July 30, 1968 G. W. BAUGHMAN 3,395,274

MOVABLE BLOCK TRAIN SPEED CONTROL SYSTEM

Filed Jan. 12, 1966 2 Sheets-Sheet 1

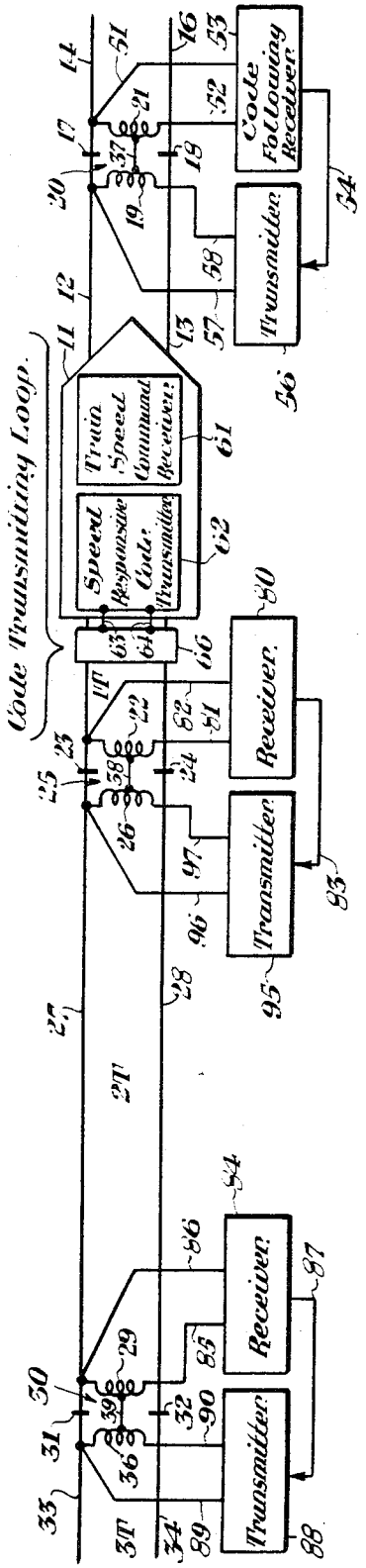


Fig. 1.

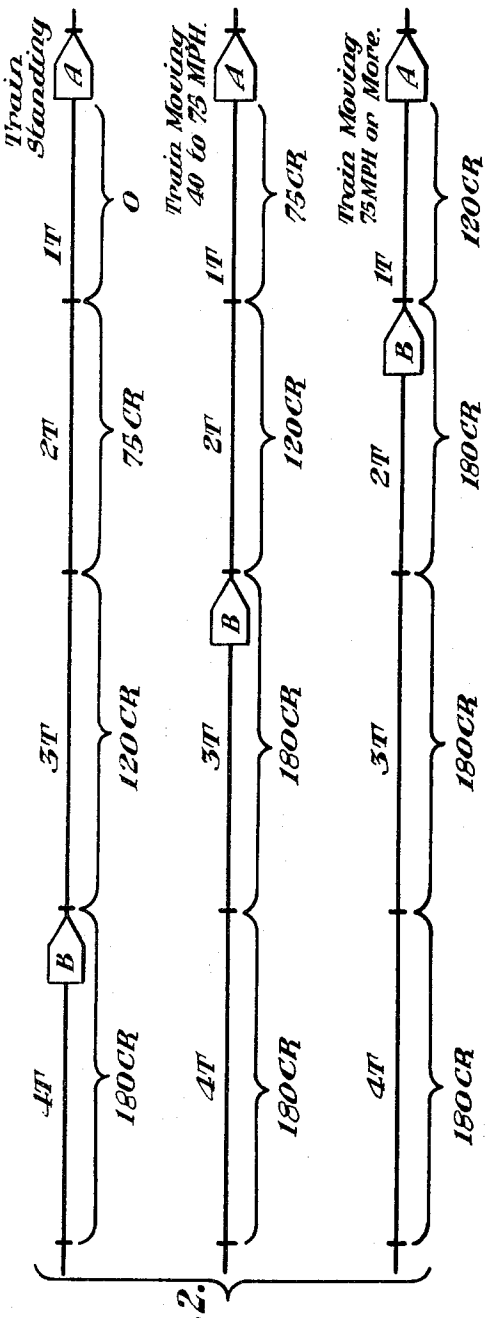


Fig. 2.

INVENTOR.
George W. Baughman.
BY
W. L. Stout
HIS ATTORNEY

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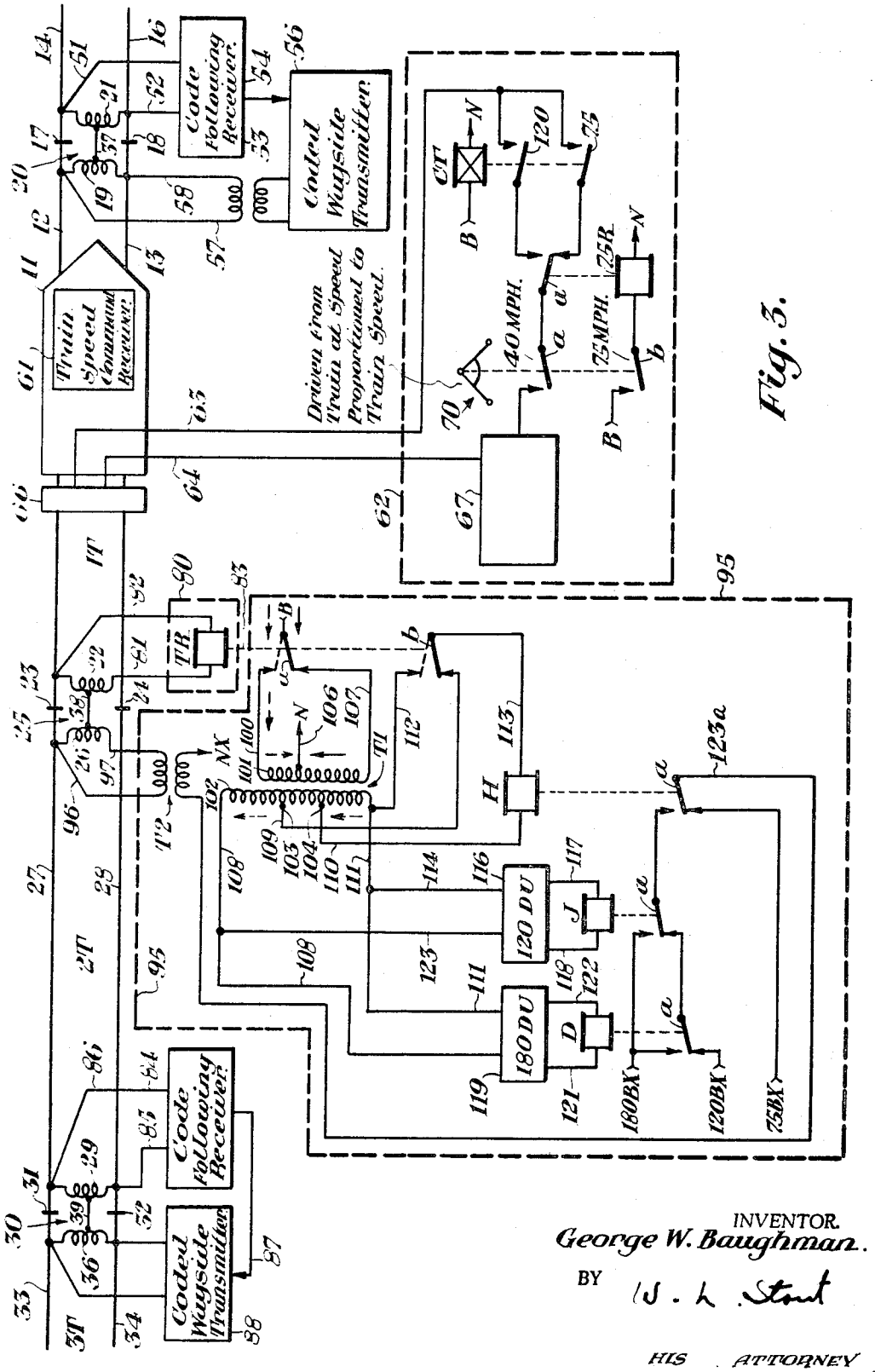


Fig. 3.

INVENTOR.
George W. Baughman.
BY J. L. Stout
HIS ATTORNEY

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MOVABLE BLOCK TRAIN SPEED CONTROL SYSTEM

George W. Baughman, Swissvale, Pa., assignor to Westinghouse Air Brake Company, Swissvale, Pa., a corporation of Pennsylvania

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4 Claims. (Cl. 246—187)

ABSTRACT OF THE DISCLOSURE

This invention relates to a train speed control system which includes a wayside transmitter arrangement to deliver a speed control signal to trains approaching the wayside transmitters. A train speed command receiver and a train speed responsive transmitter are carried by each train. The train speed responsive transmitter produces a train speed control signal output at the rear of the train which is always indicative of a more restrictive train speed command than a train speed command signal received from a wayside transmitter arrangement being approached. The train speed responsive transmitter is thereby effective to control the speed of a following train.

This invention relates to a movable block system for controlling the speed of one or more vehicles in such a manner that a vehicle operating within the system will automatically control the speed of a following vehicle.

More specifically this invention relates to a train speed control system which includes a wayside transmitter arrangement to deliver a speed control signal to trains approaching the wayside transmitters. A train speed command receiver and a train speed responsive transmitter are carried by each train. The train speed responsive transmitter produces a train speed control signal output at the rear of the train which is always indicative of a more restrictive train speed command than a train speed command signal received from a wayside transmitter arrangement being approached. The train speed responsive transmitter is thereby effective to control the speed of a following train.

Close headway between trains has become the rule rather than the exception in modern high speed rapid transit systems. With decreasing headways being demanded to accommodate increased passenger transportation densities the problem of assuring that one train cannot overtake another slowly moving train has become manifestly critical. The prior art handled this problem by using flagmen and some improvement has been attained by extensive use of wayside signaling. These just noted approaches have not provided a completely fail-safe manner of avoiding rear end collisions. Even prior art systems that brought the following train to a halt automatically failed to provide a sufficiently small headway which is called for in high speed rapid transit applications.

The invention to be described more fully hereafter allows significant decreases in headway under all dynamic conditions that are demanded by rapid transit systems of the present and the foreseeable future. In the system to be described, train speed control signal information which is fed into the track at the rear of a train is always for a slower speed than that at which the train is moving. This means that the speed at which a following train would be authorized to move would always be less than the speed of the train immediately ahead. This will tend to give a reasonable spread of separation and thereby avoid the possible compounding of an accident in the event of sudden derailment of the lead train. Use of the invention to be described will allow control of the speed

of a train as it approaches an occupied station track. The greater the speed of the train leaving the station, the greater would be the authorized speed of the following train as it approached the station.

It should be recognized that while the invention is to be described in a railway environment, the invention is intended to include all mass transit applications where vehicle speed control is essential. Accordingly, the references made hereafter to trains and rails are intended to refer equally to vehicles, and to electrically conductive elements.

It is therefore an object of this invention to provide a train speed control system in which the headway between trains may be reduced to a minimum by the utilization of a train speed control signal fed to the tracks at the rear of a train.

It is another object of this invention to provide a positive, dynamically responsive speed control system for vehicles operating at minimum headways.

Another object of this invention is the provision of a train-carried speed control arrangement that may be readilly installed in territories that incorporate track detection sections separated by insulated joints.

In the attainment of the foregoing objects a movable block train speed control system is provided in territories characterized by the presence of a plurality of consecutive track sections defined by insulated joints. A train speed command, signal producing wayside transmitter is electrically coupled to the rails at the exit end of each track section and this transmitter provides a train speed command signal to control a train's speed entering the track section. Each wayside transmitter is controlled by a wayside receiver electrically coupled to the rails at the entrance end of the next succeeding track section. The trains that operate within the system have thereon a train speed responsive transmitter which transmitter has a signal output which is always less than the train speed command signal from the wayside transmitter of the track section entered by the train. This output from the train speed responsive transmitter is transmitted via an induction loop above the rails at the rear of the train which induces in the rails the output from the train speed responsive transmitter. This output signal induced in the rails controls the next wayside transmitter, to the rear through the wayside receiver of the track section entered to produce a train speed control signal in the next track section to the rear, which train speed control signal is dependent upon the signal produced by the train speed responsive transmitter.

In addition to the train speed responsive transmitter on each train there is also a train speed control unit which receives train speed control signals from the rails of the track section occupied. This train speed control unit responds to a train speed control signal from the wayside transmitter of the track section entered unless the track section is occupied by a train, at which instance the train speed control unit responds to and is controlled by the signal output from the train speed responsive transmitter of the train which is already occupying the track section.

Other objects and advantages of the present invention will become apparent from the ensuing description of illustrative embodiments thereof, in the course of which reference is had to the accompanying drawings in which:

FIG. 1 illustrates in block diagram form an embodiment of the movable block train speed control system of the invention.

FIG. 2 is an illustration of the typical resultant coded speed control signal pattern that could arise in the employment of the invention.

FIG. 3 is a circuit diagram of the system set forth in FIG. 1.

A description of the above embodiment will follow and then the novel features of the invention will be presented in the appended claims.

Reference is now made to FIG. 1 in which there is illustrated in block diagram form a system which has incorporated therein the invention to be described more fully hereinafter. Specifically, there is depicted a train **11** traveling upon the rails **12** and **13**. The train **11** passes through a plurality of track detection sections 1T, 2T and 3T as noted in FIG. 1. The train **11** carries thereon a train speed command receiver **61** which receives train speed command signals from the wayside. The train speed command signals received determine the speed of the train.

Each track detection section 1T, 2T and 3T is characterized, for example, with reference to track detection section 1T by the presence of insulated joints **17** and **18** at the right end of track detection section 1T and insulated joints **23** and **24** at the left-hand end of track detection section 1T. The rails **12** and **13** at the right-hand end of the track detection section 1T are electrically interconnected by a winding **19** of impedance bond **20** which functions to balance the propulsion return current between the rails **12** and **13** when this system is employed in electrified territory. The exact details of the impedance bond **20** as well as the other impedance bonds **25**, **30** to be noted hereafter may be had upon a study of the copending application for Letters Patent of the United States, Ser. No. 382,551, filed on July 14, 1964 by Ralph Popp, for Electric Induction Apparatus, now Patent No. 3,268,843, issued Aug. 23, 1966. The winding **22** of the impedance bond **25** at the left-hand end of the track detection section 1T electrically interconnects the rails **12** and **13** at that end. Electrically connected via the leads **57** and **58** to the rails **12** and **13** at either end of the winding **19** of the impedance bond **20** is a wayside transmitter **56**. This wayside transmitter **56** delivers a train speed command signal to the rails **12** and **13** which is received by the train speed command receiver **61** through the conventional use of induction coils, not shown, but mounted on the front of the train over the rails **12** and **13**. The wayside transmitter **56**, in turn, is controlled by a code following receiver **53** which has its output **54** connected to the transmitter **56**. This code following receiver and its precise function will be described more fully hereafter. At this point it is sufficient to say that the code following receiver is electrically connected via the leads **51** and **52** to the rails **14** and **16** at either end of the winding **21** of the impedance bond **20**. This code following receiver **53** is designed to detect the presence of coded energy in the rails **14** and **16** and produce an output over the output **54** from the code following receiver **53** which, in turn, controls and determines the output from the wayside transmitter **56** which is feeding the rails **12** and **13** of the track detection section 1T.

If track detection section 1T is unoccupied, a track circuit would be completed between the wayside transmitter **56**, through electrical leads **57** and **58**, the rails **12** and **13** and finally the wayside code following receiver **80** at the left-hand end of the track detection section 1T. The wayside receiver **80** is electrically connected to the rails **12** and **13** via the electrical leads **81** and **82**. This wayside receiver **80**, in turn, has a control output **83** which controls the wayside transmitter **95** which is electrically connected via the leads **96** and **97** to the rails **27** and **28** of the track detection section 2T. These rails **27** and **28** are electrically interconnected by winding **26** of impedance bond **25**. Therefore, with the wayside transmitter **95** electrically connected to the rails **27** and **28** an additional circuit is completed which includes the wayside transmitter **95**, the electrical leads **96** and **97**, the rails **27** and **28**, the electrical leads **85** and **86**, and the wayside code following receiver **84**. It will be seen that the wayside receiver **84** has an output **87** which, in turn, feeds the wayside transmitter **88** which is electrically connected to the rails **33** and **34** via the the electrical leads **89** and **90**. The rails **33** and **34** are electrically interconnected by a winding **36** of the impedance bond **30** at the right-hand end of the track detection section 3T, each of the track detection sections 1T, 2T and 3T being defined, respectively, by the presence of insulated joints **17**, **18**, **23**, **24** and **31**, **32**. It will be noted that the windings **19**, **21**, **22**, **26**, and **29** and **36** are center tapped and are connected by electrical center tap leads **37**, **38** and **39**, respectively.

Returning now again to the description of the train **11** and its car-carried equipment. As has been noted, there is located on each train to be utilized in the system a train speed command receiver **61** which receives the train speed command signals of a specific character which signal controls the train and is received inductively from the rails which the train is passing over.

The train also carries a speed responsive code producing transmitter **62** which is electrically connected via the leads **63** and **64** to a code transmitting loop **66** positioned in the rear of the train over the rails which the train is passing over. This code transmitting loop **66** inductively induces in the rails immediately beneath it, behind the train, a signal dependent upon the signal selected to be transmitted by the speed responsive code transmitter **62**.

In general, it may be said that the speed responsive code transmitter detects the speed at which the train is actually traveling and is responsive to this actual speed to produce a train speed command signal to be delivered by the code transmitting loop **66** to the rails. This train speed command signal will always be of a character to effect a lower speed limit on a following train than the train speed command signal being received by the train speed command receiver **61** from the wayside transmitter **56** which the train **11** is approaching in this figure. In other words, should the train **11** be receiving from the wayside transmitter **56** a train speed command signal which authorizes a maximum speed, the train speed responsive code transmitter **62** would detect the actual speed of the train and produce a signal which would enforce a lower speed limit on a following train than the signal being delivered to the train **11** from the wayside transmitter **56**. This signal would be impressed in the rails **12** and **13** immediately at the rear of the train **11**.

It will be seen that in every situation to be described hereafter there will always be impressed in the rails immediately behind the train a train speed command signal which commands a lower train speed than the actual speed at which the train **11** is traveling. Therefore, in the track detection section or that portion of the track detection section immediately following the train there is always present a command signal indicative of a more restrictive train speed command. Therefore, a train (not shown) similar to train **11** approaching from the rear of train **11** would receive in its train speed command receiver a signal indicative of a more restrictive speed and thereby effect a slowing of the second or following train with respect to the speed of the train **11**.

In the left-hand portion of track detection section 1T, the code following wayside receiver **80** with the train **11** occupying track detection section 1T will be shunted by the wheels and axles of the train so that the receiver will not receive current from the circuit which included the wayside transmitter **56**. The only signal that the wayside receiver **80** will be able to detect or pick up is that signal induced in the rails by the code transmitter loop **66** at the rear of train **11**. Accordingly, a signal delivered by the code transmitting loop **66** will travel along the rails **12** and **13** over the electrical leads **81** and **82** to the wayside code following receiver **80** whereupon this receiver **80** will control the wayside transmitter **95** via the output **83** to produce in the track detection section 2T a train speed command signal which is dependent upon the speed at which train **11** is advancing. This may be better ap-

preciated from a study of FIG. 2 in which three distinctive situations are schematically illustrated. It is intended that FIG. 2 graphically illustrate the dynamic operation of the system. The precise cooperation of the wayside transmitters and receivers with the train speed responsive transmitter of the train will be explained in more detail with reference to FIG. 3.

Now with reference particularly to FIG. 2, it will be seen that at the upper portion of FIG. 2, there is depicted a situation where train A shown at the right in this figure is standing, for example, in a station, in track detection section 1T. Since the train is standing in the station, the speed responsive transmitter located within the train would not have an output since the train only permits an output when the train is moving. Accordingly, the transmitting loop of the train A would not deliver to the rails any signal at all. Therefore, it will be seen that immediately to the left in the rear of the train A there is no signal in the rails behind the train in detection section 1T. Should a train somehow approach and enter this track detection section 1T, its train speed command receiver would not receive a signal and this train would immediately come to a halt. It will be appreciated as the description proceeds that whenever a train speed command signal is absent, as in the present instance, the track detection section 2T will then receive a command signal at a rate of 75 cycles per minute which, of course, is indicative of a restrictive speed but one which is not actually intended to bring the train to a halt. The presence of a code rate of 75 in the track detection section 2T, in turn, induces or causes to be produced in track detection section 3T a coded command rate of 120 cycles per minute and the presence of this coded command rate of 120 in the track detection section 3T produces a coded rate in section 4T of 180 cycles per minute. This 180 code rate is indicative of full speed ahead. Accordingly, the train B depicted in track detection section 4T will receive a signal at the 180 code rate and this train B will then operate in a full speed ahead mode.

In the second dynamic situation depicted immediately beneath the situation just described in which train A is standing, there is illustrated a dynamic situation where train A is moving at a speed between 40 and 75 miles per hour. Train A, in a manner to be described hereafter, and its associated train speed responsive transmitter will produce in its code transmitting loop at the rear of the train A a train speed command signal which is at a 75 code rate. Therefore, should a train be entering the track detection section 1T, this train would receive a command code rate of 75 and, therefore, would follow at the speed commanded by the 75 code rate. In this instance, this speed would not be sufficient for the train following train A to overtake the train A. In a similar maner to that which was described with reference to the train standing in the station, the presence of a 75 code rate in track detection section 1T would produce in track detection section 2T a coded command rate of 120, and the presence of a code rate of 120 in track detection section 2T would produce a code rate of 180 in track detection section 3T. This code rate of 180 in track detection section 3T would produce a code rate of 180 in track detection section 4T.

As this figure illustrates, the train B in track detection section 3T would receive a code rate of 180 and, therefore, train B would proceed at a full speed ahead.

There is depicted in FIG. 2 one final situation where at the bottom of this figure train A is moving at 75 miles per hour or more. In this situation, the speed responsive code transmitter in train A would produce a code rate of 120. Now the train A is operating at its full speed ahead or its maximum rate and, therefore, the train A would have produced immediately behind it in the track detection section 1T a code rate of 120. This 120 code rate would be indicative of a speed less than the full speed ahead that the train A is traveling.

It will be seen that the headway permissible between train A and train B constantly decreases as the train speed of the lead train increases but at all times the command speed immediately following the lead train is less than the authorized command speed at which the lead train is traveling.

In these types of situations, it will be seen that the headway between trains may be greatly reduced and the trains following each other are sure of the fact that at no time will there ever be a situation in which the second or following train may overtake the lead train and thereby produce a collision. The reason for this is that as a train slows down the speed responsive code transmitter located on the lead train A will produce a more restrictive code rate which will cause the following train B to slow down as it approaches the track detection section that the train A is occupying.

It will be seen, therefore, that the arrangement to be described more fully hereafter presents an inventive approach which takes into account the dynamic nature of trains starting and stopping, entering and leaving stations, and in addition takes into account the fact that trains may be caused to slow down within the system. At all times, the invention to be described hereafter will permit a safe headway between following trains, while simultaneously allowing the headway to be reduced to the minimum consistent with safety. The result that follows is that maximum traffic density will be permitted on any section of rail within the system.

Reference is now made to FIG. 3 which illustrates a preferred embodiment of the invention and includes all the essential elements of a complete circuit diagram setting forth the invention. In FIG. 3 wherever possible, reference symbols have been employed similar to those used with reference to FIG. 1 and, accordingly, a detailed reiteration of those elements already described with reference to FIG. 1 will only be mentioned again to the extent that they are essential to understand the operation of the system set forth in FIG. 3.

The train **11** is depicted in the right-hand portion of FIG. 3 in the same manner as was depicted in FIG. 1. This train **11** is operating in track detection section 1T. The train **11** receives a coded train speed command signal from a wayside transmitter **56**, via the electrical leads **57** and **58** and the rails **12** and **13** of the track detection section 1T. This train speed command signal is received by the train speed commnad receiver **61** which inductively picks up the signals from the rails **12** and **13**. It will be recognized that if the train speed command receiver **61** receives a command signal which is indicative of a maximum authorized speed the train would gradually increase its speed until the authorized speed commanded by the wayside transmitter **56** is reached. It is during this increase of speed by the train **11** that this system and the invention being described has one significant use in that there is placed in the rails **12** and **13** at the rear of a train a command signal which is indicative of a more restrictive speed than the actual speed of the train. As a practicable matter in most instances the speed commanded by the signal being delivered to the rear of the train is less than the authorized speed being commanded by the wayside transmitter **56** at the right-hand end of the track detection section 1T. By convention, the wayside transmitter **56** is connected at the exit end of the track detection section 1T to the rails **12** and **13** by the leads **57** and **58**. The entrance end of the track detection section is defined as the left-hand portion of the track detection section 1T where the wayside receiver **80** is electrically connected via leads **81** and **82** to the rails **12** and **13** immediately adjacent the insulated joints **23** and **24**.

The train **11** has located thereon a speed responsive code transmitter **62** depicted in this figure removed from the train **11**. It should be understood that the speed re-

sponsive code transmitter **62** is mounted on the train, and for purposes of illustration only is set forth beneath and away from the train **11**. This transmitter **62** is electrically connected via the leads **63** and **64** to the code transmitting loop **66** positioned over the rails **12** and **13** at the rear of the train. The speed responsive code transmitter has an oscillator **67** which is producing a carrier frequency of a sufficient level so that this energy when placed in the rails will be effective to actuate the code following receiver **80** positioned at the entrance end of the track detection section **1T**. The oscillator **67** provides as has been noted, a constant carrier frequency energy and this constant carrier frequency energy is delivered through a speed responsive switching mechanism **70**. The speed responsive switching mechanism **70** is driven by a suitable connection to one of the train's axles (the connection to the axle is not shown). The speed responsive switching mechanism **70** has in this illustration two ranges of operation, one between 0 and 40 miles per hour and another between 40 and 75 miles per hour. The speed responsive mechanism **70** closes its front contact *a* at 40 miles per hour and closes its front contact *b* at 75 miles per hour and in so doing completes the following circuits. When the speed responsive mechanism **70** which is connected to the axle of the train is producing a rotary output to the speed responsive mechanism **70** which causes the mechanism to centrifugally advance the contact *a* into a closed position with the front contact *a* of the speed responsive mechanism **70** a circuit will then be completed from the oscillator **67**, through the front contact *a* of the speed responsive mechanism **70**, the back contact *a* of the repeater relay **75R**, the contact **75** of the code transmitting relay CT, lead **63**, to the transmitting loop **66**, and thence over lead **64** back to the oscillator **67**. In other words, the code transmitting relay CT, which receives its energy from a battery source having B and N terminals, will open and close the contact **75** at the code rate of 75 cycles per minute, thereby interrupting the energy from the oscillator **67**. At this rate, this energy from the oscillator **67**, as has been noted, is being delivered over the front contact **75** of the code transmitting relay CT. Coded energy is then supplied to the code transmitting loop **66** and thence to the rails **12** and **13** in the rear of the train.

When the train is operating at a speed of 75 miles per hour, the speed responsive mechanism **70** causes the contact *b* to complete a circuit from the battery terminal B over the front contact *b* of the speed responsive mechanism **70** through the repeater relay **75R** to the negative battery terminal N. In the completion of this circuit, the contact *a* of repeater relay **75R** completes a circuit for the transmitting loop **66** over the front contact *a* of the speed responsive mechanism **70** and the front contact *a* of the repeater relay **75R**. This allows the energy from the oscillator **67** to pass over this front contact *a* of the speed responsive mechanism **70**, over the front contact *a*, the repeater relay **75R** where this energy is interrupted at a 120 code rate by the code transmitter relay 120 contact. This coded energy is delivered to the electrical lead **63**, through the transmitting loop **66** and electrical lead **64** which is connected back to the oscillator **67**.

It will, therefore, be seen that the train speed responsive transmitter **62** has various distinctive operating ranges, namely, when the speed of the train is below 40 miles per hour there are no circuits completed between the oscillator **67** and the code transmitting loop **66**. Accordingly, the absence of a signal in the rails immediately behind the train establishes the most restrictive train speed condition for any train that might enter the track section occupied by train **11**. When the speed of the train reaches 40 miles per hour, a circuit is completed which permits a coded energy signal at the 75 code rate to be delivered to the code transmitting loop **66** which then places in the rails **12** and **13** immediately behind the train a signal indicative of a maximum permissible speed which is proportional to the 75 code rate. When the train **11** reaches its maximum speed of 75 miles per hour or greater, the code rate of 120 is delivered to the code transmitting loop **66** and, therefore, there is coded signal energy in the rails **12** and **13** immediately behind the train **11** of a 120 code rate. In the system being described, there has been presented four distinctive speed ranges for the trains of this system. They are as follows: When there is an absence of a signal or zero code rate in the rails this is the most restrictive condition and the train will brake to a stop. When there is a code rate of 75, the train may operate up to but not in excess of 40 miles per hour. When there is a code rate of 120, the train may operate between the speeds of 30 and 75 miles per hour but may not exceed 75 miles per hour and should the train receive a code rate of 180, the train would be permitted to travel in excess of 75 miles per hour or at the maximum authorized speed. When the train ahead is moving at 40 miles per hour it authorizes the following train to advance at 30 miles per hour. It will be seen, therefore, that immediately behind the train **11** there is induced in the rails **12** and **13** three distinctive conditions. These distinct conditions are a zero code rate, a 75 code rate, or a 120 code rate. The manner in which this affects the other blocks of the system being described will now be set forth.

When there is an absence of a signal in the rails **12** and **13**, the receiver **80** with its track relay TR, which receives or detects the presence of energy in the rails **12** and **13** via the leads **81** and **82**, will be inactive. In other words, the relay TR will not be energized and this will result in the following circuits being completed in the wayside transmitter **95**.

With the track relay TR deenergized, a circuit is completed from battery terminal B, through the back contact *a* of the track relay TR, the lower portion of the transformer **T1**, and back to the battery terminal N through the center tap **106** of the primary winding of transformer **T1**. The presence of a coded current in the primary winding of transformer **T1** will induce in the secondary winding of the transformer **T1** an alternating current which has been indicated by a solid arrow in the central portion of the secondary winding of the transformer **T1**. This current will flow from the terminal tap **103** through the secondary winding to the terminal tap **104**, thence along the leads **110** through the winding of the relay H the lead **113**, back contact *b* of the track relay TR, and the lead **109** back to the terminal **103**. Relay H picks up over the circuit just traced. With non-coded or steady state direct current in the primary, there is no current induced in the secondary and, therefore, relay H remains in its released position. In other words, in the absence of any code rate, the mere fact this circuit has been completed will not allow the relay H to pick up. Therefore, in the absence of a signal in the rails **12** and **13**, with the relay TR deenergized, the relay H will not be picked up and the following circuit will be completed within the wayside transmitter **95**. Current from a power source BX–NX coded at a 75 rate will be delivered over the back contact *a* of the relay H, thence over the lead **123***a* to the transformer **T2** of the transmitter **95**, where this 75 code rate will be delivered via this transformer **T2** and the leads **96** and **97** to the rails **27** and **28**. Accordingly, under the conditions just described, when the track detection section **1T** immediately behind the train **11** has a zero code rate or the absence of a signal in the rails, there will automatically appear within the rails **27** and **28** of the track detection section **2T**, a signal of 75 code rate. Accordingly, a train that would appear in the track detection section **2T** would operate at the speed commanded by the 75 code rate, and upon entering the track detection section **1T** the train, which has not been shown but has been schematically set forth in FIG. 2, would receive no signal immediately behind the stopped train **11** and the second train or following train would come to a halt. It should also be recognized that the second train

would also come to a halt should the train **11** be accelerating from a zero actual speed up to the speed of 40 miles per hour.

A second dynamic situation will now be described. As the train speed increases, that is, the train speed of train **11** increases to and reaches 40 miles per hour, the circuit previously noted between the oscillator **67** of the train speed responsive transmitter will be completed and there will be delivered to the code transmitting loop **66** a coded energy signal at a 75 code rate. When the train **11** is operating at its actual speed of 40 miles per hour or greater there will be a signal in the rails **12** and **13** immediately behind the train at a 75 code rate. With a 75 code rate signal present in the rails **12** and **13**, the following circuits will be caused to be completed in the wayside transmitter **95**. The track relay TR of the wayside receiver **80** is a code following track relay which will open and close its contacts in accordance with the code rate received from the rails **12** and **13**. Therefore, the track relay TR will open and close its contacts *a* and *b* at a code rate of 75. This code rate of 75 will cause the following circuits to come into operation in the wayside transmitter **95**. As has been noted, with the track relay in its released position, a circuit is completed through the code detecting relay H, but the code detecting relay H will not respond unless the circuit is interrupted at some code rate. This code detecting relay responds when coded energy is delivered to the relay TR. When this occurs, track relay TR picks up thereby opening its back contacts and closing its front contacts. In this condition the current, shown by a dotted arrow, will flow from the battery terminal B over the front contact *a* of the track relay TR through the upper portion of the primary of transformer **T1**, and back to the battery terminal N from the center tap terminal **106**. This passage of current through the primary winding of the transformer **T1** which is represented by the dotted arrow in the lower portion of the secondary winding of the transformer **T1**. This current will flow through the secondary winding of the transformer **T1** to the terminal tap **104**, thence along the lead **110** through the relay H, the lead **113**, the front contact *b* of the track relay TR, and finally the electrical lead **112** back to the lower end of the second winding of the transformer **T1**. When the circuit is interrupted by the opening and closing of the contacts *a* and *b* of the track relay TR, the code following relay H will respond by being energized and, therefore, picking up its contact *a* so that the 75 code rate being delivered from the terminal BX will be interrupted and a new code rate will be delivered in the following manner. As long as the 75 code rate and only the 75 code rate is being recognized by the track relay TR, there will be present in the secondary winding of the transformer **T1** a coded signal which will be of the 75 code rate. This signal will appear simultaneously in the electrical lead **108**, which is connected to the resonant frequency selective circuit **180D**, designated by reference symbol **119**. The frequency selective circuit **180D** will only respond when the energy being delivered is at a 180 code rate. Therefore, in the absence of such a signal of a code rate of 180 there will be no output from the resonant frequency selective circuit **119** and the relay D will not be energized through the electrical leads **121** and **122**. In a similar manner, there is connected in parallel across the electrical leads **108** and **111**, which leads **108** and **111** emanate from either end of transformer **T1**, the electrical leads **123** and **114**. Coded energy at the 75 code rate will therefore also appear in leads **123**, **114**. The resonant frequency selective circuit **116**, which was designated thereon **120D**, will not respond to the 75 code rate but will only produce a direct current signal in the leads **118** and **117** to energize relay J when the code rate present in the leads **123** and **114** is at a 120 code rate. Therefore, the relays D and J remain inactive in the presence of a 75 code rate being delivered by the code following relay of the wayside receiver **80**.

The following circuit is now completed in the wayside transmitter **95** with the code following relay H being energized by the 75 code rate. The coded energy at the 120 code rate is delivered from the terminal BX over the back contact *a* of the relay D, the back contact *a* of the relay J and the front contact *a* of the relay H to the lead **123***a*, where this 120 coded energy is delivered to the transformer **T2** which induces in the leads **96** and **97** the 120 coded signal. This 120 code rate signal is impressed in the rails **27** and **28** in the track detection section **2T**.

Under the situation just described, it will be recognized that when the train **11** is operating at a speed of 40 miles per hour or greater there will at least be a signal induced in the rails **12** and **13** at a code rate of 75, which, in turn, will cause to be delivered in the track detection section **2T** a code rate of 120. Therefore, a train (not shown) entering the track detection section **2T** would receive an authorized speed command represented by the code rate of 120. As the train proceeds from the track detection section **2T** into track detection section **1T**, this code rate will decrease to a code rate of 75 and the second or following train will proceed at this more restrictive speed command. There is possibe another range of operation.

When the train reaches 75 miles per hour, that is, an actual speed of 75 miles per hour, the speed responsive mechanism **70** of the train speed responsive transmitter **62** will complete the circuit as noted earlier when the contact *b* of the speed responsive mechanism **70** is closed. This will cause, as has been noted, the delivery of a coded signal to the code transmitting loop **66** at the rate of 120. Therefore, there will appear in the rails **12** and **13** immediately behind the train **11** coded energy at the 120 code rate whenever the train is operating at 75 miles per hour or greater. This 120 code rate will produce the following coded energy signal in the track detection section **2T**. With a 120 code rate being delivered to the wayside receiver **80** via the leads **81** and **82** from the rails **12** and **13**, track relay TR is driven at the 120 code rate. The track relay contacts *a* and *b* will be actuated at a 120 code rate. The fact that a circuit is now being completed at a 120 code rate will be detected by the code detecting relay H in the same manner that the 75 code rate was detected and described earlier. Therefore, without regard to the code rate being delivered the code detecting relay H will remain in a picked-up position as long as any code signal is being received by the wayside receiver **80**. With the code detecting relay picked up and a signal induced in the secondary winding of the transformer **T1** at a 120 code rate, the resonant frequency selective circuit **116** designated **120D**, which is connected via the electrical leads **123** and **114** to the leads **108** and **111** to either end of the secondary winding of the transformer **T1**, will cause a direct current signal to appear in the leads **118** and **117** from the resonant or frequency selective circuit **116**. This will energize the relay J, and with the relay J in a picked-up condition, the following code command signals will be delivered to the track detection section **2T**.

The 180 code rate will be delivered from the terminal BX over the front contact *a* of the relay J, over the front contact *a* of the relay H to the lead **123** where this 180 code rate will be delivered to the transformer **T2**, by the leads **96** and **97** to the rails **27** and **28** of the track detection section **2T**.

It will, therefore, be seen that when a code rate of 120 is delivered to the rails immediately behind the train **11** there will instantly appear in the track detection section **2T** a code rate of 180 which is indicative of a maximum authorized speed. When the train **11** is operating at this maximum speed there is always present behind it the next most restrictive train speed, namely, that of a 120 code rate.

In order that the system have a continuity of dynamic responses to the train speed commands being delivered to the rails behind the train, there is provided in a conventional manner the additional capability within the way-

side transmitter **95** of responding to the 180 code rate. In other words, since all of the wayside transmitters **88**, **95** and **56** may be affected by the presence of a 120 code rate in a preceding track detection section, there is provided the resonant or frequency selective circuit **119** in the wayside transmitter **95** and this resonant or frequency selective circuit **119**, which has **180D** designated thereon, will respond to the situation where a 180 code rate is being received by the wayside receiver **80**. Since the code following relay H is always picked up when a code is present, a circuit will be completed in the following manner. Since the presence of a 180 code rate will not be detected or produce a signal by the resonant or frequency selective circuit **116**, the relay J will be deenergized but simultaneously with this deenergization the appearance of a 180 code rate in the leads **108** and **111** from the secondary of the transformer T1 will cause a direct current signal to appear in the leads **121** and **122** from the resonant or frequency selective circuit **119**. This will energize the relay D and cause a 180 code rate command signal to be delivered from the terminal BX, over the front contact *a* of the relay D, over the back contact *a* of the relay J, the front contact *a* of the relay H to the lead **123**, whereupon this 180 code rate will be delivered to the transformer T2 and thence through the leads **96** and **97** to the rails **27** and **28**. This 180 code rate would then be received by a following train and would permit the maximum authorized speed by the following train. It should be recognized that this code following receiver and transmitter per se is part of the prior art and a more detailed description of the operation of this code following procedure may be had with reference to Nicholson et al. Patent No. 2,218,120 for Railway Traffic Control Apparatus.

By way of summary, it will be recognized that this system provides an inherent fail-safe arrangement in which following trains may decrease their headway between trains and always receive a train speed command signal that will allow them to approach the rear of a preceding train while safely maintaining a reasonable headway in all dynamic operations of the train's system. This system will, therefore, provide a most unique advance to the movable block concept of train speed control, and in so doing, will advance the state of the art to allow greater transportation rates and higher speeds within the systems because of the interlocking nature of the train speed control between trains operating within the system.

While the present invention has been illustrated and disclosed in connection with the details of the illustrative embodiments thereof, it should be understood that those are not intended to be limitative of the invention as set forth in the accompanying claims.

Having thus described my invention, what I claim is:

1. A movable block train speed control system for controlling the speed of one or more trains in territories characterized by the presence of a plurality of consecutive track sections defined by insulated joints and a train speed command signal producing a wayside transmitter at the exit end of each track section controlled by a wayside receiver at the entrance of the next succeeding track section, wherein said system has

(a) a train speed responsive transmitter means on each train, said train speed responsive transmitter means having a signal output which is always indicative of a train speed command less than the train speed command signal from said wayside transmitter of the track section entered by said train.

said train speed responsive transmitter including a signal transmitting means at the rear of said train electrically coupled to the rails of said track detection section,

said train speed responsive transmitter means including a source of signal energy and a train speed responsive switching mechanism to selectively electrically couple said source of signal energy to said signal transmitting means to thereby induce in said rails of said track detection section at said rear of said train a train speed control signal to control the speed of a following train,

said train speed responsive transmitter output controlling the wayside receiver of the track section occupied which wayside receiver in turn controls the next wayside transmitter through said wayside receiver of the track section entered to produce a train speed control signal dependent upon the signal produced by said train speed responsive transmitter means,

(b) a train speed control means on each train controlled by said train speed wayside transmitter means,

said train speed control means responsive to a train speed wayside transmitter signal of a track section entered unless said track section is occupied by a train when said train speed control means is responsive to and controlled directly by the output of said train speed responsive transmitter means of the train occupying said track section.

2. The train speed control system of claim **1** wherein said train speed command signal producing wayside transmitter is electrically coupled to the rails of said track detection section at said exit end of said track detection section.

3. The train speed control system of claim **1** wherein said wayside receiver is a signal following receiver which controls said wayside transmitter to produce in the rails of said exit end of said track detection section a train speed command signal having a value dependent upon the nature of the signal received by said wayside receiver.

4. The train speed control system of claim **1** wherein said train speed responsive transmitter means includes,

(a) a code transmitting means at the rear of said train,

(b) a source of coded energy, and

(c) a train speed responsive mechanism to selectively electrically couple said source of coded energy to said signal transmitting means to thereby produce at said rear of said train a train speed control signal to control the speed of a following train.

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ARTHUR L. LA POINT, *Primary Examiner.*

S. T. KRAWCZEWICZ, *Assistant Examiner.*