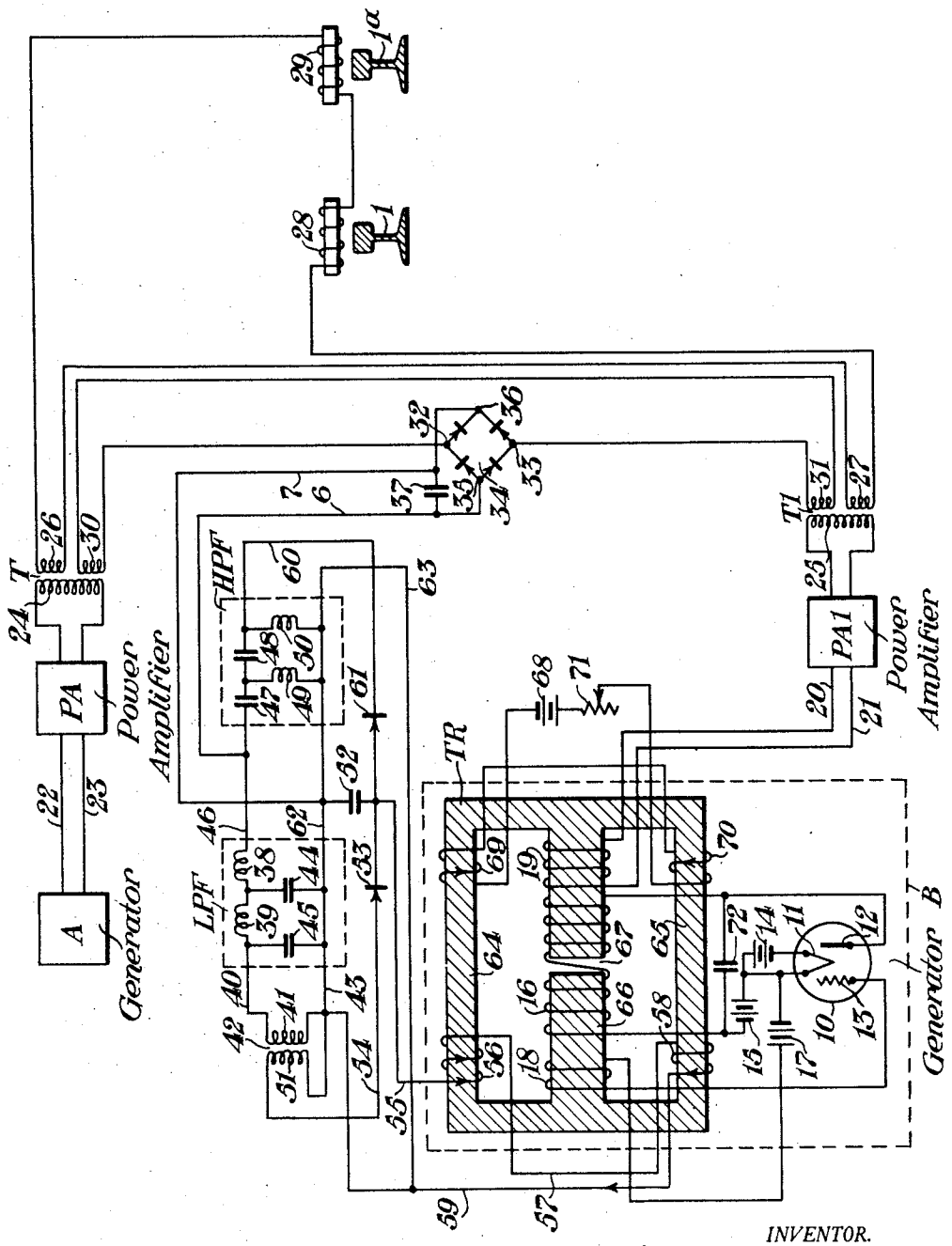
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ELECTRICAL TRANSMITTER

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ELECTRICAL TRANSMITTER

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My invention relates to electrical transmitters, and particularly to transmitters wherewith the effect of a carrier frequency current having a low frequency modulation is obtained by combining two carrier frequency currents of different frequencies.

A feature of my invention is the provision of novel and improved apparatus for accurately maintaining the frequency difference between two carrier frequencies, which are to be combined, so that the modulation effect obtained thereby is substantially constant. Other features of my invention will be apparent from the following description.

I will describe one form of apparatus embodying my invention, and will then point out the novel features thereof in claims.

The accompanying drawing is a diagrammatic view of one form of apparatus embodying my invention, which apparatus is especially adaptable for use in control systems for railway trains. It will be understood, however, that I do not wish to limit myself to this one particular application of my invention, because it may be employed wherever a modulated current is desired.

Control systems have been proposed for railway trains wherewith communication is maintained between spaced points on a train, or between two trains, or between the train and the trackway, by conveying control influences which involve a relatively high frequency carrier current having a relatively low frequency modulation. One way to obtain a carrier frequency current with a modulation superposed thereon is to combine two carrier frequency currents having a frequency difference equal to the desired modulation frequency. When this is done it is necessary to maintain the carrier frequencies sufficiently constant that the resulting modulation frequency remains constant enough for discrimination from other modulation frequencies. For example, if two carrier frequency currents of 6600 and 6650 cycles per second are to be combined to give the effect of a carrier current of the frequency of 6600 having a modulation frequency of 50 cycles per second, and if the permissible variation in modulation frequency is as great as 10%, then the difference in the carrier frequencies must be constant to within 5 cycles, which is less than 0.1% of the carrier frequency. To obtain this high degree of constancy of the frequency difference of two carrier frequencies, I propose to tie together the two generators of the two carrier frequency currents in such a manner that the frequency of one generator will be automatically varied in step with any change in their frequency difference.

In the accompanying drawing, the reference characters A and B designate two generators for supplying carrier frequency currents of say 6600 and 6650 cycles, respectively. It will be understood, however, that my invention is not limited to any specific frequencies and that the above frequencies are given by way of illustration only and will be used in this specification to assist in clarifying the description. The generator A may be any one of the several types, and as its specific structure forms no part of my invention it is shown conventionally by a symbol which represents apparatus by which a carrier frequency current is obtained independently at as nearly constant a frequency as possible. The output of the generator A is supplied over wires 22 and 23 to the input of a power amplifier PA to be shortly referred to. The generator B is preferably of the vacuum tube type in which the vacuum tube 10 is of the usual structure containing a filament 11, a plate 12, and a grid 13. The filament 11 is heated from a battery 14 by the usual simple circuit. The plate circuit associated with vacuum tube 10 can be traced from the positive terminal of a battery 15 through the winding 16 of a reactor or coupling transformer TR to be described later, plate 12, and thence by filament 11 to the negative terminal of the battery 15. The grid circuit for the vacuum tube 10 includes a biasing battery 17 having one terminal connected to the filament 11 and its opposite terminal connected to the grid 13 through a winding 18 of the coupling transformer TR. The plate circuit is tuned by a condenser 72 connected across the winding 16. The coupling between the winding 16 of the plate circuit and the winding 18 of the grid circuit being fairly close and the circuits properly tuned, sustained oscillation will result, the frequency of which will be determined by the capacity and inductance of the plate and grid circuits in the usual manner. The parts are so proportioned and adjusted that the generated oscillations will have the normal frequency of 6650 cycles. All other parts remaining fixed, it follows that the frequency can be varied by varying the inductance of the windings 16 and 18 in a manner to appear hereinafter. The output circuit for the generator B comprises a secondary winding 19 of the coupling transformer TR which is connected to the input of a power amplifier PA1 over the wires 20 and 21.

The power amplifiers PA and PA1 receive and amplify the output of the generators A and B,

respectively, and deliver the amplified power to a transmitting circuit. These power amplifiers PA and PA1 may be of any suitable type such as the usual vacuum tube. They are shown conventionally in order to simplify the drawing as much as possible. The output of the power amplifier PA is supplied to the primary winding 24 of a transmitting transformer T, and in like manner the output of the power amplifier PA1 is supplied to the primary winding 25 of a transmitting transformer T1. The secondary winding 26 of transformer T and the secondary winding 27 of transformer T1 are connected in series to the transmitting circuit which in this instance includes inductor coils 28 and 29 located in inductive relation with the traffic rails 1 and 1^a, respectively, of a railway track, as will be readily understood by an inspection of the drawing. The secondaries 26 and 27 may each be connected to a separate inductor should it seem desirable to do so. As a matter of fact the output of secondaries 26 and 27 may be supplied to any form of a transmitting circuit.

Secondary windings 30 and 31 of transformers T and T1, respectively, are connected in series to the input terminals 32 and 33 of a full wave rectifier 34. The output terminals 35 and 36 of rectifier 34 are connected by wires 6 and 7 to the terminals of a condenser 37 and also to the input of a low pass filter LPF and to the input of a high pass filter HPF both of which will be described later. It follows that the carrier frequency currents of 6600 and 6650 cycles supplied from the secondaries 30 and 31, respectively, are rectified and produce a pulsating voltage of the beat frequency of 50 cycles per second across the terminals of the condenser 37. The condenser 37 will by-pass the high frequency components of the rectified current, while the direct current component will be short-circuited through a circuit that can be traced from the output terminal 36 through wires 7, 62 and 43, primary winding 41 of a transformer 42 to be referred to later, wire 40, inductances 39 and 38 of the low-pass filter LPF and wires 46 and 6 to the opposite output terminals 35 of rectifier 34. It is to be noted that the rectifier 34 is so arranged in the circuit that current flows toward the wire 7 and away from the wire 6 making the wire 7 positive and the wire 6 negative in the output circuit. That is to say, the combination of the 6600 frequency current induced in the secondary 30 of transformer T with the 6650 frequency current induced in the secondary 31 of transformer T1 when passed through the full wave rectifier 34 will cause a pulsating voltage of the beat frequency of 50 cycles to appear at the terminals of the condenser 37, the high frequency components passing through the condenser 37 and the direct current component flowing in the circuit traced above. Although both the high frequency components and the direct current component of the output of the rectifier 34 perform no useful function, the pulsating voltage appearing at the condenser 37 is utilized to govern the frequency generated by the generator B as will appear as the specification progresses.

The low pass filter LPF includes inductances 38 and 39 in series and capacities 44 and 45 in parallel in the usual manner for low pass filters and the parts of this filter are so proportioned and adjusted that it has a cut-off frequency of 50 cycles per second. The output of the filter LPF is applied to the primary winding 41 of the transformer 42, the secondary winding 51 of which is provided with an output circuit that can be traced from the upper terminal of secondary 51 through wire 54, half wave rectifier 53, wire 55, winding 56 of reactor TR, wire 57, a second winding 58 of reactor TR and wires 59 and 43 to the lower and opposite terminal of secondary 51. A condenser 52 is connected between wires 55 and the junction of wires 62 and 7 as will be readily understood by an inspection of the drawing. It is clear that when a pulsating voltage having a frequency less than the cut-off frequency of 50 cycles is applied over the wires 6 and 7 from the condenser 37 to the input of the low pass filter LPF the pulsating voltage is passed to the primary 41 of transformer 42 causing thereby an alternating voltage of a corresponding frequency to be induced in the secondary winding 51, while for all pulsating voltages having a frequency of 50 cycles and upward, substantially no voltage is passed by the low pass filter LPF to the primary 41 and no voltage is induced in the secondary 51. When an alternating voltage is induced in the secondary 51 a rectified current will flow from the secondary 51 through wire 54, rectifier 53 in its low resistance direction as indicated by an arrow, wire 55, winding 56, wire 57, winding 58 and wires 59 and 43 to the opposite terminal of secondary 51. That is to say, rectifier 53 causes a unidirectional current to flow from the secondary 51 through the windings 56 and 58 of the coupling transformer TR in the direction indicated by the arrows. The condenser 52 will function to smooth out the pulsations of the current.

The high pass filter HPF includes capacities 47 and 48 in series and inductances 49 and 50 in parallel in the usual manner for high pass filters, and the parts of this filter are so proportioned and adjusted that it also has a cut-off frequency of 50 cycles per second. The output of the high pass filter HPF includes wires 63 and 59, winding 58 of reactor TR, wire 57, winding, 56, wire 55, half wave rectifier 61 in its low resistance direction and wire 60 to the opposite output terminal of filter HPF. Pulsating voltages having a frequency above the cut-off frequency of 50 cycles when applied to the input of the high pass filter HPF over the wires 6 and 7 will be passed to the output circuit and current will flow from the wire 7, it being recalled that wire 7 is connected to the positive output terminal of rectifier 34, over wires 63 and 59, winding 58, wire 57, winding 56, wire 55, rectifier 61 and wire 60 to the wire 6. All pulsating voltages having a frequency at or below the cut-off frequency of 50 cycles, when applied to the high pass filter HPF, will be substantially blocked, so that no current will flow in the circuit just traced which includes the windings 56 and 58 of the reactor TR and the rectifier 61. It follows that pulsating voltages having a frequency of 50 cycles per second appearing at the terminals of the condenser 37 will be substantially blocked by both the high pass filter HPF and the low pass filter LPF. Pulsating voltages having a frequency less than 50 cycles appearing at the terminals of the condenser 37 will be passed by the low pass filter LPF and unidirectional current caused to flow in the windings 56 and 58 of reactor TR in the direction indicated by the arrows. Pulsating voltages having a frequency above 50 cycles per second appearing at the terminals of the con-

denser 37 will pass through the high pass filter HPF and unidirectional current will flow in the windings 56 and 58 in a direction reverse to that indicated by the arrows, the condenser 52 in each case functioning to smooth out the pulsations.

The reactor or coupling transformer TR associated with the generator B may take any one of many forms but a preferred form is that shown in the drawing which consists of two outer magnetic core members 64 and 65, and a center core member 66 having an air gap 67. The windings 16 and 18 included in the plate and grid circuits of tube 10, respectively, are mounted on the center core member 66 to form a coupling whereby the tube 10 is made to act as the generator of oscillations in the manner well known. Mounted on the center core member 66 is the secondary winding 19, and thus the oscillations generated will induce a corresponding alternating voltage in the winding 19 which will be applied to the input of the power amplifier PA1 over the wires 20 and 21 as mentioned hereinbefore. As previously stated, the parts and circuits associated with tube 10 are so proportioned and adjusted that the carrier current supplied by the winding 19 has a normal frequency of 6650 cycles per second. The reactor TR is provided with a magnetizing circuit supplied with current from a battery 68 and which circuit includes windings 69 and 70 mounted on the outer core members 64 and 65, respectively, and an adjustable resistance 71 to control the current flow. Current from the battery 68 flows in a direction indicated by arrows on windings 69 and 70 to produce a direct magnetic flux in the core members of the reactor TR. The windings 69 and 70 are alike and are connected in such a direction that the direct magnetic fluxes produced thereby are additive and will flow in the magnetic circuit which includes the outer core members 64 and 65 rather than through the center core 66 due to the air gap 67. The connection of windings 69 and 70 is thus such that there is no net alternating voltage induced therein due to the generated oscillations. The resistance 71 and the windings 69 and 70 are so proportioned that a magnetic flux density, well below magnetic saturation, is obtained for the core members of reactor TR so that an increase in the direct magnetic flux density will decrease the inductance of windings 16 and 18 and cause an increase in the frequency of the generated current, while a decrease in the direct magnetic flux density will increase the inductance of windings 16 and 17 and cause a decrease in the frequency of the generated current.

With both generators A and B supplying their stated frequencies, namely, 6600 and 6650, the pulsating voltage appearing at the terminals of the condenser 37 has the beat frequency of 50 cycles per second which, as pointed out hereinbefore, is blocked by both the high pass filter HPF and the low pass filter LPF and substantially no current flows in the windings 56 and 58 of reactor TR and the direct magnetic flux density remains constant at the value determined by the windings 69 and 70. As long as the outputs of generators A and B thus remain constant with a frequency difference of 50 cycles there is supplied to the transmitting circuit the combination of the two carrier frequencies to give the effect of a carrier current of the frequency of 6600 modulated at 50 cycles.

I will now assume that the frequency of generator B falls too low, somewhat below 6650, or that the frequency of generator A rises too high, somewhat above 6600, so that in either case the frequency difference becomes somewhat less than 50 cycles. The low pass filter LPF at once passes the pulsating voltage appearing at the terminals of condenser 37 and an alternating current is induced in the secondary 51 of transformer 42. This alternating current induced in secondary 51 is rectified by the rectifier 53 causing unidirectional current to flow in the windings 56 and 58 in the direction indicated by the arrows. The magnetic flux created in the cores of the reactor TR by current in the windings 56 and 58 flowing in the direction indicated by the arrows is additive to that already set up by the windings 69 and 70 with the net result that the magnetic flux density is increased, the inductance of windings 16 and 18 decreased and the frequency of generator B increased until the frequency difference of 50 cycles is again obtained. In the event the generator B delivers a carrier frequency somewhat above 6650 cycles, or if the output of generator A falls below its 6600 cycles so that the frequency difference becomes greater than 50 cycles, the pulsations appearing at the terminals of condenser 37 will be passed by the high pass filter HPF to its output circuit where rectifier 61 causes unidirectional current to flow in the windings 56 and 58 in a direction reverse to that indicated by the arrows. This time the magnetic flux created by the windings 56 and 58 opposes that created by the windings 69 and 70 with the net result that the inductance of windings 16 and 18 is increased causing the frequency of generator B to be reduced until the frequency difference of 50 cycles is again obtained.

Although I have herein shown and described only one form of apparatus 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 combination, a first generator adapted to supply alternating current at a given frequency, a second generator including a vacuum tube and a magnetic reactor, a plate winding and a grid winding for said vacuum tube and mounted on a common magnetic path of the reactor, a first circuit means including a biasing battery and a winding of the reactor to establish a predetermined steady flux density in said common magnetic path to determine the frequency of the second generator, a second circuit means including a winding of the reactor, and control means governed by the frequency difference of the output of said generators for causing current to flow in said second circuit means in one direction or the other in accordance with an increase or a decrease in the frequency difference above or below a given value for varying the steady flux density whereby the frequency difference of said generators is maintained substantially constant at said given value.

2. In combination, a first generator of alternating current, a second generator of alternating current whose frequency may be varied by varying the inductance of a reactor having a ferromagnetic core, a detector supplied with current from both generators to produce a current having a frequency equal to the difference between the frequencies of the two generators, a low pass filter and a high pass filter both supplied by current from the detector, a first circuit including a

winding mounted on the core of said reactor and a battery whereby a continuous magnetic flux is superposed on the alternating flux in at least a part of said core, a second circuit including another winding mounted on the core of said reactor, means for causing the output of one of said filters to flow in said second circuit in a direction to increase the continuous flux and the output of the other filter to flow in said second circuit in a direction to decrease the continuous flux whereby the frequency of the second generator is controlled in such a manner as to maintain the frequency difference of the two generators substantially constant.

3. In combination, a first and a second generator of alternating current and arranged to have a predetermined frequency difference, a reactor having a center and two outer ferromagnetic cores, a control winding mounted on the center core of said reactor for varying the frequency of said second generator by variation in the inductance of said winding, biasing means for the reactor to establish a continuous magnetic flux of sufficient magnitude so that changes in it cause changes in the inductance of the control winding, means governed by the output of both generators to produce pulsations having a frequency equal to the actual frequency difference of said generators, a first and a second filter and said first filter adapted to pass frequencies above said predetermined frequency difference and said second filter adapted to pass frequencies below said predetermined frequency difference, means to impress said pulsations on the input of said filters, a first and a second winding mounted on the outer cores respectively of the reactor and wound in opposite directions so that voltages induced therein by the alternating flux of the control winding cancel and hence add their effects when excited by a direct current, a first rectifier to cause the output of the first filter to flow in said first and second windings in a direction to decrease the continuous flux, and a second rectifier to cause the output of the second filter to flow in said windings in a direction to increase the continuous flux, whereby the frequency of said second generator is varied to maintain a substantially constant frequency difference for said generators.

4. In combination, a vacuum tube generator of alternating current of a given frequency, a reactor having a center and two outer ferromagnetic cores and on the center core of which are mounted a plate winding and a grid winding for the tube, a first circuit means including a biasing battery and a winding on each of the two outer cores of said reactor for superposing a continuous magnetic flux on the alternating flux, said continuous flux being of such magnitude that a change in it causes a change in the inductance of the reactor and hence a change in the frequency of the generator, a second circuit means including a winding on each of the two outer cores of said reactor, control means governed by the output of the generator for obtaining a direct current whose value is determined by the frequency above or below said given frequency, and rectifiers to cause the current supplied by the control means to flow in said second circuit in a direction to increase the continuous flux when the frequency is below the given frequency and in a direction to decrease the continuous flux when the frequency is above the given frequency whereby the frequency of said generator is maintained substantially constant.

5. In combination, a vacuum tube generator of alternating current of a given frequency, a reactor having a center and two outer ferromagnetic cores, a plate winding and a grid winding for the tube and mounted on the center core of said reactor, a first circuit means including a winding on each of the two outer cores of said reactor for superposing a continuous magnetic flux on the alternating flux, said continuous magnetic flux being of sufficient magnitude so that changes in it cause changes in the inductance of the reactor and hence changes in the frequency of the alternating current, a second circuit means including a winding on each of said outer cores arranged in such a manner that voltages induced therein by the alternating flux cancel, control means governed by the output of said generator for obtaining a direct current whose value depends upon the frequency above or below said given frequency, and means for causing the current supplied by said control means to flow in said second circuit in a direction to increase or decrease the continuous flux in accordance with a corresponding decrease or increase in the frequency of the output of said generator.

6. In combination, a reactor having a center and two outer ferromagnetic cores, an alternating current generator of a given frequency and having a control winding mounted on the center core of said reactor for varying its frequency by variation in the inductance of said winding, biasing means for the reactor to establish a continuous flux of sufficient magnitude so that changes in it cause changes in the inductance of the control winding, a first and a second filter both supplied with energy from the output of said generator and said first filter adapted to pass current in response to a frequency above said given frequency and said second filter adapted to pass current in response to a frequency below said given frequency, a first and a second winding mounted on the outer cores respectively of the reactor and wound in opposite directions so that voltages induced therein by the alternating flux of the control winding cancel and hence add their effects when excited by a direct current, a first rectifier to cause the current passed by the first filter to flow in said first and second windings in a direction to decrease the continuous flux, and a second rectifier to cause the current passed by the second filter to flow in said windings in a direction to increase the continuous flux, whereby the frequency of said generator is maintained substantially constant.

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