REACTANCE VALVE CIRCUIT ARRANGEMENTS

Filed Dec. 20, 1954

FIG. 1.

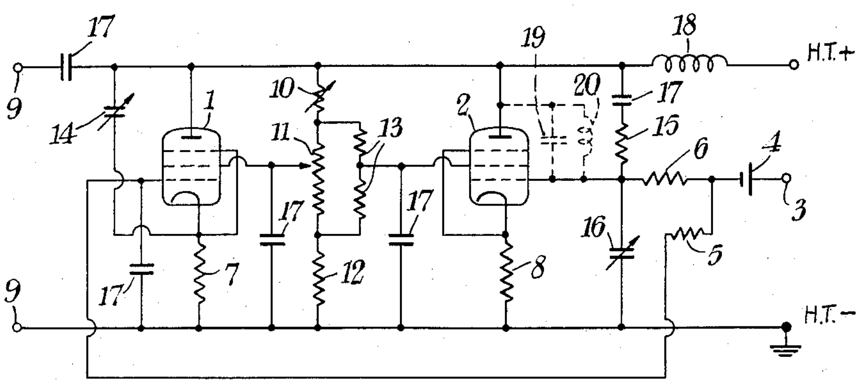
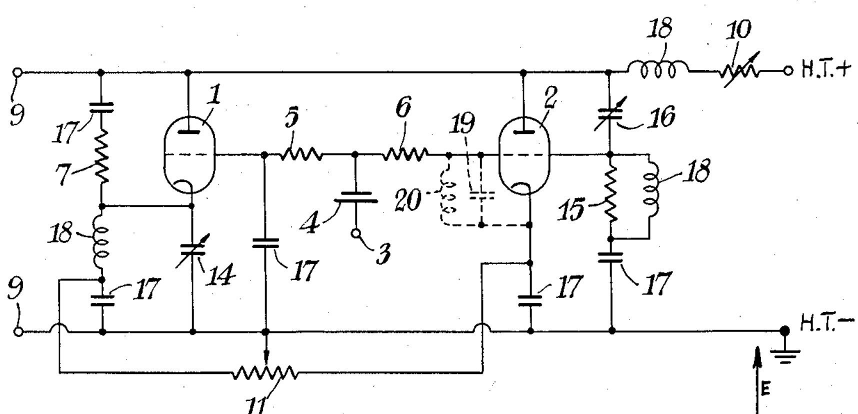


FIG. 2.



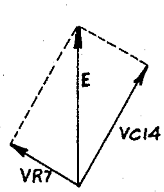


FIG. 3

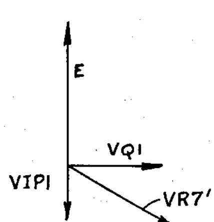


FIG. 4

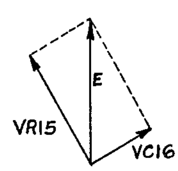


FIG. 5

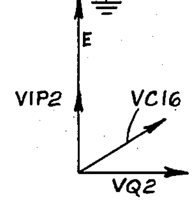


FIG. 6

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2,965,862

Patented Dec. 20, 1960

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2,965,862

REACTANCE VALVE CIRCUIT ARRANGEMENTS

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Filed Dec. 20, 1954, Ser. No. 476,495

Claims priority, application Great Britain Jan. 15, 1954

8 Claims. (Cl. 333—80)

This invention relates to reactance valve circuit arrangements, that is to say to circuit arrangements of the kind in which a thermionic valve is utilized to present susceptance, for example for inclusion in a resonant circuit, the value of which can be controlled by applied control potential. Reactance valve circuit arrangements are well known per se and are in wide use for a variety of purposes, notably for automatic frequency control and frequency modulation.

An important defect of most known reactance valve circuit arrangements is that they do not, in practice, present a pure susceptance and that variation of the control potential is also accompanied by variation of conductance. This effect produces amplitude modulation in the circuit whose frequency is to be controlled. In many cases such amplitude modulation is highly undesirable and it is the main object of the present invention, therefore, to eliminate such effects without adding seriously to the complexity or cost of the apparatus.

Known single valve reactance valve circuit arrangements fall into one or other of two classes, those in which the arrangement produces positive damping and those in which the arrangement produces negative damping. In both classes the arrangement includes a phase shifting network, composed of resistances and reactances, which usually extends from anode to control grid and thence to cathode in the case of an arrangement with positive damping and from anode to cathode and thence to the control grid in the case of an arrangement with negative damping. In both classes the theoretical requirement for pure susceptance to be manifested is that the output current of the valve shall be in quadrature with the voltage at the output terminals, i.e. the anode voltage and the anode current shall be in quadrature. In practice, however, this requirement is not satisfied with known arrangements because of the necessary presence of both resistance and reactance in the phase shifting network, and, accordingly, pure susceptance is not manifested and undesired amplitude modulation in addition to the desired frequency modulation is obtained.

According to the present invention there is provided a reactance valve circuit arrangement comprising two valves each having a different phase shifting network, and interconnected to act as a reactance valve across an output circuit, a modulation input circuit connected to feed modulation potential to the input electrodes of said valves in phase, one of said valves having its phase shifting network connected so as to feed in phase current to the output circuit and the other valve having its phase shifting network connected so as to take in phase current from the output circuit, each valve supplying in addition a quadrature component of current to the output circuit, said output circuit being so connected to the output electrodes of the valves that the output circuit current is the sum of the output electrode currents, the arrangement being such that the effective in phase current fed by one of the valves to the output circuit is substantially equal in magnitude and opposite in sign to the effective

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in phase current taken from the other of the valves, the quadrature component adding to supply a net quadrature component of current. In this way, the effect of resistive components manifested by one valve is counterbalanced by the opposite effect of resistive components manifested by the other, damping manifested at the output terminals being confined to that due to the fixed circuit elements.

The individual reactance valve circuits which together form the combination provided by this invention may be as known per se, the invention residing in their combination in such manner that the undesired amplitude modulation effects of the one are compensated by those of the other.

For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made to the accompanying drawing in which:

Fig. 1 shows diagrammatically a first reactance valve circuit arrangement;

Fig. 2 shows diagrammatically a second reactance valve circuit arrangement; and

Figs. 3–6 are vector diagrams explanatory of the theory of operation of the circuit arrangement of the invention.

Referring to Fig. 1, the arrangement therein shown comprises two similar valves 1 and 2, exemplified as pentodes, with their suppressor grids connected to their cathodes as in the usual way. Modulating or control potential is applied at terminals 3 to the control grids of both valves in parallel, there being a common bias source 4 and individual grid resistances 5 and 6. The cathode of each valve is connected to earth and HT— through its own cathode leg resistance 7 or 8. The anodes of the two valves are connected together and through a by-pass condenser to one of the two output terminals 9 between which terminals variable susceptance is to be manifested and to which, in use, a tuned circuit (not shown) is connected. A resistance network is included in a path across the high tension supply, this network including a variable resistance 10, a potentiometer 11 and a fixed resistance 12. The screen grid of the valve 1 is connected to the variable tap of the potentiometer 11 and the screen grid of valve 2 is connected through resistance 13 to the opposite ends of the resistance of the potentiometer 11. By adjusting the resistance 10 the gains of the two valves may be adjusted in unison, while by adjusting the tap on the potentiometer 11 the gain of one valve may be varied in relation to that of the other.

Each valve has a phase shifting network associated therewith, that for the valve 1 comprising an adjustable condenser 14 between anode and cathode, and the cathode leg resistance 7 already referred to, and that for the valve 2 comprising a resistance 15 effectively between anode and control grid and a condenser 16 between the control grid and earth. Thus the valve 1 has its phase shifting network connected to provide negative damping, i.e. it feeds in phase current to the tuned circuit while that of 2 provides positive damping, i.e. it takes in phase current from the output circuit. By-pass condensers and radio frequency chokes for the frequencies at which the reactance valve is to operate are provided as required, the former being indicated by the reference numeral 17 and the latter by the reference numeral 18. It will be seen that the reactance valve circuits, considered separately and apart from their combination, are known per se.

In practice, the arrangement is adjusted so that the in phase component at the grid of valve 1 is in anti-phase relation with the in phase component at the grid of valve 2. It may be shown that this result is achieved if the gains of the two valves are adjusted to equality, the resistances 7 and 8 are made equal and the product of the values of the condensers 14 and 16, the resistances 15 and 7 and the square of the frequency (in angular measure) is made equal to unity. The said result can also be achieved with resistances 7 and 8 of unequal values if the gains of the two valves are chosen of suitably different values. Thus, in the extreme theoretical case in which the value of resistance 8 is zero, the gain gm_2 of valve 2, should be equal to

$$\frac{gm_1}{1+(gm_1R_7)}$$

where gm_1 is the gain of valve 1 and R_7 is the value of resistance 7.

It will be obvious that the various self capacities of the valves necessarily form parts of the circuit. Thus the anode-control grid capacity of the valve 2 is indicated in broken lines at 19. In most cases the magnitudes of these self capacities will be too small to require consideration but at very high frequencies they may have to be taken into account in designing the apparatus. For an arrangement which is intended to operate over only a narrow band of frequencies it will usually be of advantage to "tune out" a self capacity such as the capacity 19 and an inductance for this purpose is indicated in broken lines at 20. In order to ensure that the valve (valve 1) whose phase shifting network produces negative damping shall not oscillate at some parasitic frequency, an antiparasitic "stopper" resistance (not shown) of small value, e.g. 33 ohms, may be inserted adjacent the control grid of the said valve 1, i.e. between the resistance 5 and the said control grid.

The modification shown in Fig. 2 is broadly similar to that of Fig. 1 but uses a grounded grid triode for the valve whose phase shifting network produces negative damping. It is, in general, not preferred to the arrangement of Fig. 1, but may be found more convenient for use on frequencies high enough to make pentodes unsatisfactory. Corresponding references are used for corresponding parts in Figs. 1 and 2. The modulating or control potentials are applied at terminal 3 to the control grids of both valves in parallel, as before, and the anodes are connected together. The phase shifting networks of the two valves are slightly differently arranged from the case of Fig. 1, that of valve 1 including resistance 7 effectively between anode and cathode and condenser 14 effectively between cathode and earth, while that of valve 2 includes condenser 16 between anode and control grid and resistance 15 between control grid and earth. Because of the different connections of the elements of the phase shifting networks the chokes 18 and by-pass condensers 17 are somewhat differently connected as compared to Fig. 1.

Figs. 3–6 show the vector relationships of voltage under varying conditions of operation of the circuit of Fig. 1. Assuming the vector E of Figs. 3–6 to be the voltage across the terminals 9, it will be seen from Fig. 3 that this vector E is composed of two mutually perpendicular vectors VC14 and VR7, the vector VC14 being the voltage across condenser C14 and the vector VR7 being the vector of the voltage across the resistance 7. The grid of the valve V1 is effectively earthed at R.F. frequency by the condenser 17 and therefore voltage VR7 is applied between the cathode and grid of valve 1. It will be seen that an equal but opposite voltage, shown in Fig. 4 as VR7', is effectively the voltage on the grid of valve 1, and this vector may be regarded as having two components VQ1 perpendicular to the vector E and VIP1 collinear with, but in opposite direction to E.

Referring to Fig. 5 the vector E can also be regarded as being made up of two components VR15 and VC16, these being equivalent to the voltages across R15 and C16, respectively. Provided that the ratio of resistance 7 to the reactance of condenser 14 is equal to the ratio of the reactance of condenser 16 to the resistance 15, then VR15 and VC16 will be equal respectively to VC14 and VR7, and the angles which the component vectors of Fig. 5 make with the vector E will be equal to the angles which the corresponding component vectors of Fig. 3 make with vector E but will be of opposite sense. Vector VC16 is composed of two components as shown in Fig. 6, VIP2 in phase with vector E and VQ2 perpendicular thereto. It will, therefore, be clear that provided the gains of valves 1 and 2 are equal, the anode currents derived from the voltages VIP1 and VIP2 will cancel while the currents derived from voltages VQ1 and VQ2 will add. Thus no in-phase currents will appear in the anode circuit.

Control potential is applied in parallel via terminal 3 to the control grids of valves 1 and 2 and so varies the amount of quadrature current flowing in the anode circuit and thus causes the circuit arrangement to vary its effective reactance, the anode quadrature current of each valve increasing with an increase in control potential and decreasing with a decrease in control potential.

In Fig. 2, as in Fig. 1, one of the valve self-capacities is indicated in broken lines at 19 and an inductance which may be used to tune it out if required is shown, in broken lines, at 20. The common adjustment resistance 10 is now in the common HT+ lead to the valve anodes and the relative adjustment potentiometer 11 is connected as shown.

The invention is not limited to the precise circuits shown, for example inductive reactances may replace the capacitative reactances shown in the phase shifting networks.

I claim:

1. A reactance valve circuit arrangement comprising two valves, each including at least a cathode, a control grid and an anode, said anodes being commonly connected, an output circuit connected between said commonly connected anodes and a point of reference potential, an input circuit connected in parallel to the control grids of both said valves, a different phase shifting network individual to each of said valves, the phase shifting network for one of said valves comprising a reactance effectively connected between the anode and cathode thereof and a resistance effectively connected between the cathode thereof and said point of reference potential, the control grid of said last mentioned valve being effectively connected to said point of reference potential at frequencies at which said phase shifting network is designed to be operative, the phase shifting network for the other valve comprising a resistance effectively connected between the anode and control grid thereof and a reactance of similar nature to said first mentioned reactance connected between the control grid thereof and said point of reference potential, the cathode of said other valve being connected by means of a resistance to said point of reference potential.

2. A reactance valve circuit arrangement as set forth in claim 1 wherein each of said reactances is constituted by a condenser.

3. A reactance valve circuit arrangement as set forth in claim 2 wherein each of said reactances is constituted by a condenser and wherein the product of the values of capacitance of the condensers and the resistances in the phase shifting networks and the square of the frequency in angular measure is equal to unity.

4. A reactance valve circuit arrangement as set forth in claim 1 in which each of said two valves has a screen grid and wherein a potentiometer is connected between the anodes and cathodes of said valves, a variable tap on said potentiometer connected to the screen grid of one valve, and a connection from said potentiometer to the screen grid of the other valve.

5. A reactance valve circuit arrangement comprising two valves, each comprising at least a cathode, a control grid and an anode, said anodes being commonly connected, an output circuit connected between said commonly connected anodes and a point of reference potential, an input circuit connected in parallel to the control grids of both said valves, a different phase shifting network individual to each of said valves, the phase shifting

network for one of said valves comprising a resistance effectively connected between the anode and cathode thereof and a reactance effectively connected between the cathode thereof and said point of reference potential, the control grid of said last mentioned valve being effectively connected to said point of reference potential at frequencies at which said phase shifting network is designed to be operative, the phase shifting network for the other valve comprising a reactance of similar nature to said first mentioned reactance connected between the anode and control grid thereof and a resistance connected between the control grid thereof and said point of reference potential, the cathode of said other valve being effectively connected to said point of reference potential.

6. A reactance valve circuit arrangement as set forth in claim 5 wherein each of said reactances is constituted by a condenser.

7. A reactance valve circuit arrangement comprising two valves, each including at least a cathode, a control grid and an anode, a circuit connecting both of said anodes in such manner that in operation there is a common anode voltage connected to both of said anodes, different phase shifting means individual to each of said valves, each of said means having an intermediate point

thereon and providing voltages at such intermediate points that differ in phase from said common anode voltage by equal angles of less than 90° and of opposite sense, means connecting said intermediate point of one of said phase shifting means to the control grid of one valve and the said intermediate point of the other phase shifting means to the cathode of the other valve, thereby to control the anode currents of said valves in such manner that the out-of-phase components thereof are in quadrature with the common anode voltage and will add while the in-phase components will subtract, and means for applying control potential in parallel to corresponding electrodes of both said valves to control the gains thereof.

8. A reactance valve circuit arrangement as set forth in claim 7 wherein further means are provided for individually adjusting the gains of said valves.

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