

Oct. 6, 1970

G. M. THORNE-BOOTH

3,532,877

RAILWAY TRACK SIGNALLING SYSTEM

Filed Nov. 29, 1967

3 Sheets-Sheet 1

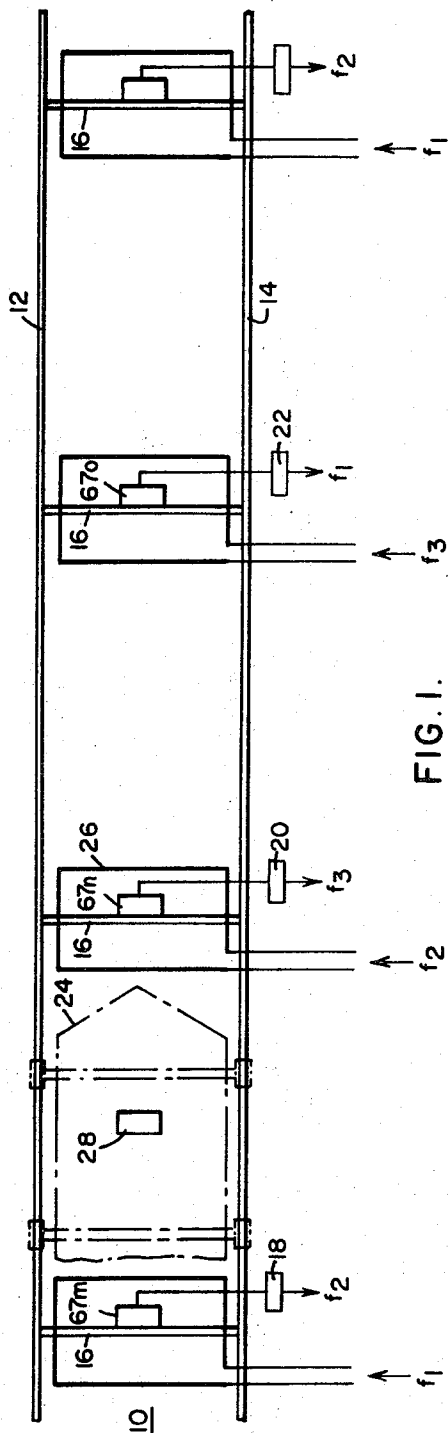


FIG. 1.

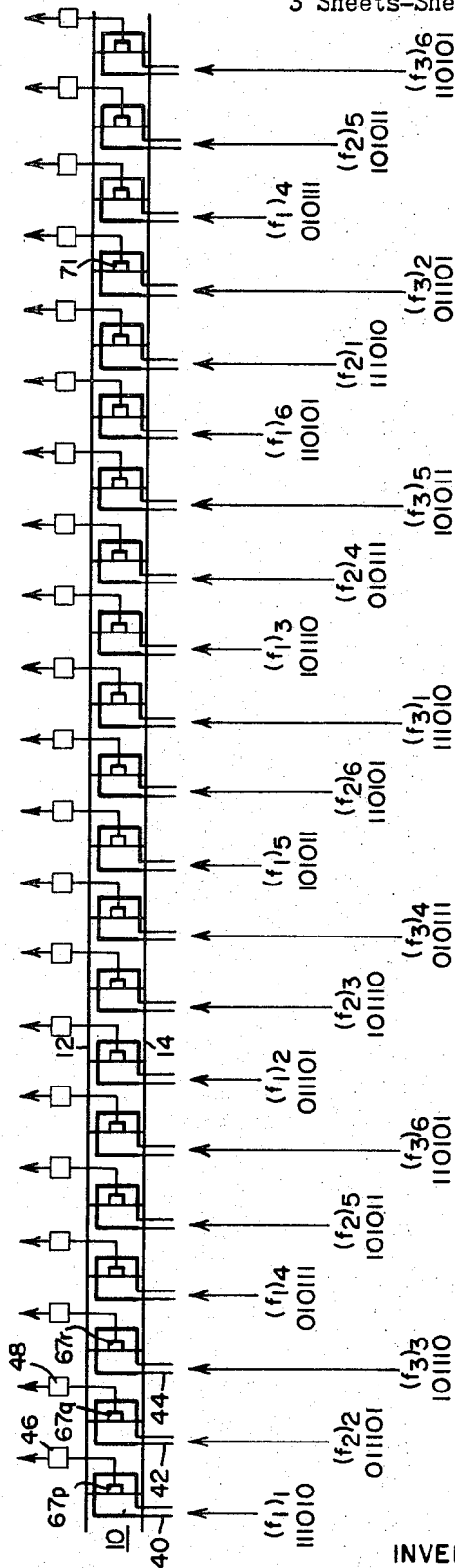


FIG. 2.

WITNESSES:

Bernard R. Giequy
James A. Young

INVENTOR
George M. Thorne-Booth

BY *W. Brodahl*
ATTORNEY

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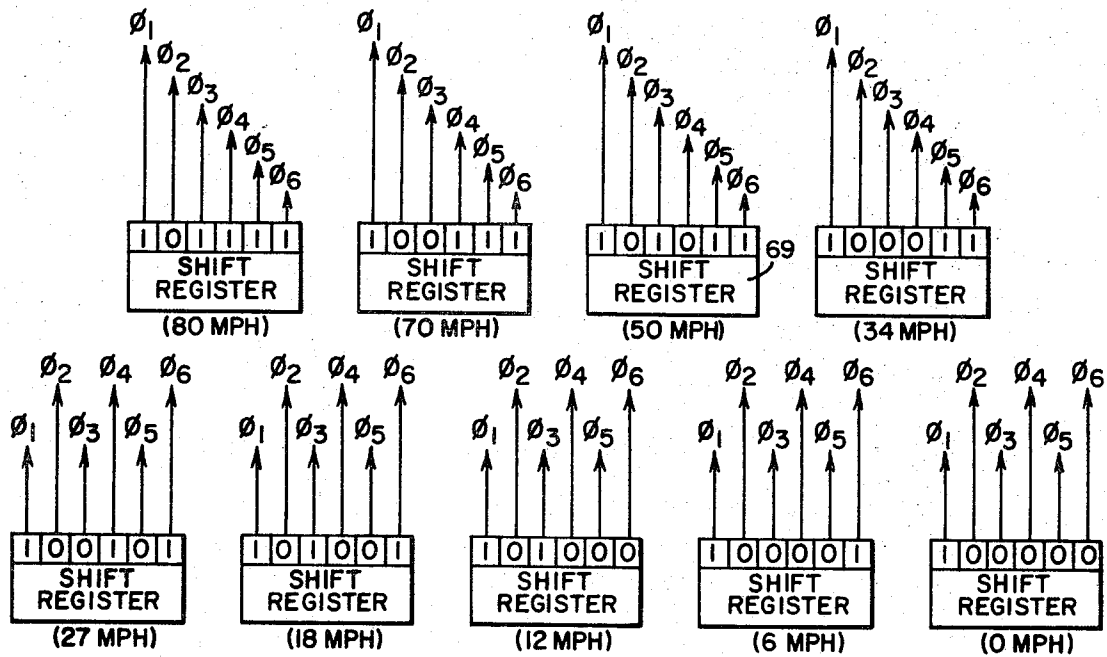


FIG. 3.

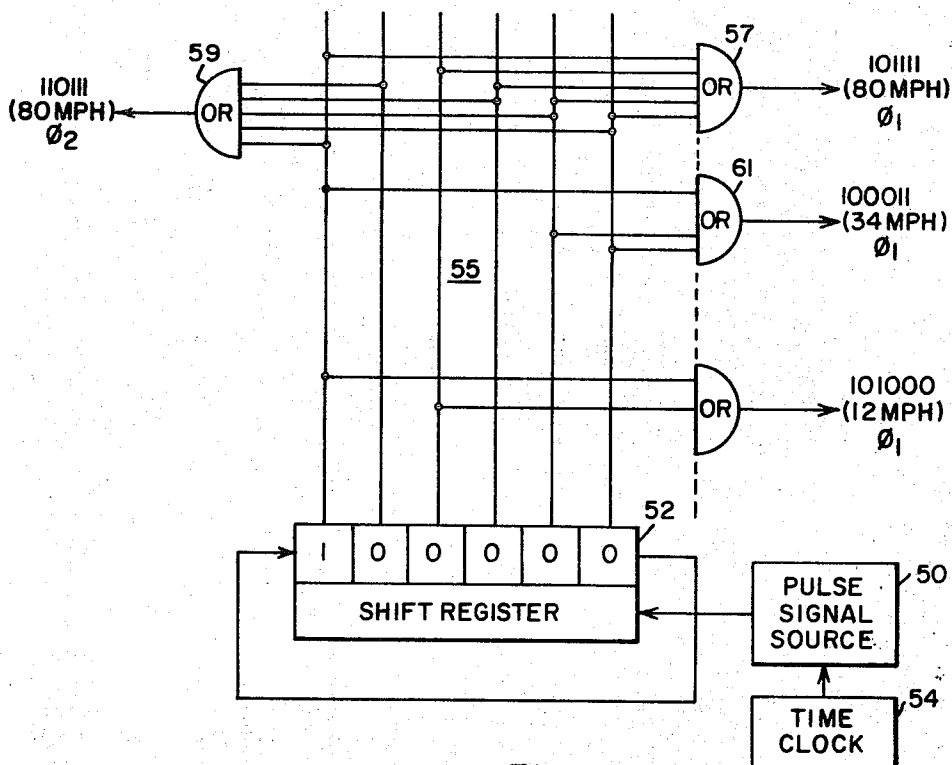


FIG. 4.

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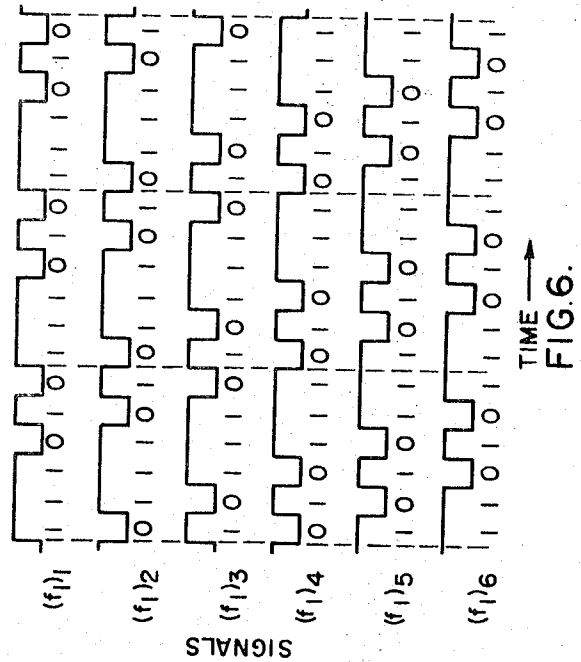
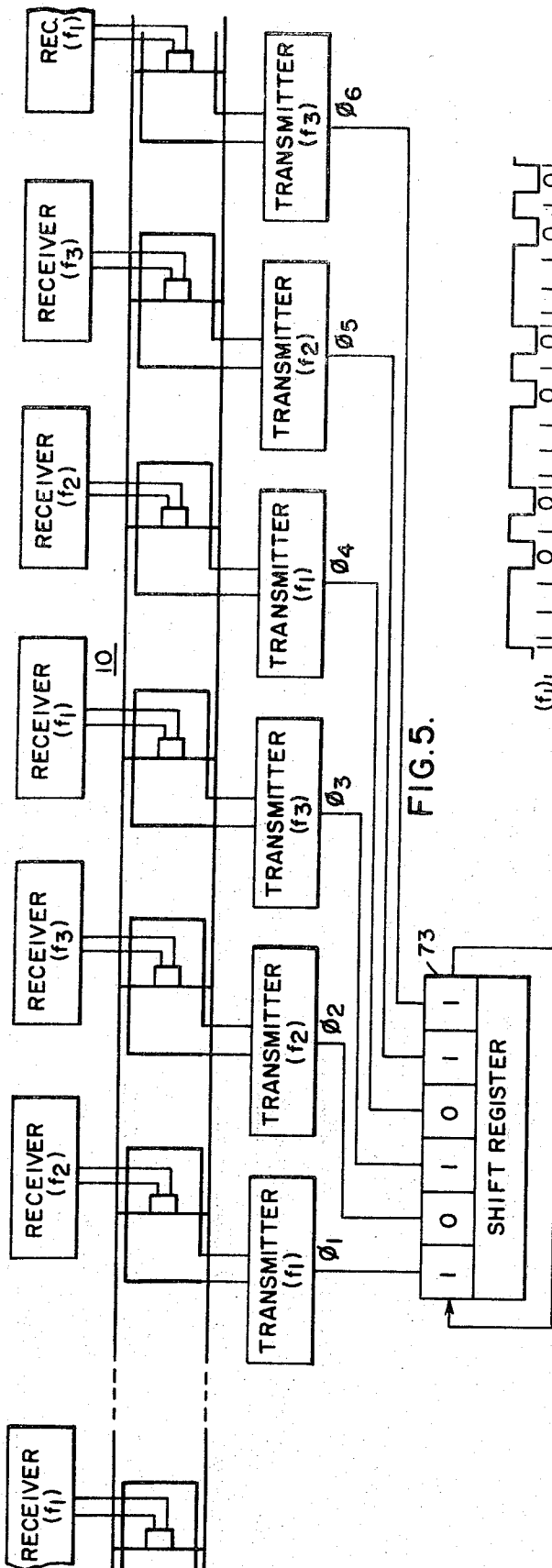
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3,532,877

RAILWAY TRACK SIGNALLING SYSTEM

George M. Thorne-Booth, Murrysville, Pa., assignor to Westinghouse Electric Corporation, Pittsburgh, Pa., a corporation of Pennsylvania

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Int. Cl. B611 21/10

U.S. Cl. 246—63

10 Claims

ABSTRACT OF THE DISCLOSURE

In accordance with the present invention a railway signalling system is provided for operation with transit or railway systems, where it is desired to obtain a considerable number of isolated orthogonal train vehicle position sensing channels. Such channels should be isolated and repeated only at separation distances large enough to assure fail-safe vehicle position sensing through adequate signal attenuation between two otherwise identical signals for the purpose of avoiding erroneous positional information being received even under fault conditions. This is accomplished by dividing the conductive track, which may be made of steel, into discrete signal communication blocks by means of low impedance members that are connected between the two rails of the track at the respective ends of each defined signal block. Additionally the number of diverse signal carrier frequencies is reduced to three, with the desired orthogonality between adjacent signal block channels operating at identical frequencies being separated by orthogonal signal coding of the modulation which is impressed upon the transmission carrier. Comma free coded signals are phase shifted and utilized to effect in this manner adequate separation for the intended application.

CROSS REFERENCE TO RELATED APPLICATIONS

The present invention is related to the invention covered by a first patent application entitled "Remote Transmission of Control Signals" by George M. Thorne-Booth and Chauncey S. Miller and filed May 11, 1967, Ser. No. 637,723, and a second patent application entitled "Remote Signalling System for Train Control" by George M. Thorne-Booth filed May 11, 1967, Ser. No. 637,684.

BACKGROUND OF THE INVENTION

Train vehicle track signalling systems must be designed to be fail-safe in operation because of the human life and valuable property dependent upon their operation and to avoid the occurrence of dangerous operational conditions. This has previously been accomplished by defining the vehicle track into a plurality of signalling blocks, with each such block being adapted to indicate the presence of the train vehicle within that block through cooperation of a particular frequency signal transmitter and a signal receiver operative with that block such that the receiver senses a higher amplitude signal when the block is not occupied due to the short circuiting effect of the vehicle wheel trucks when the block is occupied. To avoid signal interference from adjacent signal blocks, a considerable number of different signal frequencies are employed. A sufficiently large physical separation is provided between like signal frequency vehicle presence detecting signal blocks to assure adequate attenuation of the similar frequency signal from any remote transmitters. This previous signalling system required a large number of diverse frequency channels and necessitated narrow band filters on the signal receivers.

It has further been the previous practice to amplitude modulate the transmitter signals to assure a unidirectional mode of failure.

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SUMMARY OF THE INVENTION

The track signalling system of the present invention successively provides signals of three different carrier frequencies and separates each signal block by connecting a low impedance signal conductor between the track rails at each respective end of every signal block. Comma free train movement control signals, such as a speed control coded control signals operative with an automatic train control system, are supplied to the train vehicle in a manner to be effective to satisfactorily communicate with the train vehicle as it moves between the successive signal blocks for the purpose of transmitting desired movement control signals, for example vehicle speed controlling signals. Additionally, individual signalling blocks receive time shifted train vehicle position sensing signals that are operative with wayside located receivers having a time reference in their operation to enable each wayside receiver to distinguish the signal transmitted to the particular signal block and to be operative with that wayside receiver. The train vehicle carried movement control signal receiver has no time reference in its operation and therefore it accepts the movement command signals with no regard to the respective time shift modulation of each of those signals relative to the signals of adjacent signal blocks.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates the general signal block communication system here provided including respective signal transmitting and cooperating signal receiving antennas;

FIG. 2 illustrates one suitable signal coding arrangement of the present invention;

FIG. 3 illustrates one suitable time shifted signal provision arrangement for the signals provided;

FIG. 4 shows a modified time shifted signal provision arrangement for the movement control and vehicle presence detection system of the present invention;

FIG. 5 shows how the time shifted signals are supplied to the signal frequency transmitters for operation in conjunction with respective train position detection receivers; and

FIG. 6 illustrates the time shifted signals that are provided by the respective outputs of the shift register shown in FIG. 5.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIG. 1 there is shown a vehicle track 10 including an electrically conductive first rail 12 and second rail 14. Low impedance conductors 16, made of copper or like material, are periodically connected between the rails 12 and 14 to define signalling blocks as will be later described in greater detail. Coupled to each of the low impedance conductors through a signal receiving antenna, such as antenna 67m is a receiver, such as receiver 18 operative to receive the unique vehicle position sensing signal which energizes the particular signal block operative with the receiver 18. The next adjacent signal block has a receiver 20 operative to sense the vehicle position signal energizing that signal block. The next adjacent signal block has a receiver 22 operative to sense the vehicle position signal energizing that signal block. A vehicle generally indicated at 24 is moving along the track 10 in a direction from left to right and is shown positioned within the signal block operative with the receiver 18. A signal transmitting antenna 26 is positioned to energize the signal block operative with the receiver 18 with a uniquely time or phase shift modulated vehicle position detecting signal of a selected frequency as will be later described. A vehicle movement speed control signal is coupled to the vehicle 24 through operation of a vehicle carried re-

ceiver 28 as, for example, the binary sequence signal receiver and direct control for a moving vehicle disclosed in the previously referenced patent application, Ser. No. 637,723.

In FIG. 2, there is shown the track 10 in a more generalized manner to indicate the successive provision of signal blocks each being defined by a low impedance conductor connected between the rails 12 and 14. The transmitting antenna 40 shown in FIG. 2 is energized with a first position detection signal 111010 having a carrier frequency f_1 to give a speed command of 50 m.p.h. to the vehicle. The next successive transmitting antenna 42 is energized with a position detection signal 011101 having a carrier frequency f_2 as indicated in FIG. 2, to give a speed command signal of 50 m.p.h. with a unique phase modulation. The next successive transmitting antenna 44 is energized with a detection signal 101110 having a carrier frequency f_3 to give a speed command signal of 50 m.p.h. and a unique position detection signal. The succeeding antennas are energized as shown in FIG. 2. A signal receiving antenna 67p is positioned to couple with the low impedance conductor at the location of transmitting antenna 40. Antenna 67p is connected to a signal block receiver 46 which is operative to receive the position detection signal at frequency f_2 induced by the operation of the transmitting antenna 42. A receiver 48 is operative with the next successive signal block to receive the position detection signal at frequency f_3 induced by the transmitting antenna 44. The successive signal blocks are similarly provided with signal receiving apparatus and cooperating signal transmitting apparatus to energize and receive the successive signalling blocks with the position detection and vehicle speed command signals as indicated in FIG. 2.

In FIG. 3, there is illustrated the time or phase shifted characteristics of each of the respective speed control signals supplied to the signal blocks, where it is desired that given vehicle speed conditions be realized. The different time shifted signals are applied to successive signal blocks to give vehicle presence detection isolation. In FIG. 4, there is diagrammatically set forth one suitable embodiment to provide the desired time shifted signal arrangement to give the desired signal isolation effect for train vehicle presence detection in accordance with the teachings of the present invention. In FIG. 4, there is shown a pulse signal source 50 which sequentially energizes a shift register 52 with a comma free coded position signal having a time characteristic determined by a time clock 54. The plural stages of the shift register are illustrated with one signal storage condition being illustrated as stored within the shift register with the respective stages being connected to the illustrated time shifted output conductors 55, logic circuits 57, 59, 61 and so forth for energizing the corresponding signal blocks with the momentary digital signals shown. More specifically, the OR logic circuit 57 provides as its output speed control signal the 80 m.p.h. control signal 101111 when the shift register 52 is shifted through its cycle of operation by successive signals from the pulse signal source 50. The OR logic circuit 59 provides this same speed control signal to the vehicle carried receiver, but the wayside vehicle position detection receiver senses the different time shift of its output signal. In this way, and as shown in FIG. 2, the adjacent signal blocks, if several are energized with the same speed control signal, will be energized with a different carrier frequency and with a different phase or time shift modulated vehicle presence detection signal. With specific reference to FIG. 2, the position signal sensitive antenna 67r will receive the speed control signal 010111 at frequency f_1 as phase four of the 50 m.p.h. output signal from a shift register, such as the shift register 69 shown in FIG. 3, while this same position detection signal will not be supplied to the thirteen successive signal blocks in the direction toward the right (as shown in the drawing), but is again supplied to

the fourteenth signal block which is the one to the right side of the location of the antenna 71. The other stages of the shift register 52 is similarly operative to energize the indicated transmitting antennas, operative with the track 10.

In FIG. 5 there is shown the manner in which the three successive carrier frequency signals are modulated by the respective time shifted or phased output signals from the plural stage of shift register 73 which could correspond to the shift register 69 shown in FIG. 3. In this way successive signal blocks of the track 10 are uniquely energized to permit the associated vehicle position detecting signal wayside receivers to operate in a substantial fail-safe manner to determine the location of a vehicle occupied signal block. It is to be understood that each wayside receiver is coordinated with the operation of its associated frequency signal transmitter, so a frequency difference detection (sometimes called frequency selective detection) can be made between the transmitted vehicle speed control signal and the received signal as well as a time shift or phase difference detection for the purpose of determining when a vehicle occupies a particular signal block and thereby prevents the receiver from receiving the speed control signal.

Thusly it will be seen that in accordance with the teachings of the present invention, a number of diverse frequencies such as the illustrated three frequencies set forth in the drawings have been provided and the desired orthogonality between adjacent channels operating at identical frequencies is obtained by time shift or phase coding of the modulation which necessarily is impressed upon the transmission carrier. The vehicle receiver does not have a time reference in its operation and therefore as the vehicle moves through the successive signal blocks the receiver carried by the vehicle causes the vehicle to move at the desired operational speed or speeds in that the train carried receiver looks at all the successive signals energizing the successive signal blocks as being a speed command signals. In this regard it should be understood that in the actual operation of the disclosed vehicle control system it is not necessary for each of the illustrated signal blocks to have the same movement command signal. For example, a first signal block or a first group of signal blocks could have a first speed command signal and then a second signal block or second group of signal blocks could have a different speed command signal of either a greater speed value or a lesser speed value. In the event of an emergency condition, it is likely that subsequent signal blocks would be given a 0 m.p.h. speed command signal. It should be additionally understood that adjacent to station platforms and the like the movement of the train is controlled in this manner and therefore the physical length of the signal block may be changed and successive signal blocks probably will have different vehicle command signals. In the operation of the wayside position control apparatus the received signals are compared with the relevant transmitted signals through appropriate fail-safe circuitry and a clear signal block indication is only available if a correctly coded signal is obtained through operation of both the wayside circuitry and the cooperative receiver operative with the particular signal block being monitored. Stated another way, a clear signal block indication is available only if the received signals and the relevant transmitted signals match.

In FIG. 6 there is generally illustrated how a given speed command signal will be time shifted in relation to its application to a carrier frequency signal. This time shift characteristic provides a means to differentiate the energizing signals applied to respective signal blocks.

It can be seen that the present invention permits a substantial reduction in the number of diverse carrier frequencies required to safely control the movement of a plurality of vehicles along a given track. A predetermined coded signal is used to transmit vehicle movement com-

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mand information and the same carrier signal is used for train presence track signalling, it being a simple matter to obtain the desired orthogonality between adjacent signal blocks in the manner herein disclosed. This control system permits a substantial reduction in the necessary bandwidths of the vehicle carried receivers since these receivers only have to accommodate three different carrier signal frequencies instead of a substantially greater number of carrier frequencies.

The present invention has been described with a certain degree of particularity. However, it should be understood that various modifications and changes can be made in the arrangement and operation of the individual control signals and the like without departing from the scope and spirit of the present invention.

I claim as my invention:

1. In signal transmission apparatus operative with a conductive track and a vehicle traveling on the track whose movement is controlled by a movement controller selectively responsive to any one of a predetermined set of vehicle movement control signals, said track being electrically separated into a plurality of successive signal blocks for controlling the movement of a vehicle, said apparatus having a transmitter means coupled to said track for energizing said plurality of successive signal blocks with individual control signals such that each control signal has an individual position identification characteristic and such that each control signal represents an individual selected one of said predetermined sets of vehicle movement control signals, the improvements, comprising:

said transmitter means being operative to supply a transmission signal having a predetermined frequency characteristic for energizing each signal block, said predetermined frequency characteristic being one of a predetermined number of frequency characteristics representing signal block position information and assigned among signal blocks such that the frequency characteristic for each block is different from those impressed upon signals energizing immediately adjacent signal blocks,

said transmitter means also being operative to modulate the transmission signal for each signal block in accordance with a repetitive binary sequence, said binary sequence being a selected one of a predetermined set of comma free binary sequences, each sequence of the set representing a different vehicle movement control signal,

first sensing means associated with said vehicle for sensing repetitive binary sequence modulations of the transmission signal energizing the signal block which the vehicle instantly occupies as it moves along the track, said sensing means being adapted to couple the sensed binary sequence modulations to the vehicle controller, and

second sensing means operative with each signal block and being located at the wayside of said track, said second sensing means being selectively responsive to the associated predetermined frequency characteristic of the transmission signal energizing the signal block to determine the presence of a vehicle in any signal block.

2. A railway signalling system operative with electrically conductive track which is divided into a plurality of electrically separated signal blocks for controlling the movement of at least one vehicle along said track, said vehicle carrying a movement controller means selectively responsive to any one of a predetermined set of movement control signals to control vehicle movement, said system including,

transmitter means connected to each of said signal blocks for supplying a block energization signal thereto,

said transmitter means being operative to provide a block energization signal having a predetermined

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frequency characteristic, said predetermined frequency characteristic being one of a predetermined number of frequency characteristics representing signal block position information and assigned among the signal blocks such that this same characteristic as supplied to a given block is not supplied to any adjacent signal block for a predetermined number of signal blocks away from said given signal block, said transmitter means also being operative to modulate the block energization signal in accordance with a repetitive binary sequence, said binary sequence being a selected one of a predetermined set of comma free binary sequences, each sequence of the set representing a different movement control signal,

first sensing means operative to sense said repetitive binary sequence modulation component of the block energization signal of the signal block in which a vehicle is traveling and to couple same to the movement controller means carried by the vehicle, and second sensing means operative with said track and responsive to the frequency characteristic component of each block energization signal to identify any signal block which may be occupied by a vehicle.

3. The apparatus of claim 1, with

said first sensing means being carried by said vehicle.

4. The apparatus of claim 1, with

said track being divided into said successive signal blocks by means of low impedance members connected between the rails of the track at the respective ends of each signal block.

5. The apparatus of claim 1, with

said second sensing means being operative to determine presence of a vehicle in any signal block through cooperation of the transmitter means and said second sensing means such that a higher amplitude signal is sensed when the block is not occupied due to the short circuiting effect of the vehicle wheel trucks when the block is occupied.

6. The apparatus of claim 1, with

said signal transmitter means further being operative to time shift encode the binary sequence modulation of the transmission signal for each signal block in accordance with a predetermined time shift characteristic which is different from that supplied to the next occurring signal blocks furnished an identical frequency characteristic in either direction away from the instant signal block,

said second signal sensing means including means for comparing the time shift characteristic of binary sequence modulation of the transmission signal energizing the instant signal block with that of the relevant signal transmitted by the transmitter means,

said second sensing means being selectively responsive to a signal energizing the instant signal block having both the aforesaid predetermined frequency characteristic and a binary sequence modulation time shift characteristic which matches that transmitted by the transmitter means.

7. The apparatus of claim 6, with

said track being divided into said successive signal blocks by means of low impedance members connected between the rails of the tracks at the respective ends of each signal block.

8. The system of claim 2, with

said first sensing means being carried by the vehicle.

9. The system of claim 2, with

said second sensing means being operative to identify any signal block which may be occupied by a vehicle through cooperation of the transmitter means and said second sensing means such that a higher amplitude signal is sensed when the block is not occupied due to the short circuiting effect of the vehicle wheel trucks when the block is occupied.

10. The system of claim 2, with
 said transmitter means further being operative to time
 shift encode the repetitive binary sequence modulation
 component of the block energization signal in
 accordance with a predetermined time shift char-
 acteristic, said predetermined time shift characteristic
 being one of a predetermined number of different
 such characteristics also representing signal block
 position identification information, said number of
 different characteristics being assigned among the
 signal blocks such that this same one time shift
 characteristic as supplied to a given block is not
 supplied to successively occurring signal blocks fur-
 nished an identical frequency characteristic for a
 predetermined number of such successively occur-
 ring signal blocks away from said given block,
 said second sensing means including means for com-
 paring the time shift characteristic of the repetitive
 binary sequence modulation of the block energiza-

tion signal with that of the relevant signal transmitted
 by the transmitter means,

said second signal sensing means being selectively
 responsive to block energization signals having the
 combined characteristic of both the aforesaid one
 frequency characteristic and a binary sequence mod-
 ulation time shift characteristic which matches that
 transmitted by the transmitter means.

References Cited

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ARTHUR L. LA POINT, Primary Examiner

G. H. LIBMAN, Assistant Examiner

U.S. Cl. X.R.

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