

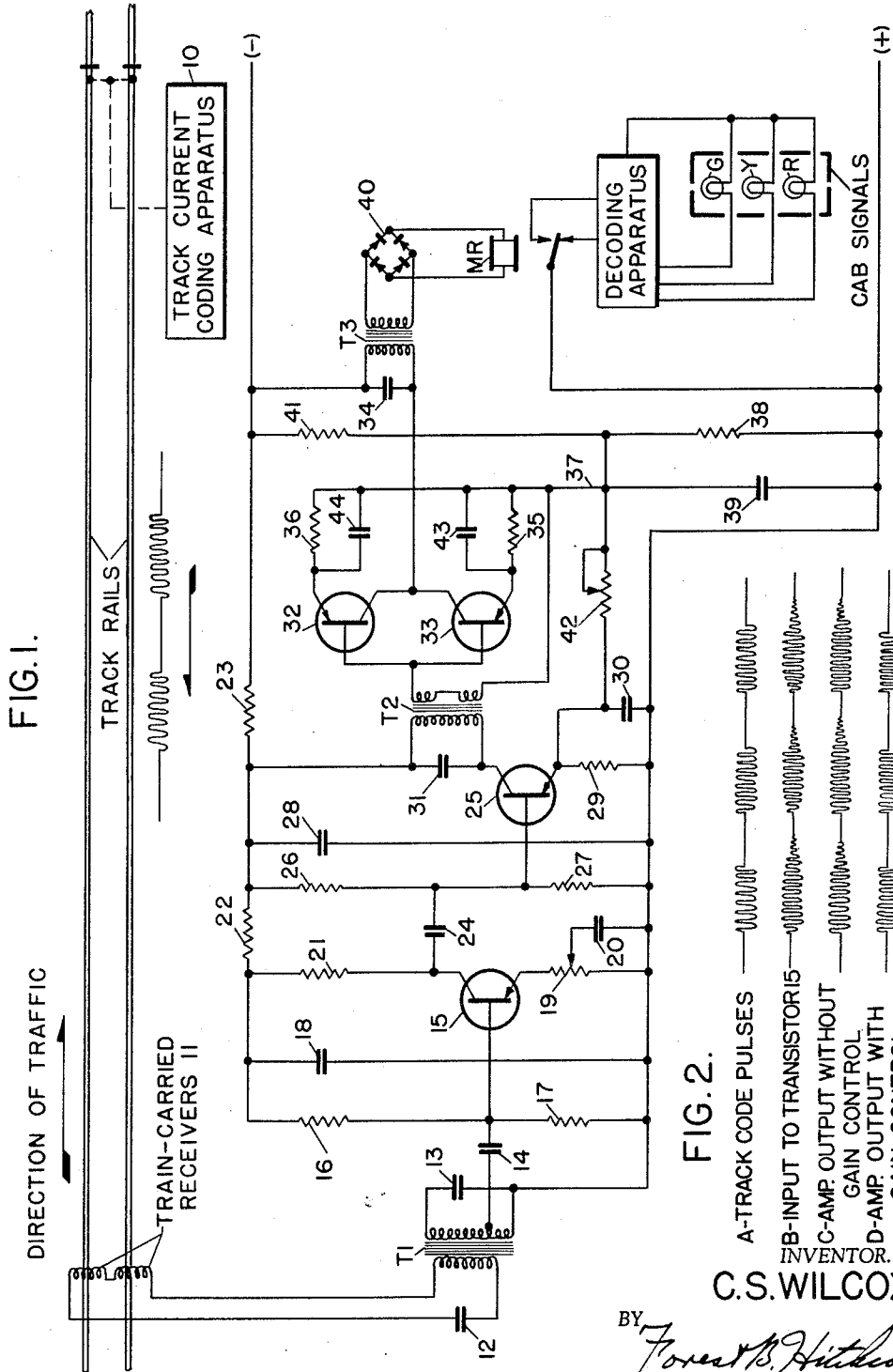
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CAB SIGNALING SYSTEM FOR RAILROADS

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CAB SIGNALING SYSTEM FOR RAILROADS

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4 Claims. (Cl. 246—63)

This invention relates to railway signaling apparatus and more particularly pertains to an improved cab signaling system having a transistor amplifier.

Cab signaling apparatus makes it possible to provide indications continuously in a locomotive cab as to traffic conditions on the track ahead. Essentially, this is accomplished by applying pulses of electrical energy at distinctive coding rates to the track rails at the exit end of each track section. These pulses travel along the track rails toward the train and induce voltages in receiver coils mounted on the locomotive and positioned over the track rails ahead of the leading wheels. The train-carried equipment amplifies the induced voltage pulses and detects their rate of occurrence. Since the particular coding rate in effect at any time corresponds to the traffic conditions ahead, it becomes possible to provide one of a number of different aspects to the trainman which reflect existing traffic conditions.

The conditions under which the track code pulses are detected on the train are often very poor, and the train-carried equipment must therefore be of a special nature in order to provide the highly reliable operation that is demanded in railway signaling practice. Because the train-carried receiver coils must have some minimum clearance with respect to the track rails, the magnetic coupling between track rails and receivers is relatively loose so that a low amplitude of voltage is ordinarily induced in the receiver coils. In addition, spurious voltages of considerable amplitude in relation to the desired signal are also frequently induced in the receiver coils thereby tending to interfere with the proper reception of the coded rail currents. For example, it has been found that the earth's magnetic field may be actually stronger than the magnetic field produced by the coded rail current when the rail current is of low amplitude. In addition, stray currents of the usual power frequency such as 60 cycles per second are often found with a considerable amplitude in the track rails. The train-carried apparatus must, therefore, be able to respond not only to induced voltages of a very low level but must also be able to distinguish between the legitimate coded rail current and spurious rail currents that may exist.

Another difficulty arises from the fact that the coded rail currents vary considerably in amplitude. For example, near the feed end of a track section the coded rail currents have at times been found to have an amplitude of as much as 20 amperes; whereas, near the entrance end of a long track section, the rail current may be as low as one-half ampere. The cab signal amplifying apparatus must be organized to operate properly over this extremely large range of amplitude. One advantage of the circuit organization provided by this invention is the ability to cope with these large variations of input signal without any deleterious effects.

As with all signaling apparatus for railroads, reliability and fail-safe operation is of the utmost importance. The cab signaling apparatus in use until now has employed electron tube amplification which is, of course, subject

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to becoming inoperative as the result of tube failure. The cab signaling equipment of this invention, by using transistors exclusively, overcomes this difficulty to a large extent.

Accordingly, one object of this invention is to provide a cab signaling system for railroads comprising a highly reliable transistor amplifier.

An additional feature of this invention is to provide a transistor amplifier for cab signaling apparatus that is responsive to the legitimate rail currents but is, at the same time, relatively impervious to extraneous rail currents and other spurious voltages induced in the receiver coils.

Another object of this invention is to provide a cab signaling system having a transistor amplifier whose operation remains substantially constant over a wide temperature range.

Another object of this invention is to provide a cab signaling system having a transistor amplifier providing no distortion of the output even though the input may vary over a very wide range as a result of extremely large variations of amplitude of the coded rail current.

Other objects, purposes, and characteristic features of this invention will in part be obvious from the accompanying drawing and in part pointed out as the description of the invention progresses.

In describing this invention in detail, reference will be made to the accompanying drawing illustrating one specific embodiment of this invention and in which:

Fig. 1 diagrammatically illustrates the cab signaling system of this invention, particularly illustrating in detail the amplifier circuit organization; and

Fig. 2 illustrates certain wave forms of voltage provided as an aid in illustrating the operation of the present invention.

To simplify the illustration and facilitate the explanation of this invention, various parts and circuits have been shown diagrammatically. Certain conventional illustrations have been used, and the drawing has been made to make it easier to understand the principles and manner of operation rather than to illustrate the specific construction and arrangement of parts that might be used in practice. The symbols (+) and (—) indicate the opposite terminals of a suitable source of direct current power used for operation of the transistors.

Described briefly, the cab signaling equipment of this invention comprises receiver coils positioned on the locomotive so as to inductively couple with the track rails. The two coils are series connected, and the voltage induced therein is applied through filtering circuit means as an input signal to a transistor voltage amplifier stage. The function of the filtering means is to discriminate between the desired and the spurious receiver voltages. The output of the first amplifier stage is further amplified by a second voltage amplifier stage, and the output of this stage is then transformer-coupled to a transistor power amplifier stage. Each output pulse of the power amplifier is then rectified and the resulting direct current pulse used to energize an electromagnetic relay. The relay is thus in an energized state during each received rail code pulse and is deenergized in the interval between successive rail pulses.

A contact of this relay is effective, as it operates alternately between its front and back positions, to provide a chopped direct current to the decoding apparatus. This decoding apparatus can operate most efficiently to detect the coding rate and cause the proper signal aspect to be displayed when it receives a symmetrical input, and this can occur only if the decoding relay is normally in its picked-up and dropped-away conditions for nearly equal periods of time as it responds to the track code pulses. Consequently, the track current coding apparatus

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is preferably organized to provide equal "on" and "off" times of the coded rail current. When the coded rail current is of a normal amplitude, the output of the power amplifier rather faithfully follows the rail code pulses so that the output relay readily operates in the desired manner to provide a symmetrical input to the decoding apparatus. However, when the rail current is of a very high value, there generally occurs a "ringing" of the various tuned circuits appearing in the amplifier organization. As a result, the amplified signal does not suddenly decay at the termination of a code pulse but persists until the ringing has subsided. Under some conditions, the ringing may persist for a sufficiently long time that it will carry-over from the end of one code pulse until the beginning of the next. This not only results in an asymmetrical operation of the output relay but may even result in the failure of this relay to drop away between successive code pulses. In that event, the decoding apparatus does not receive the required chopped direct current and thus can only display the red aspect that is ordinarily displayed when no code pulses are received. It will be apparent from the detailed description that follows how the amplifier organization of this invention has been organized to overcome this liability so that the output relay will operate in a symmetrical manner over the entire range of amplitude of track code pulses that may occur in practice.

Fig. 1 illustrates diagrammatically the track current coding apparatus 10 which is well known in the art, and is effective to apply to the track rails pulses of alternating current as graphically illustrated below the track rails. These code pulses of alternating current have a predetermined frequency which is preferably different from the usual power frequencies such as 60 cycles per second. It has been the practice to employ a frequency of 100 cycles per second for this purpose. These code pulses travel along the track rails towards an advancing train which has ahead of its leading pair of wheels two train-carried receivers 11 each mounted in an inductive relationship with one of the track rails. The two receivers are connected in series and through a tuning capacitor 12 to the two terminals of the primary winding of a transformer T1. The capacitor 12 is selected to have a value that will resonate the series tuned receiver 11 to the frequency of the coded rail current. As a result, this circuit is highly responsive to the 100 cycle coded rail current but far less responsive to extraneous currents at other frequencies. The result then is that a pulse comprising cycles of 100 cycle energy appears in the primary winding of transformer T1 corresponding to each rail code pulse, and this results in there being induced in the secondary winding of this transformer a similar pulse of 100 cycle frequency.

The secondary winding is also tuned by the capacitor 13 to the rail current frequency, thereby providing additional discrimination against spurious inputs occurring at other frequencies. A connection is made from a low impedance tap of the secondary winding of transformer T1 through a coupling capacitor 14 to the base of transistor 15. This transistor as well as all the others shown in Fig. 1 are of the p-n-p junction type. Other types of transistors can also be used and the circuit configuration modified according to the requirements of such other transistors. A capacitor 18 and resistors 22 and 23 provide a conventional decoupling filter. The desired operating bias for the base of this transistor 15 is provided by the voltage dividing resistors 16 and 17 connected between the left-hand terminal of resistor 22 and the (+) terminal.

The amplifier stage including transistor 15 is connected as a common emitter amplifier. The emitter is connected through a potentiometer 19 to the (+) voltage source. A portion of the resistance provided by potentiometer 19 is shunted by the connection from the tap of this potentiometer through capacitor 20 to the (+)

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terminal. Thus, the effective resistance in the emitter circuit is determined by the position of the tap of this potentiometer and is a maximum when the tap is in its lowest position. The gain of the stage is therefore varied by the amount of degeneration in the emitter circuit. The collector of transistor 15 is connected through the decoupling resistors 22 and 23 to the (-) terminal.

The amplified signal appearing at the collector terminal of transistor 15 is coupled through the coupling capacitor 24 to the base of transistor 25. This transistor is also operated as a common emitter amplifier with the bias for its base being similarly provided by the voltage dividing resistors 26 and 27. The value of bias is chosen to give a value for the collector current that will result in optimum gain of this stage. The gain is a function of the collector current at low values of collector current and decreases with a decrease of collector current.

The emitter of transistor 25 is connected through resistor 29 and capacitor 30 in parallel to the (+) terminal. As will subsequently be described, the gain of this stage of amplification is controlled by varying the voltage on the emitter.

The output signal of transistor 25 appearing in its collector circuit is transformer-coupled to the input of the single ended power output stage. Capacitor 31 connected in parallel with the primary winding of transformer T2 tunes this primary winding to the frequency of the rail current, thereby providing further discrimination against spurious currents of other frequencies.

The power amplifier stage includes the two transistors 32 and 33, and this stage is also connected in common emitter configuration. The two collectors are connected through the primary winding of transformer T3 and the parallel-connected capacitor 34 to the (-) terminal. The two emitters are connected through the resistors 35 and 36 to wire 37. These two resistors are bypassed, respectively, by capacitors 43 and 44. The two bases are connected through the secondary winding of transformer T2 also to this wire 37. Wire 37 is, in turn, connected through resistor 38 and capacitor 39 in parallel to (+). As a result of these connections, bias is provided for the transistors 32 and 33 to bias them to cut off so that they operate as class B amplifiers.

Each input code pulse transformer-coupled to the bases of the transistors 32 and 33 produces a corresponding pulse of collector current so that a voltage is induced in the primary winding of transformer T3. By transformer action, a similar pulse of alternating current appears across the terminals of the secondary winding of this transformer. A full-wave bridge rectifier 40 connected between the output terminals of the secondary winding converts the alternating current to direct current which is effective to energize the winding of the master decoding relay MR. Thus, energy is applied to the winding of this relay for each code pulse occurring in the track rails, but the relay becomes deenergized and drops away for each interval between impulses.

At the termination of each track pulse, the transistors 32 and 33 revert to their normal cutoff condition. This causes an abrupt decay in the magnetic field of the primary winding of transformer T3, thereby tending to produce a momentary output pulse of opposite polarity in the secondary winding. This situation is overcome by capacitor 34 which shunts the primary winding and tends to absorb any sudden transients appearing across this winding.

Under conditions of no signal, the two transistors 32 and 33 do not conduct current because of their class B operation. The voltage on wire 37, under such circumstance, is determined entirely by the ratio of the voltage dividing resistor 38 and 41. This voltage is applied through the variable resistor 42 to the emitter of transistor 25 and thus establishes the operating bias for transistor 25. However, when a signal is present, the two transistors 32 and 33 conduct so that there is then a

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flow of current to the emitter of each of these transistors and then through their emitter resistors 35 and 36 and through resistance 38 to the (+) terminal. The flow of this current through resistor 38 causes an increase of voltage on wire 37 which produces a corresponding increase of voltage at the emitter of transistor 25. This increase of emitter voltage has the effect of decreasing the voltage between the emitter and base of transistor 25 so that its gain is reduced with a corresponding reduction of the collector current. The greater the input to the two transistors 32 and 33, the more these transistors conduct and the more the emitter voltage of transistor 25 is increased. Each further increase of this emitter voltage causes a further reduction of gain of transistor 25. This results in a lowered input to transistors 32 and 33 to counteract for their increased output. A decrease in output of the power amplifier is effective in the reverse manner to increase the gain of transistor and thus restore the output level of transistors 32 and 33. Thus, a degenerative effect is provided.

The capacitor 39 charges to the value of the voltage across resistor 38, and capacitor 30 similarly charges to the voltage across resistor 29. Thus, at the conclusion of each code pulse amplified by the cab signal amplifier, both these capacitors 30 and 39 have become charged to the voltages in existence during the duration of the code pulse. Thus, under conditions of low amplitude of the track code pulses a relatively low voltage appears across these capacitors. On the other hand, when the track code pulses are of a very high amplitude so that transistors 32 and 33 tend to conduct a high level of current, then the voltage on wire 37 is substantially higher so that both capacitors 39 and 30 are charged to higher voltage levels. At the termination of each code pulse, these voltages on capacitors 30 and 39 cannot change instantaneously so that the voltage on the emitter of transistor 25 remains for a long time at the level it had during the code pulse. When high amplitude pulses are being received, this means that the amplifier gain is held at a minimum not only through the duration of the code pulse but also for some time afterward or until capacitors 30 and 39 have had sufficient time to discharge to their new steady-state value. As a result of this low gain of the amplifier, any voltages present as the result of ringing of the tuned circuits are effectively masked. The time constant for the discharge of capacitors 30 and 39 can be selected in accordance with the value of the variable resistor 42 to insure that the amplifier gain will stay at a reduced value for substantially the entire duration of such ringing effect or until the beginning of the next code pulse occurring at the highest coding rate.

This effect of the gain control of the cab signal amplifier of this invention is graphically illustrated in Fig. 2. Line A shows a typical wave form of the track code pulses. Line B illustrates a typical wave form of voltage occurring at the input to the first amplifier stage including transistor 15. It is assumed in these wave forms that the track current is at a high level; this causes the ringing effect at the termination of each code pulse as shown at line B. Line C shows the wave form of the output of the amplifier when the gain controlling circuit organization of the present invention is not employed. The ringing, when amplified, produces an output to energize relay MR long after the termination of each track code pulse, and in fact the relay current does not subside to the drop-away value until near the end of the "off" period. This naturally results in a highly asymmetrical operation of relay MR since the relay will then be dropped away for only a very brief interval rather than for substantially the entire "off" period of the code. Line D, on the other hand, illustrates how the ringing effect is suppressed by the amplifier. At the termination of each code pulse, the amplifier output reverts almost immediately to zero. This allows the relay MR to drop away promptly at the end of each code pulse. The relay MR thus operates in

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the desired manner, remaining in pick-up and dropped-away conditions alternately for substantially equal lengths of time.

This circuit organization is also highly effective in its compensation for the effects of temperature changes. The collector current tends to increase substantially with an increase of temperature. This causes the no-signal collector current of transistors 32 to 33 to increase with increasing temperature. In the manner already described, this increase raises the bias voltage on the emitter of transistor 25 to reduce its gain and thus the input signal to transistors 32 and 33 also. It has been found that this circuit organization is effective to provide stable operation over the temperature range from -25° F. to $+180^{\circ}$ F.

While it will be understood that the circuit specifications of the invention may vary according to the design of any particular application, the following circuit specifications are included by way of example only:

20	Capacitor 12	-----microfarads----	15
	Capacitor 13	-----do-----	.03
	Capacitor 14	-----do-----	1
	Capacitor 18	-----do-----	50
25	Capacitor 20	-----do-----	100
	Capacitor 24	-----do-----	1
	Capacitor 28	-----do-----	50
	Capacitor 30	-----do-----	100
	Capacitor 31	-----do-----	.01
30	Capacitor 34	-----do-----	.25
	Capacitor 39	-----do-----	100
	Capacitor 43	-----do-----	100
	Capacitor 44	-----do-----	100
	Resistor 16	-----ohms----	8,200
35	Resistor 17	-----do-----	1,800
	Resistor 19	-----do-----	12,500
	Resistor 21	-----do-----	5,600
	Resistor 22	-----do-----	1,000
	Resistor 23	-----do-----	1,000
40	Resistor 26	-----do-----	5,600
	Resistor 27	-----do-----	10,000
	Resistor 29	-----do-----	10,000
	Resistor 35	-----do-----	47
	Resistor 36	-----do-----	47
45	Resistor 38	-----do-----	220
	Resistor 41	-----do-----	330

Having described a cab signaling system embodying an improved transistor amplifier as one specific embodiment of my invention, I desire it to be understood that various modifications and adaptations may be made to the specific form I have shown to meet the requirements of practice.

What I claim is:

1. In a cab signaling system for railroads, means for applying pulses of alternating current having alternate "on" and "off" periods of substantially equal duration to the track rails of track sections at selected rates in accordance with traffic conditions, train carried equipment including receiver coils inductively associated with said track rails, amplifier circuit means for amplifying the voltage including a plurality of tuned circuits being selectively responsive to the frequency of the alternating current of said track code pulses, said amplifier circuit means including a transistor voltage amplifier stage and also a transistor power amplifier stage receiving its input voltage from the output of said voltage amplifier stage, circuit means governed by the level of conduction of said power amplifier transistor for providing a variable operating bias for said voltage amplifier transistor, said circuit means causing said bias to reduce the gain of said voltage amplifier transistor to a minimum during high amplitude code pulses producing a high level of output from said power amplifier transistor, said circuit means also being effective to cause said gain reducing bias voltage to persist for a time following the termination of

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each code pulse, whereby the "ringing" of said tuned circuits caused by track code pulses of high amplitude is effectively suppressed by the reduced gain of said voltage amplifier transistor, and decoding circuit means including an electromagnetic relay being operated alternately between opposite conditions in response to the output of said power amplifier stage, whereby said relay remains in its picked-up condition substantially only for the duration of each track code pulse.

2. In a cab signaling system for railroads, means for applying time spaced pulses of alternating current having substantially equal "on" and "off" times to the track rails of track sections at selected rates in accordance with traffic conditions, train-carried apparatus including a receiver coil inductively associated with each track rail, amplifier circuit means being responsive to the voltage induced in said receiver coils, said amplifier circuit means including a transistor voltage amplifier stage and also a transistor power amplifier stage receiving its input voltage from the output of said voltage amplifier stage, circuit means including a capacitor being charged to a voltage proportional to the level of conduction of said transistor power amplifier stage, biasing circuit means for said voltage amplifier stage being governed by the voltage across said capacitor, said capacitor becoming charged during each code pulse to thereby reduce the gain of said voltage amplifier and thus stabilize the output of said power amplifier stage, circuit means for providing a discharge circuit for said capacitor having a time constant causing said capacitor to substantially discharge and thereby restore the gain of said voltage amplifier to its maximum value after the termination of a code pulse just prior to the occurrence of the next code pulse for the highest rate of said track current coding, and relay means being operated alternately between opposite conditions in response to the output of said power amplifier stage, whereby said relay remains in its picked-up and dropped-away conditions in accordance with the duration of the "on" and "off" periods of the track code pulses.

3. In a cab signaling system for railroads, means for applying pulses of alternating current having substantially equal "on" and "off" times to the track rails of track sections at selected rates in accordance with traffic conditions, vehicle-carried equipment including a receiver coil inductively coupled with each track rail, transistor amplifier circuit means for amplifying the voltage induced in said receiver coils, said amplifier circuit means including a transistor voltage amplifier and a transistor power amplifier with said power amplifier receiving its input signal from the output of said voltage amplifier, biasing circuit means for said voltage amplifier being effective according to the level of said bias voltage to vary the gain of said voltage amplifier, a capacitor associated with said power amplifier and being charged to a voltage dependent on the level of output of said power amplifier, said biasing circuit means including said capacitor to thereby cause said bias to vary in accordance with the level of output of said power amplifier, discharge circuit means for said capacitor providing a time constant causing said capacitor following the termination of a code pulse to become substantially discharged only just prior to the occurrence of the next code pulse for the highest coding rate of said pulses, whereby for high levels of

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said track current said voltage amplifier gain is maintained at a low level throughout said code pulse and for a time thereafter to cause said amplifier to provide substantially zero output in response to any "ringing" output occurring between consecutive code pulses, and relay circuit means being operated alternately between opposite conditions in response to the output of said power output stage, whereby said relay remains alternately picked up and dropped away for equal periods of time at a rate corresponding to the coding rate of said track pulses.

4. In a cab signaling system for railroads, means for applying pulses of alternating current having substantially equal "on" and "off" times to the track rails of track sections at selected rates in accordance with traffic conditions, vehicle-carried equipment including receiver coils conductively associated with said track rails, amplifier circuit means being responsive to the voltage induced in said receiver coils, said amplifier circuit means including a voltage amplifier stage comprising a first transistor connected in common emitter configuration, biasing circuit means for the emitter-base circuit of said first transistor, a power amplifier stage comprising a second transistor also connected in common emitter configuration, said power amplifier receiving its input signal from the output of said voltage amplifier, a biasing resistor included in the emitter circuit of said second transistor, a capacitor bypassing said resistor, circuit means connecting said capacitor to the emitter circuit of said first transistor to thereby provide a bias voltage for said first transistor being variable in accordance with the level of conduction of said second transistor, said circuit means acting to provide a time constant for the discharge of said capacitor causing said capacitor to discharge at a rate following the termination of a track code pulse resulting in the substantial discharge of said capacitor just prior to the occurrence of the next track code pulse, whereby the gain of said amplifier circuit means is reduced throughout each code pulse by an amount dependent on the amplitude of each track code pulse and said gain remains reduced for a limited time following each code pulse to thereby suppress spurious voltages in the output of said amplifier circuit means resulting from the ringing effect produced by the high level code pulses on various tuned circuits included in said amplifier circuit means, and decoding circuit means including an electromagnetic relay being operated alternately between opposite conditions in response to the output of said power amplifier stage, whereby said relay remains in its picked-up and dropped-away conditions in accordance with the duration of the "on" and "off" periods of the track code pulses.

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