March 6, 1962 R. P. HAMMOND 3,024,357

RAILWAY SIGNALLING MEANS

Filed Jan. 10, 1958

2 Sheets-Sheet 1

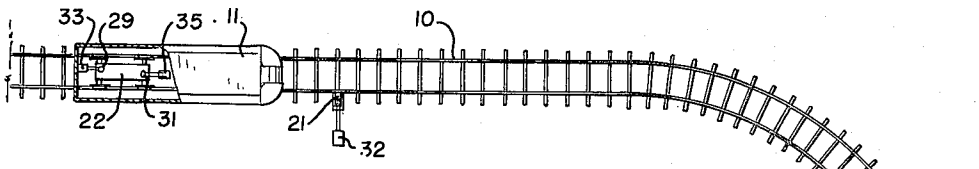


Fig. 1

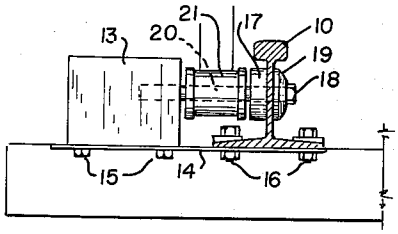


Fig. 2

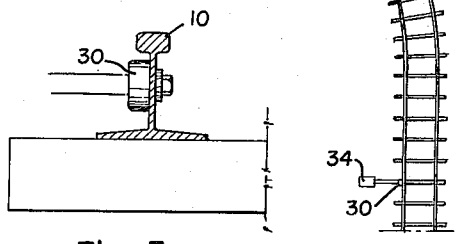


Fig. 3

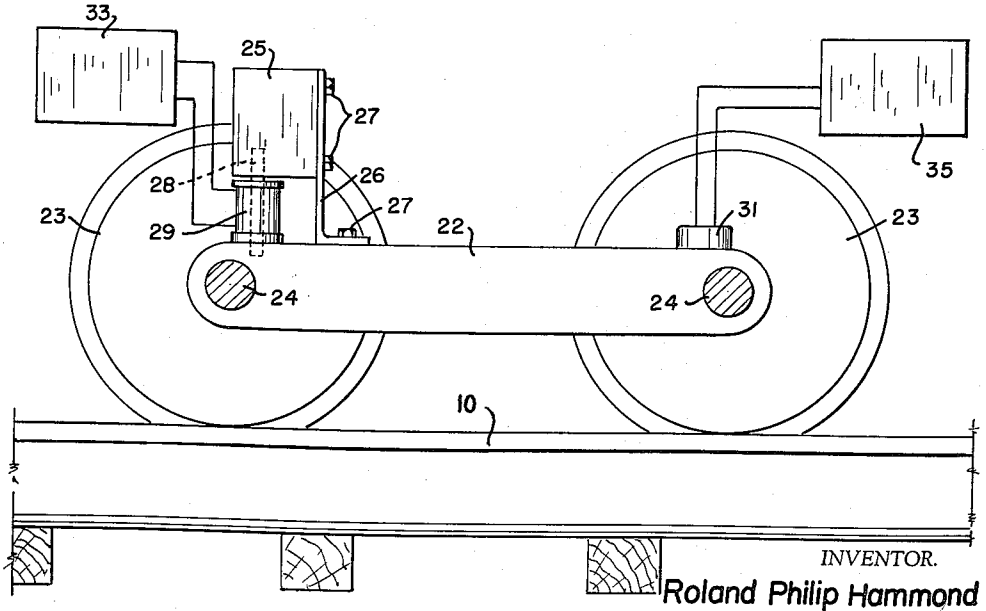


Fig. 4

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RAILWAY SIGNALLING MEANS

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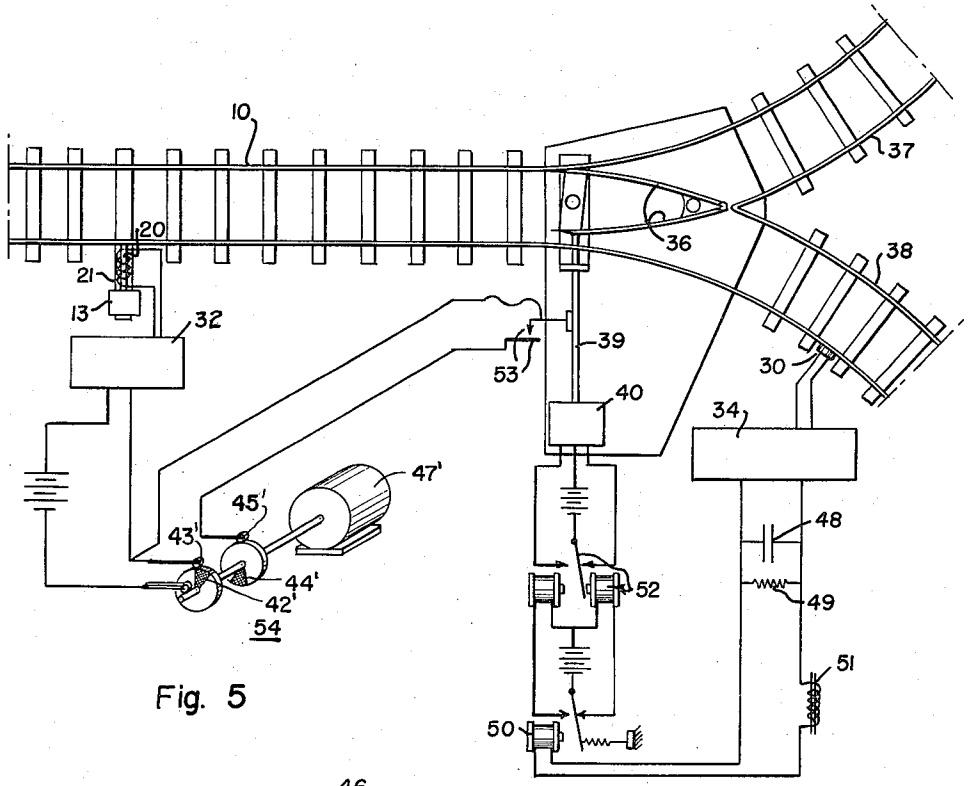


Fig. 5

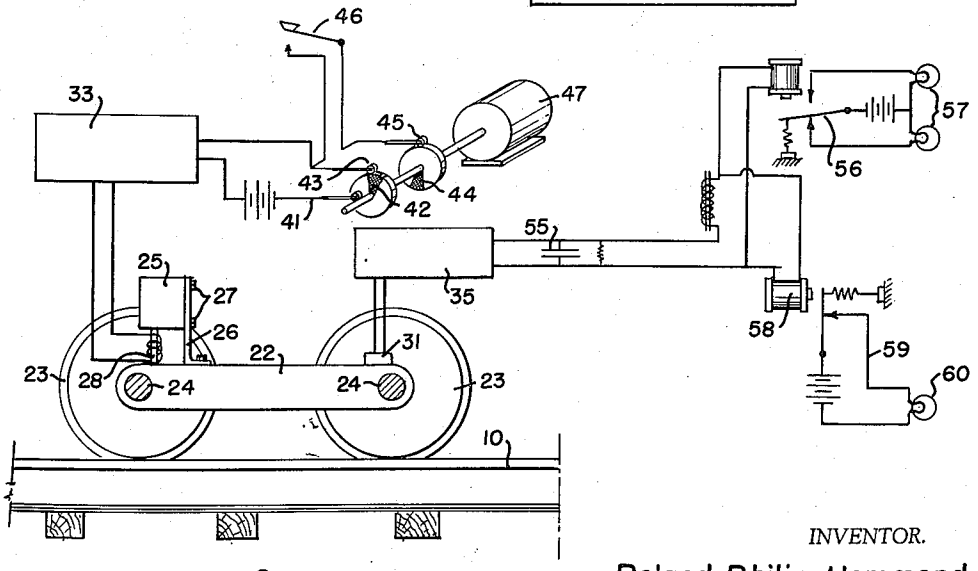


Fig. 6

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3,024,357

RAILWAY SIGNALLING MEANS

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This invention relates to a method and means for communicating between moving railway equipment and between moving equipment and wayside stations and right of way equipment. Such systems in the past have included radio communication and electric conduction through the railway rails.

Radio transmission is subject to many objections such as static interference, station interference, wave band overlap, etc., and its use is not practical for many railway uses. The use of the rails as metallic electric circuit conductors is subject to interference with and from block signaling equipment, track faults, etc. and without special bonding equipment and continuous maintenance, the rails do not form continuous conductors of uniform properties throughout the length of the system.

The principal object of this invention is to provide a system for communicating and signalling between trains and between trains and wayside stations which will avoid the difficulties encountered with radio communication and with metllic electrical circuits and which will provide positive and efficient two-way signaling to, from and between mobile rail equipment.

The improved signal transmission system utilizes sound waves at frequencies in either the audio or supersonic portions of the spectrum and is designed to transmit these sonic or supersonic vibrations through the railway rails without dependence upon the electrical conductivity of the rails.

The system contemplates the employment of a sonic generator and a pick-up device upon the mobile equipment and a similar sonic generator at each way station where it is desired to produce a signal and a similar pick-up device at each way station where it is desired to receive a sonic signal. The equipment at the way stations is to be applied directly to the railway rails and the equipment on the mobile units is applied in close proximity to the wheels whereby the latter will transmit sonic vibrations to the rails.

The improved signal system is particularly adaptable for automatic train control to provide precise positional train control from sonic signal transmitters positioned along the rail at predetermined points so as to transmit a coded signal to operate relays for accomplishing specific functions. For instance, a coded sonic transmitter could be positioned a predetermined distance in advance of a curve to give a train warning signal or to automatically cause a reduction to a safe speed for rounding the curve or a transmitter could be similarly positioned to sound the train warning signal upon approaching a grade crossing. The system is also adaptable for use with a preset programmed train control such as described in applicant's copending application Serial No. 716,087 filed February 19, 1958, and a pilot car train control as described in applicant's copending application Serial No. 714,208 filed February 10, 1958, both now abandoned.

Other objects and advantages reside in the detail construction of the invention, which is designed for simplicity, economy, and efficiency. These will become more apparent from the following description.

In the following detailed description of the invention, reference is had to the accompanying drawing which forms a part hereof. Like numerals refer to like parts in all views of the drawing and throughout the description.

In the drawing:

FIG. 1 is a diagrammatic plan view of a section of railway track illustrating typical relative positions of stations of the improved signal system to signal the approach of a track curve;

FIG. 2 is an enlarged cross-section through a track rail illustrating the means for transmitting a sonic signal to the rail;

FIG. 3 is a similar cross-section illustrating the means for detecting the sonic signal in the rail;

FIG. 4 is a diagrammatic side view of a conventional railway car truck, illustrating the signal system applied thereto;

FIG. 5 is a diagrammatic view of a track switch with the improved sonic signal system applied thereto; and

FIG. 6 is a similar diagrammatic view of the train circuits employed with the improved sonic-signal system.

In the drawing, the track rails are designated by the numeral 10, a piece of mobile equipment such as a train or car is indicated at 11. The mobile equipment 11 is provided with either or both a sonic transmitter and a sonic pick-up device and similar sonic transmitters and pick-up devices are positioned at predetermined points along the track rails 10 wherever it is desired to transmit signals to and from a moving train.

The sonic transmitters operate upon the principle of magnetostriction. Such a transmitter is illustrated in FIG. 2 for application to one of the track rails 10. The transmitter consists of a relatively heavy steel anvil block 13 fixedly monuted in spaced relation to the rail 10 by means of a tie plate 14 to which the anvil block 13 is attached by means of suitable cap screws 15 and which is attached to the rail in any suitable manner, such as by clamp bolts 16. An armature block 17 is secured against the web of the rail 10, through the medium of a cap screw 18 and a clamp washer 19, in spaced, opposed relation to the anvil block 13. The armature block 17 is rigidly connected with the anvil block 13 by means of a solid magnetostrictive core bar 20. A solenoid coil 21 surrounds the core bar 20 between the anvil block 13 and the armature block 17. When a high frequency alternating current is supplied to the solenoid coil 21, an alternating magnetic field, in the direction of the axis of the bar 20, is produced resulting in slight variations in the length of the bar. The variations will vibrate the rail 10 at a frequency corresponding to the frequency of the current supplied to the solenoid coil 21.

The sonic transmitters on the mobile equipment 11 also operate upon the principle of magnetostriction. Such a mobile transmitter is illustrated in FIG. 4 in which a car truck is diagrammatically indicated at 22 with its supporting, track-engaging wheels at 23 and journals at 24. A relatively heavy anvil block 25 of iron or steel is supported from a suitable supporting structure directly over one of the journals 24. As illustrated, the anvil block 25 is supported by means of a bracket plate 26 secured to the truck 22 and the block 25 by means of suitable cap screws 27.

A magnetostrictive core bar 28 is rigidly fixed at its extremities to the anvil block 25 and to the truck 22 directly over one of the journals 24. A solenoid coil 29 surrounds the core bar 28. The anvil block 25, the core bar 28, and the solenoid coil 29 correspond to the elements 13, 20 and 21 previously described and the vibrations are transmitted to the truck 22 and from thence through the journal 24 and the wheels 23 to the track rail 10.

The pick-up devices comprise contact microphones of any type suitable for converting mechanical vibrations into electrical impulses. Such a microphone, herein designated as a track microphone 30, is rigidly secured to the web of the track rail in any suitable manner such as indicated in FIG. 3. A similar microphone, herein designated as a truck microphone 31 is rigidly secured upon the truck

22 preferably over the journal 24 of a wheel 23, as shown in FIG. 4. The microphone may be of a type having a selective frequency response, or use may be made of well-known acoustical filters. For example, the microphone, instead of being mounted directly on the track or truck, may be mounted independently and connected by means of a tuned linkage consisting of rods, bars, or reeds with the source of sound. Such filters may greatly enchance the signal-to-noise ratio.

Each track solenoid coil 21 is connected in the output circuit of a conventional tuned oscillator 32 of any conventional type capable of producing an alternating current of a given frequency, preferably a super-sonic frequency, and of sufficient wattage to induce magnetostrictive vibrations in the core bar 20. The flow of current is controlled in any desired manner depending upon the results to be obtained. For instance, a manual control switch may be provided, or the current can be continuously interrupted by a motor-driven switch in accordance with a preset code, or the supply to the oscillator could be controlled by the operation of switch or signal equipment, depending upon the information desired to be transmitted.

Each mobile solenoid coil 29 is similarly connected in the output of a similar tuned oscillator 33 located on the mobile unit with any desired controls depending upon the uses desired.

Each track microphone 30 is connected to a conventional tuned signal receiver and amplifier 34 of any suitable conventional type depending upon the results desired. The receiver could be of a type to produce an audible signal or of an electronic switch type for operating a relay in a control circuit for operating any desired track signal and control equipment. The truck microphone 31 is connected to a receiver and amplifier 35 carried by the mobile equipment the output of which could be employed to give a visible or audible warning signal, or operate the throttle or brake equipment of the train.

One example of a use is illustrated in FIG. 1, in which the vibration-imparting track equipment 13, 20 and 21 has been applied to the rail 10 in advance of a track curve so that an ultra-sonic signal will be picked up by the truck microphone 31 of the approaching train to give a warning or a train operating signal as the curve is approached. The track microphones can be placed at desired points to pick up the super-sonic signal of the truck solenoids 29 to indicate the train has passed certain points or to operate track signals, switches, etc.

An application of the super-sonic system to track switch operation and signalling is diagrammatically illustrated in FIGS. 5 and 6 wherein the switch points are indicated at 36 for switching to a left-hand track 37 and a right hand track 38 from the main track rails 10. The switch points are shifted through the medium of a shift bar 39 from a switch motor 40. The switch points may be shifted to either track 37 or 38 from the approaching train and a signal will be returned to the train to indicate whether the desired shift has been completed through the medium of this improved super-sonic system as previously described.

For this use, the control circuit of the oscillator 33, indicated at 41, is constantly pulsed by a rotating commutator sector 42 and brush 43. A second rotating commutator sector 44, grounded to the first, rotates therewith and contacts a second brush 45 which can be placed in the control circuit 41 by means of a manual selector switch 46. The two rotating commutator sectors 42 and 44 are driven by a constant speed motor 47. The two sectors are opposed in phase so that the brushes will be alternately contacted. Thus, when the selector switch 46 is closed, the oscillator will discharge two bursts of high-frequency vibration of the rail for each revolution of the constant-speed motor 47; when the selector switch 46 is open, only one burst of vibration will be discharged.

Let us assume that when the selector switch 46 is open, it is desired to direct the train onto the right hand track 38 and when closed, it is desired to direct the train on the left hand track 37. The output vibration bursts are received from the rail at the switch location ahead of the train by the track microphone 30 and amplified by the receiver and amplifier 34. The latter amplifier is of a well-known type having a saturated output stage, so that above some minimum signal strength the bursts of high-frequency output power are of the same amplitude regardless of the intensity of the incoming signal from the train. These bursts are rectified in the amplifier to direct current and are delivered to a large output condenser 48, which is connected to a bleeder resistor 49 which acts to drain the charge from the condenser. The condenser and resistor are chosen so as to produce a relatively long time constant with respect to the burst frequency of the mobile oscillator 33. The result may be compared to a bucket brigade pouring water into a leaky tank. If every other person in the brigade drops out, the equilibrium water level in the tank will be lower than otherwise. Similarly, the voltage across the condenser 48 will be higher when the selector switch 46 is closed than when it is open. The condenser voltage is sensed by a relay 50 designed to close at a voltage substantially midway between the voltage produced with the selector switch 46 open and the voltage produced with the switch 46 closed. The relay may be of the electronic type, or of the coil type in which case the winding may serve as the bleeder resistor itself. A choke coil 51 may be necessary in the relay circuit to prevent the relay from closing from the condenser charging pulses.

The opening and closing of the voltage sensitive relay 50 controls the actuation of any suitable conventional type reversible motor control switch 52 for controlling the switch motor 40. As illustrated, the relay 50 causes the motor control circuit to normally cause the switch points to direct the traffic to the right hand track 38. Excess voltage, caused by closing the manual selector switch 46, causes the motor control circuit to actuate the switch motor 40 to move the switch points so as to direct traffic to the left hand track 37.

Thus, it can be seen that the engineer of a train approaching the switch can control the position of the switch points 36 by means of his selector switch 46. For instance, if he allows the selector switch 46 to remain open, the train will follow the right hand track 38. If he closes the switch 46, the switch points will be moved to cause the train to travel onto the left hand track 37.

It is, of course, desirable to provide means for notifying the engineer that the switch has functioned as directed. This is accomplished by placing one of the vibration transmitting devices of FIG. 2 on the rail of the approach track connected to one of the oscillators 32 and causing the feed control circuit to the oscillator to be pulsed as previously described with reference to the feed control circuit 41 of the mobile oscillator 33. For this purpose, a second pulsing set, designated in its entirety by the numeral 54 (and consisting of elements 42', 43', 44', 45' and 47', which are substantial duplicates of the elements 42, 43, 44, 45 and 47, as previously described, is placed in the feed circuit to the oscillator 32. In this second set, however, the manual selector switch 46 of the first set is replaced by a switch contact 53 on the switch shift bar 39 which serves the same function as the selector switch 46 in the mobile unit in reducing the burst frequency by half, when opened.

The pulses or bursts of vibrations thus generated travel to the microphone 31 on the mobile unit, and are amplified and converted to a direct current voltage across a condenser 55, corresponding to the condenser 48, to actuate a single-pole double-throw switch 56, corresponding to the motor control switch 52. In the mobile unit, the switch 56 controls signal lights 57 similarly to the manner in which the motor control switch 52 controls the motor 40, so that the respective signal lights will be lighted in accordance with the repetition frequency of the received bursts or pulses, and hence according to

whether the switch mechanism is in the left-hand track or the right-hand track position. Other functions could be added by well-known methods. A failure warning relay **58** is connected in parallel with the output circuit of the amplifier **35** which will act to maintain a warning signal circuit **59** open as long as the condenser voltage exceeds the lower of its two normal values. If the voltage drops below the preset value, this relay will close the warning circuit **59** to actuate an audible or visible signal **60** to indicate that the position of the switch ahead is unknown, and a visual check must be made.

In the system shown, the oscillator in the mobile unit and the receivers at the track must be tuned to a different frequency from the responding equipment, i.e., the oscillator at the rail and the receiver in the locomotive. The equipment can all be operated at the same frequency if the circuits are modified by well-known methods to give a call-respond or master-slave system, in which signals are intermittent and pass in only one direction at a time.

While the invention has been described as operating between mobile and stationary stations, it is also conceivable that ultra-sonic signals could be transmitted to the track from one mobile unit and picked up from the track by a second adjacent mobile unit to maintain spacing between train sections and to reduce the possibility of collision.

The anvil block **13** would weigh in the neighborhood of fifty pounds. The magnetostrictive core bar **20** is preferably made of thin laminations of tempered nickel alloy, insulated with varnish, and rigidly clamped and riveted together. The resulting bar is sized according to the wattage available, but may be one inch square in cross section for example.

Construction of the solenoid **21** will be determined by the power supply voltage, but may have about seven turns per volt for a one inch square bar. The wire size will be determined by the current available, using about 1000 circular mils per ampere. The high frequency power supply may be either the tuned oscillator **33** or a synchronous motor-driven alternator (the later only for frequencies up to about 20,000 cycles per second). The power supply should be capable of producing sufficient current in the solenoid **21** to give a magnetic flux of about 50,000 lines per square inch. A preferred form of power supply would be one that would give an alternating voltage superimposed upon a suitable continuous direct voltage, so that the magnetic flux varies from zero to maximum, rather than reversing. The condition may alternatively be obtained by using two windings in the solenoid, and a separate D.C. current source. Frequencies in the range of 4000 to 60,000 cycles per second may be used.

The usable distance from transmitter to detector will depend upon the power input of the transmitter, the sensitivity and discrimination of the detector and amplifier, and whether the rail is welded or bolted together. A 1000 watt generator and crystal pickup will have a usable distance of several thousand yards with welded rail.

The detectors **30** and **31** may be of the piezo-electric type or the magnetic type. For frequencies up to about 20,000 cycles per second, the construction may be similar to that used in conventional phonograph pickups. The cartridge housing is mounted inertially with respect to the rail or acoustic filter element, using a conventional spring and diaphragm or equivalent elements arranged to give the inertial mass a natural vibration frequency the same as that of the signal to be received. For higher frequencies, a specially cut piezo-electric crystal would be required, bonded to an inertial mounting so that the natural mechanical frequency is the same as the electrical frequency.

While some forms of the invention have been herein illustrated and described in some detail, it is understood that the invention is not to be regarded limited to the precise construction described, except in so far as such limitations are included within the terms of the accompanying claims, in which it is intended to claim all novelty inherent in the invention as broadly as is permissible.

Having thus described the invention, what is claimed and desired secured by Letters Patent is:

1. In a railway system including a main track having a metallic rail, a pair of branch tracks, a track switch operable to divert rail traffic to one or the other of said branch tracks from said main track, an electrically operable switch actuating mechanism adjacent said switch, vibration responsive means operatively connected to said switch actuating mechanism and operable to shift said mechanism to switch-actuating position responsive to the reception of vibrations from said rail at a predetermined pulse rate and to resist shifting of such mechanism to switch actuating position responsive to the reception of vibration at less than or greater than the predetermined pulse rate.

2. In a railway system including a main track having a metallic rail, a pair of branch tracks, a track switch operable to divert rail traffic to one or the other of said branch tracks from said main track, an electrically operable switch actuating mechanism adjacent said switch, vibration responsive means operatively connected to said switch actuating mechanism and operable to shift said mechanism to switch-actuating position responsive to the reception of vibrations from said rail at a predetermined pulse rate and to resist shifting of such mechanism to switch actuating position responsive to the reception of vibration at less than or greater than the predetermined pulse rate, said means including a microphone mounted on said rail, an amplifier in circuit with said microphone, and a relay in circuit with said amplifier and said swtch actuating mechanism.

3. The device of claim 2 together with a vibration producing means carried by a railway car on said main track and operable to induce mechanical vibrations at a predetermined pulse rate and at double the predetermined pulse rate in said rail.

4. The device of claim 3 together with hand actuable means for shifting the mechanical vibration producing means from the predetermined pulse rate to double the predetermined pulse rate whereby said switch will be controlled from the railroad car.

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