

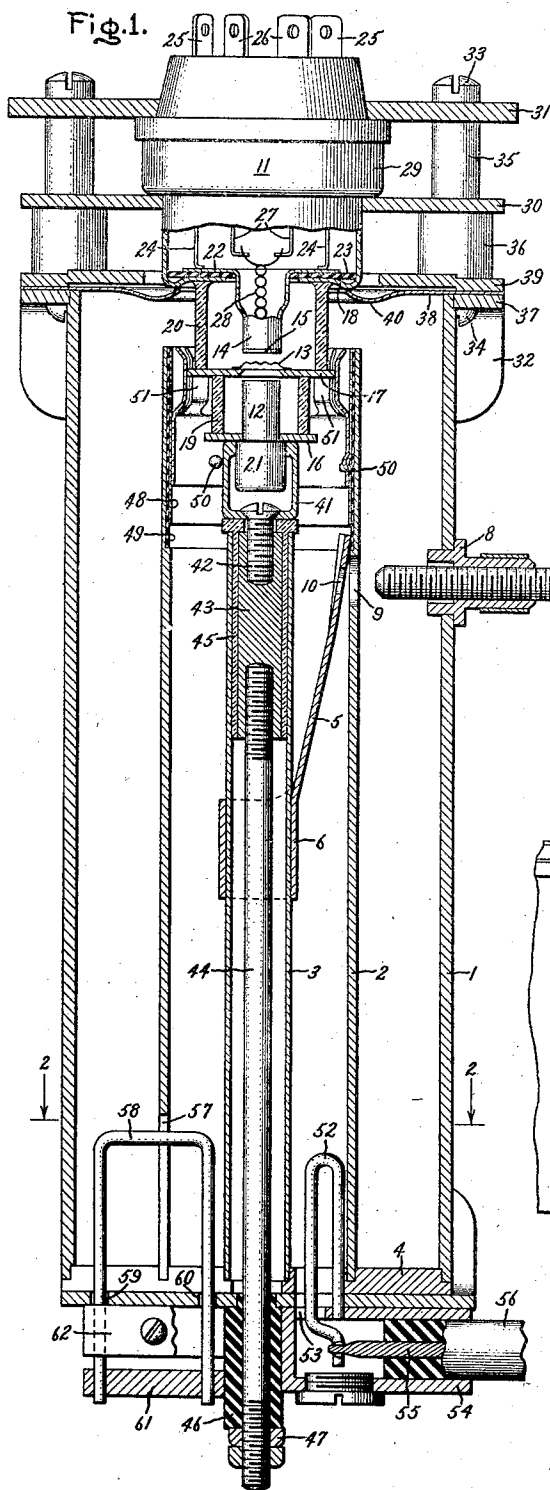
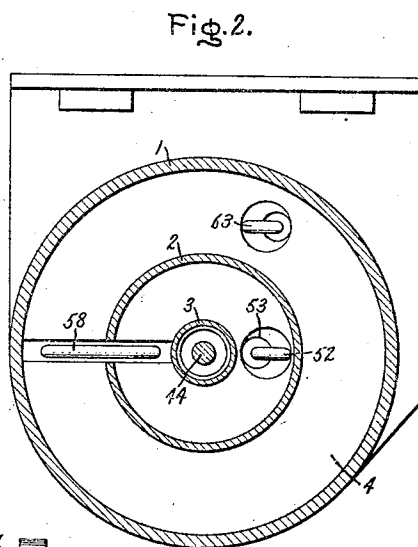
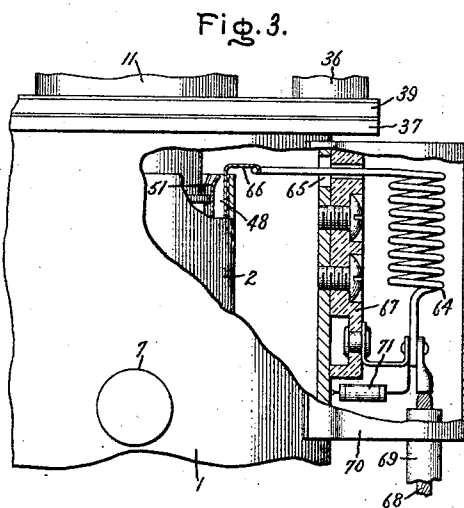
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ULTRA HIGH FREQUENCY AMPLIFIER

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ULTRA HIGH FREQUENCY AMPLIFIER

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7 Claims. (Cl. 179—171.5)

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The present invention relates to high frequency electronic apparatus and more specifically to an improved amplifier modulator for use in the ultra high frequency range.

At frequencies above 100 megacycles, it has been found that attempts to obtain large amounts of amplitude modulation usually result in introducing also objectionable amounts of frequency modulation of a carrier wave. Accordingly, it is an object of the present invention to provide a new and improved ultra high frequency system in which a large amount of amplitude modulation may be obtained without introducing a substantial amount of frequency modulation.

It is another object of my invention to provide a new and improved grid modulation circuit for a high frequency system.

It is still another object of my invention to provide a new and improved modulating circuit for a high frequency system which requires relatively small amounts of modulating signal power.

It is a further object of my invention to provide a new and improved circuit for preventing oscillations in an amplifier modulator.

One of the features of the present invention is the use in an amplifier modulator, having tuned input and output circuits coupled to an electronic discharge device, of a closed conductive loop to prevent oscillations due to feedback between the tuned circuits occasioned by the interelectrode capacitance of the device and the capacitance coupling the modulating signal to the device. The degree of coupling of the loop with the tuned input and output circuits may depend upon the values of these capacitances.

Another feature relates to a circuit for keying the grid of an electronic tube coupled to a pair of cavity resonators and for preventing the keying circuit and the interelectrode capacitance from causing oscillation of the system.

The invention itself, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the drawing, in which Fig. 1 is a sectional view of an amplifier modulator suitably embodying the invention; Fig. 2 is a view taken along the line 2—2 of Fig. 1; and Fig. 3 is a partial view of the amplifier modulator of Fig. 1 illustrating the modulating circuit thereof.

Referring particularly to Fig. 1, there is shown an amplifier modulator which comprises a series of three concentric and mutually telescoped conductors 1, 2, and 3 suitably consisting of brass or copper and preferably silver plated. At one end, the conductors are secured to a common

base 4, also constituted of a metallic material. By virtue of their mutual spacing the conductors provide, in effect, a pair of concentric transmission line sections each of which, by proper dimensioning and tuning, may be made to function as a tank circuit having a particular resonance frequency. With this consideration in mind, the outer and intermediate conductors are preferably so dimensioned that they are resonant at a desired frequency. The intermediate and inner conductors are tuned by means of a capacitance comprising a metallic spring member 5 having a sleeve portion 6 adapted to encircle the cylinder 3 and being secured thereto in a fixed position. The position of the member 5 between the cylinders 2 and 3 may be adjusted by means of an adjusting screw 7 supported on the outer conductor 1 by means of a threaded nut 8, the screw 7 passing through an aperture 9 in the intermediate cylinder 2 to contact the upper end of the spring 5. A hole 10 in the spring 5 is adapted to engage the end of the screw 7 and facilitate adjustment of the tuning capacitance which exists between the spring 5 and the cylinder 2. The extremities of the conductors 1, 2, and 3 which are remote from the base 4 are axially off-set so as to provide a step-wise arrangement which is regressive as one proceeds from the outer conductor 1 toward the inner conductor 3. This is for the purpose of facilitating the combination of the conductors with an electronic discharge device 11 which is of the type illustrated as a triode and of the type particularly described and claimed in application, Serial No. 436,633, filed March 28, 1942, in the name of James E. Beggs and assigned to the assignee of the present invention.

The electronic tube 11 comprises a cylindrical anode 12, a grid 13, and a cylindrical cathode 14, the latter element having its emissive part in the form of a flat disk 15 which faces the grid. The envelope within which these electrodes are enclosed comprises a series of three circular metal parts 16, 17, and 18 which are supported in spaced relation by glass cylinders 19, 20 sealed between them. The disk 17 provides a terminal for the grid 13 and a terminal for the anode is provided by a cylindrical enlargement 21 which is welded or soldered against the outer surface of the part 16. The cathode 14 is provided at its lower extremity with a flange 22 which parallels the under surface of the part 18, but which is separated from that part by an insulating washer 23 of mica or any other suitable insulating material. With this arrangement, the part 18 has a high

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frequency connection with the cathode through the capacity existing between this part and the flange 22, but is insulated from the cathode so far as direct current is concerned. Direct current connections are made to the cathode by means of lead-in wires 24 secured to the outer surface of part 22 and terminally connected to prongs 25 which extend from the base of the discharge tube. Additional prongs 26 and lead-in wires 27 are provided for the purpose of supplying heating current to a coiled filament 28.

The base of the electronic tube 11 includes an enlarged annular part 29 having shoulder portions which abut against fastening plates 30, 31 and may be fastened to a supporting flange 32 by means of a plurality of screws 33, 34 and separating washers 35, 36. The outer cylinder 1 has welded thereto a ring 37 so that the entire high frequency system and tube may be supported by the part 32.

An annular ring 38 clamped between the part 37 and the clamping ring 39 extends inwardly from the interior wall surface of the cylinder 1 and is provided at its inner periphery with a ring of spring fingers indicated at 40. These bear upon the exposed surface of the part 13 and are thus effectively connected with the cathode 14 as far as high frequencies are concerned by capacity coupling through the insulating spacer 23. A corresponding connection to the anode is made by an anode clip 41 having a plurality of spring fingers for engaging the outer surface of the part 21. The anode clip 41 is secured by means of a screw 42 to a conductive cylinder 43, in turn, connected to a lead-in rod 44 for supplying unidirectional currents to the anode. An insulating cylinder 45 surrounding the conductive member 43 insulates the anode unidirectional supply system from the inner cylinder 3. At its lower end, the conductive rod 44 is insulated from the base 4 by means of an insulating washer 46 held in position by means of a nut 47.

A high frequency connection between the grid terminal 17 and the intermediate cylinder 2 is made through a capacitance constituted by a thin metallic sleeve 48 disposed within the upper end of the cylinder 2 and insulated therefrom by a layer of suitable material 49, such as glass tape. In constructing the capacitance, the glass tape may be impregnated with a solvent or varnish and applied into a counterbored surface of the cylinder 2. The sleeve 48 is then inserted in place and the resultant structure baked for sufficient time to harden the varnish. The sleeve 48 is provided with a plurality of protuberances or locating marks 50 adapted to engage the corresponding locating marks on a set of contact fingers 51 which are located by the marks to a predetermined position for engaging the disk 17.

In order that high frequency energy may be taken from the cavity resonator defined by the cylinders 2, 3 for utilization in an external circuit, there is provided a coupling loop 52 which extends into the cavity formed between the members 2, 3 and through an opening 53, one end of which is conductively connected to a housing 54. The other end of the loop is connected to a conductor 55 which is insulated from the housing by means of a solid dielectric material 56 and may comprise the inner conductor of a coaxial transmission line, a portion of the outer conductor of which is constituted by the housing member 54. At a point diametrically opposite the location of the output coupling loop 52, the intermediate cylinder 2 is provided with a

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longitudinal slot 57, and a coupling loop in the form of a closed conductive member 58 extends between the cavity resonator defined by conductors 1, 2 and that defined by conductors 2, 3. The members 58, after passing through apertures 59, 60 in the base member 4, is supported externally by a conductive member 61 which likewise serves as a positioning means for the loop. The position of the loop in a desired location is maintained by a clamping arrangement 62 which also forms a short-circuiting member to complete the loop.

In order that high frequency energy may be supplied to the cavity resonator defined by the members 1 and 2 and impressed between the cathode and grid of the device 11, there is provided an input coupling loop 63, shown in Fig. 2, which extends into the cathode-grid cavity and which preferably is constructed and provided with external connections similar to those of the output coupling loop 52.

The modulation circuit for the high frequency amplifier modulator of Fig. 1 is shown in Fig. 3 and comprises a choke coil 64 located outside of the cylinder 1 and connected through an aperture 65 near one end of that cylinder with a tap 66 formed integrally with the metallic grid sleeve 43. The coil 64 is supported from a terminal board 67 of insulating material attached to the outer surface of cylinder 1 and is supplied with modulating pulses or signals from a concentric transmission line comprising an inner conductor 68 and an outer conductor 69, the latter being grounded to a housing or shield 70 which engages the choke coil 64 and is conductively connected with the outer surface of cylinder 1. A capacitance 71 is connected between the choke coil 64 and the grounded cylinder 1.

The unidirectional current connections for the triode 11 may be made in various ways. In the arrangement illustrated, neither the anode nor the cathode is assumed to be at ground potential, the former being insulated from ground by the insulating spacer 23 and the latter by the insulators 43 and 46. The cathode, moreover, is maintained at a positive potential with respect to the grid, the grid being normally maintained at ground potential until a positive modulating pulse or signal increases its potential to that of the cathode.

Like any confined space bounded by a conductive medium, the chamber enclosed between the cylinders 1 and 2 provides a system which may be made to resonate electrically at a particular frequency determined by the dimensions and configuration of the chamber and of the elements enclosed by it. This means that, under appropriate conditions, electromagnetic waves may be caused to exist within the chamber in a space distribution fixed by the nature and location of the exciting source and by the boundary conditions set by the form of the conductive structure. Such an exciting source in the system shown takes the form of the input coupling loop 63 and the configuration and dimensions of the cavity resonator formed by the conductors 1, 2 as modified by the presence of the electronic device 11 are tuned to the frequency of the waves supplied by the source 63. The confined space, when bounded by the cylinders 2 and 3 and the grid and anode of the electronic device 2, similarly may be made to resonate electrically at the same frequency by adjustment of the capacitance which exists between the spring arm 5 and the conductive walls of the resonator. This capaci-

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tance is effective to foreshorten the physical length of this section of transmission line constituted by the conductors 2 and 3 so that it resonates at the same frequency as the outer cavity resonator. Energy, therefore, may be abstracted from this inner cavity resonator by the output coupling loop 52.

It has been found that the addition of the built-in capacitor formed by the grid shell 48 and the upper end of the cylinder 2, which is required for operation of the system as an amplifier modulator, to the fixed interelectrode capacitance of the electronic device 11 increases the regeneration of this device sufficiently to cause oscillation and seriously affect the operation of the amplifier modulator circuit. The coupling loop 58 at the current nodes of the anode-grid and grid-cathode tank circuits operates as a neutralization circuit which completely eliminates regeneration at the mid band frequency of the system to which the cavity resonators are tuned and substantially neutralizes regeneration over a considerable band near the elimination frequency. Complete elimination, of course, is obtained by a proper selection of the coupling of the neutralization loop to the anode-grid and grid-cathode cavity resonators. The particular coupling required between the two tank circuits is obtained from the equation:

$$K = \sqrt{\frac{2C_1}{C_2 + C_1}}$$

where C_1 is the capacitance between the anode and cathode of the discharge device 11 when the cathode is heated to operating temperature, and C_2 is the anode-to-grid capacity of the tube which includes the capacitance required to tune the anode-to-grid resonator by the adjustment of the position of arm 5 to the proper operating frequency. Thus, it is seen that the coupling between the two tank circuits required for neutralization depends both upon the capacity required to tune the amplifier and upon the plate-to-cathode capacity of the discharge device. It can further be shown that the change in neutralization with frequency is proportional to

$$\frac{1}{R_g[1 - (\omega_0/\omega_2)^2]}$$

where R_g is the grid input resistance, and ω_0 is the frequency to which the tank circuits are tuned, and ω_2 is the frequency of the impressed wave. It is apparent from this last equation that, if the grid input resistance is sufficiently high, there is very little change in neutralization with change in frequency.

From the foregoing, it is seen that my invention provides an amplifier modulator circuit for an ultra high frequency system employing an electronic tube in which the grid of the electronic tube is keyed by the modulating signal and high frequency waves are impressed between the grid and cathode of the tube. One of the advantages of this particular system is that, when operated in the ultra high frequency range, substantially one hundred per cent amplitude modulation is obtained without any substantial amount of frequency modulation of the carrier wave. As a result, the system requires a substantially smaller amount of modulating power for satisfactory operation. Neutralization of the circuit to prevent oscillation is effected easily by adjustment of the closed conductive loop 58 coupling the tank circuits of the receiver.

While the use of the neutralization loop cou-

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pling the grid-to-cathode and the plate-to-grid tank circuits has been shown as employed in connection with a grid keyed modulator, it will be realized that such a neutralizing circuit may be employed likewise with an amplifier modulator in which the grid is operated at ground potential and the cathode is pulsed or keyed with a modulating signal.

While the invention has been described by reference to particular embodiments thereof, it will be understood that numerous modifications may be made by those skilled in the art without departing from the invention and I therefore aim to cover all such equivalent variations as come within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. An ultra high frequency amplifier comprising a pair of cavity resonators defined by three concentric conductive cylinders, an electric discharge device having an anode connected to the inner of said cylinders, a grid connected to the intermediate of said cylinders, and a cathode connected to the outer cylinder, means for impressing a signal to be amplified between said grid and cathode, means for deriving amplified signals from the resonator defined by said inner and intermediate cylinders, and means for preventing oscillation of said amplifier comprising a closed conductive loop coupled to both said resonators at points of maximum current therein.

2. An ultra high frequency modulator comprising a pair of cavity resonators, an electric discharge device having an anode, a cathode and a grid, means coupling said anode and grid to one of said cavity resonators, means connecting said grid and anode to the other of said resonators, means for impressing a high frequency signal between said grid and cathode, means supplying a modulating signal to said grid, means for deriving modulated signals from said one cavity resonator, and means for neutralizing feedback between said circuits due to the interelectrode capacitance of said tube comprising a closed conductive loop coupled to both said resonators at points of maximum current therein.

3. An ultra high frequency modulating system comprising a pair of cavity resonators defined by three concentric conductive cylinders, an electric discharge device having an anode connected to the inner of said cylinders, a grid connected to the intermediate of said cylinders and a cathode connected to the outer cylinder, means for impressing a wave to be amplified between said grid and cathode, the cavity resonator defined by said outer and said intermediate cylinders being tuned to the frequency of said wave, means for tuning the cavity resonator defined by said intermediate and said inner cylinders to said frequency, means supplying a modulating signal to said grid, and means for neutralizing feedback between said resonators due to the interelectrode capacitance of said device and said tuning means.

4. An ultra high frequency modulating system comprising a pair of cavity resonators defined by three concentric conductive cylinders, an electric discharge device having an anode connected to the inner of said cylinders, a grid connected to the intermediate of said cylinders and a cathode connected to the outer cylinder, means for impressing a wave to be amplified between said grid and cathode, the cavity resonator defined by said outer and said intermediate cylinders being tuned to the frequency of said wave, means for tuning the cavity resonator defined by said

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intermediate and said inner cylinders to said frequency, means supplying a modulating signal to said grid, and means for neutralizing feedback between said resonators due to the interelectrode capacitance of said device and said tuning means, said last means comprising a closed conductive loop coupled to said resonators at points of maximum current therein.

5. In an ultra high frequency system, the combination comprising an electric discharge device having an anode, a cathode and a grid, a first cavity resonator connected between said anode and said grid, said resonator comprising a first conductive cylinder connected to said anode, a second conductive cylinder concentrically surrounding said first cylinder, a metallic sleeve positioned within said second cylinder, said metallic sleeve being conductively connected with said grid and insulated from said second cylinder to form therewith a coupling capacitance between said grid and said second cylinder, a second cavity resonator connected between said cathode and said grid, and means for neutralizing feedback between said resonators through the interelectrode capacity of said device and through said coupling capacitance comprising a closed conductive loop coupled between said resonators.

6. An ultra high frequency amplifier comprising a pair of cavity resonators defined by three concentric conductive cylinders, an electric discharge device having an anode connected to the inner of said cylinders, a grid connected to the intermediate of said cylinders through a capacitance, and a cathode connected to the outer of said cylinders, means for impressing a signal to be amplified between said grid and said cathode, and means for preventing oscillation of said am-

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plifier due to feedback between said resonators through said capacitance and the interelectrode capacity of said device comprising a closed conductive loop coupled to said resonators in the vicinity of points of maximum current therein.

7. An ultra high frequency modulator comprising a pair of cavity resonators defined by three concentric conductive cylinders, an electric discharge device having an anode connected to the inner of said cylinders, a grid connected to the intermediate of said cylinders through a capacitance, and a cathode connected to the outer of said cylinders, means for impressing a wave between said grid and cathode, the cavity resonator defined by said outer and said intermediate cylinders being tuned to the frequency of said wave, means for tuning the cavity defined by said inner and said intermediate cylinders comprising a variable capacitor connected therebetween, means connected with said grid for supplying a modulating signal thereto, and means for preventing oscillation of said modulator due to the feedback between said resonators through said capacitance and said tuning means comprising a closed conductive loop coupled to said resonators and positioned at points of maximum current therein.

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The following references are of record in the file of this patent:

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