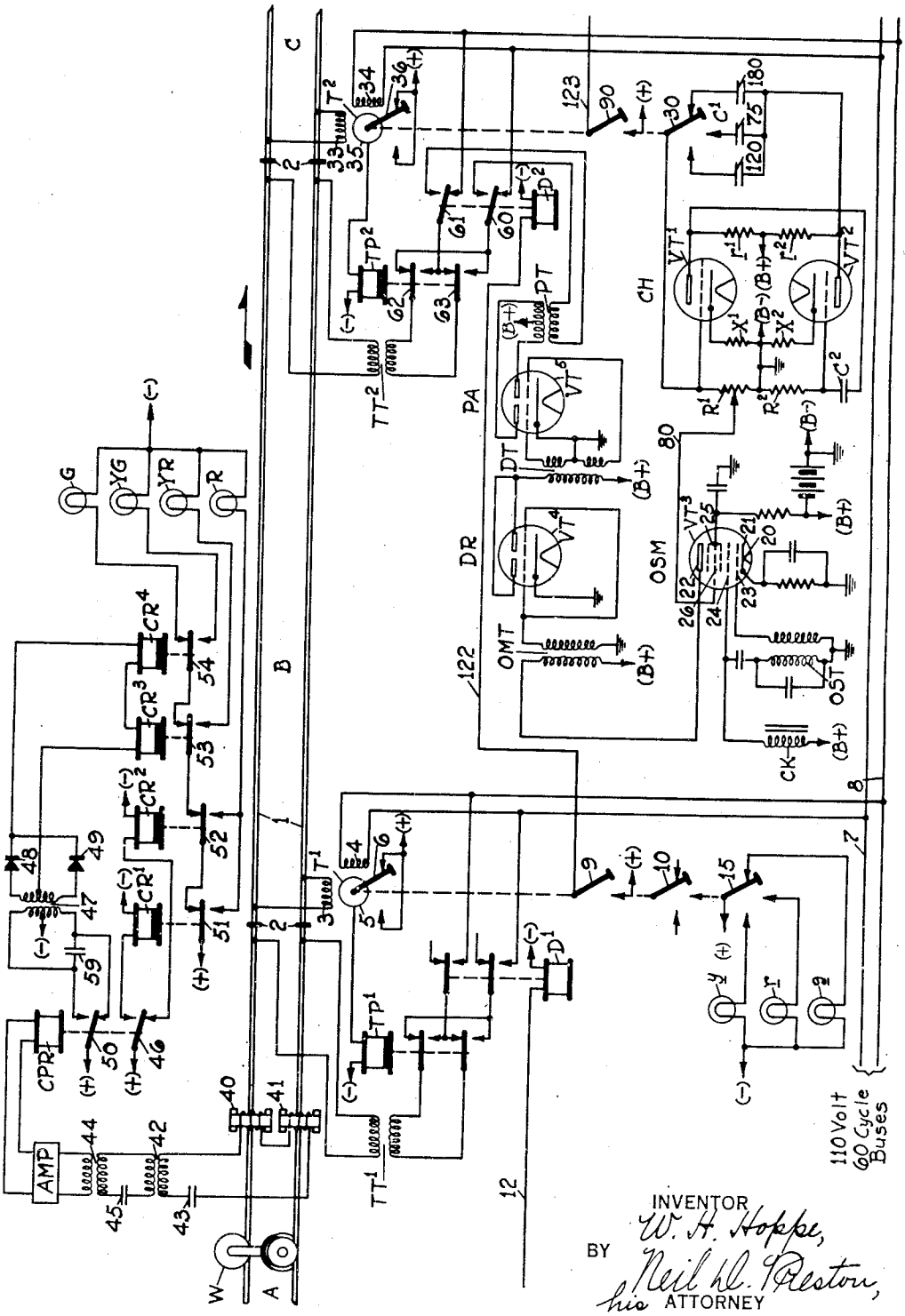
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CONTINUOUS INDUCTIVE CODED TYPE TRAIN CONTROL SYSTEM

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CONTINUOUS INDUCTIVE CODED TYPE TRAIN CONTROL SYSTEM

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This invention relates to train control and cab signalling systems and it more particularly pertains to a coder-oscillator for use in train control and cab signalling systems of the continuous inductive coded type.

A train control or cab signalling system of the continuous inductive type is one in which car carried electro-responsive relays and devices are maintained energized in response to current in the trackway, so that failure of the current supply will result in the deenergization of the devices. In other words, the system operates on the closed circuit principle which causes a more restrictive indication to be given upon current failure.

A continuous inductive coded type system is one in which current in the track rails is coded, with the car carried relays maintained energized and dropped in combination in accordance with the character of the code applied to the track circuit and received by the apparatus on the car. The present invention is illustrated in the drawing as applied to a railway cab signalling system, but it will be obvious that, since the present invention is more particularly directed to a coder-oscillator, the invention may be used in other systems, such as train control and the like.

In coding the track circuit current in cab signalling systems of the type under consideration, it is expedient to provide apparatus along the trackway for characterizing the code, that is, applying impulses in one code which are distinctive from impulses in another code.

It has been customary to employ a coder of the motor driven type for coding a fixed frequency alternating current. Such a coder has certain disadvantages which the present invention overcomes by using a vacuum tube oscillator for providing the fixed frequency alternating current and a vacuum tube "chopper" for characterizing the code. By the use of such an oscillator and "chopper", it has been found that a more constant oscillator frequency and more accurate code characters are provided than formerly obtained from motor driven apparatus, and since there are no mechanically moving parts in such an oscillator and coder, it is more reliable and more economical to maintain.

In view of the foregoing and other important considerations it is proposed, in accordance with the present invention, to employ a vacuum tube oscillator for obtaining a distinctive alternating current of a frequency of 100 cycles per second, and to employ a vacuum tube coder arranged to chop or modulate this 100 cycle current at rates of 75, 120, and 180 impulses per minute. Although the particular embodiment chosen to illustrate the present invention makes use of a frequency of 100 cycles per second and codes of 75, 120, and 180 per minute, it is to be understood that the invention is not limited to a system making use of the above values, since these values have been chosen for convenience in describing the invention.

From the foregoing it will be observed that the use of a vacuum tube coder has another advantage over the usual code wheel type coder driven by a motor, in that any desired code frequency can be readily provided for most efficient operation. With the mechanical or code wheel type coder, it is necessary to make use of frequencies which are multiples of the rate of rotation of the motor shaft. For example, with a motor shaft rotating at 20 R. P. M., the codes provided by code wheels or cam contactors are of such values as 80, 120, and 180 impulses per minute.

Other objects, purposes and characteristic features of the present invention will be apparent from the accompanying drawing when considered in connection with the following description.

The drawing illustrates in diagrammatic form one embodiment of trackway apparatus and one embodiment of car carried apparatus in accordance with the present invention.

Apparatus

The trackway apparatus has been illustrated as applied to a railway track having rails 1 divided by insulating joints 2 into blocks A, B, and C. Each block is preferably provided with a track circuit comprising the track rails themselves, a circuit including a supply transformer TT (with suitable exponent) at the exit end of the block for supplying alternating current to the rails and a circuit including one winding of a track relay T (with suitable exponent) at the entrance end of the block.

Each track relay, in the form shown, is of the polyphase motor type, comprising two stator windings 3 and 4 of relay T^1 (windings 33 and 34 of relay T^2) and a rotor 5 (35 of relay T^2) which actuates contact finger 6 (36 of relay T^2). Winding 3 of relay T^1 (and winding 33 of T^2) are the track windings of the track relays and are connected directly with the track rails of the corresponding block, while the other winding 4 (34 of relay T^2) is the polarizing winding permanently supplied with alternating current from the same source as the track rails, that is, the supply buses 7 and 8.

With such a relay, when current is sent through the track winding 3, for example, in one phase the rotor 5 is actuated in one sense. When current is sent through the track winding 3 in an opposite phase the rotor 5 is actuated in the opposite sense, and when there is no current in the track winding or no current in the polarizing

winding, or none in both windings, the relay is deenergized and the rotor assumes a neutral position. The relay therefore provides for three positions based on shifting phase of current in the track circuit and stopping current flow. For convenience these relay positions will be referred to as normal with the contacts in their right hand positions as illustrated, reverse with the contacts in their left hand positions and neutral with the contacts in their midpositions.

One contact of each track relay in its three positions is arranged to control the wayside signals. Other contacts of the track relays control various other circuits as will be more clearly pointed out later in the description.

Since the apparatus of the various blocks is the same, like parts of each block have been designated by like reference characters having a distinguishing exponent corresponding to the block. Furthermore, the vacuum tube coder and its control by the track relay, as well as the selection of its output codes, has been illustrated in connection with the exit end of block B only. It will be understood that a like coder is associated with the exit of each other block and controlled by the track relay associated with the entrance end of the next block in a like manner.

Although wayside signals will be located at the entrance to each block, for the sake of simplicity they have not all been illustrated in the accompanying drawing. These signals may be of any suitable type and controlled by the associated track relay in its normal, reverse and neutral positions. Since the track relay manifests, clear, caution and stop conditions by actuating its contacts to normal, reverse and neutral positions respectively, it is obvious that these manifestations may be provided by operating semaphore or light signals over circuits controlled by the T relay contacts. This portion of the railway signalling system, however, forms no part of the present invention. As an example of the control of wayside signals, signals *g*, *r* and *y* are illustrated as controlled by contact 15 of relay T^1.

At each signal location a neutral type distant relay D (with suitable exponent) is provided and controlled by a circuit in such a way that it is normally deenergized, being energized when a train enters the block. The D relay switches the track circuit from the 60 cycle track current to the 100 cycle coded current.

A track repeater relay TP (with suitable exponent) of the slow acting neutral type is associated with each track relay. Its function is to reverse the alternating current applied to the track at the exit end of the block for reversing the track relay at the entrance end when the next block in advance is occupied.

Although the TP and D relays and the wayside signals are illustrated as being energized from direct current, it is obvious that they can be energized from an alternating current source of supply, such as the 110 volt 60 cycle buses. In this event the relays will be of the alternating current type.

The coder connected to the exit end of each block by the picking up of the associated D relay, comprises five vacuum tubes VT^1, VT^2, VT^3, VT^4, and VT^5. Since it is proposed to generate the 100 cycle current at each coder location, no 100 cycle supply line is required. Although the vacuum tube coder associated with the exit end of block B is the only one illustrated in detail, it will be understood that those at the exit ends of other blocks are of similar arrangement.

VT^1 and VT^2 comprise a "chopper" or code impulser CH, the function of which is to provide the low, medium and high rate impulses for making up the codes which are applied to the track circuit under various conditions.

VT^3 is an oscillator-mixer OSM, the function of which is to supply the 100 cycle alternating current coded in accordance with the code rate supplied by the "chopper."

The output of OSM is coupled to a driver DR which in turn is coupled to a power amplifier PA, the function of these stages being to step up the coded 100 cycle current to a value suitable for operating the car carried decoder.

Various coupling transformers, condensers, resistors and inductances are provided, the purpose of which will be brought out in detail in the following description. It will be noted that the output circuits of these various tubes are illustrated as being connected to a source of supply indicated (B+) with the other terminal of this source indicated as (B—). It will be understood that this source of supply may be batteries or it may be obtained from the well known power supply or rectifier arrangement. Furthermore, the oscillator-mixer stage may be shielded to prevent intercoupling between its circuit and the circuits of the other stages if necessary.

Referring to the car carried signalling apparatus shown above the track, this apparatus includes two inductoriums or receivers 40 and 41, each comprising a laminated core structure having projected poles and containing a winding disposed over the track rails directly ahead of the first axle and wheels W of the train. These receivers are so connected in series that voltage induced in the windings due to alternating current flowing in one direction in one rail and in the other direction in the other rail are cumulative. The circuit including coils 40 and 41 also includes the primary winding of transformer 42 and condenser 43 in series.

The secondary winding of transformer 42 is connected in series with the primary winding of transformer 44 in a circuit including condenser 45. The secondary winding of transformer 44 is connected to a suitable amplifier AMP which amplifies the received current and applies it to the code primary relay CPR. It will be understood that condensers 43 and 45 are of a value which tunes the circuits in which they are connected so that these circuits resonate at the track circuit frequency, for example, 100 cycles per second.

Code responsive slow acting relays CR^1, CR^2, CR^3, and CR^4 are employed for receiving and displaying the received codes on lamps G, YG, YR, and R.

Relay CR^1 is energized when relay CPR is energized and relay CR^2 is energized when relay CPR is deenergized by means of an obvious circuit controlled by contact 46 of relay CPR. Relays CR^1 and CR^2 are comparatively quick in operating so that they will pick up for a single impulse of the highest code rate, that is, 180 impulses per minute. These relays are sufficiently slow releasing so that they will not drop when the code rate received is only 75 impulses per minute. It will thus be apparent that both relays CR^1 and CR^2 will be in their picked up positions if any coding current is received. Relay CR^2 will be in its picked up position if no current is received. Relay CR^1 will be in its picked up position if 100 cycle current is continuously received. Thus relays CR^1 and CR^2 both being in their

picked up positions manifest that coded current is being received.

Relays CR^3 and CR^4 are connected in series and receive double wave rectified current from the secondary winding of transformer **47**, since this secondary winding is provided with a midtap connected to relays CR^3 and CR^4 in series and the end terminals of the secondary winding are connected through rectifiers **48** and **49**, which are in turn connected together and to the other terminals of the relays in series.

The primary winding of transformer **47** is provided with a midtap connected to the (—) terminal of the battery and the end terminals of the primary winding are alternately connected to the (+) terminal of the battery in accordance with the position of contact **50** of relay CPR. Condenser **59** is connected across the primary winding of the transformer for the purpose of avoiding sparking at contact **50**.

The core structure and the primary turns of transformer **47** are so proportioned that the core becomes fully magnetized to a definite extent for each position of contact **50** while relay CPR receives coded current from the track. In other words, the periods of energization and deenergization of relay CPR are of sufficient duration to bring the magnetization of the transformer structure up to a certain point and this magnetization is changed in direction for each change in the position of contact **50**. From the above it will be apparent that equal units of energy may be derived from the secondary winding of transformer **47** for each position of contact **50**, so that the amount of energy transmitted to the windings of relays CR^3 and CR^4 by the operation of contact **50** is directly proportional to the rate of operation of this contact.

Relays CR^3 and CR^4 are of the slow acting type. Relay CR^3 is quick in picking up so that it will assume its picked up position when either a 120 or a 180 code rate is applied to relay CPR, but will drop when only a 75 code rate is applied to relay CPR. Relay CR^4 will pick up in response to a 180 code rate and will drop if either a 120 code rate, a 75 code rate or no code is received by the car carried apparatus.

From the above discussion it will be apparent that any one of the three codes will cause relays CR^1 and CR^2 to be picked up. A 120 code rate will cause relays CR^1, CR^2, and CR^3 to be picked up. A 180 code rate will cause relays CR^1, CR^2, CR^3, and CR^4 to be picked up.

These four relays are provided with contacts **51**, **52**, **53**, and **54** arranged to energize circuits which are connected to the lamps in such a way that lamp G is lighted when all four relays are picked up. Lamp YG is lighted when relays CR^1, CR^2, and CR^3 are picked up with relay CR^4 dropped. Lamp YR is lighted when relays CR^1 and CR^2 are picked up with relay CR^3 dropped. Lamp R is lighted when either or both relays CR^1 and/or CR^2 is dropped.

Operation

It will be assumed that the filaments of the tubes are lighted, either continuously or by being connected to the energizing source of current by the operation of the D relay in response to the entrance of a car into the associated block. The heater elements of the tubes are thus active.

With a car in block A as illustrated, the car carried apparatus is receiving the 180 rate code (clear) because the next two blocks are unoccupied and relay T^1 is in its normal position.

If block C is occupied, relay T^2 will be in its neutral position which deenergizes relay TP^2 at open contact **36**. Relay TP^2 down reverses the 60 cycle current to block B which in turn reverses relay T^1. Contact **10** of relay T^1 in its reverse position causes the 120 rate code, (second block in advance occupied) to be applied to block A.

With block B occupied, relay T^1 will be in its neutral position which deenergizes relay TP^1 at open contact **6**. Relay TP^1 down reverses the 60 cycle current to block A but, due to the car shunt, the track relay connected to block A is in its neutral position. Contact **10** of relay T^1 in its neutral position causes the 75 rate code (next block in advance occupied) to be applied to block A.

With block A occupied no code will be received by the illustrated car carried apparatus because of the shunt ahead of the receiver **40—41**. The above code rates are selected and applied by the coder in a manner which will be obvious from the following description relating to the operation when the car enters block B.

When the car shunt is applied to the rails of block B, winding **3** of relay T^1 is shunted which effects the actuation of the relay contacts to their neutral positions. A circuit is now closed for picking up relay D^2 which extends from (+), contact **9** of relay T^1 in its neutral position, conductor **122** and winding of relay D^2 to (—). Red wayside signal *r* is lighted by an obvious circuit closed by contact **15** in its neutral position.

Since contact **30** of relay T^2 is in its normal position, "chopper" CH is modulating the 100 cycle alternating current generated by oscillator-mixer OSM at the 180 code rate, with driver DR and power amplifier PA applying this code to transformer PT. The operation of the tubes will be discussed later. The 180 code rate induced in the secondary winding of transformer PT is connected to the rails of block B by means of track transformer TT^2 and a circuit extending through front contacts **60** and **61** of relay D^2 and front contacts **62** and **63** of relay TP^2.

With relay T^2 in its reverse position, manifesting the occupancy of the second block in advance of block B (block D for example), contact **30** causes "chopper" CH to modulate the 100 cycle current at the 120 code rate and this code is applied to the rails of block B over the above described circuit.

With relay T^2 in its neutral position, manifesting the occupancy of the next block in advance of block B (block C), contact **30** causes "chopper" CH to modulate the 100 cycle current at the 75 code rate and this code is applied to the rails of block B over the above described circuit. The particular code rates are determined by the particular condenser C^1 having the code rate associated therewith.

With block B occupied by a car which provides a shunt ahead of receiver **40—41**, no 100 cycle current will be received by the apparatus associated with this receiver.

With a clear code (180 rate) being received, relays CR^1, CH^2, CR^3, and CR^4 will be maintained picked up for lighting lamp G.

With a first caution code (120 rate) being received, relays CR^1, CR^2, and CR^3 will be maintained picked up and relay CR^4 will be dropped for lighting lamp YG.

With a more restricted caution code (75 rate) being received, relays CR^1 and CR^2 will be main-

tained picked up and relays CR^3 and CR^4 will be dropped for lighting lamp YR.

With a stop condition, no code will be received which effects the picking up of relay CR^2 and the dropping of relays CR^1, CR^3 and CR^4 for lighting lamp R. In the event of a trouble condition which prevents any 180 cycle current being received, the same relay operation will be effected to light lamp R.

In the event of a trouble condition which prevents the coding of the 100 cycle current but permits the 100 cycle continuous current to be received, relay CR^1 will be maintained picked up and the other relays dropped for lighting lamp R.

The circuit for relay D^1, including conductor 12, is for the purpose of switching the 100 cycle coded current on to block A when a car enters this block. Similarly, the circuit including contact 90 of relay T^2 and conductor 123 is for the purpose of switching the 100 cycle coding current on to block C when a car enters this block.

With block B unoccupied and relay T^1 actuated to the right as an indication that the next two blocks in advance are unoccupied, an obvious circuit is closed by contact 15 for lighting wayside lamp *g*. With blocks C occupied, relays T^2 and TP^2 will be down for actuating the contacts of relay T^1 to the left which closes an obvious circuit at contact 15 for lighting wayside lamp *y*.

"Chopper" CH comprises tubes VT^1 and VT^2, so intercoupled that impulses are sent through resistance R^1 at a 75, 120 or 180 per minute rate as determined by the particular condenser C^1 connected to the input of tube VT^1. The output circuits of these tubes extend from (B+), resistances r^1 and r^2, plate-heater elements of tubes VT^1 and VT^2 and resistances X^1 and X^2 to (B—). Resistance R^2 is included in the input of VT^2.

Since the output of tube VT^1 is coupled to the input of tube VT^2 by condenser C^2 and the output of tube VT^2 is coupled to the input of tube VT^1 by condenser C^1, these tubes set up local oscillations at a rate determined by the value of C^1 and C^2. Condenser C^1 is variable in three steps in accordance with the position of contact 30, therefore the oscillations through resistance R^1 are at rates (75, 120, and 180) suitable for modulating the fixed 100 cycle current for the purpose of providing the codes.

The oscillator-mixer tube VT^3 and its associated circuits comprise what is known in the radio art as a "pentagrid" converter. It has found practical use as an oscillator-detector in a superheterodyne receiver. This tube comprises the usual filament 20, heater cathode 21 and plate 22. Grid 23 is the control grid for the oscillator portion of the tube and grid 24 is the anode for the oscillator. The two grids 25 are connected together within the tube and are used to accelerate the electron stream emitted from cathode 21. Grids 25 also form an electrostatic shield for shielding grid 26 from the other elements in the tube. Grid 26 is the control grid for modulating the oscillator (100 cycle) current.

It will be noted that the oscillator anode (grid 24) and the shield (grid 25) are maintained at (+) potential with respect to cathode 21 which is connected to ground and (—). It is to be understood that the terminals marked (B+) do not necessarily connect to the same (+) potential, but this indication means that they are maintained at some desirable (+) potential with respect to the cathode, this potential being determined by the operating characteristics of the tube.

The electrons emitted from cathode 21 are controlled in their flow to the oscillator anode 24 by grid 23. By selecting the proper inductance and condenser values in the circuit including choke CK and oscillator transformer OST, the electron stream flowing through grid 23 is modulated at a frequency of 100 cycles per second. Since grids 25 are at a (+) potential with respect to cathode 21, the 100 cycle electron stream is brought under the influence of grid 25 to accelerate the stream towards plate 22.

The "chopper" frequency (75, 120 or 180 cycles per minute) is applied to grid 26 by means of the adjustable tap on resistance R^1 and conductor 80. Since the low side of R^1 is at ground potential with cathode 21, the drop across the portion of R^1 to which the tap is connected is applied to the input circuit of the oscillator comprising grid 26 and cathode 21. Therefore the electron stream, which is modulated at the oscillator frequency (100 cycles per second as above described), is further modulated by the "chopper" frequency, thus producing components of plate current, the frequencies of which are the various combinations of the oscillator and "chopper" frequencies.

The output of the oscillator-mixer is coupled to the input of voltage amplifier or driver DR by transformer OMT, with the output of the driver connected to the input of power amplifier PA by transformer DT. The output of the power amplifier is coupled to track transformer TT^2 by means of power transformer PT.

Having thus described one specific embodiment of a cab signalling system, it is desired to be understood that the particular arrangements illustrated and suggested are only typical of applicant's invention and are not intended to indicate the exact circuit design and specific arrangement of parts to carry out the features of the invention. This particular form has been chosen to facilitate in the disclosure, rather than to limit the number of forms which the invention may assume and it is further desired to be understood that various modifications may be made in order to meet the various problems encountered in practice. Furthermore, the arrangement illustrated may be used in a train control system as well as in a cab signalling system, the system may be varied in the number of track sections to which the invention is applied and the amount of apparatus at each section and carried by the car to suit local conditions, all without in any manner departing from the spirit or scope of the present invention, except as limited by the appended claims.

What I claim is:—

1. In a coder for creating and applying a plurality of selected codes to a railway track circuit, a vacuum tube oscillator-mixer, means controlled by said oscillator-mixer for supplying an alternating current of fixed frequency to said track circuit, a vacuum tube modulator, means controlled by said modulator and said oscillator-mixer for forming said alternating current into codes comprising said fixed frequency current modulated at different rates, means including a plurality of electrical condensers for controlling said modulator in accordance with the codes to be formed, and means controlled in accordance with traffic conditions for selectively connecting said condensers to said modulator.

2. In a coder for creating and applying a plurality of selected codes to a railway track circuit, a vacuum tube oscillator-mixer, means controlled by said oscillator-mixer for supplying an alter-

nating current of fixed high frequency to said track circuit, a vacuum tube modulator, means controlled by said modulator and said oscillator-mixer for forming said alternating current into codes comprising said high frequency current modulated at different rates, means including a plurality of electrical condensers for controlling said modulator in accordance with the codes to be formed, and means controlled in accordance with traffic conditions for selectively connecting said condensers to said modulator whereby the proper codes are formed.

3. In a system of electrical signalling including a series of electrically distinct circuits, means for exciting each of said circuits with a first alternating current signal current, means for changing the phase of said first signal current, a vacuum tube oscillator for exciting each of said circuits with a second alternating current signal current, a vacuum tube modulator for modulating said second signal current to provide code signals, and means interlinking said circuits whereby the phase of said first signal current determines the modulation of said second signal current.

4. In a train control system, a track electrically divided into a plurality of sections, means including an oscillatory circuit associated with each section for applying high frequency alternating current to the rails of such section only when such section is occupied by a railway vehicle, means including a single vacuum tube for producing and modulating said high frequency alternating current at various low frequency rates in accordance with the traffic conditions in advance, and train carried governing means selectively responsive to said low frequency rates.

5. In a train control system, a section of track divided into blocks, a source of low frequency current connected to each block, a vacuum tube oscillator for at times applying a high frequency current to each block, means connected to each block for switching such block from said low frequency current to said high frequency current, and means responsive to the presence of a train in one of the blocks for causing said vacuum tube oscillator to intermittently control the application of said high frequency current to such block at a low frequency rate.

6. In a train control system, a section of track divided into blocks, a source of low frequency current connected to each block, a vacuum tube oscillator for at times applying a high frequency current to each block, means connected to each block for switching such block from said low frequency current to said high frequency current, and means responsive to the presence of a train in certain ones of the blocks for causing said vacuum tube oscillator to intermittently control the application of said high frequency current to such block at various low frequency rates determined by the block the train is in.

7. In a train control system, a section of track divided into blocks, a vacuum tube oscillator associated with one of said blocks providing a source of high frequency current, means connected to one of said blocks for controlling the connection of said high frequency current to such block, and means responsive to the presence of a train on the rails of one of said blocks for causing said oscillator to intermittently operate at a rate to vary the rate of application of said high frequency current to said one block.

8. A railway signalling system comprising track rails, a track circuit comprising said rails and a source of high frequency alternating current, a trackway circuit for controlling the application of said high frequency alternating current to said track circuit, an electronic oscillator mixer, a track relay, a plurality of signals, a source of low frequency alternating current, means controlled by said track relay for causing said oscillator mixer to mix said low frequency alternating current with said high frequency alternating current to provide coded currents, and means controlled by said coded currents for operating said signals.

9. In combination, a stretch of railway track divided into sections, an oscillator operating at a high frequency rate, a modulator operable at a low frequency rate, means including said oscillator for mixing said high and said low frequencies for producing a modulated high frequency current, train control means for selectively applying said modulated high frequency current to said sections, and train carried means selectively responsive to said modulated high frequency current.

10. In combination, a stretch of railway track divided into sections, an oscillator operating at a high frequency rate, a modulator operable at a plurality of low frequency rates, means including said oscillator for mixing said high and said low frequencies for producing a plurality of modulated high frequency currents, train controlled means for selectively operating said modulator at a plurality of low frequency rates, train controlled means for selectively applying said modulated high frequency currents to said sections, and train carried means selectively responsive to said high frequency currents.

11. In combination, a stretch of railway track divided into sections, an oscillator operating at a high frequency rate, a modulator operable at a plurality of low frequency rates in accordance with traffic conditions in certain of said sections, means including said oscillator for mixing said high and said low frequencies for producing a plurality of modulated high frequency currents as determined by said traffic conditions, train controlled means for selectively applying said modulated high frequency currents to certain others of said sections, and train carried means selectively responsive to said modulated high frequency currents whereby said traffic conditions are indicated on the train.

12. In combination, a stretch of railway track divided into sections, a vacuum tube oscillator operating at a high frequency rate, a vacuum tube modulator operable at a plurality of low frequency rates in accordance with traffic conditions in certain of said sections, means including said oscillator for mixing said high and said low frequencies for producing a plurality of modulated high frequency currents as determined by said traffic conditions, train controlled means for selectively applying said modulated high frequency currents to certain others of said sections, and train carried means selectively responsive to said modulated high frequency currents whereby said traffic conditions are indicated on the train.

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