

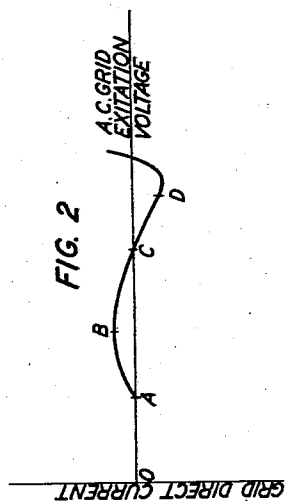
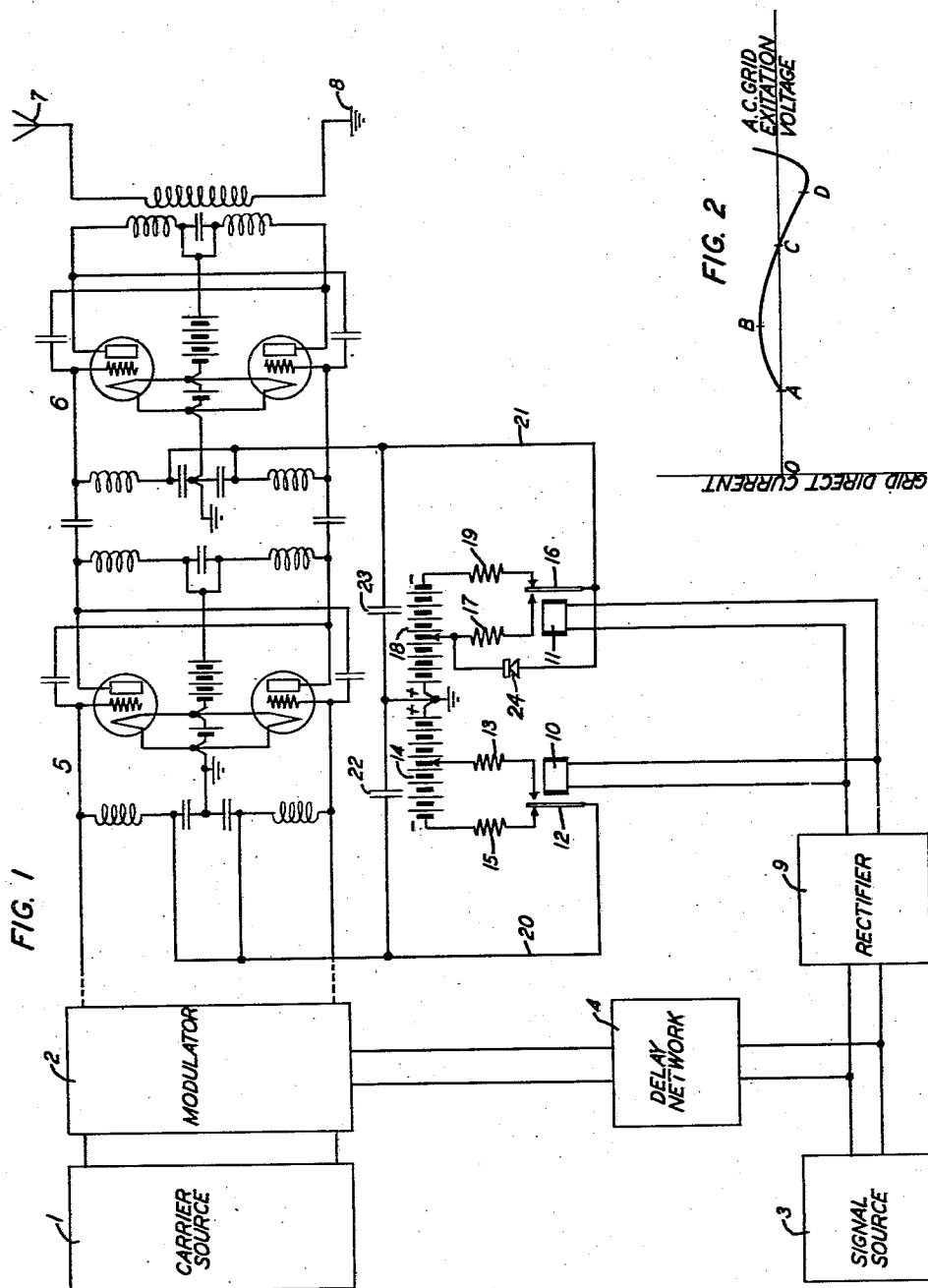
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CONTROLLING OR KEYING ARRANGEMENT

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CONTROLLING OR KEYING ARRANGEMENT

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This invention relates to controlling or keying arrangements for high power radio transmitters and more particularly to arrangements of the kind in which keying or the starting and stopping of transmission is effected by controlling the grid bias voltage of one or more power amplifier stages.

In order to utilize power amplifiers to full capacity it is customary to operate the vacuum tubes with considerable secondary emission of electrons from the grids. Commonly the current leaving the grid due to secondary emission exceeds the current entering, so that the result is a reverse grid current. These conditions accompany the application of large exciting voltages which cause the grid to swing strongly positive during a portion of each cycle. Since there is generally very little resistance in the input circuits of amplifiers of this type, the grid current does not usually operate to modify the grid bias.

When it is desired to control the output of the amplifier it is customary to do so by changing the grid bias. When it is desirable that the change in the output be gradual rather than sudden a smoothing arrangement such as a resistance-capacity filter in the grid circuit becomes necessary. Because of the flow of grid current through the resistance of the filter the grid bias is affected by the grid current. When secondary emission is large, so that the grid current decreases or reverses with increasing grid voltage, the flow of grid current in the filter resistances produces an unstable grid bias which tends to become indefinitely more positive until overloading or damaging of the tube results.

In accordance with the invention the filter resistance is shunted with a rectifier, poled in the proper direction to freely pass the reverse grid current. In this way the grid bias is effectively removed from the influence of the reverse current and is controlled by the grid current only when the latter is positive. As a result, the grid cannot become materially more positive than the normal bias imposed by the grid biasing source. The circuit is then stabilized and the vacuum tube is not subject to overloading.

In the accompanying drawing, Fig. 1 shows the embodiment of the invention in a radio telephone transmitter and Fig. 2 is a graph used in explaining the invention.

In the system of Fig. 1, a carrier source 1 is arranged to supply a carrier wave to a modulator 2. For effecting modulation of the carrier wave, a signal source 3 is connected to the modulator, a delay network 4 being interposed to permit any

desired switching operations to be completed while the signal wave traverses the network. The output circuit of the modulator is connected to a train of high frequency amplifying stages of which two are shown. These are denoted generally by 5 and 6, the latter of which is coupled to an antenna 7 and ground 8. The signal source is also connected to a rectifier 9 which is in turn connected to the respective operating windings 10 and 11 of a pair of electromagnetic relays. The armature 12 associated with winding 10 is provided with a front contact connected through a resistor 13 to an adjustable point in a grid biasing device exemplified by a battery 14. The armature 12 is also provided with a back contact which is connected through a resistor 15 to the negative terminal of the battery 14. The armature 16 associated with the relay winding 11 is provided with a front contact connected through a resistor 17 to an adjustable point in a battery 18 and with a back contact which is connected through a resistor 19 to the negative terminal of the battery 18. The armature 12 is conductively connected through a lead 20 and conventional grid supply arrangements to the grids of the amplifying stage 5. The armature 16 is similarly connected through a lead 21 to the grids of the amplifying stage 6. The positive terminals of the batteries 14 and 18 are grounded, as are likewise the cathodes of the amplifying stages 5 and 6. A pair of condensers 22 and 23 are connected respectively from the leads 20 and 21 to ground. Finally, a valve or rectifier 24 is connected between the relay armature 16 and the adjustable point in the battery 18. For reasons which will be explained below, the valve 24 is so directed as to pass current freely from the grid conductor 21 to ground through the adjustable point of the battery 18 and to substantially block current in the reverse direction.

In the operation of the system of Fig. 1, the carrier wave is supplied to the modulator by source 1 along with signals from source 3. The modulated wave is amplified in the stages 5 and 6 and impressed upon the antenna system 7, 8 for transmission to a distant point in known manner. The radiation of carrier waves is subject to voice or signal control by means of the rectifier 9, relays 10 and 11 and the grid batteries 14 and 18 in a known manner. The control is such that the carrier is radiated only during the actual signaling, with a consequent saving of power in intervals between signal elements, that is, between successive speech trains. The carrier suppression is effected by causing a paralyzing or

blocking value of grid bias to be applied to the stages 5 and 6 under control of the signals. To avoid mutilation of signals, the delay network 4 controls the application of the signal to the modulator, providing a suitable period for operation of the relays before the modulated carrier wave is applied to the stage 5.

When the system is in the inactive condition, the relay windings 10 and 11 are normally deenergized and the relay armatures 12 and 16 are resting against their respective back contacts. The condenser 22 is charged to the full battery voltage, biasing the stage 5 beyond cut-off and thereby substantially preventing transmission of the carrier. The condenser 23 is likewise fully charged, thus causing stage 6 to be biased in similar manner to a condition wherein transmission of carrier through this stage is substantially prevented.

When a signal is sent out by the source 3 the rectifier 9 is actuated to supply current suitable to energize relay windings 10 and 11, thereby causing armatures 12 and 16 to be moved to their respective front contacts. Armature 12, then connects the grids of stage 5 to a suitable operating potential in the battery 14 through the resistor 13. A smooth and gradual development of the operating potential on the grids is assured by the joint action of the resistor 13 and condenser 22, whereby the condenser adjusts its charge, by means of an accompanying current through the resistor, until a new equilibrium with the battery is established, in a manner that is well understood. Meanwhile armature 16 has connected the grids of stage 6 to a suitable operating potential from the battery 18 through the resistor 17. Smoothing is here effected by the joint action of the condenser 23 and resistor 17. When the operating potentials have been established the stages 5 and 6 are ready to amplify the output wave from the modulator.

When the signal current falls at the end of a signal element the relay windings 10 and 11 are immediately deenergized. The armatures 12 and 16 fall back, and the condensers 22 and 23 gradually charge up to the full battery voltages, with accompanying current through the resistors 15 and 19, respectively. When this action has been completed, the stages 5 and 6 are blocked and the control system is in the normal state, ready for the next signal element.

Fig. 2 shows in a general way the course of the grid current characteristic in stage 6 when various voltages of grid excitation are employed. In the region between the origin O and the point A the grid excitation is so low that the grids remain negative continually throughout the cycle of the high frequency wave. There is practically no grid current under this condition. With greater excitation grid current commences to flow and increases continuously between A and B. In the neighborhood of B the bombardment of the grid by the electrons from the filament is sufficiently intense to produce noticeable secondary emission from the grid. As the secondary emission increases the grid current increases less rapidly and eventually decreases as shown in the region BC. At C the grid current reverses, due to more electrons leaving the grid than entering. Further increase of the excitation increases the amount of reverse grid current until a certain maximum current is reached. Thereafter the current decreases and eventually a second reversal occurs.

In the operation of stage 6 as a power ampli-

fier, the development of the full output power of the vacuum tubes requires them to be operated under conditions of grid excitation which result in strong secondary emission and in a reversal of the grid current. The normal grid current in a typical case is indicated by point D on the curve of Fig. 2. If the grid current path external to the vacuum tubes contains a substantial amount of resistance, the fall of potential produced in this resistance by the reverse grid current will oppose the normal negative bias of the grid and, if large enough, may reduce the effective bias to zero or make it positive. The reduction of the grid bias tends to increase the reverse grid current with the result that a cumulative action occurs which produces a condition of instability. Parasitic oscillations may occur or the plate current of the vacuum tubes may rise to a destructive value.

In the amplifier illustrated, resistance 17, which controls the rate of growth of the amplified waves in stage 6, lies in the path of the grid current and, in the absence of suitable preventive means, would give rise to the type of instability described above. In accordance with the invention, this resistance is shunted by rectifier 24 which opposes the flow of normal grid current and offers a very small resistance to reversed grid currents. Since the rectifier does not come into action until the grid excitation has developed to substantially its full value, the resistance capacity filter 17, 23, is fully effective to control the growth of the amplifier output and to prevent the development of keying transients during the growth period. When the output has been fully developed and the secondary emission currents established, the rectifier 24 acts as a low resistance shunt to resistance 17 and thereby prevents an unstable condition being established.

To further promote stability and also to avoid distortion of signals in the amplifying stage 6, it is desirable that the rectifier 24 should maintain the potential drop across its terminals virtually constant regardless of current fluctuations over a wide range. For this reason a gas-filled diode tube or mercury vapor rectifier is particularly suitable, although other forms of valves and rectifiers may be used.

The valve 24 performs an additional function at the time when the signal ceases and the relay winding 11 deenergizes. The armature 16 then breaks away from its main contact, but due to the fact that the contact is paralleled by the valve 24 and because of the low resistance of the valve relative to the resistor 17, the main current is carried by the valve and the current which is broken at the contact is relatively small. Sparking at the contact is in this way substantially prevented. The deenergization of the windings 10 and 11 results in a gradual blocking of stages 5 and 6. The grid current through the valve 24 is thus safely reduced without imposing severe requirements upon the relay contact.

While the invention has been described in connection with its embodiment in a radio telephone transmitter it will be appreciated that it is equally applicable for telegraph purposes in systems where keying is effected by changing the grid bias of a power amplifier. Thus, in the circuit of Fig. 1, the signal source 3 may be a source of telegraph impulses in which case relays 10 and 11 operate as keying relays for interrupting the carrier in accordance with the telegraph pulses. For telegraph purposes modulator 2 and the con-

nection thereto from the source 3 become unnecessary and may be omitted. Rectifier 9 may also be omitted since the relays may operate directly from the telegraph pulses.

5 What is claimed is:

1. In a two-stage amplifier, in each stage, a condenser connected between the respective grid and cathode, a biasing source, a relay for changing the voltage of the respective biasing source;
10 means for connecting the biasing source across the respective condenser, said means including series resistors for controlling the rate of charge and discharge of the condensers and a rectifier connected between the grid and the cathode of
15 the second stage with its conductive direction from the amplifier grid toward the amplifier cathode.

2. In a two-stage amplifier, in each stage, a condenser connected between the respective grid
20 and cathode, a biasing source, a relay for changing the voltage of the respective biasing source, means for connecting the biasing source across the respective condenser, said means including series resistors for controlling the rate of charge
25 and discharge of the condensers, and a unidirectional

tionally conductive gas-filled tube connected between the grid and the cathode of the second stage with its conductive direction from the amplifier grid toward the amplifier cathode.

3. In a two-stage amplifier, grid biasing means
5 tapped for a plurality of voltages, individual relays for each stage to transfer the respective grids from one voltage tap of said biasing means to another, means for actuating said relays substantially simultaneously, a resistor in series with
10 one of the voltage taps for the second stage amplifier, and a rectifier connected between the grid and cathode of said second stage amplifier and poled to conduct from the grid towards the
15 cathode.

4. In a multistage amplifier, grid biasing means, relays in two of the stages for simultaneously changing the voltages applied to the respective grids by the biasing means, and a rectifier connected in parallel with the contacts of
20 the relay in the stage nearer the output, the conductive direction of the rectifier being from the grid toward the cathode.

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