Feb. 25, 1947. R. D. BROWN, JR 2,416,513

MULTIVIBRATOR

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Fig. 1.

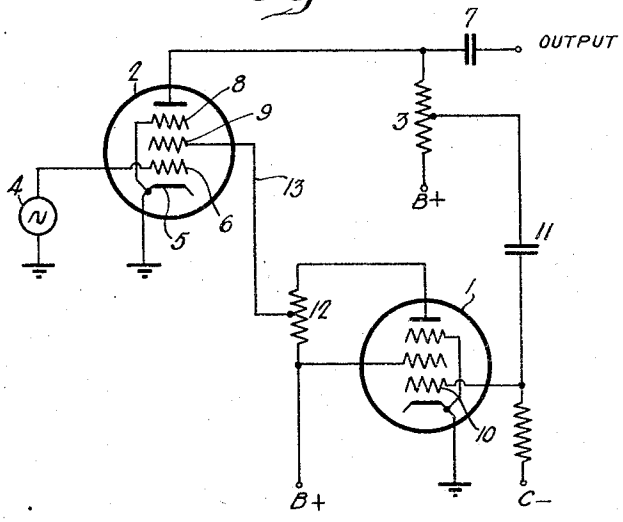
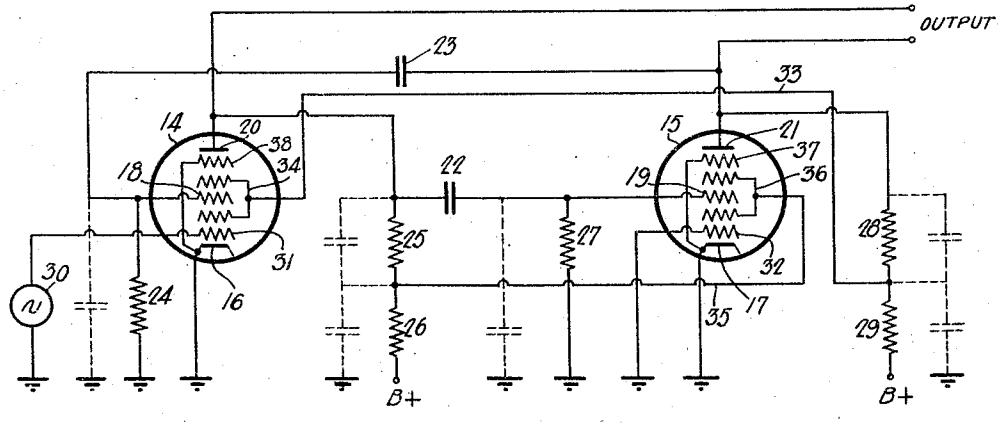


Fig. 2.



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MULTIVIBRATOR

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5 Claims. (Cl. 250—36)

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This invention relates to vacuum tube circuits, and more particularly to resistance-coupled vacuum tube amplifier circuits which are constructed and arranged to operate at high frequencies, or over wide frequency bands. The invention is capable of general application, but is particularly useful in those instances where conventional resistance-coupled amplifiers become unsatisfactory due to high interelectrode capacities. The invention is especially adapted for use in wide-band video amplifier circuits, and in multivibrator circuits intended for operation as carrier amplitude limiters in the intermediate frequency stages of frequency modulation radio receivers.

In the development of vacuum tube amplifiers for use at high frequencies attention was early directed to the screen grid tube as a superior type of radio frequency amplifier. This superiority is in part a result of its low effective control-grid-to-anode capacity which enables its use, with good stability and high amplification, at frequencies beyond those for which the triode is suited. However, the insertion of the screening element produces a substantial increase in the tube's input capacity, i. e., in the direct interelectrode capacitance as measured between the input grid, on the one side, and all of the remaining electrodes on the other. In conventional pentodes this capacitance is about double that for triodes. This high input capacitance is not ordinarily serious in tuned amplifiers where the input capacity of the tube may be used to tune the input circuit. But, as is well known, in untuned wide-band systems the increased input capacity seriously limits the maximum frequency at which the system is operable, and tends, at high frequencies, to short circuit the signal source with which it is directly in shunt.

It is a principal object of this invention to provide means for effectively diminishing the input capacity of amplifier tubes having screen grids, and thereby to extend the frequency range over which the tubes are useful.

It is another object of the invention to increase the maximum frequency at which the multivibrator type of oscillator is operable.

It is still another object of the invention to provide a multivibrator capable of functioning at frequencies of the order of several megacycles.

It is a further object of the invention to provide a signal amplitude limiter of the multivibrator type capable of operating in the intermediate frequency amplifier channel of frequency modulation receivers.

The invention itself, as well as other of the objects thereof, will be understood by those skilled in the art from a consideration of the following detailed description and the accompanying drawing, in which

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Fig. 1 is a schematic illustration of a circuit utilizing the invention; and

Fig. 2 is a schematic illustration of a multivibrator circuit embodying the invention.

Reference is now made to Fig. 1 in which the invention is applied to a single-stage vacuum tube amplifier. Ignoring, for the moment, the pentode 1, the amplifier stage will be seen to consist of a conventional amplifier circuit comprising the pentode 2 together with an output load resistor 3. The signal to be amplified, derived from the source 4, is applied between the cathode 5 and control grid 6 of the pentode 2, while the amplified output signal may be derived from the anode circuit of the tube by way of the coupling condenser 7. In addition to the elements mentioned, the pentode includes a suppressor grid 8 which is conveniently connected to the cathode 5, and a screen grid 9 which would ordinarily be connected to a source of fixed positive potential (not shown). The input capacity of the pentode 2 consists largely of the capacity between the control grid 6 on the one side and the cathode 5 and screen grid 9 on the other. Capacity also exists between the control grid 6 and the anode and suppressor grid 8, but since the latter elements are more remote from the control grid the contributions of these elements are of less importance.

At the higher frequencies a considerable charging current flows into the control grid 6 from the signal source 4, and this charging current is largely due to the physical proximity of the cathode 5, here shown connected to ground, and to the screen grid 9, which in conventional practice is at ground potential so far as the radio frequency input signal is concerned. As the signal frequency increases in magnitude, the charging current also increases, thus placing an abnormally heavy load upon the signal source 4, and effectively short-circuiting the input circuit of the pentode 2.

According to the present invention, the interelectrode capacity effects between the input grid 6 and the screen grid 9 are substantially nullified by the application to the screen grid 9 of a signal which is similar in frequency, phase, and magnitude to the signal applied to the input grid 6. This may be accomplished through the agency of an auxiliary pentode 1. In the embodiment of the invention illustrated in Fig. 1, output signal from the pentode 2 is derived from the load

resistor 3 and impressed on the input grid 10 of pentode 1 by way of the coupling condenser 11. The output signal of the auxiliary pentode 1, as taken from a point on the anode load resistor 12, is applied to the screen grid 9 of pentode 2 by way of the conductor 13. Since a phase reversal occurs in each of the pentodes, the signal applied to the screen grid 9 is in the same phase as the original signal applied to the control grid 6, and by a suitable choice of tap locations on the impedances 3 and 12 the magnitude of the signal supplied to the screen grid 9 may be made equal to that present on the control grid 6. When the alternating voltages appearing on the grids 6 and 9 are equal in magnitude, and of like phase, it is evident that no charging current can flow from the control grid 6 to the screen grid 9, and thus one cause of the objectionable charging current is eliminated. However, it is also within the scope of the invention to compensate wholly or in part for the capacity effects between the control grid 6 and the cathode 5. This may be accomplished by supplying to the screen grid 9 a signal of greater magnitude than that present on the control grid 6. Under these conditions charging current will flow from the screen grid 9, as a source, to the control grid 6, and by suitably adjusting the magnitude of the voltage supplied by the pentode 1 it is readily possible to compensate for the charging current taken by the control grid-to-cathode circuit of the pentode 2. Similarly it is possible to compensate for the charging current drawn by other of the electrodes or by the distributed capacity associated with the conductors connected to the grid 6.

Aside from its desired capacity-compensating effect, the application of the in-phase signal to the screen grid 9 produces no substantial change in the operation of the amplifier, and no disadvantageous effects are introduced. This is largely because the screen grid-to-anode mutual conductance of the tube is small compared to the control grid-to-anode mutual conductance, and consequently the control effect of the screen is negligible. At low signal frequencies where tube input capacity would have no effect on circuit performance, the application of the signal voltage to the screen 9 has no substantial effect on the gain of the tube. However, at the high signal frequencies where gain would normally fall off rapidly with frequency the present circuit tends to reduce the effective input capacity and to maintain favorable operating conditions within the amplifier circuit.

Referring now to the details of the circuit of Fig. 1, it will be noted that the input signal to the auxiliary pentode 1 is derived from an intermediate point on the resistor 3. This practice is preferred because through this expedient the distributed capacities to ground of the coupling condenser 11 and the lead wires associated therewith are not connected directly in shunt with the anode circuit of the amplifier pentode 2, and in this way the output capacity of this pentode is not adversely effected by the presence of the auxiliary pentode 1. In practice it will normally be desirable to employ intermediate taps on both the resistors 3 and 12 (as shown) in order to restrict the over-all gain of the auxiliary pentode circuit to that which is just necessary to compensate for the capacity effects hereinbefore described. In the circuit shown, plate and screen potential for the pentode 1, and screen potential for the pentode 2, is derived from a common source B+. This is a convenient connection, but obviously separate sources may be employed if desired.

In general it is not difficult to design an auxiliary pentode circuit capable of providing, even at very high frequencies, a signal for application to the screen grid 9 which is equal to or somewhat greater than the signal applied to the input grid 6. This is because the overall gain of the auxiliary pentode circuit need not be large, being, in general, substantially less than unity, or of the order of unity, depending upon the gain of the amplifier pentode 2. Under these circumstances, and by providing the auxiliary pentode with low impedance input and output circuits, the operating frequency of the pentode 1 may be extended far beyond its normal range.

Reference is now made to Fig. 2 in which the invention is applied to a multivibrator circuit which is adapted for use as an amplitude limiter in frequency modulation radio receivers or the like. The multivibrator of Fig. 2 embodies the novel features of the amplifier of Fig. 1, but is of particular interest in that no auxiliary vacuum tubes are required, each of the multi-grid tubes 14 and 15 serving not only as elements in the multivibrator circuit, but also as the "auxiliary" vacuum tube for the other. Ignoring for the moment the features introduced by the present invention, the multivibrator will be seen to comprise the vacuum tubes 14 and 15, with their cathodes 16 and 17, their control grids 18 and 19, and their anodes 20 and 21. The electrodes enumerated are interconnected to produce a conventional multivibrator circuit. Thus the input grid 19 of tube 15 is coupled to the anode 20 of tube 14 by way of a coupling condenser 22, while the input grid 18 of tube 14 is coupled to the anode 21 of tube 15 by way of a coupling condenser 23. The tube 14 may be provided with a suitable grid leak resistor 24 and an anode load circuit comprising the serially connected resistors 25 and 26. Similarly the tube 15 may be provided with a grid leak 27 and anode load resistors 28 and 29. An input signal from a source 30 may be applied to the tube 14 through an input grid 31. The corresponding input grid 32 of the tube 15 may be connected to ground, but if a balanced source of signal is provided, the signal may be supplied to both input grids in push-pull relation. The output signal of the multivibrator may be taken from either of the anodes 20 or 21, or if desired the output signal may be taken from the anodes in push-pull relation as shown, the push-pull connection giving twice the output provided by the single-side connection.

The vacuum tube 15, in addition to its conventional function in the multivibrator, is related to the vacuum tube 14 in much the same way as the auxiliary vacuum tube 1 of Fig. 1 is related to its associated vacuum tube 2. Thus in Fig. 2 output signal from the tube 15 is derived from the junction between the anode load resistors 28 and 29, and is applied by way of the conductor 33 to the screen grid element 34 of tube 14. Similarly output signal from the tube 14 is derived from the junction of the anode load resistors 25 and 26 and is applied by way of the conductor 35 to the screen grid 36 of the tube 15.

In addition to the hereinbefore described physical circuit elements, the schematic of Fig. 2 also shows, in dashed lines, the effective capacities associated with the tube electrodes. Thus the capacity in shunt with the grid leak resistor 24 represents the sum of the effective capacities from the grid 18 to the screen grid 34, from the grid

18 (and plate 21 of tube 15) to ground, from the plate 21 of tube 15 to the suppressor grid 37 of tube 15, and the load capacity of the tube 15. The capacity shown in shunt with the load resistor 28 represents the capacity from the grid 18 of tube 14 to the screen grid 34 of tube 14. This capacity is included in the capacity in shunt with the grid leak resistor 24, but it is here isolated. The capacity shown in shunt with the load resistor 29 represents the capacity from the screen grid 34 of tube 14 to the suppressor grid 38, and to the input grid 31 of the tube 14. The capacities shown in shunt with the grid leak resistor 27 and the load resistors 25 and 26 correspond to those above mentioned.

In the preferred form of the invention, the time constants of the six R.-C. circuits, which include the resistors 24 to 29 inclusive, are preferably made equal by a suitable selection of the several resistors. Under these conditions the effective capacities of the circuit disappear at all frequencies for which the equality is substantial. Even if this preferred adjustment is ignored with respect to the grid leak resistors 24 and 27, it will be advantageous to adjust the time constants of the R.-C. circuits which include the resistors 25, 26, 28 and 29.

In the design of amplifier and multivibrator circuits constructed in accordance with the principles of the invention, the following relations, while not advanced as limitations to the invention, will be helpful. Taking C_g as the interelectrode capacity between the grid 18 and the screen grid 34, and taking C_s as the capacity between the screen grid 34 and all the other electrodes exclusive of grid 18, in the preferred embodiment

$$\frac{R_{28}}{R_{25}+R_{26}}$$

is greater than zero, but less than

$$\frac{C_s}{C_g+C_s}$$

Moreover, in general, the lower the values of R_{25} and R_{26} the higher the effective frequency of operation, but the higher the level of the minimum signal which must be applied to reach the limit effectively. The corresponding resistors associated with the second tube 15 may be similarly evaluated.

The multivibrator circuit illustrated in Fig. 2 may advantageously be employed wherever a multivibrator capable of generating a signal of high fundamental frequency is required. The multivibrator circuit shown is capable of being synchronized with signals from the source 30 whose frequency is well in excess of one megacycle, a frequency which formerly represented the upper practical limit for multivibrators of conventional design.

The multivibrator of Fig. 2 is particularly well adapted for use as a signal amplitude limiter in the intermediate frequency channel of a frequency modulation radio receiver. The conventional form of multivibrator, on the other hand, is largely inoperative at the intermediate frequency generally used in frequency modulation receivers. Even were the intermediate frequency made so low that this consideration did not apply, the deviation of the frequency-modulated carrier would cause it to reach frequency regions in which the conventional multivibrator is unreliable. The present invention however eliminates the difficulties previously considered inherent in the multivibrator, and provides a nonresonant limiter system which is readily synchronized with the frequency-modulated intermediate frequency signal. It also provides an amplifier of simple construction capable of high gain while limiting the output, in addition to providing a push-pull source of limited signals using a single side input signal.

Although the invention has been described and illustrated with particular reference to certain preferred embodiments, it should be understood that numerous alterations and modifications may be made within the scope of the invention as defined in the appended claims.

I claim:

1. A multivibrator circuit adapted for operation at high frequencies, comprising a pair of vacuum tubes, each having at least a cathode, control grid, screen grid and anode, a load resistor connected to each of said anodes, said cathodes, control grids and anodes being interconnected to provide multivibrator operation, means for coupling the screen grid of the first of said tubes to an intermediate point on the load resistor of the second of said tubes, and means for coupling the screen grid of said second tube to an intermediate point on the load resistor of said first tube.

2. A multivibrator circuit as claimed in claim 1, wherein at least one of said tubes is provided with an auxiliary grid, and wherein a synchronizing signal is applied to said grid for controlling the period of oscillation of said circuit.

3. A multivibrator circuit adapted for operation at high frequencies, comprising a pair of vacuum tubes, each having at least a cathode, control grid, screen grid and anode, a first pair of load resistors serially connected in the anode circuit of the first of said tubes, a second pair of load resistors serially connected in the anode circuit of the second of said tubes, a first condenser connected between the anode of said first tube and the control grid of said second tube, a second condenser connected between the anode of said second tube and the control grid of said first tube, a connection between the screen grid of said first tube and the junction of said second pair of load resistors, and a connection between the screen grid of said second tube and the junction of said first pair of resistors.

4. A multivibrator circuit as claimed in claim 3, characterized in that the time constants of the circuits formed by the said resistors and the capacities in shunt therewith are substantially equal.

5. A multivibrator circuit as claimed in claim 3, wherein grid leak resistors are connected between the control grid and cathode electrodes of said tubes, and characterized in that the time constants of the circuits formed by the said grid leak and load resistors and the capacities in shunt therewith are substantially equal.

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