United States Patent

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[54] **BROKEN RAIL DETECTOR**

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[51] **Int. Cl.** **B61l 23/04**

[58] **Field of Search**.....246/121, 34 CT, 34 R, 40, 58

[56] **References Cited**

UNITED STATES PATENTS

3,450,875	6/1969	Whitten et al.	246/34 CT
2,975,272	3/1961	Renick et al.	246/34 R
3,450,873	6/1969	Whitten et al.	246/34 CT
2,754,413	7/1956	Martin	246/34 R

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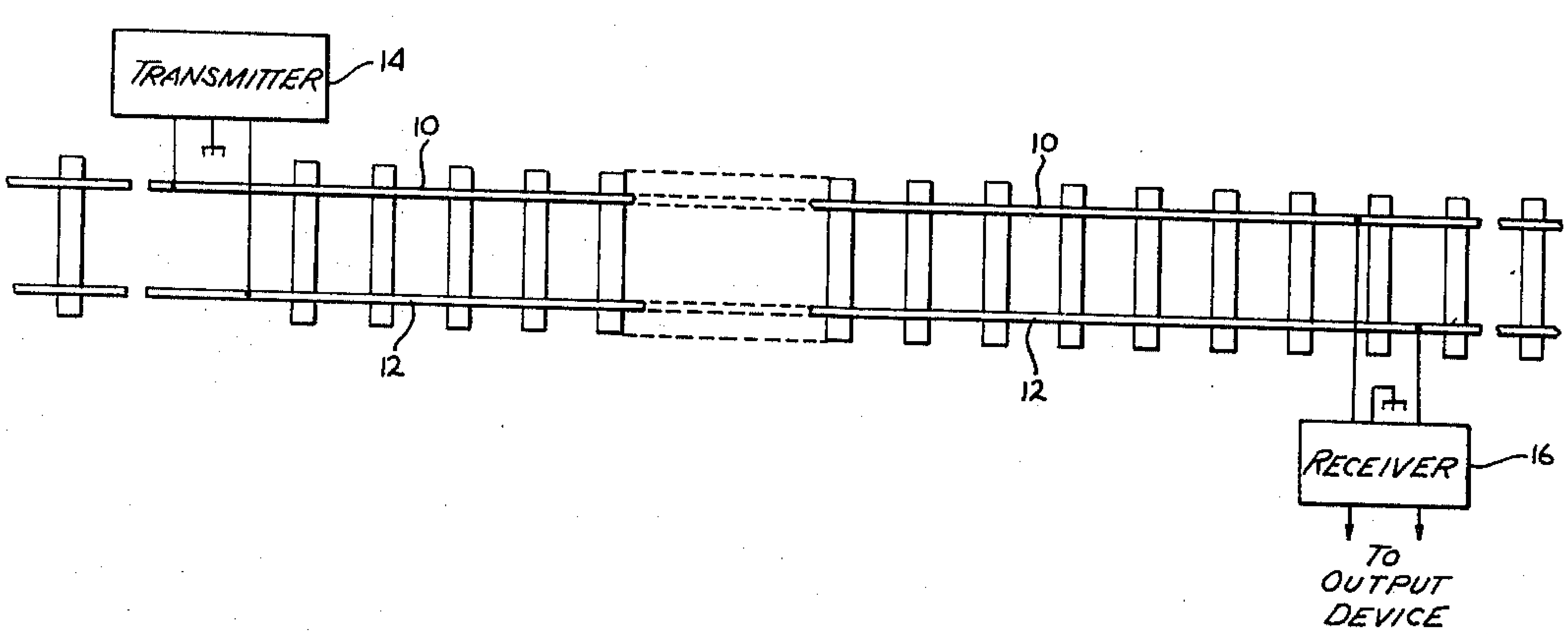
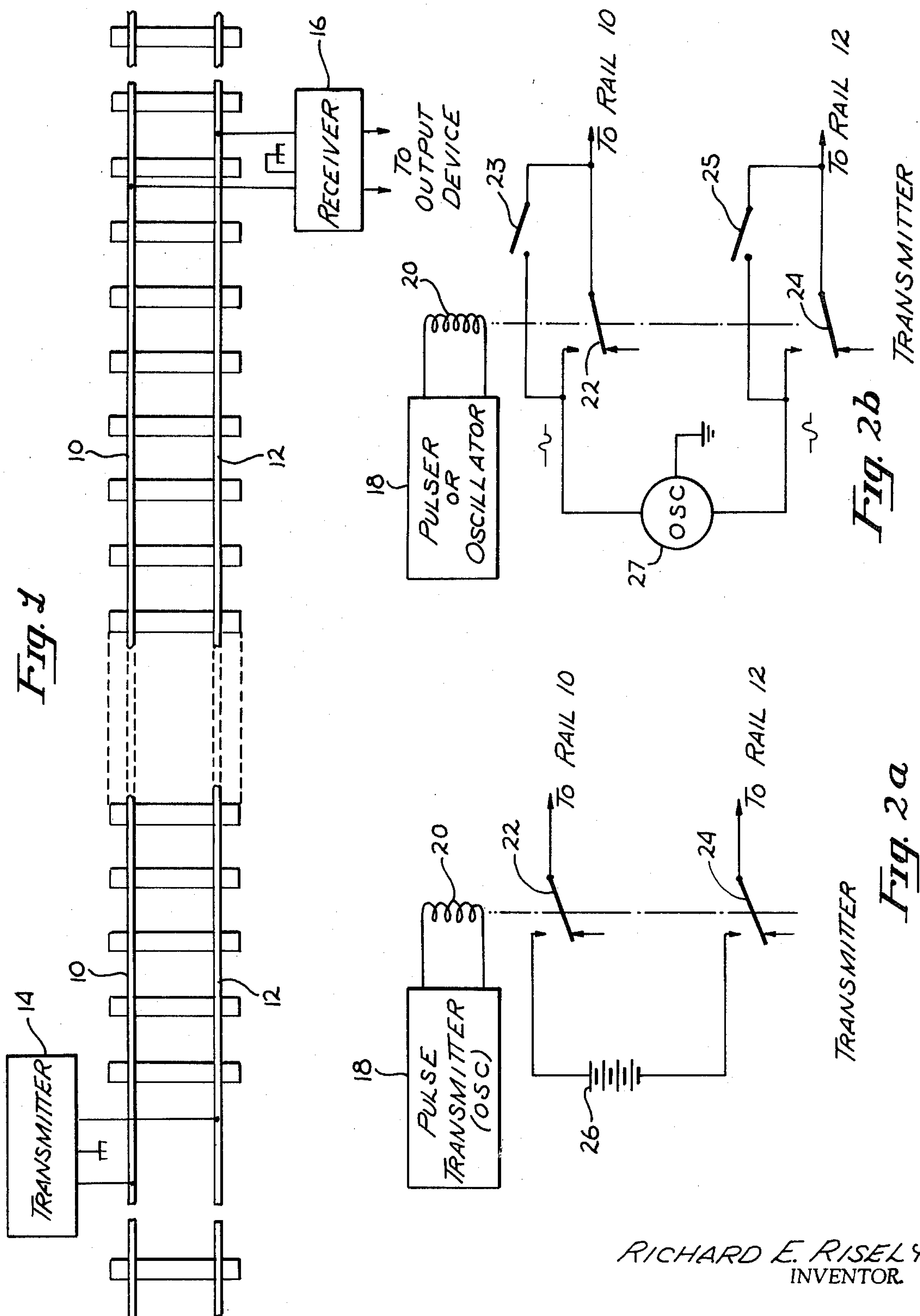
[57] **ABSTRACT**

Herein described is apparatus for detecting a broken rail in a pair of railroad rails. The apparatus includes a transmitter which provides pulses of a predetermined code to a relay which intermittently, according to the code, applies electrical energy to each track at different polarities. A receiver receives the coded energy at a position remote from the transmitter and change in the received code indicates to the transmitter that a change in the track characteristics has occurred.

12 Claims, 6 Drawing Figures





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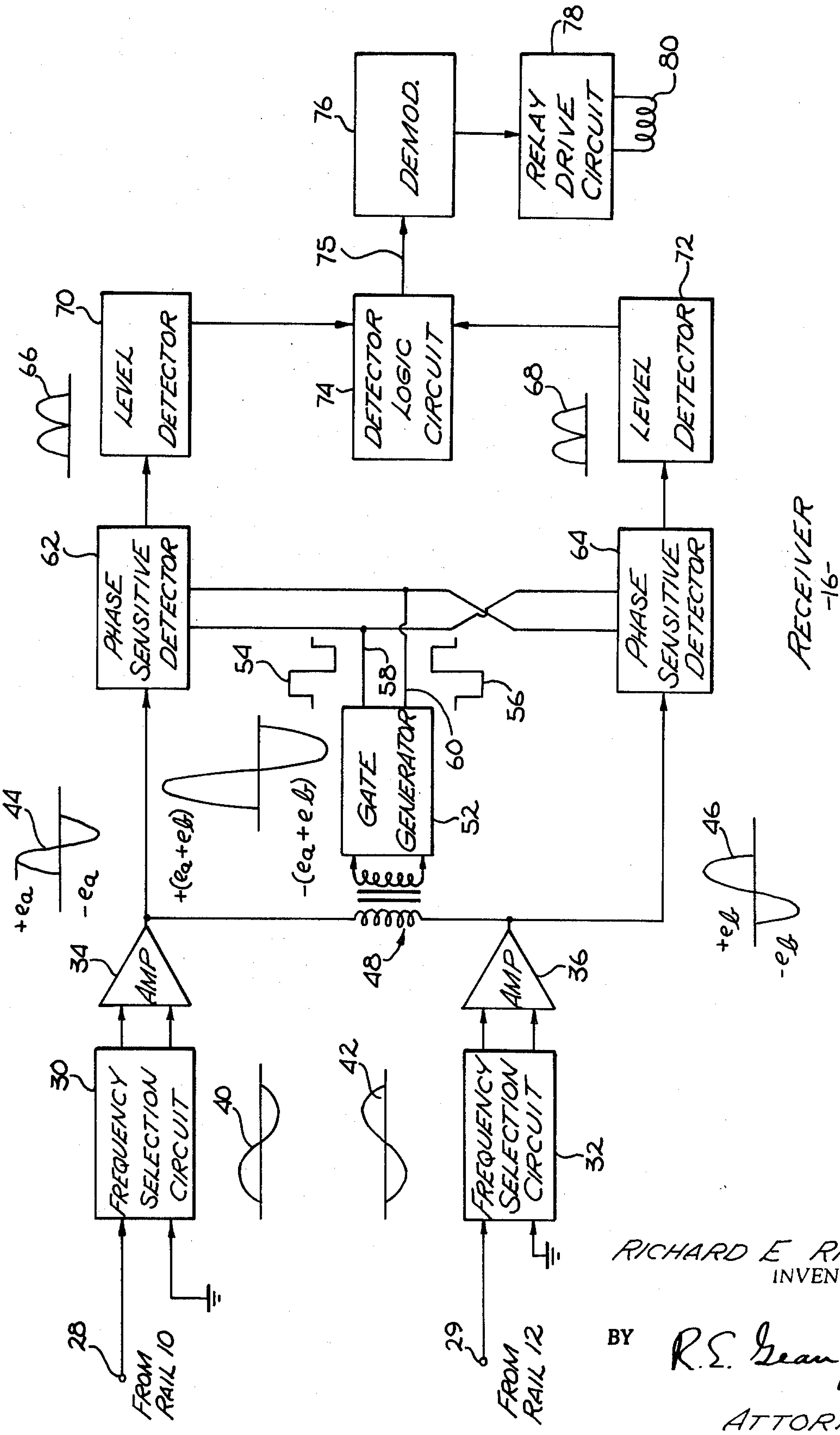

Fig. 3

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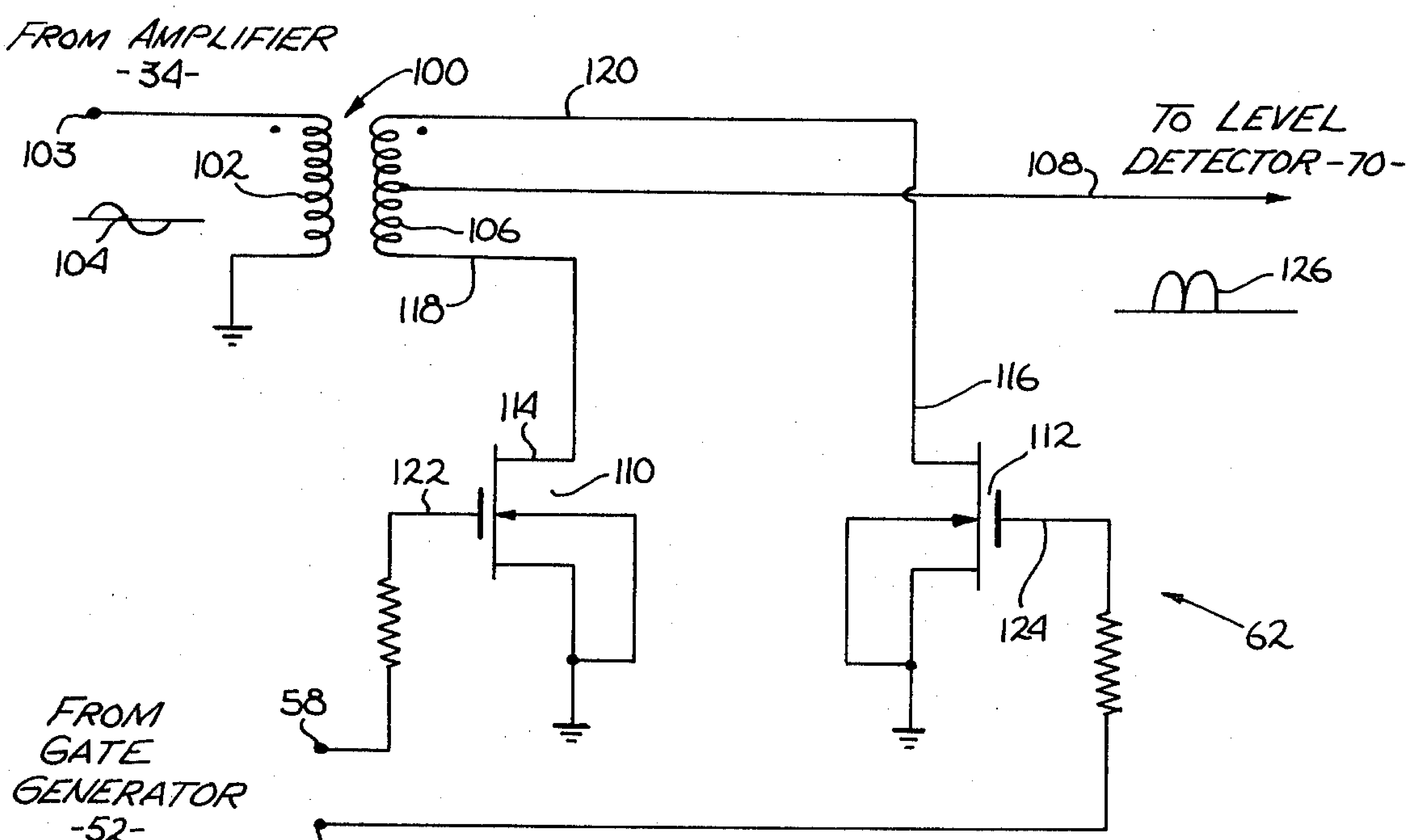

Fig. 4

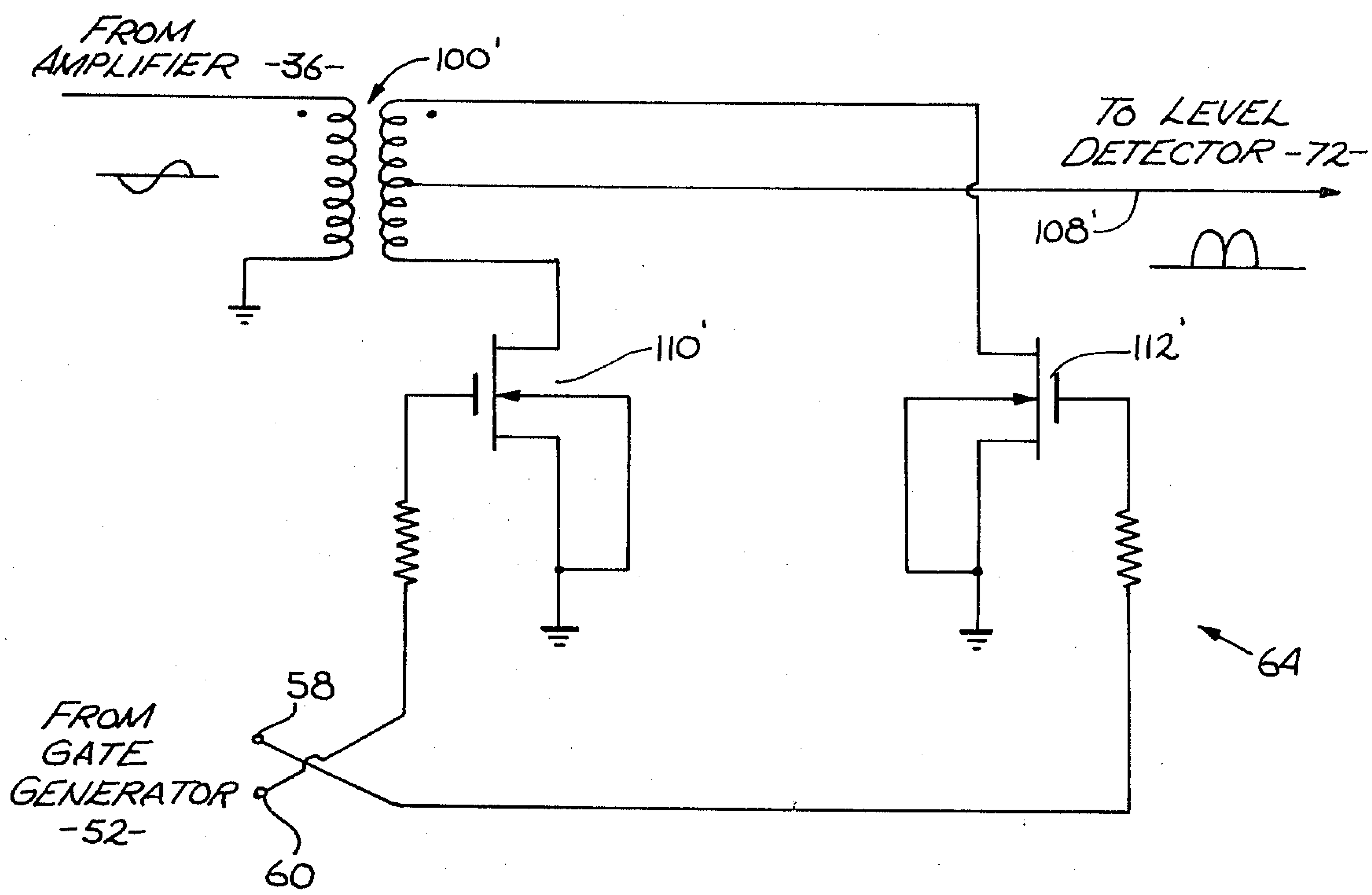

Fig. 5

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BROKEN RAIL DETECTOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to railroad signalling devices and more particularly to a novel and improved system which detects a break in either one of the rails in a railroad track.

2. Discussion of the Prior Art

Heretofore many systems have been devised to detect a broken rail in a pair of railroad tracks. Included among these are the type which senses disturbances in a magnetic field formed around the railroad track under test. The magnetic field is generated by a high D.C. current which is passed through the rails. Systems of this type are set forth in the prior art.

The use of railroad tracks as a transmission media for coded signal from transmitting to receiving stations has been used in the prior art in the past. Track transmitting and receiving systems presently are used to detect the presence or absence of a vehicle on a track section. In this type of system, the wheels of a train shunt the track to cause a loss of signal at the receiver and thereby indicate the presence of a train in the track area between the transmitter and receiver. In the continuity testing art, pulse signals are transmitted down a suspect transmission line and the magnitude and time relationship between the transmitted and reflected pulses if any, indicates the magnitude and location of the fault, respectively.

The fact that the railroad tracks are now used for an electrical transmission media, the tracks virtually become crowded with electrical signals. This creates a problem that the signals thereon become inseparable and therefore errors can be made in detecting broken rails, detecting presence of vehicles and the like.

In the general field of track circuits used in railway signal systems, a common weakness exists in the lack of ability thereof to reliably detect a broken rail. This weakness is partly because railroad tracks, when used as an electrical circuit, experience a gross change in their electrical characteristics with changes in atmospheric conditions. These changes in electrical properties result in a number of undesirable conditions. For instance, the electrical currents flowing through a track signal circuit between a battery feedpoint and a relay connection to the rails will suffer losses, or attenuation, resulting in an undetermined current flowing through the track relay at any given time. Too, the losses of electrical energy are dissipated into ground, through variable leakage paths, resulting in an uncharted signal circuit current in the ground. As a result of the losses and attenuations first set forth, it is impossible to maintain an exact operating current through the relay without making adjustments to overcome high and low current levels which occur during weather changes. The latter condition results in a possible source of signal current through the ground, which can feed energy back into a rail which has become broken, the level of which depends upon the track ballast conditions. It can be shown that a sufficient current will exist to sustain the operation of the track relay under certain conditions which are commonly encountered in track circuit applications. Thus, a need has arisen for a new electrical system which effectively detects a broken rail.

SUMMARY OF THE INVENTION

Briefly described, the present invention set forth in the described embodiment includes a transmitting means which is coupled to a pair of rails at one end of a track circuit. The transmitter is adapted to apply direct current electrical signals, for example, to each rail in a manner which is coded, either by polarity, time division multiplexing, or both, or the like. The resultant electrical signals impressed on each rail may, for example, have a distinct electrical polarity in relation to each other as well as to a ground reference. Two individual voltage sensing receiving means are included which are designed to accept a particular polarity and code, whereby one pair of input terminals is coupled between one rail and earth ground, and the second pair of input terminals is independently connected between the other rail and earth ground. This unique technique of sensing of the track circuit signals is one of the features of this invention. Electronic utilization circuitry is included which will operate a relay continuously until a broken rail or a train is detected.

Using this system, a very positive indication of a broken rail is obtained in the receiver. This indication occurs because the electrical potential on the receiver side of the break in the rail will be the same as ground. Consequently, there will be no input signal to the receiver which is sensing between the broken rail and ground. Further, when a train, or any electrical short circuit, is located between the transmitter and receiver, the receiver will detect this condition since both rails will become the same potential with respect to ground. Unbalance in the losses between each rail and ground do not disturb this detection property since this will only result in a change in electrical polarity occurring at one receiver input terminal, which is treated the same as a loss of signal in the receiver sensing circuitry.

The present invention provides a technique of detecting broken rails which is far more effective than devices heretofore set forth. The present invention using the aforesaid techniques is effective in longer lengths of tracks than prior art devices and yet still maintain the precise accuracy needed for current safety standards employed by the railroad industry today.

A further feature of this invention is that when the pulse technique is used, an improved signal-to-noise ratio is possible over the longer length track circuits.

DESCRIPTION OF THE DRAWINGS

These and other features and advantages will become more apparent to those skilled in the art when taken into consideration with the following detailed descriptions wherein like references correspond to like and corresponding parts throughout the several views and wherein:

FIG. 1 is a block diagram of the basic system of one embodiment of this invention;

FIGS. 2*a* and 2*b* are block diagrams and partial electrical schematic drawings of the transmitters used in the embodiments set forth;

FIG. 3 is a block diagram of the receiver used in the embodiment set forth in FIG. 1; and

FIGS. 4 and 5 are electrical schematic diagrams of the phase detectors used in the receiver set forth in FIG. 3.

DESCRIPTION OF ONE PREFERRED EMBODIMENT

Turning now to a more detailed description of one embodiment of this invention, there is shown in FIG. 1 a railroad track including a pair of rails, each of which is given the reference numerals **10** and **12**. Positioned at one end of the track is a transmitter **14** and at the other end, remote from the transmitter **14**, is a receiver **16**. Electrical energy is induced into the rails **10** and **12** by the transmitter **14** and received at the receiver **16**.

One embodiment of a transmitter used in the embodiment set forth in FIG. 1 is shown in FIG. 2. An oscillator or pulse transmitter **18** is provided and provides pulses of electrical energy to a relay coil **20**. The pulses may be of a predetermined time duration so that coded pulses are provided. The relay coil **30** actuates a pair of switches **22** and **24** which applies electrical energy from a battery **26** to the rails **10** and **12** each time they are closed. The battery **26** is arranged to provide electrical energy to each rail **10** and **12** at different polarities. In this embodiment a negative polarity is applied to rail **10** when switch **22** is closed and positive polarity is applied to rail **12** when switch **24** is closed.

The opposite polarity coded pulses are applied to the receiver **16** through the rails **10** and **12**. The receiver **16** includes means for determining whether or not both signals are received by the receiver **16**. Should one signal be missing, that is, not received by receiver **16**, then it is an indication that a broken rail is present between the transmitter **14** and the receiver **16**.

An example of a receiver **16** which operates in accordance with one of the principles of this invention is shown in FIG. 3. A pair of input terminals **28** and **29** is coupled directly to the rails **10** and **12** respectively to receive the coded pulses of the transmitter **14**. The terminals **28** and **29** are coupled into a pair of frequency selection circuits **30** and **32** respectively which may be band pass filters which are tuned to the frequency of the coded pulse from the transmitter **14**. This eliminates any signals from reaching the receiver circuitry and the ultimate utilization circuitry except the pulse coded signals from the transmitter **14**. The other inputs of the frequency selection circuits **30** and **32** are connected to the ground reference.

It may be desirous to provide either A.C. signals or a modulated A.C. signal to the rails **10** and **12**. To do this, FIG. 2*b* shows that the battery **26** is replaced with an oscillator **27**. For continuous operation, bypass switches **23** and **25** are closed. For modulated signals, bypass switches **23** and **25** are opened and pulser or oscillator **18** is enabled.

Suitable amplifiers **34** and **36** are coupled to the outputs of the frequency selection circuits **30** and **32** respectively to amplify the coded pulses to an acceptable amplitude to be used in the receiver **16** when detecting signal errors.

The signals from the transmitter **14** to the input terminals **28** and **29** may be sinusoidal crossing through the zero crossing point as shown in the graphs **40** and **42**. This, then, being a further example of useful transmitted signals, can operate in place of the pulses heretofore mentioned.

Means are then included to set forth whether or not a loss has occurred as to one of the signals. This loss is due to the fact that a rail is broken and continuity of the track circuit is discontinued. This can be accomplished in the remainder of the circuitry set forth in FIG. 3. The circuitry shown therein is operating on the assumption that the signals received are A.C. as shown in graphs **40** and **42** and the transmitter **14** is generating A.C. signals into the tracks **10** and **12**.

The signals from amplifiers **34** and **36** appear as shown in graphs **44** and **46** wherein $+e_a$ is the positive going signal and $-e_a$ is the negative going signal from track **10** and $+e_b$ is the positive going signal and $-e_b$ is the negative going signal from track **12**. Both signals e_a and e_b are applied to the primary winding of a transformer **48** and the signals are combined therein to produce the signal shown in graph **50**. The primary winding and the secondary winding of transformer **48** are shown in the given relation by the phase dots indicated thereon.

The secondary winding of transformer **48** is applied to a gate generator **52** which generates gate signals as shown in graphs **54** and **56**. These gate signals are produced on output leads **58** and **60** and are substantially square wave gating signals of opposing polarities. Such gate generators are well known to those skilled in the art and no attempt will be made at this time to discuss the operation thereof.

The output of amplifiers **34** and **36** are also simultaneously applied to respective phase sensitive detectors **62** and **64** respectively. The phase sensitive detectors **62** and **64** are also responsive to the signals generated by the gate generator **52**. Thus, means are herein provided for generating a signal (E_1 and E_2) which is D.C. for an A.C. continuous wave signal generated by the transmitter **14** or would follow a modulation for a modulated A.C. signal.

The output signals from phase detectors **62** and **64** would be similar to those shown in graphs **66** and **68**. It should be noted that these signals are now in phase and have positive polarities. The details of how these signals are generated will be discussed in detail in connection with FIGS. 4 and 5 hereafter.

The outputs of detectors **62** and **64** are applied to voltage level detectors **70** and **72** respectively where only signals of a predetermined threshold level are applied to detector logic circuit **74**. The exact structure and operation of such voltage level detectors are well known to those skilled in the art and no attempt will be made to describe this structure and the operation thereof. These voltage level detectors are provided to reduce spurious signals from triggering the detector logic **74**.

The detector logic **74** is of the type which gives an output only if both input signals are above threshold levels and of opposite polarities. Such a detector logic is well known to those skilled in the art and can be designed by using "AND/OR" logic. For example, assuming the output of level detector **70** is A and the output of level detector **72** is B, then detect a change in the output **75** from logic circuit **74** (stated in Boolean notation) is:

$$\text{Output } 75 = A \cdot \overline{B} + \overline{A} \cdot B$$

The output **75** from detector logic **75** is applied to a demodulator **76**. Thus, if a modulated C.W. signal is used, the carrier signal is all that is used to operate a relay drive circuit **78**. The relay drive circuit is the type which is operated when a signal is applied thereto. A loss of signal from demodulator 76 (or from detector 74 if a C.W. signal is used) will cause the relay drive circuit to cause relay 80 to drop out and indicate that there is a break in one of the rails or the track is occupied with a train shorting the rails together.

Referring now to FIG. 4, there is shown a circuit of the phase sensitive detector 62 which is responsive to the gate signals from the gate generator 52. Detector 62, in effect, provides semi-continuous wave signals (or modulations to the level detector 70) as long as gate signals are generated in the manner heretofore discussed. The purpose of phase detector 62 is to detect where a change occurs in the phase relationship of the signals applied to terminals 28 and 29 to receiver 16. Specifically, the phase detector detects a loss in signal to either input terminal.

The circuit described in FIG. 4 includes a transformer 100 which has an input winding 102 having one end 103 coupled to the output of amplifier 34. The other end of winding 102 is coupled to the ground reference. The signal applied to transformer 103 across terminal 103 and ground is the sine wave depicted in graph 104. The output winding 106 includes a center tapped output 108 which is coupled to the input of level detector 70.

A pair of insulated gate field effect transistors 110 and 112 have the drain electrodes 114 and 116 thereof coupled to ends 118 and 120, respectively, of output winding 106 of transformer 100.

Field effect transistors 110 and 112 are turned on by the gate signals on leads 58 and 60 generated by gate generator 52. The coupled configuration of field effect transistors 110 and 112 is effective to cause them to be non-conductive from drain to source with zero or negative signal on the gate electrodes 122 and 124 thereof, respectively. The gates 122 and 124 render the field effect transistors 122 and 124 conductive drain to source by positive signals being applied to terminals 58 and 60.

Thus, when a continuous A.C. signal or intermittent modulated A.C. signal is applied to receiver 16, transistors 110 and 112 are alternately enabled in phase therewith. Simultaneous therewith the secondary winding 106 induces a D.C. level (or pulsating D.C.) into level detector 70 through lead 108 as depicted by graph 126.

The circuit 64 set forth in FIG. 5 operates in a manner similar to that shown in FIG. 4 with the exception that field effect transistor 110′ is enabled by positive signal applied thereto from terminal 60 (rather than terminal 58 as set forth in FIG. 4) and field effect transistor 112 is enabled by positive signals applied thereto from terminal 58 (rather than terminal 60). The center tapped output from transformer 100′ is applied to lead 108′ to level detector 72.

Thus, there is shown in FIGS. 4 and 5 phase detectors 62 and 64 which are capable of providing signals to ultimate logic circuits as long as the opposing relationship thereto is present.

The herein described embodiment of this invention provides one mode of carrying out the invention hereinafter defined in the claims.

Having thus described one embodiment of this invention, what is claimed is:

1. A broken rail detector useful in detecting broken rails in a pair of rails including:

a transmitter coupled to said pair of rails and being adapted to apply an A.C. signal to said rails with each rail receiving signals of different phase relationships, said transmitter including an oscillator, a relay being coupled to said oscillator and being enabled by signals from said oscillator, a source of electrical energy, and switching means being responsive to said relay and being coupled between said source and the rails;

a receiver coupled to said pair of rails at a location remote from said transmitter and being adapted to receive signals transmitted from said transmitter through said rails and being adapted to have an output signal when the received signals maintain the different phase relationship; and

signal means coupled to said receiver and responsive to the output signal therefrom for providing an indication upon a loss of output signal from said receiver.

2. A broken rail detector useful in detecting broken rails in a pair of rails including:

a transmitter coupled to said pair of rails and being adapted to apply an A.C. signal to said rails with each rail receiving signals of different phase relationships;

a receiver coupled to said pair of rails at a location remote from said transmitter and being adapted to receive signals transmitted from said transmitter through said rails and being adapted to have an output signal when the received signals maintain the different phase relationship; and

signal means coupled to said receiver and responsive to the output signal therefrom for providing an indication upon a loss of output signal from said receiver; said receiver including:

a first circuit coupled to one of said rails including a first phase sensitive detector being responsive to a gate signal;

a second circuit coupled to the other one of said rails including a second phase sensitive detector being responsive to the gate signal;

a gate generator coupled to said first and second circuits and responsive to the phase of the signals applied thereto for generating gate signals for the first and second phase sensitive detectors; and

logic means coupled to said first and second circuits for providing an output on the loss of an input from either one of said first and second circuits.

3. The broken rail detector as defined in claim 2 and further including an amplitude level detector coupled between each phase sensitive detector and said logic means.

4. The broken rail detector as defined in claim 2 and including a demodulator coupled between said logic means and said utilization means.

5. The broken rail detector as defined in claim 2 wherein said transmitter including:

an oscillator;

a relay being coupled to said oscillator and being enabled by signals from said oscillator;

a source of electrical energy; and

switching means responsive to said relay and being coupled between said source and the rails.

6. The broken rail detector as defined in claim 5 wherein said source of electrical energy being a battery.

7. The broken rail detector as defined in claim **5** wherein said source being another oscillator.

8. A broken rail detector useful in detecting broken rails in a pair of rails including:

an oscillator adapted to provide A.C. electrical signals;

a source of electrical energy;

means coupled to said oscillator for applying said source of electrical energy to the rails;

a first circuit coupled to one of said rails at a point remote from the point where the source is applied;

a first phase sensitive detector coupled to said first circuit and being responsive to the gate signals;

a second circuit coupled to the other rail at said remote point;

a second phase sensitive coupled to said second circuit and being responsive to the gate signals;

a gate generator coupled to said first and second circuits and being responsive to the phase of the signals applied thereto for generating gate signals for said first and second phase sensitive detectors;

logic means coupled to said first and second phase sensitive detectors for providing an output on the loss of an input from either one of said first and second circuits; and

utilization means coupled to said logic means and being responsive to output therefrom.

9. The broken rail detector as defined in claim **8** wherein said source of electrical energy being a battery.

10. The broken rail detector as defined in claim **8** wherein said source of electrical energy being another oscillator.

11. The broken rail detector as defined in claim **10** and further including a demodulator being coupled between said logic means and said utilization means.

12. The broken rail detector as defined in claim **8** and further including amplitude detectors coupled between each said phase sensitive detectors and said logic means.

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