

[54] **COMBINED HIGH AND LOW FREQUENCIES FOR TRACK CIRCUIT**

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 [22] Filed: **May 4, 1970**
 [21] Appl. No.: **34,236**

[52] U.S. Cl. **246/40**
 [51] Int. Cl. **B61L 23/30**
 [58] Field of Search 246/34 R, 34 CT, 36, 40;
 325/29, 8; 340/258 R, 258 B

[56] **References Cited**

UNITED STATES PATENTS

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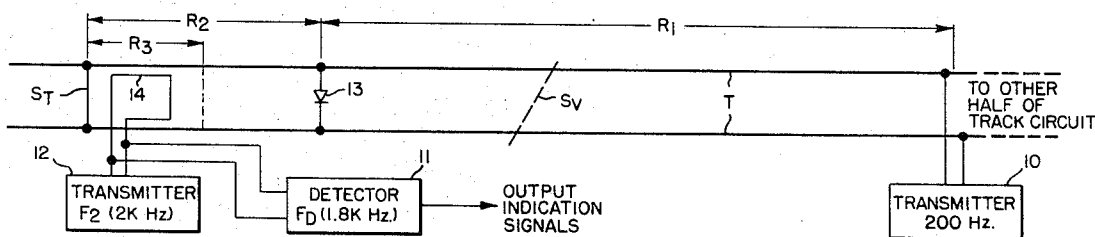
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[57] **ABSTRACT**

A continuous rail alternating current track circuit has been provided having shunts at extreme ends for terminating the circuit. A track transmitter is coupled to the rails for center feeding the circuit with a first signal having an associated effective range less than the distance to the shunt. The improvement for providing accurate detection of a vehicle shunt between the termination shunt and the end of the effective range of the signal includes a transmitter located at each end of the track circuit coupled to the rails for propagating a second signal at least to the range end of the first signal. Means at the range end of the second signal modulates the first and second signals in the rails to high and low side-band frequencies and a detector means at each end of the track circuit responds to at least one side-band frequency for detecting the modulated frequency and providing indication of vehicle presence when the side-band frequency is interrupted.

6 Claims, 5 Drawing Figures



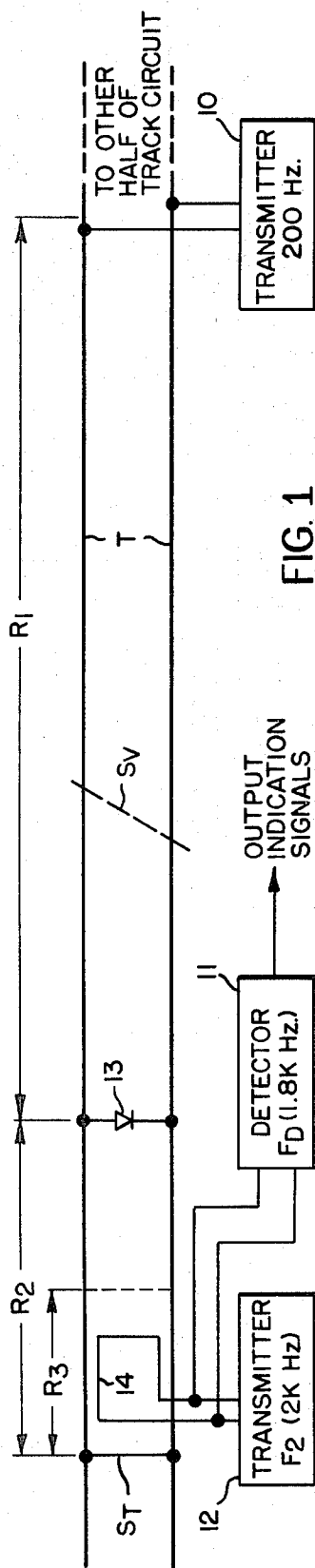


FIG. 1

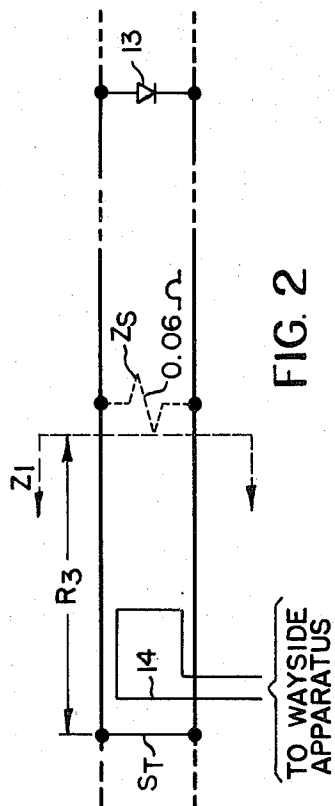


FIG. 2

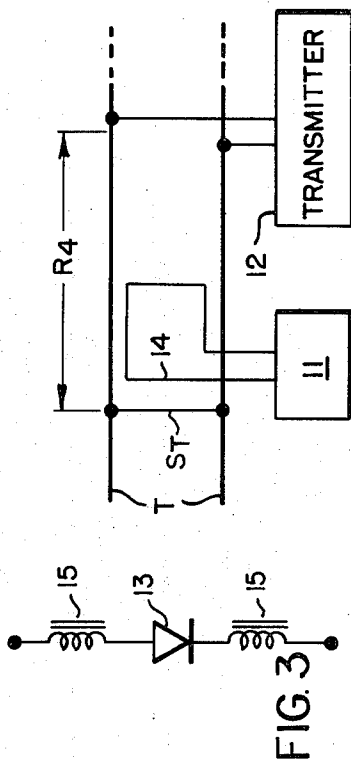


FIG. 3

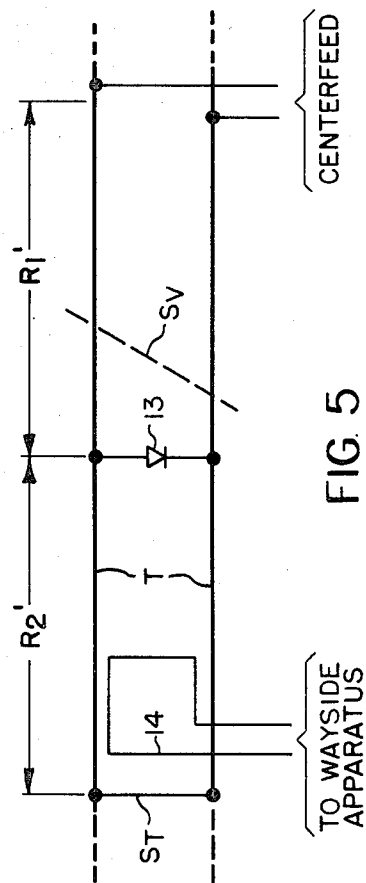


FIG. 5

COMBINED HIGH AND LOW FREQUENCIES FOR TRACK CIRCUIT

BACKGROUND OF INVENTION

This invention relates to track circuits and particularly to jointless track circuits having terminating shunts for defining block ends.

Jointless track circuits generally have poor definition; that is, a train approaching the end of the circuit may show occupancy at varying distances depending on ballast resistance and battery voltage. With D.C. track circuits having insulated joints, it is possible to have relatively long track circuits and even with a poorly shunting vehicle, a relay held up at one end by a power source feeding the track circuit from the other end will drop away and provide detection of a vehicle under the most unfavorable conditions. With jointless track circuits, however, the track rail is continuous and termination of the track circuit is accomplished by means of a shunt across the rails at the extreme ends of the circuit.

When considering the impedance of a D.C. track circuit, rail inductance is disregarded because its effect on the total impedance of the circuit is effectively zero. Using alternating current, however, introduces the factor of inductive rail impedance with increases as the frequency of the input current increases. For purposes of railway signaling operation, the shunt provided by a railroad vehicle is considered to be 0.06 ohm as a standard. As the vehicle shunt moves towards the terminal shunt of the circuit, it is quite reasonable to assume that at a certain point near the end of the track circuit the terminal shunt would draw more current than the vehicle shunt. This is because the impedance of the rails coupled by the terminal shunt is less than the vehicle shunt impedance. Under these circumstances, however, a device responsive to track current for detecting the presence of a vehicle would lose sight of the approaching shunt when the track impedance is reduced to less than the vehicle shunt impedance such that the current flowing through the shunt is substantially higher than the vehicle shunt.

If a track circuit is fed at the center with a 200 hertz signal, the impedance of the tracks shorted at 1,000 feet from the terminal shunt looks like 0.6 ohms. At distances of at least greater than 1,000 feet from the terminal shunt, it is reasonable to assume that the current flowing through the train shunt would reduce the current at the terminal sufficiently for a vehicle to be detected. However, as the train moves into the last 1,000-foot section, the current in the terminal shunt increases and the vehicle detection might be lost. A 10 to 1 ratio of the impedance of the track circuit shunted at a thousand feet to the vehicle shunt is taken as an example and represents a considerable safety margin. This ratio may be reduced to substantially less than this; however, for the purposes of this disclosure this ratio is reasonable and, in fact, represents an anticipated safety requirement. At 2,000 hertz, the impedance of the rails increases with frequency and the end zone which is ambiguous is reduced to 120 feet. Therefore, the higher the frequency used the shorter the ambiguous zone of detection. It is a fact however, that for high frequencies the range of the signal is considerably reduced by the increased inductive impedance of the rails as the frequency increases and in fact with a 2,000 hertz signal the circuits would have to be terminated every thousand feet.

The problem, therefore, is to provide a maximum length track circuit without an ambiguous zone so that the presence detection of a vehicle will not be lost until the vehicle actually leaves the particular block.

It is therefore an object of the present invention to provide a system which obviates the limitations and disadvantages of the described prior arrangement.

It is another object of the present invention to provide an improved track circuit having a considerably long length.

It is another object of the present invention to provide a system which provides unambiguous detection of a vehicle anywhere in the block.

SUMMARY OF INVENTION

There has been provided in the present invention a continuous rail alternating current track circuit having shunts at extreme ends for terminating the circuit and a relatively low frequency track transmitter coupled to the rails for center feeding the track circuit with a low frequency signal having an associated effective range less than the distance to the shunt. The improvement for maximizing the track circuit length and providing accurate detection of a vehicle shunt between the terminal shunt and the end of the effective range of the low frequency signal includes a relatively high frequency transmitter located at each end of the track circuit coupled to the rails for propagating a high frequency signal at least to the range end of the low frequency signal. Means located at the range end of the low frequency signal modulates the low and high frequency signals in the rails to high and low side-band frequencies, and a detector at each end of the track circuit responds to at least one side-band frequency for detecting the modulated frequency and providing indication of vehicle presence when the side-band frequency is interrupted.

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.

DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a schematic diagram of one-half of a center fed track circuit incorporating apparatus necessary for practice of the present invention.

FIG. 2 illustrates impedance criteria in end zone detection.

FIG. 3 is a diagram of an alternate form of the modulating means.

FIG. 4 is an alternate form of feeding a signal to the track circuit.

FIG. 5 illustrates the variations possible in positioning of the elements necessary for practicing the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference to FIG. 1, the track circuit of the present invention generally takes on the form of a set of continuous track rails T fed by a relatively low frequency transmitter 10. This track circuit is center fed and only the left side of the track circuit is shown because of its symmetry about the transmitter 10. The track rails T are terminated at the extreme ends by track shunts S₁ which are fixed shunts for defining the end of the track circuit. The transmitter 10 transmits a signal capable of reaching the shunts S₁ in the order of 200 Hz. However, the effective range of the signal for purposes of unambiguous detection of a vehicle shunt represented by the dotted line S₁ is the distance R₁. The remaining distance R₂ to the shunt S₁ is that to which this discussion is primarily focused. The detector 11 tuned to a specific frequency F₀ is generally responsive to the frequency of the transmitter 10 and will provide an indication of vehicle presence when the vehicle shunt S₁ is present between the transmitter 10 and the detector 11. In the present invention, however, the detection frequency is modified to respond to a modulated frequency which if interrupted will provide indication of a vehicle in the track section. The reason for this different frequency will be explained further in the discussion.

If a second track transmitter 12 is inductively coupled to the rails T through loop 14 in the R₂ section, a second signal F₂ may be introduced into the rails which could be useful in providing for the end zone detection represented by the R₂ range. In addition, if a nonlinear element such as the diode 13 is coupled to two transmitters generating different frequencies, the nonlinear element will modulate the two frequencies to provide sum and difference frequency signals. Sums and differences of the frequencies F₁ and F₂ in this discussion chosen to be 200 Hz and 2 kHz respectively are represented by legends F_s and F_d representing 2.2 kHz and 1.8 kHz. The

detector 11 is tuned to the frequency F_D (1.8 kHz). This lower frequency F_D is more useful because it has a longer effective range and provides a stronger signal at the detector 11. The detector 11 is coupled to the rails T by a loop coil 14 which is inductively responsive to the difference frequency F_D . If a vehicle represented by the shunt S_1 enters the track section T, it interrupts either of the two transmitter frequencies F_1 and F_2 and this suppression of the transmitter frequencies is picked up by the loop 14 and coupled to detector 11 from which an output indication signal is generated. When the shunt S_1 is in the section R_1 or R_2 of the track circuit, the 200 hertz signal is suppressed and the detector 11 which is finely tuned to the difference frequency F_D provides its indication. With the difference frequency F_D suppressed, the detector provides its indications and the end zone detection is quite accurate.

With a 2 kHz signal generated by the transmitter 12, the ambiguity, represented by the distance R_3 in the end zone detection, is probably no more than perhaps 10 feet and the length of any railroad vehicle would sufficiently overlap this distance such that presence of a vehicle would always be detected.

In this ambiguous zone R_3 the impedance of the track circuit looking towards the termination shunt ST is perhaps 0.15 ohms at the frequency values previously discussed. Impedance Z_s represents the standard adopted for a typical vehicle shunt and is assumed to be 0.06 ohms. A signal coupled into the rails T is divided between the two impedances Z_1 and Z_s in a ratio of 1 to 2.5. This ratio of signal division is further increased between the difference frequency signal F_D is reflected back from the diode 13 and the division ratio of the signal is effectively squared to a value of 1 to 6. The presence of the diode 13 therefore increases the sensitivity of the system as well as providing the modulation of the transmitter frequencies F_1 and F_2 .

In terms of effective distances, the range R_1 is perhaps 6,500 feet at 200 hertz and the range of R_2 is approximately 1,000 feet. The transmitters 10 and 12 are capable of transmitting signals having a sufficient strength over the associated ranges.

FIG. 3 shows the diode 13 and two choke coils 15. This configuration is used in order to attenuate the high frequency modulation products above the 2 kHz frequency range. These coils provide for the suppression of these modulation products or harmonics of the transmitter frequencies and eliminate the possibility of any spurious signals from interfering with the proper detection of the vehicle in the track section.

The total length of the track circuit is about 15,000 feet counting the right hand part of the track circuit not shown. This is considerably long for a track circuit and is particularly useful in mainline operations where long freight trains are generally present.

The system therefore provides for maximally long track circuits using continuous rail while eliminating the problem of ambiguity in the end zones near block boundaries defined by the track shunt S_T . This arrangement also provides for a particularly economical method of utilizing track circuits for continuous rail on mainline railroads by minimizing the amount of equipment necessary for a particular stretch of track. Utilizing track circuits having a length of almost 3 miles with the equipment shown in the present disclosure is considerably convenient for railroad signaling purposes. The incorporating of diode 13 as the means for modulating the transmitter frequencies F_1 and F_2 because it is an inactive device eliminates the necessity for having a power source at the diode location and essentially equipment is only necessary every 7,500 feet.

An alternative form of the invention is shown in FIG. 4 wherein the transmitter 12 is current coupled to the rails T at the distance R_4 from the termination shunt S_T . It is necessary to move the leads from the transmitter 12 out this distance in order to generate a voltage across the rails T. The impedance

of the rails T looking towards the shunt S_T at this point is approximately 0.6 ohms in a 10:1 ratio to the standard shunt impedance Z_s of 0.06 ohms. The signal coupled to the rails at R_3 sees sufficient impedance in order to provide a usable voltage across the rails T. The mode of coupling however is not critical and voltage or current may be used as conditions require.

FIG. 5 shows a similar track circuit as in FIG. 1, however, the position of the diode 13 is different. The distances R_1' and R_2' are approximately equal. The system does not require large differences in the frequencies F_1 and F_2 ; that is, a maximum length may be achieved by choosing the values of F_1 and F_2 which are substantially different and adjusting the position of the diode 13. The system is shown in FIG. 1 in order to illustrate the capability of increasing end zone detection and maximizing the current length. It is true, however, that the end zone detection capability is not wholly dependent on the position of the diode 13. Again the relative positioning of the diode 13 is a matter of choice for particular applications.

The signals from the transmitter 10 or 12 may also be coded. That is, information from other sources such as adjoining track circuits may be coupled from block to block by a coded signal caused by either F_1 or F_2 . For example, encoding apparatus may be included in the transmitter 12 with appropriate decoding apparatus located at the detector 11 which may modify the output indication signals in accordance with intelligence other than vehicle presence detection.

While there has been described what is at present considered to be the preferred embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein 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 alternating current track circuit having shunts at extreme ends for terminating the circuit and a track transmitter coupled to the rails for center feeding the circuit with a first signal having an associated effective range less than the distance to the shunt wherein the improvement for providing accurate detection of a vehicle shunt between the shunt and the end of the effective range of the first signal comprises:

- a second transmitter located at each end of the track circuit coupled to the rails for propagating a second signal at least to the effective range end of the first signal;
- means at the range end of the second signal for modulating the first and second signals in the rails to high and low side-band frequencies; and
- detector means located at each end of the track circuit coupled to the rails and responsive to at least one side-band frequency for detecting the modulated frequency and providing indication of vehicle presence when said side-band frequency is interrupted.

2. The apparatus of claim 1 wherein said modulating means is a rectifier coupled from one rail to the other.

3. The apparatus of claim 2 wherein said modulating means further includes a series connected choke coil for attenuating harmonic modulation products above the high side-band frequency.

4. The apparatus of claim 2 wherein said rectifier is a diode.

5. The apparatus of claim 1 wherein said detector means is responsive to the low side-band for receiving maximum signal strength.

6. The apparatus of claim 1 wherein said first and second signals are relatively of low and high frequency respectively for utilizing long effective range capability of the low frequency signals and short ambiguous region capability of high frequency signals.

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