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C. H. McADIE ET AL

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LOAD CONTROL WITH SINGLE CONTROL TUBE

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Fig. 1.

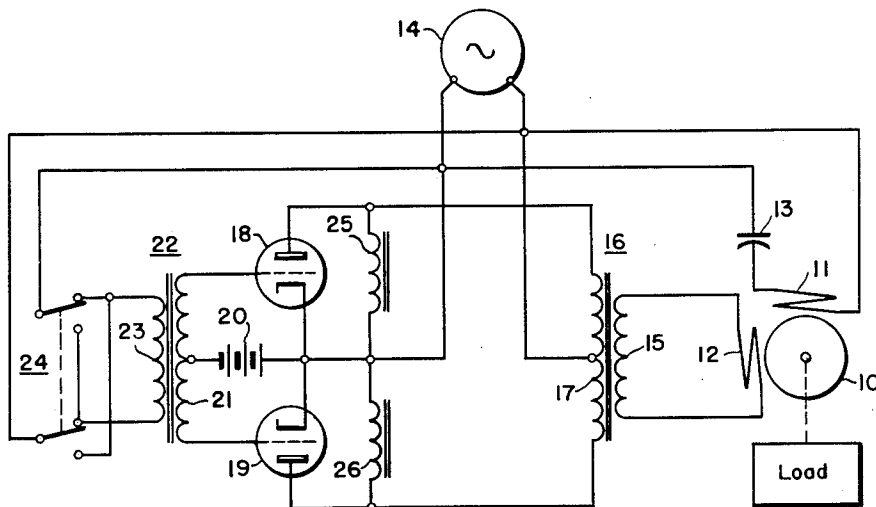
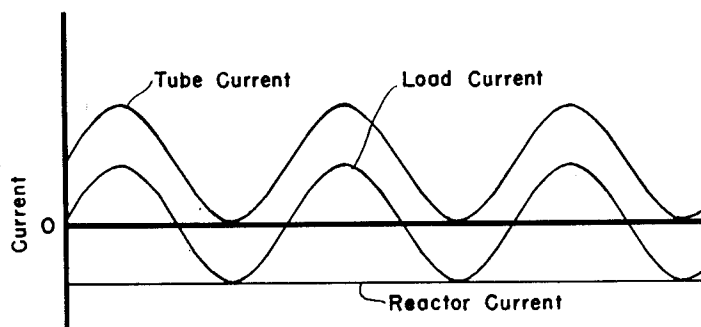


Fig. 2.



WITNESSES

Edwin E. Basler
Leon J. Taja

INVENTORS

Colin H. Mc Adie &
Charles K. Hooper

BY

Paul E. Friedemann
ATTORNEY

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LOAD CONTROL WITH SINGLE CONTROL TUBE

Colin H. McAdie, Baltimore, and Charles Keith Hooper, Linthicum Heights, Md., assignors to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

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6 Claims. (Cl. 318—207)

This invention relates to control systems which are sensitive both to magnitude and phase of applied signals, and relates more particularly to servo-amplifiers having electron tubes operated on alternating current.

It is a common practice in the design of servo-amplifiers to use D. C. power for the amplifier tubes which conduct alternately and supply a full-wave A. C. output which may be used for operating a servomotor. It is desirable in many cases, as where a relatively large amount of power is required, to use A. C. power directly for the amplifier tubes. If A. C. power is used directly in the usual circuits in which the anodes of the tubes go positive and negative together so that only one tube can conduct for a given control grid phase, only half-wave pulses are applied to the load. This results in a loss in power and sensitivity.

In the U. S. Letters Patent No. 2,677,086, issued on April 27, 1954 to Colin H. McAdie, a control circuit is disclosed which permits the use of A. C. power for the amplifier tubes of a servo-amplifier while delivering a full-wave output, and which uses a pair of diodes and a pair of capacitors for supplying the half-waves which are missing from the outputs of the usual A. C. operated servo-amplifiers. The present invention is an improvement over that disclosed in the above mentioned application in that fewer components are used.

In an embodiment of the present invention, A. C. power is applied between the midpoint connection of the primary winding of the output transformer, and the cathodes of the amplifier tubes as in the usual A. C. powered servo-amplifier which delivers only half-wave pulses at its output. A reactor is connected between the cathode and anode of each amplifier tube. At the usual power frequency used the reactor would usually have an iron core. When the control electrode of one of the amplifier tubes is positive at the same time its anode is positive, it conducts. When the phase reverses, current from the reactor flows through the tube. When the phase returns to its original position, the reactor current continues to flow through the tube with the load current. The reactors thus supply the half-waves which are missing from the outputs of the usual servo-amplifiers operated directly on A. C.

An object of this invention is to operate a servo-amplifier tube on A. C. while providing full-wave output.

Another object of this invention is to operate a servo-amplifier tube on A. C. to provide full-wave output without using rectifiers.

Another object of this invention is to reduce the number of components required for providing full-wave output from a servo-amplifier tube operated on A. C.

This invention will now be described with reference to the drawing, of which:

Figure 1 is a diagrammatic showing of a servo-amplifier embodying this invention, and

Fig. 2 is a plot of curves showing the ideal wave-forms desired in the circuit of Fig. 1.

A servo-motor 10 illustrated as a two-phase induction

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motor, has the usual field windings 11 and 12. Winding 11 is energized through the capacitor 13 from the A. C. source 14. Winding 12 is energized by the secondary winding 15 of the output transformer 16 which has a primary winding 17 connected to the anodes of the push-pull connected high vacuum triode amplifier tubes 18 and 19.

The cathodes of the tubes 18 and 19 are connected together and through a bias battery 20 to a mid-point connection of the secondary winding 21 of the input transformer 22. The control grids of the tubes are connected to opposite ends of the winding 21. The primary winding 23 of the input transformer is connected through the reversing switch 24 to the A. C. source 14. The reactors, or inductors, 25 and 26 are connected between the cathodes and anodes of the tubes 18 and 19, respectively. The A. C. source 14 is connected between the cathodes of the tubes and a midpoint connection of the primary winding 17 of the output transformer 16.

In operation, when the switch 24 is closed in one of its two positions for causing the tube 18 to conduct, A. C. from the source 14 supplied through the input transformer 22 will cause the control grid of the tube 18 to become positive when the control grid of the tube 19 is negative and vice versa. A. C. from the source 14 supplied between the midpoint tap of the primary winding 17 of the output transformer 16, and the interconnected cathodes of the tubes 18 and 19, will cause the anodes of the tubes to become alternately positive and negative together. The grid and anode of the tube 19 cannot be positive at the same time so that the tube 19 cannot conduct.

When alternating current is first applied in a direction such that the grid of tube 18 is negative, a small current will flow through the inductor 25, the value of this current being determined by the inductive reactance of the inductor 25. When the A. C. voltage reverses so that the grid of the tube 18 is positive at the same time its anode is positive, the tube will conduct and supply a positive D. C. pulse but it will also carry the inductor current which started to flow during the previous half-cycle. The inductor current will increase on successive alternate half-cycles until the circulating current around through the tube and inductor is equal to the peak value of the load current.

Fig. 2 of the drawing illustrates the wave forms of the tube, inductor and load currents which would result from a resistance-less inductor and tube. The load current is the sum of the tube and inductor currents. When the tube current is zero, load current continues to flow. Thus, the missing half-cycles of load current during the periods of non-conduction of the tube, are supplied.

In a practical circuit, the amplifier tube and inductor have resistance so that the wave forms of current are not ideal as shown by Fig. 2. However, the variations from ideal are of small consequence so that for all practical purposes, both halves of a sine-wave voltage would be supplied to the field winding 12.

The A. C. source 14 will supply through the capacitor 13 and the field winding 11, an alternating current which will be 90° out-of-phase with the current in the field winding 12 so that a rotating magnetic field will be set up which will cause the rotor of the motor 10 to rotate in the direction of field rotation.

When it is desired that the rotor of the motor 10 rotate in the opposite direction, the switch 24 will be closed in its other position, shifting the phase of the A. C. voltage applied to the input transformer 22 through 180°. This will cause the tube 19 to conduct when its grid is positive at the same time its anode is positive during alternate half-cycles. The inductor 26 will supply the load current during the other half-cycles, resulting in the

combination of the tube 19 and the inductor 26 supplying full-wave alternating current to the field winding 12 in the same way the combination of the tube 18 and the inductor 25 does as described in the foregoing.

The switch 24 merely illustrates the principle of operation. In a practical servo-system switch 24 would ordinarily be replaced with some error sending device.

The phase of the full-wave current supplied by the tube 19 and inductor 26 is opposite to that supplied by the tube 18 and inductor 25, so that the rotor of the motor 10 will be rotated in the opposite direction.

The inductors 25 and 26 can be made of commercially available material, no special type of iron being required for their cores.

In conventional servo-motor circuits operating on A. C. and delivering half-wave pulses, there is usually a relatively large D. C. component of current which represents wasted power, and often causes undesired saturation of circuit components. Another advantage of this invention is that such a D. C. component is greatly reduced.

While one embodiment of the invention has been described for the purpose of illustration, it should be understood that the invention is not limited to the exact circuits and circuit components illustrated and described, since modifications thereof may be suggested by those skilled in the art, without departure from the essence of the invention.

We claim as our invention:

1. A control circuit comprising a high vacuum electron amplifying tube having a control electrode, a cathode and an anode; an input transformer having a primary winding for connection to a source of alternating current, and having a secondary winding connected to said control electrode and cathode; an output transformer having a primary winding connected to said anode, and having a secondary winding for connection to a load; connections for applying an alternating current difference of potential between said primary winding of said output transformer and cathode, and an inductor connected directly between said anode and cathode.

2. A control circuit comprising first and second electron tubes having interconnected cathodes, and having control electrodes and anodes; an input circuit for supplying a first alternating current difference of potential between said control electrodes and cathodes, the potential supplied to one control electrode being opposite in polarity to the potential supplied to the other electrode; a load inductor connected to said anodes, said inductor having a midpoint tap; connections for supplying a second alternating current difference of potential between said cathodes and said mid-point tap; an inductor connected directly between the anode and cathode of the first electron tube and a second inductor connected directly between the anode and cathode of the second electron tube; a load circuit coupled to said load inductor, and means for reversing the phase of said first potential.

3. A control circuit comprising first and second electron tubes having interconnected cathodes, and having control electrodes and anodes; an input transformer having a secondary winding connected to said control electrodes and cathodes, and having a primary winding for connection to a source of alternating current; an output transformer having a primary winding connected to said anodes, and having a secondary winding for connection to a load, said primary winding of said output transformer having a midpoint tap; connections for supplying an alternating current difference of potential between said tap and cathodes; an inductor connected directly between the anode and cathode of the first elec-

tron tube and a second inductor connected directly between the anode and cathode of the second electron tube, and means for reversing the phase of the current supplied to said primary winding of said input transformer.

4. A servo-amplifier comprising an alternating current motor having a plurality of primary windings; an electron tube having a control electrode, a cathode and an anode; an input circuit for supplying an alternating current difference of potential from an alternating current source between said control electrode and cathode, a load inductor connected to said anode; connections for supplying an alternating current difference of potential from said source between said inductor and cathode; an inductor connected directly between said anode and cathode; means coupling one of said primary windings to said load inductor, and means including a capacitor for connecting another of said primary windings to said source.

5. A servo-amplifier comprising an alternating current motor having a plurality of primary windings; an electron tube having a control electrode, a cathode and an anode; an input transformer having a secondary winding connected to said control electrode and cathode, and having a primary winding for connection to an alternating current source; an output transformer having a primary winding connected to said anode, and having a secondary winding connected to one of said primary windings, said primary winding of said output transformer having a midpoint tap, connections for supplying an alternating current difference of potential from said source between said primary winding of said output transformer and said cathode; an inductor connected between said cathode and anode, and means including a capacitor for connecting another of said primary windings to said source.

6. A servo-amplifier comprising an alternating current motor having a plurality of primary windings; first and second electron tubes having respectively cathodes, anodes and control electrodes; an input transformer having a secondary winding connected to said control electrodes and said cathodes, and having a primary winding for connection to a source of alternating current; an output transformer having a primary winding connected to said anodes, and having a secondary winding connected to one of said motor primary windings, said primary winding of said output transformer having a midpoint tap; connections for supplying an alternating current difference of potential between said tap and said cathodes, an inductor connected directly across the anode and cathode of the first electron tube and a second inductor connected directly across the cathode and anode of the second electron tube; means including a capacitor for connecting another of said motor primary windings to said source of alternating current, and means for reversing the phase of the current supplied by said source to said primary winding of said input transformer.

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