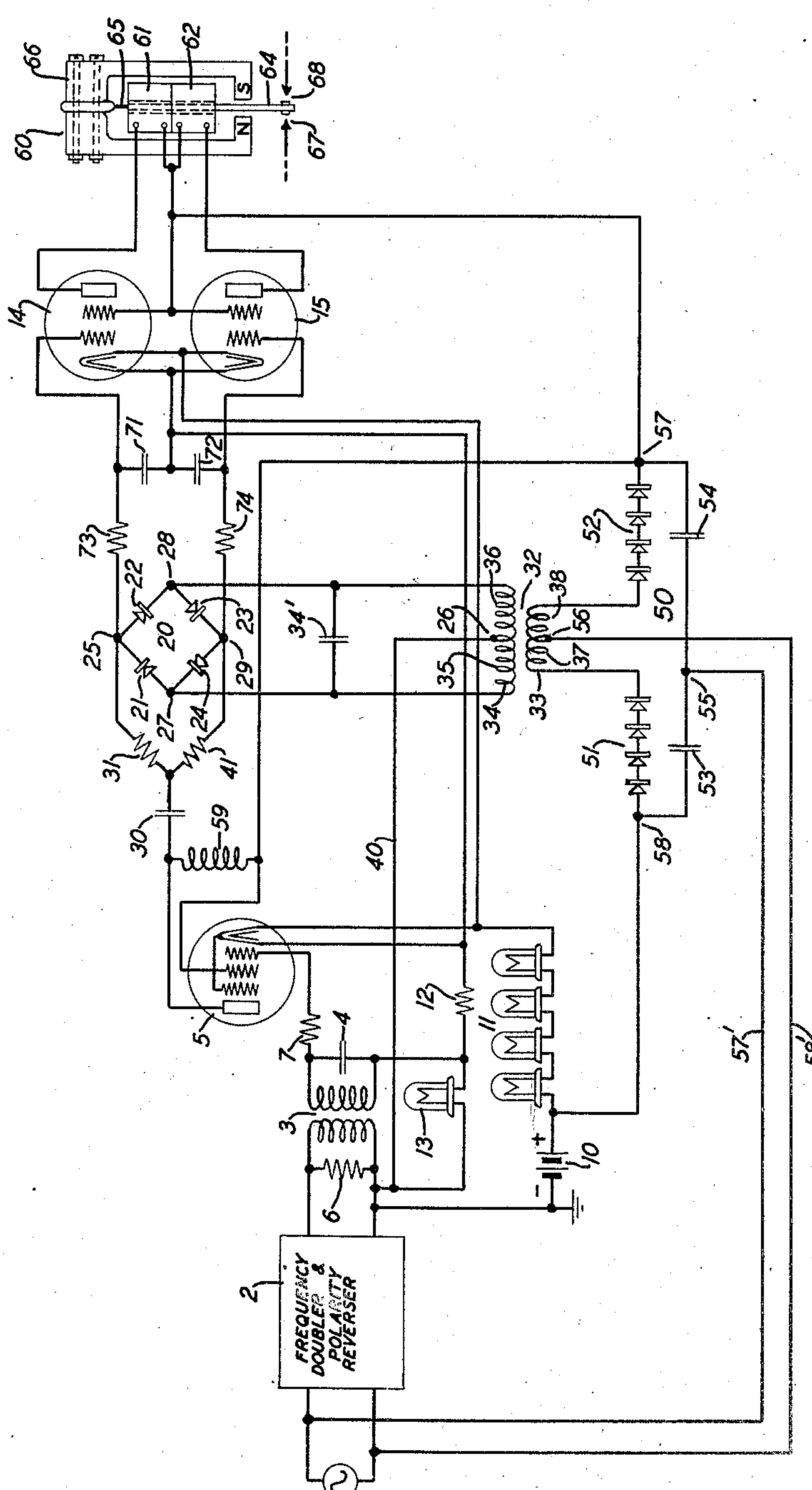
Jan. 13, 1948. R. W. KETCHLEDGE 2,434,273

WAVE TRANSLATING SYSTEM

Filed Jan. 21, 1943



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Patented Jan. 13, 1948 2,434,273

UNITED STATES PATENT OFFICE

2,434,273

WAVE TRANSLATING SYSTEM

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Application January 21, 1943, Serial No. 473,083

8 Claims. (Cl. 250—27)

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This invention relates to wave translation and especially to frequency translation.

An object of the invention is to produce direct current of polarity or sign varying in accordance with the polarity or phase-sign of an alternating current wave which at times has polarity reversals, i. e., phase changes of 180 degrees. The alternating current wave having the polarity reversals will be called the signal wave.

It is also an object of the invention to obtain reliable operation of devices responsive to direct current, as for example vacuum tubes, switches and clutches, in opposite senses in accordance with the polarity of an alternating current wave.

In one specific application of the invention the direct current device to be operated is a differential relay. The signal wave is applied to a rectifier. A reference wave is applied to the rectifier as a control wave. It is of the same frequency as the signal wave but of constant polarity and preferably always either substantially in phase coincidence with the signal wave or in phase opposition to the signal wave. The reference wave so controls the rectifier that the rectifier passes to each of the differential windings of the relay substantially none of the reference wave and only time elements of the signal wave that are determined by the reference wave. For example, when the signal wave is in phase with the reference wave the rectifier passes to one winding of the differential relay, through a low-pass filter and direct current amplifier if desired, only the positive half-cycles of the signal wave, and passes to the opposed winding of the relay, through a low-pass filter and direct current amplifier if desired, only the negative half-cycles of the signal wave; and when the phase of the alternating current signal reverses, so that the phase difference between the signal wave and the reference wave is 180 degrees, the rectifier passes to said one winding only the negative half-cycles of the signal wave and passes to said opposed winding only the positive half-cycles of the signal wave.

Other objects and features of the invention will be apparent from the following description and claims.

The single figure of the drawing shows diagrammatically a system embodying the invention in the specific form referred to above. However, the invention is not limited to this specific circuit.

Source 1 supplies alternating current, for instance a sine wave having a frequency of 400 cycles per second, to a device 2 which doubles the frequency and produces phase reversals of the resulting 800-cycle sine wave of alternating current at time intervals which may be long compared to a period of 800-cycle wave, as for example many times as long or even of any desired greater order of magnitude. The intervals may be regular or irregular, that is, equal or unequal, and the reversals may take place at any desired relative times or points (i. e., at corresponding points or at different points) in the particular cycles (of the 800-cycle wave) during which they occur. The device 2 may be, for example, a harmonic producing device such as a non-linear element, for example, a rectifier, and a phase reversing device, for instance a switch for reversing the connection between two pairs of contacts, or for instance a Wheatstone bridge whose unbalance in opposite directions may cause phase reversals.

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The 800-cycle signal wave having the polarity reversals passes through transformer 3, tuned to that frequency by condenser 4, to the grid circuit of amplifier tube 5 which amplifies the signal. Across the primary winding of transformer 3 is a 200-ohm resistor 6 which is used for impedance matching to the frequency doubler and polarity reverser 2. A .5-megohm resistor 7 in the grid lead of tube 5 prevents appreciable loading of transformer 3 when the 800-cycle signal wave is large enough to cause grid current flow in tube 5. The filament heating current for tube 5 is supplied from 24-volt battery 10 through four ballast lamps 11 in a series, a 3-ohm grid bias resistor 12 for tube 5, and a ballast lamp 13. The filament is in parallel with the filaments of balanced amplifier tubes 14 and 15 referred to hereinafter.

The amplified 800-cycle wave with the polarity reversals is applied to a rectifier 20 therefor, comprising, for example, rectifying elements of the dry contact type, for instance, copper-oxide rectifying elements 21, 22, 23, 24 connected and poled as shown, or for example thermonic diodes, for instance, 6H6 vacuum tubes. This wave is applied from tube 5 across element 21 through a circuit including the plate of tube 5, a .2-microfarad condenser 30 for stopping direct current, a .3-megohm resistance 31, element 21, coil 35 of secondary winding 34 of transformer 32, conductor 40, lamp 13, resistance 12, and the cathode of tube 5. The 800-cycle wave from amplifier 5 is applied across element 22 through a circuit including the the plate of tube 5, condenser 30, resistance 31, element 22, coil 36 of winding 34, conductor 40, lamp 13, resistor 12 and the cathode of tube 5. The 800-cycle wave from amplifier

5 is applied across element 23 through a circuit including the plate of tube 5, condenser 30, a .3-megohm resistance 41, element 23, coil 36 of winding 34, conductor 40, lamp 13, resistance 12, and the cathode of tube 5. The 800-cycle wave from amplifier 5 is applied across element 24 through a circuit including the plate of tube 5, condenser 30, resistance 41, element 24, coil 35 of winding 34, conductor 40, lamp 13, resistance 12, and the cathode of tube 5.

Elements 21, 22, 23 and 24 are alike, and coils 35 and 36 are alike. Elements 21 and 22 connecting points 27 and 28 form two adjacent balancing arms of a balanced Wheatstone bridge, with coils 36 and 35 forming the respectively opposite ratio arms. A diagonal of this bridge has its terminals at point 25 and the grounded center point 26 of winding 34. This diagonal includes resistance 31, condenser 30, the plate-cathode path in tube 5, resistance 12, lamp 13 and conductor 40. This diagonal applies the signal wave from tube 5 across corners 25 and 26 of the bridge. Winding 34 applies across the other corners 27 and 28 of the bridge an 800-cycle reference wave as pointed out hereinafter.

Elements 23 and 24 form two adjacent ratio arms of a second balanced Wheatstone bridge, with coils 35 and 36 forming the respectively opposite ratio arms. A diagonal of this bridge terminates at points 29 and 26. This diagonal includes resistance 41, condenser 30, the plate-cathode path in tube 5, resistance 12, lamp 13 and conductor 40. This diagonal applies the signal wave from tube 5 across corners 29 and 26 of the bridge. The other corners are 27 and 28. As just noted, winding 34 applies across the points 27 and 28 a reference wave of the same frequency as the signal wave, i. e., 800 cycles per second.

The reference wave, however, is of constant polarity and preferably, for maximum sensitivity of the rectifier, has its zero points occur at substantially the same instants at which the zero values of the signal wave occur. That is, preferably the reference wave is always either in phase with the signal wave or in phase opposition to the signal wave. The reference wave is induced in winding 34 by pulses of direct current in coils 37 and 38 of winding 33 of transformer 32. These coils are alike and are included in a frequency doubler and voltage doubling rectifier device 50.

The device 50 comprises also two like groups of rectifying elements 51 and 52, for instance, dry contact rectifying elements which may be copper-oxide rectifiers or selenium rectifiers, for example, and further comprises two like condensers 53 and 54. Voltage from the 400-cycle source 1 is supplied through conductors 57′ and 58′ across points 55 and 56 of the device 50. The alternating current source alternately charges condensers 53 and 54 through the rectifying elements 51 and 52, respectively, and maintains a direct current voltage across each condenser approximately equal to the peak value of the alternating current source. The condensers form a series circuit across points 57 and 58 and their voltages in this circuit are cumulative or of the same polarity. Thus, the direct current voltage across points 57 and 58 is the combined voltage of the condensers, which is approximately twice the peak voltage of the alternating current source 1. This direct current voltage may be, for example, 40 volts. This voltage, added to that of the 24-volt battery 10, supplies the plate and screen grid currents for tubes 5, 14 and 15,

point 57 being connected directly to the screen grids of all of the tubes, and being connected to the plate of tube 5 through inductance 59 and to the plates of tubes 14 and 15 through like differential windings 61 and 62 of an electromagnetically operated device 60, for example, a direct current differential polar relay. The relay tongue or armature 64 is an extension of a flat spring 65 rigidly fastened to permanent magnet 66, and extends between the north and south poles N and S of the magnet to cooperate with the fixed contacts 67 and 68. The windings 61 and 62 may be mounted or supported around the armature, which they magnetize. The tongue 64 is normally biased by spring 65 to neutral or non-contacting position between contacts 67 and 68, with the direct currents in windings 61 and 62 equal. The tongue is operated to engage one of the contacts, for closing a circuit through that contact and the tongue, when the direct current in winding 61 exceeds that in winding 62, and is operated to engage the other contact for closing a circuit through the latter contact and the tongue, when the direct current in winding 62 exceeds that in winding 61.

The grid and cathode of tube 14 are connected across a .05-microfarad condenser 71; and the grid and cathode of tube 15 are connected across a like condenser 72. The voltage across bridge points 25 and 26 is fed to the grid and cathode of tube 14 through a circuit including a 1-megohm resistor 73, condenser 71, resistance 12 and lamp 13; and the voltage across bridge points 29 and 26 is fed to the grid and cathode of tube 15 through a circuit including a resistor 74 which is a duplicate of resistor 73, condenser 72, resistance 12 and lamp 13. The tubes 14 and 15 are two like direct current amplifiers forming a balanced direct current amplifier. Tube 14 amplifies the direct current fed to its grid and cathode from bridge points 25 and 26; and tube 15 amplifies the direct current fed to its grid and cathode from bridge points 29 and 26. Resistance 73 and condenser 71 form a low-pass filter, which may be used to remove the ripple from the voltage fed to tube 14, leaving only the direct current component; and resistance 74 and condenser 72 function as a similar filter for the input to tube 15.

The direct current voltage drop across resistance 12 and lamp 13 supplies negative bias for the control grid of tube 14 through 21 and 22 and to the control grid of tube 15 through 23 and 24.

The resistances of coils 35 and 36 are negligibly low compared to resistance 31 or resistance 41 (and to resistance 73 or resistance 74). Also, the impedance to alternating current of coils 35 and 36 between terminals 27 and 28 joined together and terminal 26 is low because the voltage from terminal 28 to 26 will tend to equal that from terminal 26 to 27, due to the coupling between coils 35 and 36.

As indicated above, pulses of direct current through coils 37 and 38 induce in winding 34 an alternating voltage of 800 cycles per second, that is, the second harmonic of the 400-cycle voltage of source 1. A condenser 34′ tunes the circuit of winding 34 to this harmonic. This selected 800-cycle wave is applied, as the reference wave referred to above, across points 27 and 28 of the rectifier 20 for the signal wave from tube 5, to so control the rectifier 20 that the rectifier passes to tubes 14 and 15, and through them to windings 61 and 62 of relay 60, substantially none of the reference wave and only time elements of the signal wave that are determined by the reference wave.

For example, assuming the reference voltage and the signal voltage pass through their zero values at the same instants, and considering these voltages to be in phase when the instantaneous values of the signal potential at point 25 have the same sign as the corresponding instantaneous values of the reference potential at point 28, then with the signal voltage and the reference voltage in phase, during the alternate half-cycles of the signal wave in which the instantaneous signal potentials are positive at point 25 and at point 29 the reference wave acts as a negative biasing voltage on elements 21 and 22 and as a positive biasing voltage on elements 23 and 24. The reference wave thus causes the circuit between points 25 and 26 through 21 and 35 to be of high impedance (or effectively an open circuit as regards signal transmission from tube 5 to tube 14) and causes the circuit between points 25 and 26 through 22 and 36 similarly to be effectively an open circuit, so the positive potential of the signal is transmitted from 25 to the grid of tube 14, to cause the current through winding 61 to be above its normal value; while at the same time the reference wave causes the circuit between 29 and 26 through 23 and 36 to be a circuit of negligible impedance or substantially a short-circuit and causes the circuit between points 29 and 26 through 24 and 35 to be substantially a short-circuit, so transmission of the positive potential of the signal from 29 to the grid of tube 15 is substantially prevented. Thus, the tongue of relay 60 engages one of the fixed contacts. In the intervening half-cycles of the signal wave, i. e., when the instantaneous signal potentials transmitted from tube 5 to point 25 and to point 29 are negative, the reference wave acts as a positive biasing voltage on elements 21 and 22 and a negative biasing voltage on elements 23 and 24, thus preventing the negative potential of the signal from affecting the potential of the grid of tube 14 and the current in winding 61 (which remains above its normal value because of the charge on condenser 71) and causing the negative potential of the signal to reach the grid of tube 15 and reduce the current in winding 62 below its normal value and so increase the force of engagement of tongue 64 with the fixed contact just mentioned. Thus, the relay tongue remains against that contact as long as the signal is transmitted in phase with the reference wave. The relay may be too sluggish to follow even the individual pulses of direct current that windings 61 or 62 would receive in the absence of condensers 71 and 72.

On the other hand, with the phase of the signal reversed, so that the signal voltage and the reference voltage are in phase opposition, then it is during the alternate half-cycles of the signal wave in which the instantaneous signal potentials are negative at point 25 and at point 29 that the reference wave acts as a negative biasing voltage on elements 21 and 22 and as a positive biasing voltage on elements 23 and 24. The reference wave thus causes the negative potential of the signal to be transmitted from point 25 to the grid of tube 14 and prevents transmission of the negative potential of the signal from 29 to the grid of tube 15, so the tongue 24 engages the fixed contact opposite the one just mentioned. In the intervening half-cycles of the signal wave, i. e., when the instantaneous signal potentials at point 25 and at point 29 are positive, the tongue likewise is in engagement with that contact; for the reference wave, acting as a positive biasing voltage on elements 21 and 22 and as a negative biasing voltage on elements 23 and 24, prevents the positive potential of the signal from being transmitted to the grid of tube 14 and causes it to be transmitted to the grid of tube 15.

In short, in the operation of the system, during alternate half-cycles of the reference wave (and so of the signal wave) the reference wave causes the diodes 21 and 22 to be substantially open circuits and the diodes 23 and 24 to be of negligibly low or substantially zero impedance; so point 25 assumes a positive or negative potential with respect to ground, depending on the polarity or phase of the signal wave at the time, and point 29 assumes substantially ground potential. In the intervening alternate half-cycles the reference wave causes the diodes 23 and 24 to be substantially open circuits and the diodes 21 and 22 to be short-circuits; so point 29 assumes a negative or positive potential with respect to ground, depending on the polarity or phase of the signal wave at the time, and point 25 assumes substantially ground potential. Thus, when the signal wave has one polarity or phase the grid of tube 14 receives a resultant potential of one sign and the grid of tube 15 receives a resultant potential of opposite sign, and for each grid the resultant potential is the reverse when the polarity or phase of the signal is the reverse. Consequently, tongue 64 is operated to one side or the other of its neutral position depending on the polarity of the signal wave or phase of the signal. The reference wave thus operates the diodes as a switching device, in synchronism with the signal voltage, to alternately short-circuit the input circuits of tubes 14 and 15 for periods equal to half-cycles of the signal wave. For maximum sensitivity of the system, the diode switch should be operated in phase or 180 degrees out of phase with the signal wave (i. e., the reference voltage should pass through zero values at the same instants as the signal voltage). It should be noted that with the particular form of switching device shown the output voltage cannot exceed a certain limit determined by the magnitude of the reference wave; because if the signal wave across 25 and 26 and across 29 and 26 attempts to exceed one-half of the reference wave across 27 and 28, one of the diodes 22 or 21 will conduct with low impedance (at a time when the reference wave is attempting to bias it negatively) and will thereby prevent further rise of the voltage transmitted to tube 14, and one of the diodes 23 or 24 will conduct with low impedance (at a time when the reference wave is attempting to bias it negatively) and will thereby prevent further rise of the voltage transmitted to tube 15. However, although limiting may occur, there is no possibility for polarity reversal of the direct current voltage transmitted to tube 14 or tube 15 without a reversal of the polarity or phase of the signal wave applied to rectifier 20, and the reference wave amplitude only determines the maximum voltages obtainable as inputs to tubes 14 and 15. False operation of relay 60 cannot be caused by the signal wave amplitude being large, even if it be two or more times that of the reference wave. The rectifier 21, 22 is not sensitive to polarity but rather to time. That is, it passes current to its load device 14 at times determined by the reference wave regardless of the sign of the signal voltage transmitted through condenser 30. The same may be said with reference to rectifier **23, 24** and its load device **15**.

Transmission of the reference voltage to tube **14** is prevented by balance of the bridge whose ratio arms include elements **21, 22, 35** and **36**. Similarly, transmission of the reference voltage to tube **15** is prevented by balance of the bridge whose ratio arms include elements **23, 24, 35** and **36**.

What is claimed is:

1. A wave translating system comprising a source of alternating signal current having phase reversals, a direct current responsive load device, a path for connecting said source to said device, a source of reference current of the frequency of said signal current, and a balanced Wheatstone bridge circuit shunted across said path including said source of reference current and having one pair of opposite corners connected to said path and having its other pair of opposite corners connected to said source of reference current, said bridge circuit comprising a pair of adjacent arms in series forming a circuit connecting said other pair of corners, each of said arms comprising a two-terminal rectifying element, and said rectifying elements being poled in the same direction in said circuit connecting said other pair of corners.

2. A system comprising control means controlled in accordance with phase relations between an alternating current signal wave of reversible polarity and a reference wave, a direct current load device operable in opposite senses according to the polarity of the alternating current signal wave, a source for supplying said signal wave, and a circuit connecting said control means between said source and said load device including transmission apparatus responsive to direct current for controlling transmission from said source to said load device, said system further comprising a rectifying and frequency multiplying network for providing said reference wave and said last-mentioned direct current, said network comprising a bridge circuit having a pair of adjacent ratio arms each comprising a condenser and a second pair of adjacent ratio arms each comprising a rectifying element and an inductance coil, an alternating current input circuit for applying across one arm of said first pair of ratio arms and one arm of said second pair of ratio arms in series a voltage to be rectified and multiplied in frequency, a direct current output circuit for the rectified voltage connected across said condensers in series for supplying direct current to said apparatus, an alternating current output circuit including a portion of said control means coupled to said coils for deriving therefrom an alternating current wave of a frequency which is a harmonic of the frequency of said applied voltage, and means for rendering said alternating current output circuit selective to said harmonic frequency.

3. A wave translating system comprising a source of alternating current of given frequency, means for producing therefrom a signal current of twice said given frequency having phase reversals, rectifying means for rectifying said signal current, a direct current load device for operation by the rectified current from said rectifying means in accordance with the phase of said signal current, amplifying means connected in tandem with said rectifying means between said source and said load device, and a voltage doubling rectifier and harmonic producer connected to said source and supplying to said amplifying means rectified current for energizing said amplifying means and supplying to said rectifying means alternating current of twice said given frequency for controlling the transmission efficiency of said rectifying means.

4. A wave translating system comprising a source of alternating current of given frequency, means for producing therefrom a signal current of twice said given frequency having phase reversals, a space discharge amplifying device having an anode, a cathode and a discharge control grid for amplifying said signal current, four two-terminal rectifying devices connected in series forming a closed circuit and poled in the same direction in the closed circuit, means comprising a resistance connecting said anode to the junction point of a pair of said rectifying devices, means comprising a resistance connecting said anode to the junction point of the other pair of said rectifying devices, a coil connected from one junction point between said pairs to the other junction point between said pairs, a connection between said cathode and the midpoint of said coil, a balanced amplifier including two space discharge amplifying devices each having an anode, electron emitting means and a discharge control grid, a low-pass filter connecting said first-mentioned junction point and said mid-point with said control grid and electron emitting means of one of said amplifying devices of said balanced amplifier, a low-pass filter connecting said second-mentioned junction point and said mid-point with said control grid and electron emitting means of the other of said amplifying devices of said balanced amplifier, a circuit connected across said source comprising two parallel branches, one of said branches having in series a condenser, a rectifier poled to transmit positive half-cycles of current of said source, and an inductance, and said other branch having in series a condenser, a rectifier poled to transmit negative half-cycles of current of said source, and an inductance, said inductances being so coupled to said coil that they respectively alternately produce like inductive effects on said coil, a circuit connected across said condensers in series for supplying space current for said first-mentioned amplifying device, and a condenser connected across said coil for tuning said coil to a frequency twice that of said source.

5. A system comprising control means controlled in accordance with phase relations between an alternating current signal wave of reversible polarity and a reference wave, and a direct current load device connected to said control means for operation in opposite senses according to the polarity of the alternating current signal wave, said control means comprising a transformer having a primary winding and a secondary winding, a path connected across said secondary winding including a pair of rectifying devices in series poled in the same direction in said path, and a second path connected across said primary winding including a pair of rectifying elements poled in the same direction in said second path, said system further comprising a source for supplying said signal wave connecting a point of said secondary winding intermediate its ends with a point of said first-mentioned path lying between said devices, and means for providing said reference wave including said transformer and a source of voltage of half the frequency of the signal wave connecting a point of said primary winding intermediate its ends with a point of said second path lying between said elements.

6. A wave translating system comprising a source of alternating current having phase reversals, a direct current responsive load device, a path for connecting said source to said device, a source of reference current of the frequency of said alternating current, and a circuit across said path responsive to said reference current to increase the impedance of said circuit to said alternating current during alternate half-cycles only of said reference current regardless of the phase relation of said alternating and reference currents, said circuit comprising two parallel branches each including a rectifying element, said rectifying elements being poled in the same direction in the series loop circuit constituted by said branches.

7. A wave translating system comprising a source of alternating signal current having phase reversals, means for supplying a reference wave of the frequency of said alternating current without phase reversals, two switching devices connected to said source and comprising four rectifying devices in series in a circuit with the rectifying devices poled in the same direction in the series circuit, a receiving circuit connected to said switching devices for receiving energy of said source under control of said switching devices, and means so applying said reference wave to said switching devices that when the signal wave has one phase one of said switching devices transmits from said source to said receiving circuit positive half-cycles of the signal current more readily than the intervening negative half-cycles and the other switching device transmits from said source to said receiving circuit said intervening negative half-cycles of the signal current more readily than said positive half-cycles and when the signal current has the opposite phase said one switching device transmits from said source to said receiving circuit negative half-cycles of the signal current more readily than the intervening positive half-cycles and said other switching device transmits from said source to said receiving circuit the intervening positive half-cycles of the signal current more readily than the negative half-cycles.

8. A wave translating system comprising a source of alternating signal current having phase reversals, a direct current responsive load device, a path for connecting said source to said device, a source of reference current of the frequency of said signal current, and a network shunted across said path having two parallel branches and including said source of reference current, each of said branches comprising a two-terminal rectifying element, said rectifying elements being poled in the same direction in the series loop circuit constituted by said branches, said source of reference current and said rectifying elements being all three in series.

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