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Sibley

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[54] **DETECTION OF END ZONES IN ALTERNATING TRACK CIRCUITS**

[72] Inventor: **Henry C. Sibley**, Adams Basin, N.Y.

[73] Assignee: **General Signal Corporation**, Rochester, N.Y.

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[52] **U.S. Cl.** .... **246/34 CT,** 246/40
[51] **Int. Cl.** **B61l 23/30**
[58] **Field of Search** .... 246/34 R, 34 CT, 36, 40

[56] **References Cited**

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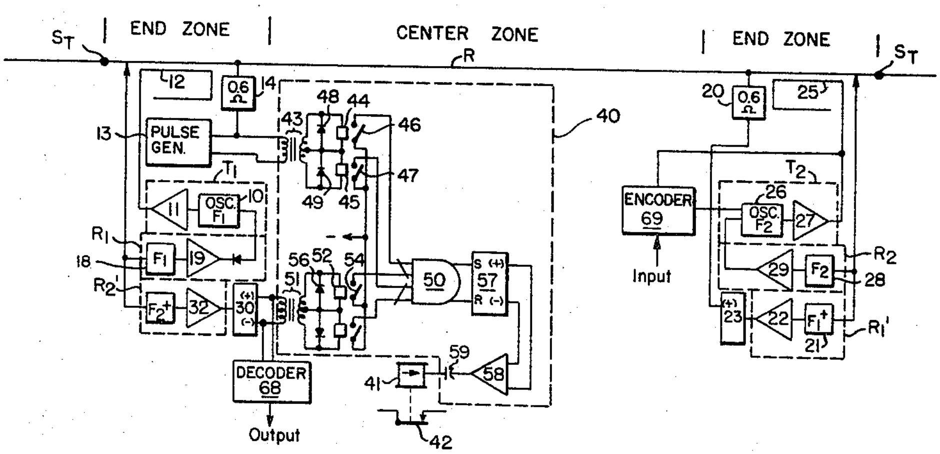
Primary Examiner—Arthur L. La Point
Assistant Examiner—George H. Libman
Attorney—Harold S. Wynn

[57] **ABSTRACT**

A continuous rail track circuit apparatus having termination shunts at each end detects the presence of a railroad vehicle shunt across the rails and indicates vehicle presence. Shunt means near one end of the track circuit periodically introduces a test shunt across the track, and receiver means coupled to the rails near the other end of the track circuit is sensitive to changes in track circuit parameters occasioned by the test shunt and respondingly introduces a reply test shunt in accordance with the period of the shunt means. Means at the first end of the circuit sensitive to changes in track circuit parameters occasioned by the reply test shunt provides indication of vehicle presence when the change in track circuit parameters ceases.

9 Claims, 4 Drawing Figures



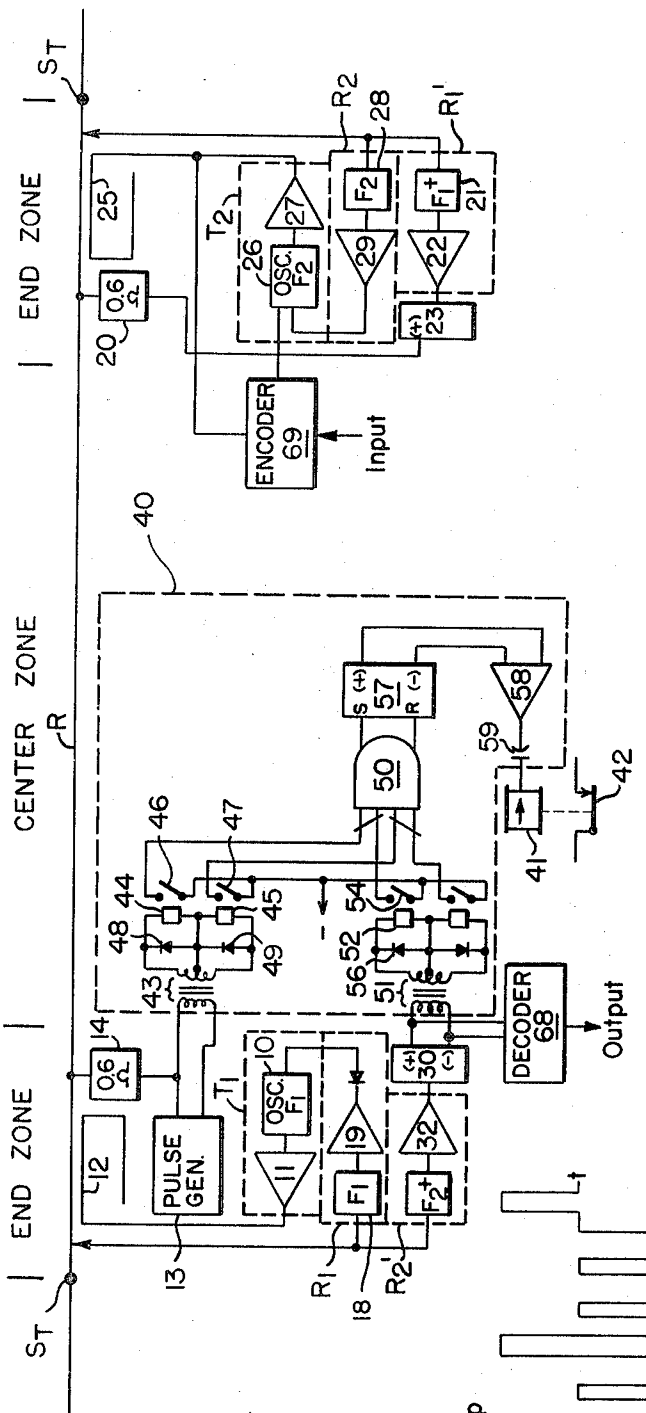


FIG. 1

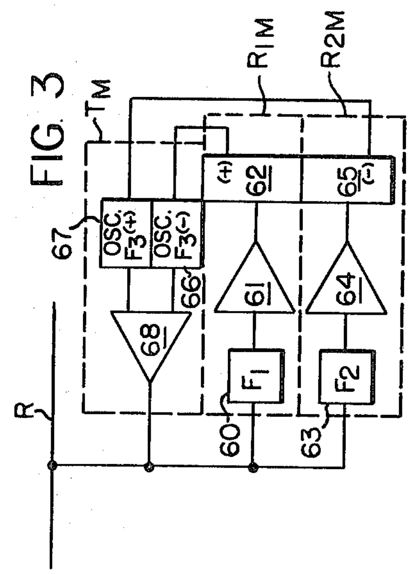


FIG. 3

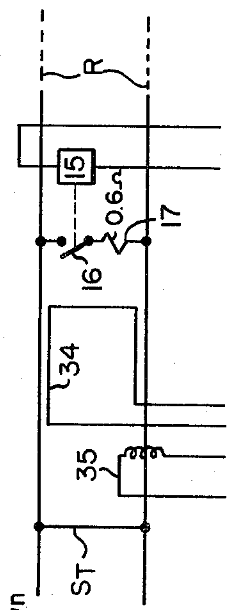


FIG. 2

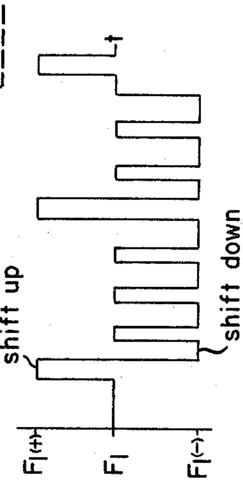


FIG. 4

DETECTION OF END ZONES IN ALTERNATING TRACK CIRCUITS

BACKGROUND OF INVENTION

This invention relates to track circuits and in particular continuous rail track circuits having termination shunts at each end.

When the track circuits are operated without insulated joints, two serious problems arise. First, the ends of the circuit are poorly defined so that the location of a vehicle is vague, and secondly, the signal is not confined to the circuit so that there is an interference along the various circuits along the track. If conductors cannot be interrupted, then the only way to terminate the circuit is by a short. A track section terminated by shorting bars overcomes the two problems above reasonably well, but adds a new problem. Since the train must be considered to be less than a perfect short circuit, the train close to the shorting bar will have very little effect on the track circuit and will not be detected. The length of this blind spot depends on frequency and the adjustment of the receiver can easily range between 2,000 feet at 65 hertz and 10 feet at 7 kHz.

The scheme herein is for a track circuit which is terminated by a shorting bar and can detect a single 0.06 ohm shunt within a foot or two of the ends.

It is therefore an object of the present invention to provide an arrangement which substantially obviates one or more of the limitations and disadvantages of the described prior arrangements.

It is another object of the present invention to provide a continuous rail track circuit capable of accurately detecting a railroad vehicle near the end zones.

SUMMARY OF INVENTION

There has been provided a continuous rail track circuit apparatus having termination shunts at each end. The track circuit detects the presence of a railroad vehicle shunt across the rails which is indicative of vehicle presence. Shunt means near one end of the circuit periodically introduces a test shunt across the tracks and a receiver means coupled to the rails near the other end of the circuit is sensitive to changes in the circuit parameters occasioned by the test shunt. The receiver periodically introduces a reply test shunt in accordance with the period of the shunt means and means at the first end of the circuit is sensitive to changes in circuit parameters occasioned by the reply test shunt and provides indication of vehicle presence when the change in circuit parameters ceases.

The track circuit parameters referred to as being changed by the shunt are an increase in track circuit current in the area of a test shunt and a resulting increase in carrier current shift frequency feeding the track circuit as a means for communicating the detection of the test shunt at one end of the track circuit to the opposite end of the track circuit.

There has also been provided a track circuit having three zone defined track circuits including a center zone track circuit and two end zone track circuits having one end coupled to an end of the center zone and terminated at the other end of the termination shunt. The track circuits have characteristics such that the signals present in the rails and blocked by a vehicle shunt present in the center zone and increased by a vehicle shunt present in the end zones. Means responsive to both the blockage and increase in the signals provides indication of vehicle presence.

For a better understanding of the present invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawings, while its scope will be pointed out in the appended claims.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a schematic diagram showing the apparatus necessary for practice of the present invention;

FIG. 2 is a circuit detail showing track coupling and the shunt means;

FIG. 3 is a repeater station for extending track circuit length; and

FIG. 4 is a waveform diagram showing introduction of coded information as well as vehicle detection.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Alternating current track circuits generally require transmitters to drive the circuit at each end by means of loops. These loops may be 8 feet long with eight to 32 turns, the larger number being required for low frequencies. Receivers sense current at the ends opposite their transmitters by means of loops or small coils mounted close to the rail. The train anywhere along the track, except close to the ends, will reduce the current into the receivers to the point where detection is certain. The ends are the problem. A train close to the end will not reduce received current appreciably, but it will increase the transmitted current. Receivers tuned to the local transmitter frequencies are added to each end to detect when track current is increased by a train.

The system described here shows three track circuits detecting vehicles. In the center zone or circuit most of the length of the track circuit vehicles are detected in the conventional closed circuit manner. The two end zone circuits are checked by the open circuit series method and the three readings are combined in a logic scheme that provides fail-safe train detection, security against operation by false signals, and a choice of such options as a simple repeater to double the circuit length and message handling capability for traffic control and cab signals.

The end zone requiring special detection means is a length of track having the shorting bar at one end and having an impedance of approximately 0.6 ohm looking into the other end. If a train having a shunt value of 0.06 ohm stands at the end of this track section, the current divides sending approximately 90 percent through the train axle and leaving only 10 percent for the receiver at the far end of the track section. A train further from the end will cause a greater reduction in receiver current because the end zone has even a higher impedance. The series circuits at the ends must detect a train at a distance where the track impedance is 0.6 of an ohm or more. These values of 0.6 ohm for a typical end zone impedance and 0.06 ohm for a standard shunt are set in accordance with certain principles of safety for providing margins relative to the track conditions.

At a frequency of 500 hertz, a track circuit of this type will probably work well over a mile with ballast resistances as low as 5 ohms in 1,000 feet. The end zones; that is, the 0.6 ohm track sections are about 500 feet long. A short poor shunting vehicle might be lost within 500 feet of the ends unless the special end zone circuits are used.

The transmitting loop and its 8 foot section of track may be considered as a transformer feeding a mile long track circuit with a short at the far end. This mile long track circuit will look like a load that varies between 2 and 7 ohms depending on ballast resistance if there are no trains. If a train is within 500 feet of the end, the transformer will feed a load of 0.6 ohm or less. The receiver sensing transmitter current must indicate occupancy when the current is that value which flows through 0.6 ohm or less. At lower current values it need not indicate occupancy because track current increases as the shunt moves away from the receiver and at the current value that flows into a mile of wet track, for example, 2 ohms it must not indicate occupancy. There is a range, therefore, of current values which must satisfy an empty track circuit under worst ballast conditions; that is, a 2 ohm value for the entire length and must be compatible with an arbitrarily set impedance value of 0.6 ohm for 500 feet.

The current detector is tested by simulating a train at the limit of the end zone. Since by the conventional method of track shunting it is possible to detect a train at a distance of greater than 500 feet from the end of the track circuit, it is not necessary to simulate the train in the mid-range of the circuit. However, in the end zones a resistor of 0.6 ohm is connected across the track at the end of the transmission loop and will affect the circuit such that the same current in the track circuit is produced as if a train were present within the 500 foot end zone section. This resistor is alternately switched in and out of the circuit continually testing the end zone circuit. This resistor affects only the end zone being tested and has negligible effect on the signal transmitted from the end zone being tested to the other end of the circuit. If this were not true, there would be no problem detecting trains near the ends.

This track circuit uses track transmitters which are of the frequency shift keyed type. Receivers responsive to the transmitters can detect which way the transmitters are shifted and have the added safety feature that they will respond to both shifts simultaneously so that any interference that produces what looks like an impossible condition, will not be resolved but will result in a safe failure. This carrier equipment plus cycle checked logic combine the end zone and main line signals.

The following is a description of the overall scheme with respect to FIG. 1. The schematic diagram of FIG. 1 shows a railroad track circuit including a set of rails indicated by reference R terminated at end by a termination shunt S_T. The first or left end of the track circuit is fed by a track transmitter T_1 including an oscillator **10** capable of generating an F_1 frequency and an amplifier **11** which increases the gain of the carrier frequency F_1 and couples it to the rails R through a loop transmitter **12**. A pulse generator **13** drives a track test shunt **14**. Shown in FIG. 2, this consists of a relay **15** driving its contact **16** in series with a 0.6 ohm resistor **17** coupled across the track rails R. This track test shunt **14** periodically is coupled across the rails R and the shunt in the rails produced by the coupling of the F_1 signal by loop **12** increases. A receiver R1 responsive to the F_1 frequency is capable of detecting an increase in track current. The receiver R_1 consists of a filter **18** and a detector **19** calibrated so as to detect some threshold current. When such a condition exists as when the test shunt **14** is coupled across the rails R, the detector **19** provides a signal to the transmitter T_1 and in particular to the oscillator **10**. This signal causes the oscillator to shift up the basic frequency F_1 to some preselected value F_1+. This signal F_1+ is thence coupled to the rails R through loop **12** and transmitted to the second or right end of the track circuit.

A receiver R_1' responsive to the shifted frequency drives a return shunt relay **20**. The receiver R_1' consists of a filter **21** which responds to the frequency F_1+ and an amplifier **22** which is used to increase the gain of the received signal and drive a flip-flop **23** one output of which is coupled to the return shunt **20**. As in FIG. 2, the return shunt **20** actuates a contact **16** coupled in series with a resistor **17** across the rails R. This periodic shunting in accordance with the receiver R_1' causes an increase in the track current. Track current for the second end is provided by a second transmitter T_2 feeding the rails through transmitting loop **25**.

Transmitter T_2 consists of an oscillator **26** generating a frequency F_2 and an amplifier **27** for increasing the gain of the oscillator signal and coupling the second carrier F_2 to the rails R via the transmitting loop **25**. When the return shunt **20** is coupled across the rails, the current necessarily increases and a receiver R_2 responsive thereto drives the transmitter T_2 into a shifted frequency F_2+. The receiver R_2 consists of a filter **28** responsive to the carrier frequency and a detector **29** capable of detecting a preset current threshold for providing a signal to the transmitter T_2. When the receiver R_2 provides the shift signal to the transmitter T_2, the shifted frequency signal is coupled to the rails through the loop coil **25** and transmitted back to the left end of the track circuit. A receiver R_2' is responsive to the shifted frequency F_2+ and provides an output signal to flip-flop **30**. The receiver R_2' consists of a filter **31** and a driving amplifier **32** for providing an output signal to the flip-flop **30**.

The pulse generator **13** is coupled to output logic circuitry **40**, as is the R_2'. For each positive-going pulse of the generator **13**, the test shunt **14** is activated which causes an increase in track current and shift-up of frequency oscillator **10** with a subsequent reaction at the right end of the track circuit and a return test shunt, which is in turn received by the receiver R_2'. The inputs to the output logic **40** must occur with a certain predetermined phase relation one to the other. If, for any reason, the return test shunt is interrupted as by a failure of the apparatus or a vehicle shunt, the output logic **40** will provide an indication of such a condition by deenergizing the output relay **41** and dropping its associated front contact **42**. A train in the center section of the track circuit, about 500 feet from each termination shunt S_T, will completely interrupt communication from one end of the track circuit to the other. However, when the train approaches the vicinity of the end zone; that is, the last 500 feet before the termination shunt S_T, at some predetermined current value the receiver R_1 or R_2 depending upon the direction of travel of the vehicle will be activated by an increase in the current. As long as the train is present in that end zone, the current in the track circuit remains above that threshold and the receiver R_1 or R_2 is always activated. The period rate of introducing the test shunt **14** to the circuit by pulse generator **13** is therefore substantially bypassed because the transmitter R_1 is always in the shift-up position. Under such conditions, the output logic **40** senses a cessation of the inputs at required periodic intervals and causes the relay **41** to drop its contact **42**. The logic **40** as previously noted in response for holding the relay **41** energized only wne its two inputs are satisfied. By holding the transmitter frequency T_1 in the shift-up condition, the apparatus at the right end of the track circuit is incapable of repeating the shift.

Pulses from the generator **13** coupled through transformer **43** alternately activate the relays **44** and **45** and their associated contacts **46** and **47** respectively. Diodes **48** and **49** assure that only pulses of the proper polarity actuate the associated relay. The contacts **46** and **47** are coupled to AND gate **50** to alternate sets of associated inputs. The second input to the output logic **40** is provided from the output of flip-flop **30** through transformer **51** for driving the relays **52** and **53** and their associated contacts **54** and **55** respectively. The diodes **56** and **57** permit activation of the associated relays **52** and **53** only upon proper polarity as provided through the transformer **51** from the flip-flop **30**. The contacts **54** and **55** are also coupled to the AND gate **50** to alternate inputs and as can be seen from the drawing, the contacts **46, 54** and **47, 55** are associated inputs to the AND gate **50**. Only when two associated inputs to the AND gate **50** are energized simultaneously and the other two inputs are deenergized will an output occur from the AND gate **50** for setting and resetting the flip-flop **57**. Alternate energization of the flip-flop's inputs for setting and resetting activate a driver **58** which produces pulses to the relay **41** for maintaining the front contact **42** closed. Capacitor **59** maintains the relay **41** during successive pulses from the relay driver **58**. If the period of the pulse generator **13** becomes out of correspondence with the period of activation of the return shunt **20** and the associated shift frequency F_2+ as received by the receiver R_2', then the output logic **40** will cease to produce energy for driving the driver **58** and maintaining relay **41**. For each positive-going pulse of pulse generator **13**, there should be a single pulse from the flip-flop **30** on the associated (+) output. Such a positive-going pulse from the generator **13** and the flip-flop **30** will cause the associated relays **44** and **52** to close contacts **46** and **54** respectively satisfying the associated inputs to the AND gate **50**. Similarly, a negative-going pulse of the generator **13** and a negative output (−) from the flip-flop **30** will cause the relays **45** and **33** to close the contacts **47** and **55** respectively satisfying the associated inputs to the AND gate **50** for resetting the flip-flop **57**. Unless therefore the signal output of the transmitter T_2 provided by the activation of the return test shunt **20** is received by receiver R_2' in a certain phase relation to the pulse generator **13**, no output occurs from the output logic **40**.

Any condition such as vehicle presence which would cause either of the receivers R_1 or R_2 to provide a continuous shift-up signal will cause a cessation of this phased relation of the carrier F_1+ and the period return of F_2+.

If it were desired to increase the length of the track circuit, a repeater station near the mid-point of the track circuit may be installed and substantially double the length of the circuit. The repeater circuit is coupled to the rails R at the mid-point as shown in FIG. 3 and a receiver R_{1M} including filter **60** and amplifier **61** drive frequency detector **62** which drives one input of transmitter T_M. The second receiver R_{2M} responsive to F_2+ includes a filter **63** and amplifier **64** driving frequency detector **65** which has an output which drives a second input to transmitter T_M. Frequency detectors **62** and **65** are connected to oscillators in the transmitter T_m one of which is a shift-up oscillator **66** and the other is a shift-down oscillator **67**. The receivers at opposite ends of the track circuit shown in FIG. **1** corresponding to R_1' and R_2' are responsive when used in connection with the repeater station to the F_3+ and F_3- signals respectively. The same continuity of indication is provided using the repeater station. However, an extra frequency shift transmitter T_M is necessary and variation in the receiver circuits necessary for receiving the particular mid-station signals are provided. This modification provides for nearly double the track length with a minimal amount of additional apparatus.

Code communications may be incorporated into this track circuit by utilizing an encoder **69**. By coupling the encoder **69** to oscillator **26**, a shift-down signal may be provided which is illustrated in the waveform diagram of FIG. **4**. The center frequency or carrier F_1 and a shift-up to the F_1+ signal provides the vehicle detection information as previously described. The shift from F_1 to F_1-, however, can be utilized to provide coded information during the times when the test shunt **14** and return test shunt **20** are not activated by initiating the shift-up phase of the vehicle detection. If, for example, as is contemplated in the present invention, a test shunt is introduced every second or some short interval of time, perhaps 50 milliseconds, then the remainder of the one second interval is available for transmission of coded information. Under these conditions, therefore, it is possible to provide not only vehicle detection information but also the cab signaling and other useful indications without the necessity of providing wayside line wires.

Decoding is accomplished by coupling decoder **68** to one input of the output logic **40** associated with flip-flop **30**. Information from encoder **69** may be supplied by some program or other external source such as for example a hot box detector. Decoder **68** output may be coupled to a signal on other warning devices to be actuated in accordance with the information supplied by encoder **69**. The above is merely an example and it is obvious that many purposes may be seen by such a communications channel.

There has therefore been provided a system which incorporates the economical features of continuous rail track circuits with accurate end zone detection. There has also been provided a system which can be readily adapted to provide for a continuous signaling from one wayside to the train without the necessity of wayside line communication channels.

While there has been described what is at present considered to be the preferred embodiment of the present invention, it will be obvious to those skilled in the art that various changes and modifications may be made without departing from the invention, and it is therefore aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A continuous rail track circuit apparatus having termination shunts at each end for detecting the presence of a railroad vehicle shunt across the rails indicative of vehicle presence comprising:

a. shunt means near one end of the circuit for periodically introducing a test shunt across the tracks;

b. receiver means coupled to the rails near the other end of the circuit sensitive to change in circuit parameters occasioned by said test shunt for respondingly introducing a reply test shunt in accordance with the period of the shunt means; and

c. means at the first end of the circuit sensitive to change in circuit parameters occasioned by said reply test shunt for providing indication of vehicle presence when said change in circuit parameters ceases.

2. The track circuit apparatus of claim **1** wherein the shunt means includes:

a. driver means at the first end for shunting the rails in the vicinity of the termination shunt;

b. transmitter means coupled to the rails at the first end for feeding the rails with a carrier signal; and

c. shift means responsive to an increase in track current occasioned by the test shunt for shifting the frequency carrier signal.

3. The track circuit apparatus of claim **2** wherein said test shunt means comprises:

a. an impedance coupled to a rail calibrated in accordance with a preselected value; and

b. switch means serially connected with said impedance operative when actuated by said drive means for shunting said track with the calibrated impedance.

4. The track circuit apparatus of claim **3** wherein said driver means includes a pulse generator for providing periodic pulses of energy for actuating said switch means.

5. The track circuit apparatus of claim **2** wherein said receiver means includes:

a. reply test shunt means at the second end for shunting the rails in the vicinity of the termination shunt;

b. frequency responsive means coupled to the rails at the second end for introducing the reply test shunt in response to the shifted carrier frequency;

c. second transmitter means at the second end for feeding the circuit with a second carrier signal; and

d. second shift means responsive to an increase in track current occasioned by the reply test shunt for shifting the frequency of the transmitted signal.

6. The track circuit apparatus of claim **3** wherein the means at the first end sensitive to the change in circuit parameters includes:

a. a capture receiver coupled to the rails responsive for generating a signal in accordance with the occurrence of the second frequency shift carrier; and

b. output logic means responsive to the period of the first shunt means and the capture receiver signal for providing an output signal as long as the period of the first shunt means agrees with the occurrence of the second shifted carrier signal, said output indication of a clear track circuit and ceasing the output upon occurrence of disagreement of the signals thereby providing indication of vehicle presence.

7. The track circuit of claim **4** wherein said output logic means comprises:

a. a switching means for changing conductance state in accordance with each state of said capture receiver and said driver means;

b. gate means responsive to positive and negative conductance states of the capture receiver and driver means respectively for generating an output when said conductance states are in phase correspondence and clearing said output for indicating vehicle presence when said correspondence ceases, thereby providing synchronism of the ends of the track circuits such that spurious signals are substantially ineffective to actuate said output logic means to an unsafe condition.

8. A continuous rail track circuit apparatus having termination shunts at each end for detecting the presence of a railroad vehicle shunt across the rails indicative of vehicle presence comprising:

a. train simulation means near one end of the circuit for periodically introducing a fixed impedance across the rails commensurate with an ideal vehicle shunt at a selected distance from the end of the track circuit,

b. receiver means coupled to the rails near the other end of the circuit sensitive to change in circuit parameters occasioned by said test shunt for respondingly introducing a reply train simulation shunt in accordance with the period of the train simulator means,

c. means at the first end of the circuit sensitive to change in circuit parameters occasioned by said reply train simulation shunt for providing indication of vehicle presence when said change in circuit parameters ceases.

9. The track circuit apparatus of claim 8 wherein said fixed impedance is a value indicative of a maximum allowable train shunt, typically on the order of 0.6 ohm.

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