

May 30, 1939.

L. R. ALLISON

2,160,669

TRAIN CONTROL SYSTEM

Filed Aug. 11, 1938

2 Sheets-Sheet 1

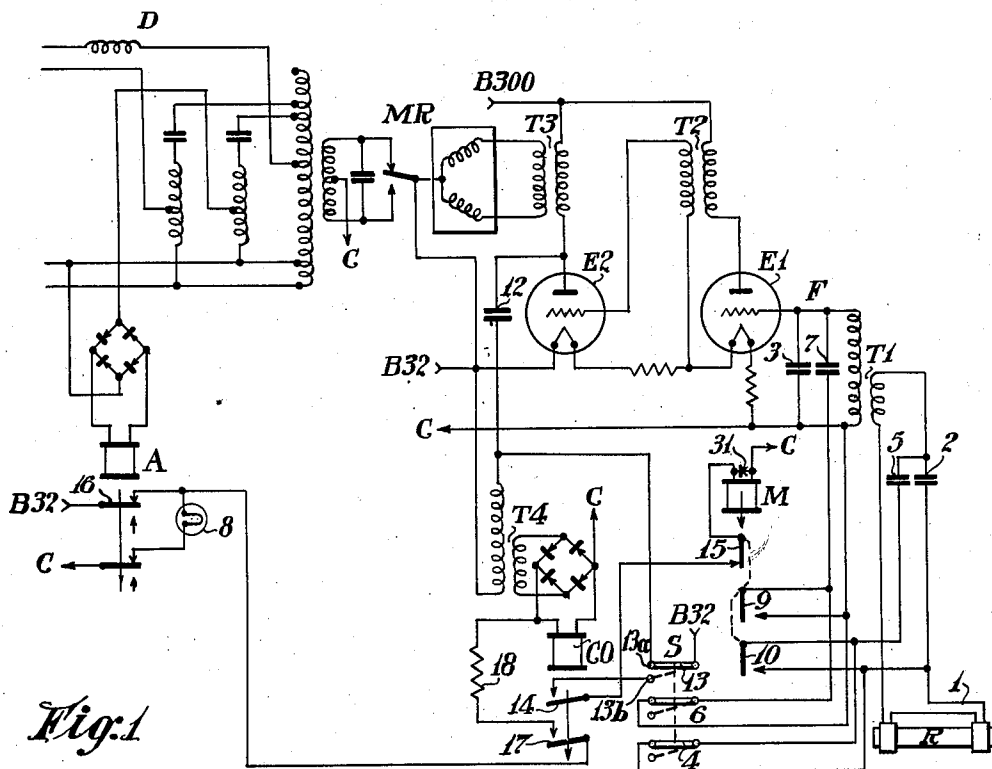


Fig. 1

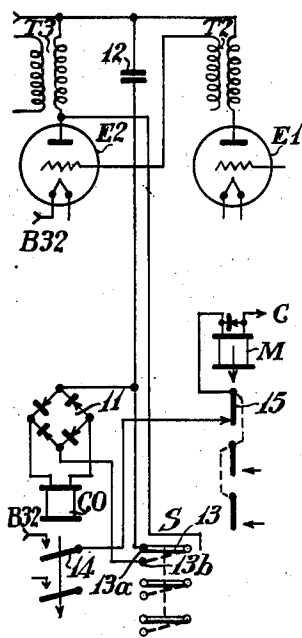


Fig. 2

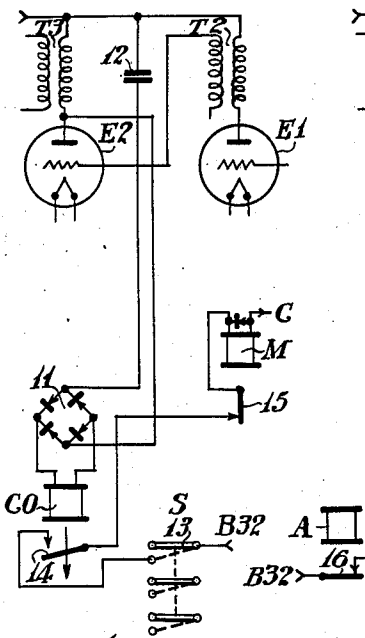


Fig. 3

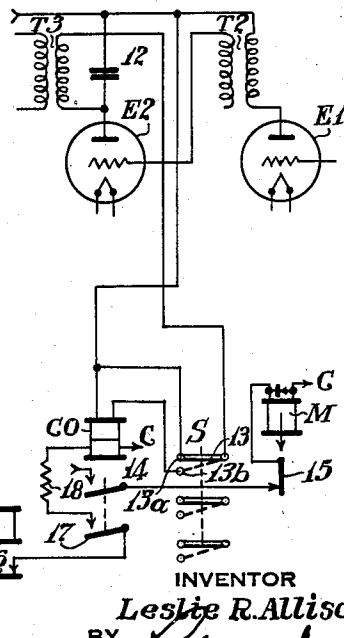


Fig. 4

INVENTOR
Leslie R. Allison
BY *Refwood*
HIS ATTORNEY

May 30, 1939.

L. R. ALLISON

2,160,669

TRAIN CONTROL SYSTEM

Filed Aug. 11, 1938

2 Sheets-Sheet 2

Fig. 5

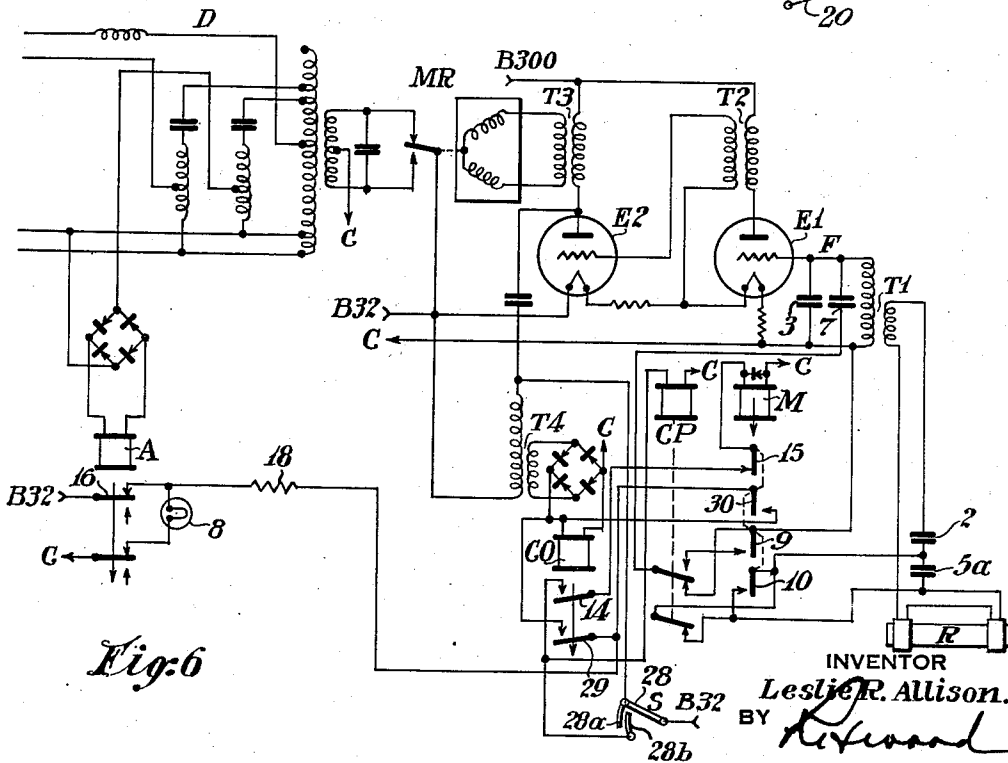
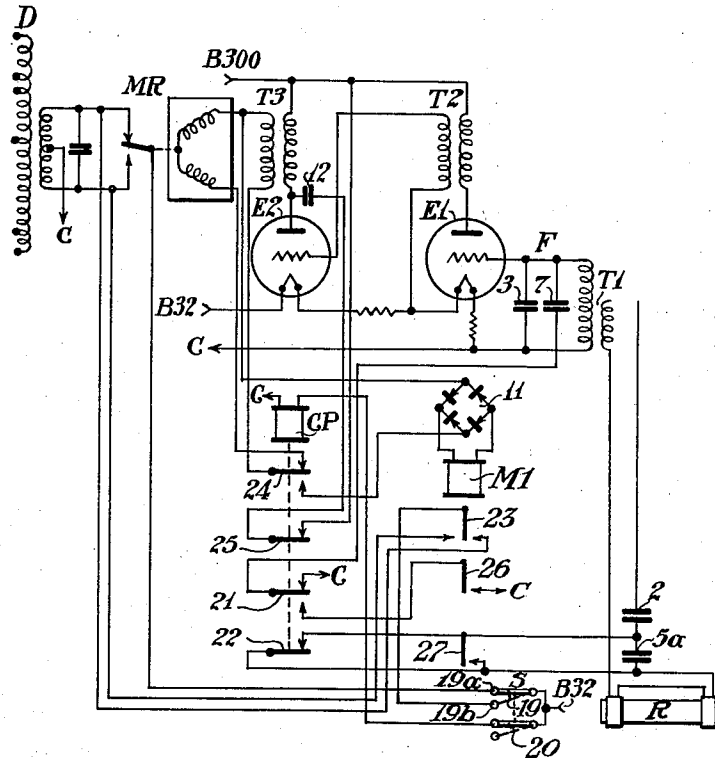


Fig. 6

INVENTOR
Leslie R. Allison.
BY
His Attorney

UNITED STATES PATENT OFFICE

2,160,669

TRAIN CONTROL SYSTEM

Leslie R. Allison, Forest Hills, Pa., assignor to
The Union Switch & Signal Company, Swiss-
vale, Pa., a corporation of Pennsylvania

Application August 11, 1938, Serial No. 224,355

19 Claims. (Cl. 246—63)

My invention relates to train control systems, and particularly to systems of the type in which a train is equipped with apparatus to be controlled by coded current or by non-coded current flowing in the trackway.

Systems are well known in which the train carried apparatus is selectively responsive to alternating current supplied to a conductor in the trackway and coded at different frequencies to produce a plurality of indications on the train. One such system in which the train carried apparatus is capable of displaying four distinctive indications including a clear indication is disclosed in United States Patent No. 1,986,679 granted to Lloyd V. Lewis on January 1, 1935.

It is also well known that train carried apparatus of the type described may be arranged to respond also to uncoded current flowing in the trackway by including on the train a modulator which periodically varies the energy received from the trackway when uncoded current is flowing therein, to cause the train carried equipment to display a clear indication. One such arrangement is shown in the copending application for United States Patent Serial No. 218,137 filed by Frank H. Nicholson on July 8, 1938, upon which my present application is an improvement.

One object of my present invention is to make the train carried modulator dependent for its operation upon the reception from the trackway of uncoded train control current of the proper frequency so that the train carried apparatus will not respond improperly to currents of other frequencies which may be present in the trackway and will not interfere with the intended operation of the equipment when the trackway is supplied with coded current.

Other objects of the invention are the provision of apparatus for protecting against false operation under various conditions, for facilitating the changeover from code to non-code operation and for simplifying the testing of the train carried apparatus.

Still other objects and purposes will be pointed out in detail during the following description.

I shall describe several forms of train control systems embodying my invention, and shall then point out the novel features thereof in claims.

In the accompanying drawings, Fig. 1 is a diagrammatic view illustrating one form of train carried apparatus embodying my invention. Figs. 2, 3 and 4 are diagrammatic views illustrating various modifications of a portion of the apparatus shown in Fig. 1 and also embodying my invention. Fig. 5 is a diagrammatic view

showing a modified form of train carried apparatus embodying my invention in which a modulator is actuated directly from the output of the train carried amplifier. Fig. 6 is a diagrammatic view illustrating certain modifications of the system shown in Fig. 1 and also embodying my invention.

Similar reference characters refer to similar parts in the several views.

Referring first to Fig. 1, the apparatus illustrated is generally similar to that shown in the Lewis Patent No. 1,986,679 and the Nicholson application Serial No. 218,137 identified above and comprises a receiver R located in inductive relation with the trackway and in which coded current which may be assumed to be of a frequency of 100 cycles per second of uncoded current which may be assumed to be of a frequency of 140 cycles per second may be induced. The receiver is connected through a receiver circuit 1 with the primary of a transformer T1, the secondary of which forms part of a filter F the output of which is delivered to the grid circuit of an amplifier tube E1.

The plate circuit of tube E1 is connected through the interstage transformer T2 with the grid circuit of a second tube E2 having its plate circuit delivering current to a load winding here shown as the primary of a transformer T3, the secondary of which is connected with the operating winding of a master relay MR. The filaments of the electron tubes E1 and E2 are supplied with energy from terminals B32 and C of a suitable source of energy not shown in the drawings and the plate circuits of these tubes are supplied with energy from terminals B300 and C of a suitable source of high potential.

The train carried apparatus also includes a cutover switch S which will usually be operated manually by the engineman and which is arranged when in the position illustrated in the drawings to condition the train carried apparatus for response to coded wayside current. When the switch S is moved to the dotted line position the train carried apparatus is conditioned for operation by non-coded wayside current.

The receiver circuit 1 is tuned by means of condenser 2 to resonance at the frequency of the non-coded current to which the apparatus is intended to respond (assumed for purposes of illustration to be 140 cycles per second), and the filter F is also tuned to resonance at this frequency by means of a condenser 3.

When the cutover switch S is in the "code" position as shown, contact 4 connects another

condenser 5 in the receiver circuit to tune this circuit to resonance at the frequency of the coded current which in the present instance is assumed to be 100 cycles per second. Under this condition also contact 6 of the cutover switch S connects a condenser 7 in the filter circuit to tune the filter also to resonance at the frequency of the coded current, that is, 100 cycles per second.

With the cutover switch in the position illustrated therefore coded current induced in receiver R will be supplied through the receiver circuit 1 and the filter F to the first stage tube E1, will be amplified by this tube and will be amplified and detected by tube E2 and will operate relay MR at the frequency of the coded variations in the received current. The master relay MR may control train carried governing means in any well-known manner. As here shown the master relay supplies energy to decoding equipment designated generally by the reference character D and including a decoding relay A which is energized to illuminate a clear signal 8 in response to a particular code which I shall term the "clear" code.

When the cutover switch S is moved to the dotted line position contacts 4 and 6 are open and condenser 5 is then removed from the receiver circuit and condenser 7 is removed from the filter circuit so that both the receiver circuit and the filter are tuned to resonance at the frequency of the uncoded current supplied to the trackway. A modulator M is provided with a contact 9 connected in parallel with contact 6 of the cutover switch and with a contact 10 connected in parallel with contact 4 of the cutover switch. Contacts 9 and 10 are operated, when the modulator is actuated, to periodically detune (for the frequency of the uncoded current) the receiver circuit and the filter by connecting condensers 5 and 7, respectively, in those circuits, and this results in periodic variation of the current delivered by the receiver to the first stage tube E1. The modulator is arranged to produce this periodic variation at the frequency of the code which operates relay A and the uncoded current varied by the modulator M therefore also operates relay A to produce on the train a clear signal in response to uncoded current in the receiver.

It may happen, through inadvertence, that the cutover switch S is left in or moved to the non-code position while the train is in code territory. Under these circumstances, if the modulator is actuated, the operation of the modulator contacts, in periodically varying the tuning of the receiver circuit and the filter, would distort the received codes, and might even cause the train carried apparatus to display an indication less restrictive than that corresponding to the received code.

This is undesirable and to prevent its occurrence I prefer to control the modulator M by the receiver current so that the modulator can be actuated only when the train carried equipment is actually receiving uncoded current of the proper frequency. In the modification shown in Fig. 1, I produce this desirable result by the provision of a control relay CO connected through a rectifier 11 and a transformer T4 in series with the by-pass condenser 12 which is connected across the plate circuit of the second stage amplifier tube E2. The transformer T4 is shunted by contact 13—13a of the cutover switch when this switch is in the code position, and under this condition of course relay CO is deenergized.

When the cutover switch is moved to the non-code position, however, the opening of contact 13—13a opens the shunt around transformer T4, and relay CO then receives energy in accordance with the alternating current component of the output of tube E2. If non-coded current is being supplied by the receiver the energy thus supplied to relay CO will be sufficient to energize it, and current will then be supplied over contact 13—13b of the cutover switch S, front contact 14 of relay CO and the driving contact 15 of the modulator M to actuate the modulator.

It should be pointed out that the false or improper operation explained above takes place only as a result of modulator operation when uncoded current is not being received, but with the apparatus shown in Fig. 1 the modulator is actuated only when the receiver is delivering 140 cycle current to the amplifier and the apparatus therefore prevents the undesired operation because relay CO can be energized to actuate the modulator only when uncoded current of the proper frequency is delivered by the receiver.

Under certain conditions there may be induced in the receiver R substantial amounts of current of frequencies different from either the coded or uncoded current to which the apparatus is intended to respond. These stray currents might charge the condenser in the receiver circuit to such an extent that when the modulator alternately connects and disconnects condenser 5 the interchange of electrostatic energy between condensers 2 and 5 might cause shock excitation of the filter F to a degree sufficient to falsely operate the clear signal 8 by improperly operating the master relay MR and the decoding relay A. With apparatus embodying my invention however, since the modulator cannot operate except when uncoded current of the proper frequency is being received, false operation due to these stray currents is effectively prevented.

One advantage of the step-down transformer T4 is to improve the temperature regulation of the rectifier 11 by making it possible to more perfectly match the impedances of the elements included in the output circuit of the second stage tube E2.

In actual practice I have found that the energy available to retain relay CO in its operated position after the modulator has commenced its operation is materially less than the energy available to pick up relay CO when uncoded current is first supplied to the apparatus and before the modulator commences its operation. This is due, in part at least, to the fact that the modulator, during a portion of each of its cycles, detunes the circuits through which energy is supplied to the amplifier, and hence reduces the energy supplied to relay CO. In order to make sure that relay CO is maintained energized after the modulator starts a stick circuit is provided from terminal B32, over front contact 16 of the decoding relay A, front contact 17 of relay CO, a protecting resistance 18 and the winding of relay CO to terminal C.

In operation, when uncoded current is first supplied to the receiver the energy delivered by the second stage tube E2 is sufficient to pick up relay CO and start the modulator. While the reduction in energy supplied to relay CO as a consequence of the coding action of the modulator upon the receiver circuit and the filter may cause relay CO to release, and thereby deenergize the modulator, the modulator is constructed to "coast" or operate through a number of cycles

after its energizing circuit is opened. One form of modulator which will operate in this manner is disclosed in United States Patent No. 1,358,876 issued May 17, 1932, to P. N. Bossart, and this "coasting" characteristic of the modulator is preferably accentuated by connecting a rectifier 31 across its operating winding. While the modulator is "coasting", relay MR will be operated through a sufficient number of cycles to energize relay A. When the modulator comes to rest, the steady uncoded energy will again pick up relay CO, before relay A releases, and the stick circuit for CO will thereafter maintain relay CO fully energized after the modulator starts, in spite of the reduction of the energy supplied to relay CO from the plate circuit of E2 as a consequence of the periodic variation in the current delivered by the receiver.

The relay CO, instead of being connected across the plate circuit of the second stage amplifier E2 as in Fig. 1, may alternatively be connected in series with the by-pass condenser 12 across the load circuit of the tube as shown in Fig. 2. In this modification the input terminals of the rectifier 11 are connected in series with the condenser 12 across the primary of the output transformer T3 through contact 13—13b of the cutover switch S when the switch is in the non-code position. When the switch S is in its code position, as shown, the relay CO is disconnected from the output circuit of the tube E2 and relay CO is then deenergized. Another modification illustrated in Fig. 2 is that the modulator M is controlled solely by its own driving contact 15 and the front contact 14 of relay CO and is not governed by a contact of the cutover switch S, as in Fig. 1.

If desired the relay CO may be permanently connected into the circuit for tube E2 as shown in Fig. 3. With this arrangement the relay CO will be energized by either coded or non-coded current but actuation of the modulator requires both that relay CO be energized and that the cutover switch S be in its non-code position.

In the modification shown in Fig. 4, relay CO is provided with two windings, the upper one of which is connected, through contact 13—13b of the cutover switch S, in series with the primary of the output transformer T3. With this arrangement relay CO is energized by the direct current component of the second stage plate current instead of the A. C. component as in Fig. 1. Since the relay CO has no rectifier and hence is not slow acting, the relay would "pump" or follow the periodic variations in the amplifier output when the modulator is operated. To prevent this, a holding circuit is provided for the lower winding of relay CO including front contact 16 of the decoding relay A, front contact 17 of relay CO and the limiting resistance 18. Thus in the same manner as previously explained in connection with Fig. 1, even though relay CO releases after the modulator M starts, the modulator will "coast" through several cycles and this will produce a number of cyclic operations of the master relay sufficient to pick up relay A and complete the holding circuit for relay CO the next time relay CO picks up.

One advantage of the modification shown in Fig. 4 is that since the relay CO is included in series with the high inductance primary of the transformer T3, the relay is immune to false energization from ripple output in the direct current filament supply. In systems of the type here contemplated the filaments of the tubes are generally energized from a train carried headlight

generator and current thus generated frequently has a substantial ripple component.

Another advantage of the modification shown in Fig. 4 is that no rectifier is required in the energizing circuit for relay CO.

Referring now to Fig. 5, the apparatus is generally similar to that shown in Fig. 1, but the modulator M1, from which the driving contact is omitted, is at times supplied through its rectifier 11 with energy directly from the output circuit of the second stage tube E2 in the place of the master relay MR which is then disconnected from this circuit. The modulator M1 periodically varies the tuning of the receiver and filter circuits and in addition supplies periodically varied current to the decoder D when the system is receiving uncoded current and the master relay MR is disconnected from the amplifier.

When the cutover switch S is in the code position, as illustrated, a repeater relay CP is energized over contact 20 of the cutover switch, and energy is supplied to the decoder D over the contact of the master relay MR and contact 19—19a of the cutover switch from terminals B32 and C. Under these conditions the modulator M1 is disconnected from the amplifier output circuit, condenser 7 is connected to the filter circuit over front contact 21 of relay CP, and a condenser 5A in the receiver circuit is shunted by front contact 22 of relay CP. The receiver circuit and the filter are then tuned to resonance at the frequency of the coded current, and if current of this frequency is supplied to the receiver, the master relay is operated in accordance with the code to operate the decoding equipment D as explained in connection with Fig. 1.

If, however, the cutover switch S is moved to the non-code position, the repeater relay CP is deenergized and energy is disconnected at contact 19—19a from the contact of the master relay MR. At the same time the closing of contact 19—19b of switch S connects energy to the decoder D over contact 23 of the modulator M1.

The opening of front contact 21 of relay CP disconnects condenser 7 from the filter circuit and the opening of contact 22 of relay CP ruptures the shunt path around condenser 5a in the receiver circuit and under these conditions both the receiver circuit and the filter are tuned to resonance at 140 cycles per second, the frequency of the uncoded current.

Furthermore the opening of front contact 24 of relay CP disconnects the master relay from the secondary of the output transformer T3 and substitutes for it at back contact 24 of relay CP the modulator M1 which is now connected through rectifier 11 directly with the amplifier output. The opening of front contact 25 of relay CP disconnects the by-pass condenser 12 from the plate circuit of the second stage tube E2 so that this tube now operates as a "class B" amplifier instead of as a detector. The modulator M1 therefore receives energy only when uncoded current is induced in receiver R and the receiver circuit and the filter are tuned to resonance at this frequency. If uncoded current is being induced in the receiver modulator M1 swings its armatures to the right, and its contact 26 detunes the filter and its front contact 27 detunes the receiver circuit to the 140 cycle non-code current. This reduces the energy supplied by transformer T3 to the modulator and the modulator armatures swing to the left, thereupon restoring the tuning of the receiver circuit and the filter and again increasing the second stage amplifier tube output to a

point sufficient to energize the modulator through another cycle. This sequence of operations continues and the modulator M therefore operates cyclically. The contact 23 of the modulator now supplies energy periodically to the decoder so that the governing apparatus is caused to display a clear indication.

It will be noted that in Fig. 5 the relay M serves not only as a modulator to periodically tune and detune the receiver circuit and filter but this relay also serves, when the cutover switch is in the non-code position, as a master relay to supply periodically varying current to the decoder for the operation of the train carried governing apparatus.

Referring now to Fig. 6, I have shown a modified form of the apparatus, generally similar to that illustrated in Fig. 1, but provided with certain additional circuits for relay CO which are of particular utility when the train carried apparatus is being subjected to test operations. In Fig. 6, the cutover switch S has only two contacts, one of which, 28—28a, is closed in the code position for shunting transformer T4 and thereby deenergizing relay CO. The other contact 28—28b of switch S is closed in the non-code position and supplies energy to a repeater relay CP and to the actuating circuit for the modulator M over front contact 14 of relay CO and the driving contact 15 of the modulator. When the switch S is in the code position relay CP is deenergized and the receiver circuit and the filter are then tuned to the frequency of the coded current as in Fig. 5. When the switch S is moved to the non-code position relay CP is energized and the receiver circuit and the filter are then tuned to resonance as in Fig. 5 to the frequency of the non-coded current.

Relay CO is then actuated by energy received from the output circuit of the second stage tube E2 and the energization of relay CO completes the actuating circuit for the modulator M which by its contacts 9 and 10 periodically tune and detune the receiver circuit and the filter to produce cyclic operation of the master relay MR for the purpose of selectively energizing the decoding relay A.

It should be noted that contacts 28a and 28b of the switch S "overlap" in order to make sure that in movement of the switch from the code position to the non-code position the repeater relay CP will become energized before relay CO is inserted in the output circuit for the amplifier.

It is customary in testing train carried apparatus of the type here involved to place the receiver adjacent a conductor to which uncoded current of 140 cycles is supplied, and then to gradually increase the value of this current and note the response of the train carried apparatus. In following this procedure, when the rail current is increased to an amount just sufficient to operate relay CO, modulator M is actuated and this produces periodic tuning and detuning of the receiver circuit and the filter as pointed out above. It may happen that this periodic variation in the amplifier input will reduce the amplifier output energy below that required to maintain relay CO energized, whereupon relay CO will release and deenergize modulator M. The modulator will gradually come to rest, whereupon the increased energy available in the amplifier due to the fact that the periodic variation in its input has ceased will again pick up relay CO. The apparatus will go through this cycle repeatedly and thereby cause flashing of the clear signal

lamp controlled by decoding relay A. This is undesirable and in order to prevent its occurrence I prefer to adjust the parts so that the pick-up value of relays CO is below that required for operation of the master relay. With this arrangement the master relay will not operate to cause flashing of the clear signal lamp unless the rail current is raised to an amount sufficient to make sure that the modulator action will not cause relay CO to release.

Furthermore I provide relay CO with two auxiliary circuits, one a stick circuit which may be traced from terminal B32 over front contact 16 of the decoding relay A, limiting resistance 18, front contact 29 of relay CO, winding of relay CO to terminal C, and the other circuit being identical with that traced above except that contact 30 of the modulator M is connected in parallel with front contact 29 of relay CO. With this arrangement, if the rail current and hence the current induced in receiver R is sufficient to actuate the decoding relay A, an auxiliary circuit for relay CO is closed either over front contact 29 of relay CO, or over contact 30 of the modulator, to hold the relay energized independently of the energy received from the amplifier output.

Furthermore I prefer to place the contacts 9 and 10 of the modulator, which when closed detune the receiver circuit and filter for uncoded current, on the same side of the modulator as the driving contact 15. With this arrangement, when the modulator actuating circuit is first closed, the armature will swing in one direction (to the right as represented in the drawings) and, after contact 15 opens, will swing back in the other direction to again close the driving contact and energize the modulator winding for the second time before contacts 9 and 10 are closed. This insures that the modulator will be fully energized and, as explained in connection with Fig. 1, will coast long enough to positively energize relay A, even though the energy supplied to CO from tube E2 is reduced below the value necessary to retain CO energized.

I have therefore provided apparatus which will facilitate testing of the equipment in that flashing of the clear signal is prevented and undesired release of relay CO is suppressed.

Although I have herein shown and described only a few forms of train control systems embodying my invention, it is understood that various changes and modifications may be made therein within the scope of the appended claims without departing from the spirit and scope of my invention.

Having thus described my invention, what I claim is:

1. In a train control system, the combination, with a receiver to be energized by modified or unmodified current flowing in the trackway and a traffic control device supplied with energy from said receiver and responsive to the influence of modified current, of a modulator for modifying the unmodified current induced in said receiver to simulate the effect of modified current and cause response of said device, and means for controlling said modulator in accordance with the energy supplied by said receiver.

2. In a train control system, the combination, with a receiver to be energized by modified or unmodified current flowing in the trackway, an amplifier and governing means controlled by said amplifier and responsive to modified current supplied to the amplifier, of circuit means for connecting said receiver with the input terminals of

said amplifier, and modulator means controlled by said amplifier for controlling said circuit means to modify unmodified current supplied from said receiver to cause response to said governing means.

3. In a train control system, the combination, with a receiver to be energized by uncoded current flowing in the trackway, an amplifier, circuit means connecting said amplifier with said receiver and governing means controlled by said amplifier and requiring coded current for its operation, of modulating means for periodically changing the tuning of said circuit means to cause the response of said governing means, and means controlled by said amplifier for actuating said modulating means only if the energy supplied by said receiver is above a predetermined value.

4. In a train control system, the combination, with a receiver to be energized by modified current of one frequency or unmodified current of a second frequency flowing in the trackway, an amplifier, circuit means for connecting said receiver with said amplifier and tuned to resonance at said one frequency, and governing means controlled by said amplifier and responsive to coded current, of a cutout switch having two positions, means controlled by said cutout switch in one position to tune said circuit means to resonance at said second frequency, modulating means for periodically changing the tuning of said circuit means, and means effective when said switch is in said one position and controlled by said amplifier to actuate said modulating means provided only the average value of the current of said second frequency in said amplifier is above a predetermined minimum.

5. In a train control system, the combination with a receiver to be energized by uncoded current flowing in the trackway, an electron tube, governing means controlled by the plate circuit of said tube and responsive to coded current, and circuit means connecting said receiver with the grid of said tube, of a relay receiving energy from the plate circuit of said tube, and modulating means controlled by said relay for periodically varying the tuning of said circuit means to modify the current supplied by the receiver to said grid for operation of said governing means.

6. A train control system comprising a receiver to be energized by uncoded alternating current flowing in the trackway, an electron tube, circuit means for energizing the grid of said tube from said receiver, governing means controlled by the plate circuit of said tube and responsive to coded current, a rectifier having its input terminals supplied with energy from the alternating component of the plate current of said tube, a relay connected with the output terminals of said rectifier, and a modulator controlled by said relay for periodically varying the tuning of said circuit means to code the current supplied to said governing means.

7. A train control system comprising a receiver to be energized by uncoded alternating current flowing in the trackway, an electron tube, circuit means for energizing the grid of said tube from said receiver, governing means controlled by the plate circuit of said tube and responsive to coded current, a transformer having its primary supplied with energy from the plate circuit of said tube, a relay connected with the secondary of said transformer, a rectifier interposed between said secondary and said relay, and a modulator controlled by said relay for periodically varying

the tuning of said circuit means to code the current supplied to said governing means.

8. A train control system comprising a receiver to be energized by uncoded alternating current flowing in the trackway, an electron tube having a grid circuit energized by said receiver, a decoding relay controlled by energy in the plate circuit of said tube and selectively responsive to the supply of coded current to said grid circuit, a second relay, means for energizing said second relay in accordance with current in the plate circuit of said tube, a stick circuit for said second relay including a contact of said decoding relay, and modulating means controlled by said second relay for periodically varying the current supplied by said receiver for actuating said decoding relay.

9. A train control system comprising a receiver to be energized by uncoded alternating current, an electron tube having a grid circuit energized in accordance with the current induced in said receiver, a master relay, a plate circuit for said tube including a load winding for controlling said relay, a by-pass condenser connected across said load winding, a rectifier having its input terminals connected in series with said by-pass condenser, a second relay connected with the output terminals of said rectifier, a modulator controlled by said second relay for periodically varying the uncoded current induced in said receiver, and decoding means controlled by said master relay and selectively responsive to coded current in said receiver.

10. A train control system comprising a receiver to be energized by uncoded alternating current flowing in the trackway, a traffic control device responsive to coded current, circuit means for energizing said device in accordance with the current in said receiver, a relay, a cutout switch, means controlled by said switch for at times placing said relay under the control of current supplied to said circuit means by said receiver, and modulating means controlled by said relay for controlling said circuit means to code the current delivered by said receiver.

11. A train control system comprising a receiver to be energized by uncoded alternating current flowing in the trackway, a traffic control device responsive to coded current, circuit means for energizing said device in accordance with the current in said receiver, a relay, a cutout switch, means controlled by said switch for at times placing said relay under the control of current supplied to said circuit means by said receiver, and modulating means controlled by a contact of said relay and by a contact of said switch for periodically varying the current delivered by said receiver.

12. A train control system comprising a receiver comprising a receiver to be energized by uncoded alternating current flowing in the trackway, a traffic control device responsive to coded current, circuit means for energizing said device in accordance with the current in said receiver, a relay constantly connected to be influenced by current supplied to said circuit means by said receiver, a modulator for periodically varying the current delivered by said receiver, a cutout switch, and a circuit controlled by said switch and by a contact of said relay for actuating said modulator.

13. A train control system including a receiver to be energized by uncoded alternating current flowing in the trackway, an amplifier including a first stage tube and a second stage tube, a decoding relay controlled by said second stage tube

and responsive to the supply of coded current to the grid of the first stage tube, circuit means for connecting said receiver with the grid of said first stage tube, a second relay, means for supplying to said relay a current in accordance with the direct current component of the second stage tube plate current, a stick circuit for said second relay controlled by a contact of said decoding relay, and a modulator controlled by said second relay for coding the current delivered to said circuit means by said receiver.

14. A train control system including a receiver to be energized by uncoded current flowing in the trackway, an electron tube having a grid circuit energized in accordance with the current in said receiver, decoding apparatus responsive to coded current and controlled by the plate circuit of said tube, a modulator for coding the current delivered by said receiver, and means for supplying actuating energy to said modulator from the plate circuit of said tube.

15. A train control system comprising a receiver to be energized by coded current of one frequency or by uncoded current of a second frequency flowing in the trackway, an electron tube circuit means for energizing the grid of said tube in response to current in said receiver, a load winding in the plate circuit of said tube, a master relay, decoding apparatus controlled by said master relay, a cutout switch, means controlled by said switch in one position to tune said circuit means to resonance at said one frequency and to energize said master relay from said load winding, a by-pass condenser connected around said load winding through a contact of said switch closed in said one position, a modulator, means controlled by said switch in another position for tuning said circuit means to resonance at said second frequency, and for energizing said modulator from said load winding, and means controlled by said modulator for periodically detuning said circuit means for said second frequency and for supplying periodic current to said decoding means.

16. A train control system comprising a receiver to be energized by uncoded current flowing in the trackway, governing means responsive to coded current, means for supplying said governing means with energy in accordance with the current in said receiver, a relay, means for supplying current to said relay in accordance with the energy supplied to said governing means, a modulator controlled by said relay for coding the current delivered by said receiver, and an energizing

circuit for said relay controlled by said modulator.

17. A train control system comprising a receiver to be energized by uncoded current flowing in the trackway, governing means responsive to coded current, means for supplying said governing means with energy in accordance with the current in said receiver, a relay, means for supplying current to said relay in accordance with the energy supplied to said governing means, a modulator controlled by said relay for coding the current delivered by said receiver, and an energizing circuit for said relay controlled by said modulator and by said governing means.

18. A train control system comprising a receiver to be energized by uncoded current flowing in the trackway, governing means responsive to coded current, means for supplying said governing means with energy in accordance with the current in said receiver, a relay, means for supplying current to said relay in accordance with the energy supplied to said governing means, a modulator controlled by said relay for coding the current delivered by said receiver, an energizing circuit for said relay controlled by said governing means and including a contact of said modulator, and a stick circuit for said relay including a front contact of said relay and controlled by said governing means but not by said modulator.

19. A train control system comprising a receiver to be energized by uncoded alternating current flowing in the trackway, an electron tube, means including a circuit tuned to resonance at the frequency of said alternating current for energizing the grid of said tube in accordance with energy delivered by said receiver, a master relay receiving energy from the plate circuit of said tube, a decoding relay controlled by said master relay and responsive to cyclic operation of the master relay, a control relay and a rectifier, means including said rectifier for supplying energy from the plate circuit of the tube to said control relay, a modulator controlled by said control relay for periodically detuning said circuit means for said alternating current to produce cyclic operation of said master relay, an energizing circuit for said control relay including a contact operated by said governing means and a contact of said modulator, and a stick circuit for said control relay including a front contact of the control relay and a contact operated by said governing means.

LESLIE R. ALLISON.