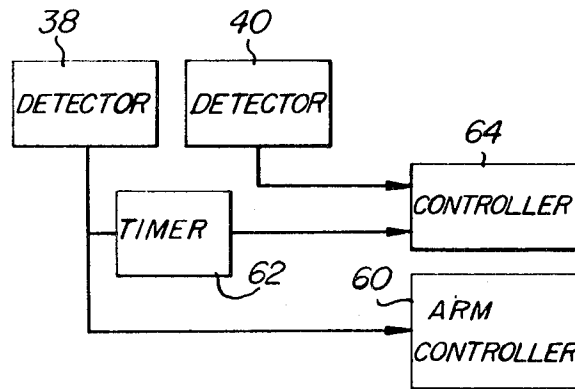


FIG. 3



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FIG. 4

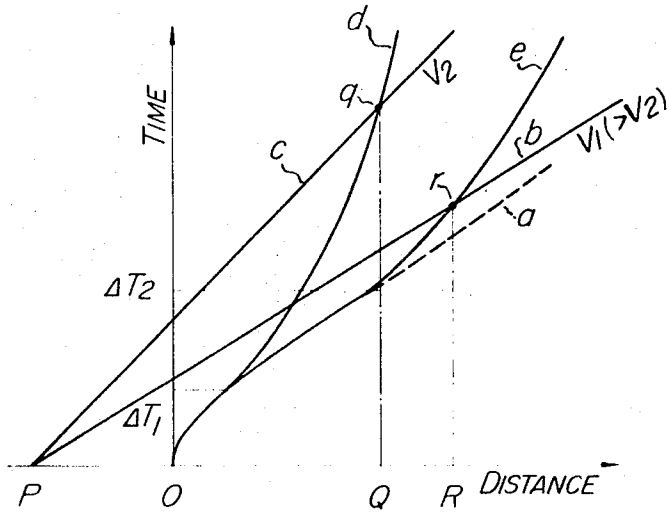


FIG. 6

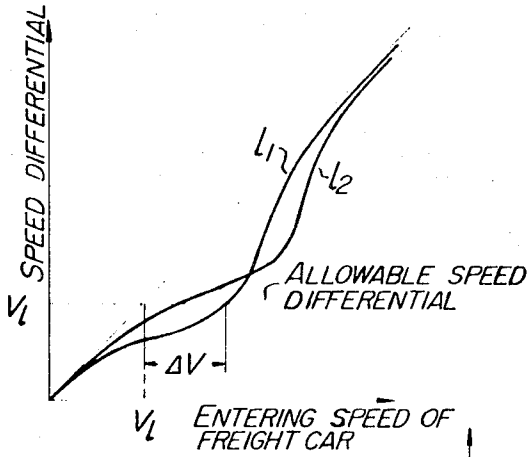
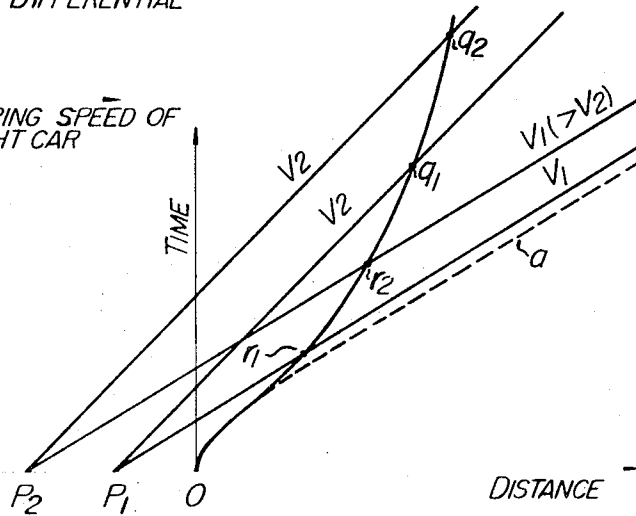


FIG. 5



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FIG. 7

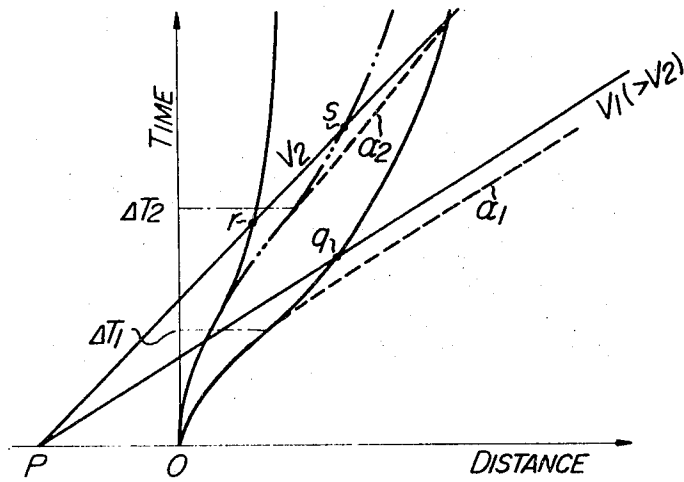
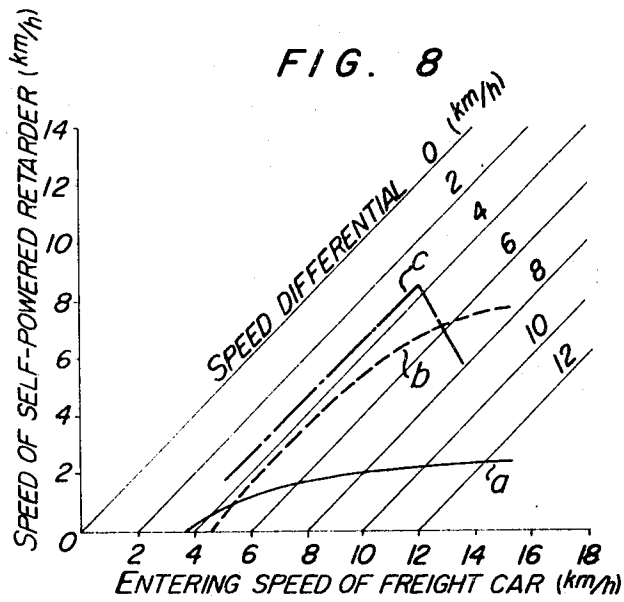


FIG. 8



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CONTROLLING SYSTEM FOR MEANS FOR ADJUSTING SPEEDS OF FREIGHT CARS IN A YARD

The present invention relates to a controlling system for means for adjusting the speed of a thrusting freight car in a yard, and more particularly relates to a system for controlling the operation of said means to enable the means to catch a thrusting freight car with a minimum impact force.

In general, a yard has arriving tracks for holding arrived freight trains standing by and assorting tracks for assorting the individual freight cars by their destinations. The assorting of the freight cars from the arriving track to the respective assorting tracks is effected by thrusting the individual freight cars, utilizing a hump in case of a hump yard, and a locomotive or a suitable thrusting device in case of a plane yard.

The freight cars for the destinations in the same direction, thus thrusting, are coupled together one after another, to organize a train for said direction. In this case, the individual freight cars are thrusting at a relatively high speed, i.e., about 20 km./h., so that if the freight car is coupled with the stationary freight train already organized at the same speed, the impact will be so large as to cause a dangerous condition.

For this reason, it has been a common practice to reduce the speed of the thrusting freight car to about 5 km./h., before it is coupled with the freight train, by means of a retarder provided at a predetermined position of the assorting track.

However, with such a fixed retarder, it is only possible to decelerate the freight car and, where the assorting track is long, there is the inconvenience that the decelerated freight car stops running before it reaches a desired position.

In order to eliminate such inconvenience, there has recently been proposed self-powered means for adjusting the speed of a freight car (self-powered retarder). This means is operative in such a manner that it receives a freight car coming into the assorting track, decelerates the freight car while travelling along therewith and stops running to release the freight car at the point when the speed of the freight car has been reduced to a predetermined level (e.g., 5 km./h.) and it has reached a predetermined location.

One of the most important problems in the operation of such self-powered retarder is the manner in which the freight car is received by the retarder. Although it is preferable to reduce the speed differential between the freight car and the self-powered retarder to zero, it is almost impossible, even if the freight cars are always thrusting at the same speed, to operate the self-powered retarder with no speed differential from the freight car at all times, because there are many factors to vary the speed, such as the type of the freight car, the condition of the track, the wind resistance and the load of the freight car.

In view of the above, efforts have been made to reduce the speed differential as close to an allowable value as possible.

One of the efforts will be described briefly hereunder: The self-powered retarder, first of all, allows the incoming freight to pass thereover to detect the freight car, and accelerates itself upon detection. As a result of the acceleration, the self-powered retarder passes the freight car and then decelerates itself to catch the freight car.

In such manner of control, however, the deceleration starting point to produce a condition of the speed differential being zero can hardly be determined, whereas if the deceleration is commenced at an optional point, it will be difficult to get the speed differential close to the allowable value. Thus, the value of the speed differential becomes instable and is always attributed to chance.

An object of the present invention, therefore, is to prolong the service life of the self-powered freight car speed adjusting means as well as to eliminate the danger involved in the freight car assorting operation, by minimizing the impact imposed on said means.

Another object of the invention is to allow the freight cars to be thrusting in a wide range of speed and thereby to enhance the efficiency of the assorting operation in a yard.

More specifically, the object of the present invention is to control the operation of the freight car speed adjusting means in a manner commensurate with the speed of the thrusting freight car and thereby to get the speed differential closer to the ideal value of zero.

One embodiment of the present invention is featured by the fact that the self-powered means for adjusting the speed of a freight car is preliminarily accelerated before it catches the freight car.

The preliminary acceleration is variable in its mode depending upon the duration of acceleration, the starting time of acceleration and the value of acceleration, and the mode of acceleration is determined in accordance with the speed of the freight car, by at least one of said factors.

Other objects, features and advantages of the present invention will become apparent from the following detailed description and the accompanying drawings which show embodiments of the invention.

FIG. 1 is a diagram for the purpose of explaining a freight car assorting operation in a yard;

FIGS. 2a-2c are a plan view, a front view and a side view respectively of means for adjusting the speed of a freight car, used in the present invention;

FIG. 3 is a block diagram of one embodiment of the controlling system according to the invention;

FIG. 4 is a graph for explaining the operation of the freight car speed adjusting means under the control of the controlling system shown in FIG. 3;

FIGS. 5 and 6 are graphs for explaining the operation of said means under the control of another embodiment of the controlling system of this invention;

FIG. 7 is a graph for explaining the operation of said means under the control of still another embodiment of the controlling system of this invention; and

FIG. 8 is a graph exemplifying the results of the experiments conducted by the present inventors.

Before going into the description of the embodiments of this invention, the yard operation and the construction of the self-powered means for adjusting the speed of a freight car, used in the yard operation, will be explained for the understanding of the present invention.

With reference to FIG. 1 which illustrates the yard operation, a freight train 12 having arrived at an arriving track 10 is decomposed and assorted successively by the destinations of the individual freight cars. Namely, a freight car thrusting from the freight train 12 proceeds into the designated one of the assorting tracks 14a-14f, according to the instruction from a control room or tower. For instance, a freight car 16 thrusting from the freight train proceeds into the assorting track 14a, and is decelerated to a predetermined speed by a self-powered retarder 18a, provided in said track, and released from said retarder at a point near freight cars 20a which are already coupled together and standing still, to be connected thereto.

The self-powered retarders 18b-18f, provided in the assorting tracks 14b-14f respectively, perform the same operation repeatedly to organize freight trains for the respective directions of destination in said respective tracks.

The construction of each of the self-powered retarders 18a-18 mentioned above, will be described with reference to FIGS. 2a-2c hereunder:

The self-powered retarder of the type described travels through a space beneath the freight car. For this purpose, the retarder is made flat as a whole, as will be described hereinafter, or alternatively a pit may be formed between the two rail tracks to provide for travelling of the retarder therein. Besides, several other types of the retarder may be considered but the present invention is not restricted in any manner by the type of retarder. In the following description of the invention, use is made of a retarder of the type mentioned first.

Referring to FIG. 2a which is a plan view of the self-powered retarder used in the system of this invention, reference numerals 22 and 22' designate rail tracks on which a freight car travels. The self-powered retarder travels along

guide rails 24 and 24', provided between the rail tracks 22 and 22'. Further, the self-powered retarder consists of a plurality of devices which are manufactured separately and assembled together to perform one function. Namely, the retarder shown is composed of a driving device 26 and a pushing device 28. These devices are provided separately because they must be made as flat as possible so as to be movable through the space below the freight car as shown in FIG. 2b (front view), though they may be manufactured as a unitary body. The driving device 26 may be further divided into a driving motor unit and a control unit therefor. The self-powered retarder produced by the present inventors is composed of the aforesaid three units. However, the constitution of the self-powered retarder does not constitute a part of the invention. For convenience in explanation, a description will be given on a self-powered retarder which consists of two units as shown.

The driving device 26 has wheels 30, 30' and 32, 32' for running along the guide rails 24, 24'. As driving source, a three-phase induction linear motor is used. Although not apparent in the Figures, the three-phase induction linear motor is mounted on the underside of the driving device 26, with its magnetic pole confronting a reaction rail 34, and energized through a current collector in sliding engagement with feeder rails 36, 36'. As another phase, i.e., a return circuit, the guide rails 24, 24' are utilized. The feeder rails 36, 36' generally have an opening on one side, with the other side and the upper and lower sides thereof being covered with an insulating material, and the current collector is inserted into said opening.

The driving device 26 also has various control means mounted thereon for operating the self-powered retarder in a correct manner as desired. These control means include detectors 38, 40 to detect the wheels of the freight car.

On the other hand, the pushing device 28 has wheels 42, 42' and 44, 44', similar to the driving device 26. It is also provided with rollers 46, 46' and 48, 48' which are brought into contact with the wheels of the freight car from both sides thereof and rotate with the respective wheels, to adjust the speed of the freight car; arms 50, 50' and 52, 52' supporting said rollers; and mechanisms 54, 56 which extend said respective arms outwardly, as indicated by the dotted lines, under hydraulic or pneumatic pressure, to locate said rollers adjacent the flanges of the respective wheels of the freight car as indicated in FIG. 2c (side view).

The driving device 26 and the pushing device 28, constructed as described above, are coupled together by means of a coupler 58 to constitute the self-powered retarder.

The controlling system for the self-powered retarder of the type described, according to the present invention, will now be described by way of several embodiments thereof.

As stated previously, the most important feature of the present invention is that the self-powered retarder is preliminarily accelerated. The mode of the preliminary acceleration is varied by the duration of acceleration, the starting time of acceleration and the value of acceleration.

First of all, the manner of controlling the duration of acceleration will be explained.

Referring to FIGs. 2a, reference numerals 38, 40 designate the detectors provided on the driving device 26 of the self-powered retarder to detect the wheels of a freight car. These detectors 38, 40 are mounted with a predetermined interval therebetween. It will be understood, therefore, that the speed of the freight car passing above the detectors can be known by measuring the period between the times when said respective detectors detect the wheel.

The output of the detector 38 is partially fed to an arm controller 60 as an instruction for extending the arms of the pushing device 28. The remaining part of the output is fed to a timer 62 to actuate the same, which has a predetermined time limit T. The output of the detector 40 is given to a controller 64 as a starting instruction for the self-powered retarder. Further, the output of the timer 62 is further fed to the controller 64 as a coasting instruction for the self-powered retarder, after said timer has counted the time limit T.

With the arrangement described above, when the freight car proceeds into the assorting track, the detector 38 detects the first wheel of the freight car, whereby the timer 62 and the controller 60 are actuated and the self-powered retarder assumes a posture of standing by, with the arms 52, 52' being extended. Thereafter, the detector 40 detects said first wheel, so that a starting instruction is given to the controller 64 and thus the self-powered retarder starts its operation.

After starting, the self-powered retarder is accelerated at a predetermined acceleration but, when the timer 62 has counted its time limit T, the coasting instruction is given to the controller 62 and the self-powered retarder begins to coast. In this case, an arrangement may alternatively be made such that the self-powered retarder is decelerated by a braking force applied thereto in response to a braking instruction.

With T' representing the period between the time when the wheel passes the detector 38 and the time when it reaches the detector 40, the period ΔT of acceleration of the self-powered retarder is $T-T'$. However, since the period T' is variable depending upon the speed of the freight car, the period ΔT of acceleration also varies according to the speed of the freight car. In other words, the value of T' becomes smaller and, therefore, the value of ΔT becomes larger, with the speed of the freight car increasing. Therefore, when the speed of the freight car is high, the period of acceleration of the self-powered retarder becomes long accordingly and the self-powered retarder begins to coast or to perform a braking operation after it has been accelerated to a high speed.

As the self-powered retarder is decelerated, the freight car catches up with the retarder and collides against the rollers 48, 48' on the extended arms 52, 52'. When the self-powered retarder catches the wheels of the freight car in the manner described, the arms 50, 50' are extended to hold the wheels between the rollers 46, 46' thereof and the aforesaid rollers 48, 48' respectively.

Thereafter, the self-powered retarder is further decelerated to a predetermined speed (e.g., 5 km/h.) and makes an inching operation up to the point where the freight car is to be released therefrom. At said point, the arms 50, 50' and 52, 52' are retracted and a brake is applied quickly, to release the freight car. The braking of the self-powered retarder may be effected by either a mechanical braking system or a counter current braking system in which the phase rotation of the three-phase AC voltage, supplied to the linear motor, is reversed. The inching operation is necessary, not only to bring the freight car to a desired position but also to stabilize the speed of the decelerated freight car at a desired level.

In the inching operation, the self-powered retarder calls for a driving force. The use of the linear motor as the driving force, as shown in FIG. 2, has an outstanding merit over the use of a rotating machine, as will be described below: namely, the number of freight car which is thrust into the assorting track is not always one but may be five or a number approximating thereto, and in case of the latter, a considerably large driving force is required for accelerating the freight cars. If the self-powered retarder is of the type which travels with the driving wheels being driven by a rotating machine, the driving force exceeds the adhesion limit between the driving wheel and the rail, resulting in a slip of the driving wheels. In contrast thereto, when a linear motor is employed for driving the driving wheels, which produces a nonadhesive driving force, the operation of the retarder is not in any manner restricted by the adhesion limit.

Now, the self-powered retarder which has released the freight car moves backward at full speed and returns to a position of standing by for the next incoming freight car. By the above step, one cycle of operation of the self-powered retarder is completed.

Next, the operation of the self-powered retarder up to the point where it catches a freight car, and the relative speed of the retarder and the freight car when said retarder catches the freight car in particular will be explained with the reference to FIG. 4.

Referring to FIG. 4, the origin 0 is the position of the roller 48 shown in FIG. 2c, and a point P indicates the position of the detector 40. The definitions of the points given above are the same in the similar graphs to be described hereinafter. Therefore, if the self-powered retarder is accelerated as indicated by the dotted line *a* from the origin 0, the speed of the freight car is varied as indicated by the straight lines *b* and *c* from the point P.

When the freight car enters the assorting track at a speed V_2 , represented by the straight line *c*, the self-powered retarder is accelerated for a period of ΔT_1 and the distance vs. time relationship of the retarder is as indicated by a curved line *d*. Thus, it will be seen that the self-powered retarder catches the freight car at a point Q. On the other hand, when the freight car enters the assorting track at a speed V_1 (which is higher than V_2) as indicated by the straight line *b*, the self-powered retarder is accelerated for a period of ΔT_2 and the distance vs. time relationship of the retarder is as indicated by a curved line *e*. Hence, the retarder catches the freight car at a point R.

The angles formed at intersections *q* and *r* by the respective straight lines and the tangents of the respective curved lines, represent the speed differential between the self-powered retarder and the freight car. It will, therefore, be obvious that when the entering speed of the freight car is high, the speed differential becomes smaller as the period of acceleration becomes longer.

Secondly, the effect of changing the starting time of the preliminary acceleration, i.e., the position of the detector to detect the wheel of the freight car, will be explained.

FIG. 5 is a graph which has exactly the same meaning as that of FIG. 4, but in the graph the position of the detector is shown at two locations P_1 and P_2 , the period of acceleration of the self-powered retarder being the same. The freight car is caught by the self-powered retarder at points q_1, r_1 and q_2, r_2 respectively, and the speed differentials at that time with respect to a varying speed of the freight car are as shown in FIG. 6. In FIG. 6, the one-dot chain line represents the relative speed of the retarder with respect to the speed of the freight car, when said retarder is stationary. In this case, the speed of the freight car is the speed differential as it is. A curved line l_1 represents a change in the speed differential with respect to the speed of the freight car when the detector is located at the point P_1 , and a curved line l_2 represents the same when the detector is located at the point P_2 .

Namely, in the case when the detector is located at the point P_1 , if the allowable speed differential is V_1 , the speed of the freight car can be up to $V_1 + \Delta V$, to hold the speed differential below the allowable value. Further, as will be apparent from a comparison between the curved lines l_1 and l_2 , if the allowable value of speed differential is greater, it is advantageous to locate the detector remote from the origin 0 to some extent, in that the upper limit of the entering speed of the freight car can be made higher. This is because the freight car assorting operation can be speeded up and an efficient use of the yard becomes possible.

Thirdly, the effect of controlling the value of acceleration in the preliminary acceleration will be discussed hereunder:

In this case, if the period of acceleration ΔT is constant, the effect of such control is essentially the same as in the case of the first embodiment wherein the period of acceleration ΔT is controlled, with the value of acceleration being constant. However, a more remarkable effect can be expected also in this case, by varying the period of acceleration ΔT depending upon the speed of the freight car.

The effect of controlling the value of acceleration is illustrated in FIG. 7. The speed of the freight car is V_1 and V_2 as in the case of FIG. 4. First of all, when the speed of the freight car is V_1 and the self-powered retarder is accelerated at an acceleration of α_1 and begins to coast or is braked after passage of a time ΔT_1 , the freight car is caught by the retarder at a point *q*. Similarly, when the speed of the freight car is V_2 and the self-powered retarder is accelerated at an acceleration of

α_2 and begins to coast or is braked after passage of the time ΔT_1 , the freight car is caught by the retarder at a point *r*. In this case, however, it should be noted that the speed differential at a point *s* where the self-powered retarder catches the freight car after having been accelerated for a time ΔT_2 at an acceleration of α_2 , is smaller than that at the point *r*.

Finally, the data actually obtained by the present inventors by practicing the present controlling system are exemplified in FIG. 8.

In the graph of FIG. 8, the axis of abscissa is scaled by the speed of the freight car and the axis of ordinate by the speed of the preliminarily accelerated self-powered retarder. The fine straight solid lines indicate the speed differential respectively. It will be seen that when the freight car enters the assorting track at a speed, for example, of 8 km./h., the speed differential is 8 km./h., if the self-powered retarder is held stationary. However, the speed differential progressively decreases with the speed of the self-powered retarder increasing, and finally becomes zero when the latter reaches 8 km./h. at which the retarder catches the freight car.

In the graph of FIG. 8, the thick solid curved line *a* is the case of the most simple mode of control wherein the duration of the preliminary acceleration if maintained at a fixed value of 0.3 second. In this case, the speed of the self-powered retarder is up to about 2 km./h. and hence only a slight decrease in the speed differential results. The dotted curved line *b* indicates a change in the speed differential when the distance from the detector 40 to the roller 48 (the distance \overline{OP} in FIG. 4) is 5 meters and the period of acceleration of the retarder is changed according to the speed of the freight car. In this case, the effect is remarkable as will be clear upon comparing the curved lines *a* and *b* with each other. The one-dot chain curved line *c* indicates a change in the speed differential when the aforesaid distance from the detector to the roller is decreased to 3.5 meters and the period of acceleration is changed according to the speed of the freight car. In this case, the effect is slightly greater than in the case of the curved line *b*. Incidentally, in the case of the curved line *c*, it will be seen that the speed differential increases abruptly when the speed of the freight car exceeds 12 km./h. This is because the distance from the detector to the roller is decreased and also because the speed of the freight car is so high that the freight car collides against the self-powered retarder in the process of acceleration of the latter as will be anticipated from the relationship shown in FIG. 6.

Although the controlling system of the invention for means for adjusting the speed of a freight car, such as a self-powered retarder, has been described and illustrated herein by way of several embodiments thereof, it is to be understood that the present invention is not restricted only to the embodiments shown but many modifications are of course possible within the spirit of the invention defined in the appended claims.

1. A controlling system for adjusting speeds of freight cars in an assorting yard comprising a self-powered mobile retarder means for retarding the speed of a moving freight car, said retarder means having arms for operatively connecting the freight car to the retarder means, detecting means on said retarder means for detecting the passage and the speed of said freight car, said detecting means being spaced a predetermined distance from said arms in a direction opposite to the direction of travel of the freight car, starting means responsive to said detecting means for preliminarily accelerating said retarder means a variable predetermined amount corresponding to the detected speed of the freight car, arm actuating means for actuating said arms to operatively connect said freight car to said retarder means after the preliminary acceleration of said retarder means, decelerating means for slowing down said retarder means and operatively connected freight car to a predetermined speed, releasing means for releasing the operative connection between said retarder means and said freight car after the freight car has been slowed to the predetermined speed, and returning means for returning said retarder means to a predetermined waiting position after the release of the

freight car, whereby the adjustment of the freight car speeds is enhanced by minimizing the speed differential between the freight car and the retarder means at the time they are initially coupled together.

2. A controlling system according to claim 1, characterized in that said starting means includes constant acceleration means for accelerating said retarder means at a constant acceleration rate for a time duration variable in accordance with the speed detected by the detecting means.

3. A controlling system according to claim 1, characterized in that said starting means includes variable acceleration means for accelerating said retarder means for a fixed period of time at an acceleration rate variable in accordance with the speed detected by the detecting means.

4. A controlling system according to claim 1, characterized in that said starting means includes means for varying both the acceleration rate and the acceleration time duration in accordance with the speed detected by the detecting means.

5. A controlling system according to claim 1, characterized in that said predetermined distance is variable such that it can be changed for different relative velocities between the retarder means and the freight car at the moment of their operative connection.

6. A controlling system according to claim 1, characterized in that said retarder means rides on tracks positioned between railroad tracks carrying the freight car.

7. A controlling system according to claim 1, characterized in that said retarder means is propelled by a linear motor.

8. A controlling system according to claim 1, characterized in that said detecting means includes a first detector for de-

tecting the initial passage of a portion of the freight car and a second detector spaced from the first detector in the freight car travelling direction to detect the presence of said portion at said second detector.

9. A controlling system according to claim 8, characterized in that said arm actuating means are operatively connected to said first detector for initiating the actuation of said arms in response to the detection of said portion by said first detector.

10. A controlling system according to claim 9, characterized in that said starting means includes controller means for starting the acceleration of said retarder means in response to the detection of said portion by said second detector and for ceasing the acceleration of said retarder means in response to a stop signal from a timer, said timer being started in response to the detection of said portion by said first detector and said timer being operative to issue said stop signal a predetermined amount of time after the timer has been started.

11. A controlling system according to claim 1, characterized in that said starting means includes controller means for starting the acceleration of said retarder means in response to the detection of said portion by said second detector and for ceasing the acceleration of said retarder means in response to a stop signal from a timer, said timer being started in response to the detection of said portion by said first detector and said timer being operative to issue said stop signal a predetermined amount of time after the timer has been started.

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