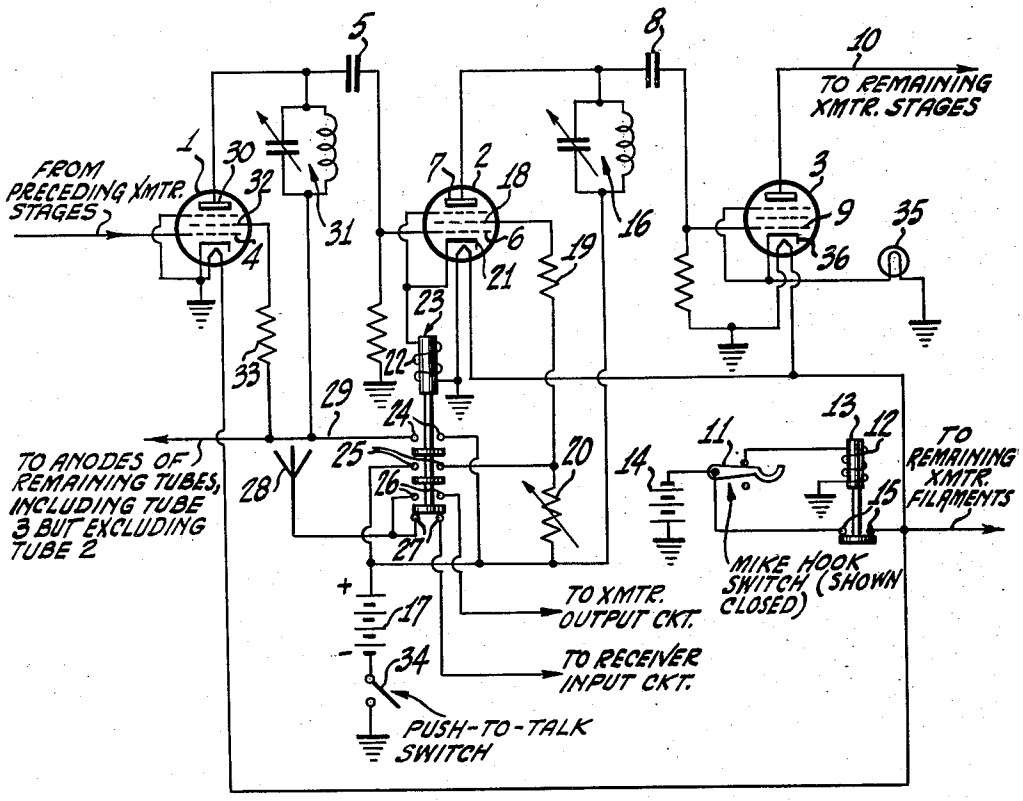
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TRANSMITTER INTERLOCK CIRCUIT

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TRANSMITTER INTERLOCK CIRCUIT

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This invention relates to an interlock circuit for transmitters, and more particularly to a circuit which prevents the application of anode voltage to the tubes of a transmitter until after the filaments have warmed up sufficiently.

The invention is particularly applicable to mobile communications equipment of the kind used in automobiles. Newly developed mobile communications equipment, operating at higher frequency, involves an increased battery drain as compared to prior equipment. In order to reduce the total battery drain, the filaments of the tubes in the mobile transmitter may be turned off during receiving periods. However, this means that the operator, when he desires to transmit, must wait until the filaments of the transmitter tubes are sufficiently heated before the anode voltage is applied to these tubes, since otherwise (if the anode voltage is applied too soon) these tubes might be damaged. Also, if the anode voltage is applied before the filaments have heated sufficiently, the transmitter power output might be of any value between zero and full power output, thus rendering communications rather uncertain. To avoid such possible tube damage and to make certain that the transmitter will operate with full power output from the instant of application of anode voltage to the transmitter tubes, it is desirable to provide an interlock on the transmitter anode voltage circuit, so that the operator cannot apply anode voltage to the transmitter tubes until after such tubes are sufficiently heated.

An object of this invention is to devise a novel circuit for preventing the application of anode voltage to the tubes of a transmitter until after these tubes are sufficiently heated.

An interlock circuit of the type previously referred to may be easily devised by using a thermally-operated timing switch arrangement or by using a timing motor circuit arrangement. However, arrangements of these types require special, extra, or additional components which increase materially the cost of the equipment.

Another object of this invention is to devise an anode voltage interlock arrangement for mobile radio transmitters which requires no extra devices other than those already present in the mobile transmitter.

The objects of this invention are accomplished, briefly, in the following manner: the filaments of the tubes in a mobile transmitter are normally deenergized but are energized in response to the removal from its hook of a microphone associated with the transmitter, and the consequent closure of the microphone hook switch. The operating winding of the antenna-changeover-relay is connected into the cathode circuit of one of the frequency multiplier tubes in the transmitter, which tube is used also as a control tube. When the microphone push-to-talk switch is depressed, anode voltage from the transmitter anode supply is applied to only the control tube. If the temperature of the emitter of this tube is then sufficiently high, the changeover relay winding is energized to switch

the antenna to the transmitter output and to apply anode voltage to all of the transmitter tubes by way of an extra set of contacts on this relay, thereby also lighting a signal lamp. If the push-to-talk switch is closed too soon, insufficient current will flow through the operating winding of the changeover relay and this relay will not be energized, thus keeping anode voltage off the transmitter tubes until the filaments have warmed up sufficiently and thereby also preventing the lighting of the signal lamp. By means of an extra set of contacts on the relay, a screen grid resistor for the control tube (which may be necessary in the circuit for proper operation of this tube as a control tube, but which is unnecessary for operation of this tube as a frequency multiplier in the transmitter) is short-circuited when the relay operates.

The objects of this invention will be better understood from the following description of an exemplification thereof, reference being had to the accompanying drawing, wherein the single figure is a schematic diagram of a circuit according to this invention.

Now referring to the drawing, the three pentode vacuum tubes 1, 2 and 3 constitute three of the stages of a mobile radio transmitter utilizing this invention and suitable for use in a vehicle. Assuming first that the transmitter is in operation, signal from the preceding stages of the transmitter is applied to control grid 4 of tube 1, is multiplied in frequency (or merely amplified) in this tube and is applied through a coupling capacitor 5 to the control grid 6 of tube 2, which acts during operation of the transmitter as the second frequency doubler (third frequency multiplier) of the transmitter and also acts as a control tube at some other times, as will hereinafter become apparent. The further-multiplied frequency appearing at the anode 7 of tube 2 is applied through a coupling capacitor 8 to the control grid 9 of tube 3, is further multiplied in frequency in this tube and is applied by way of a connection 10 to the remaining stages of the transmitter (not shown).

The mobile transmitter of this invention is usually associated with a mobile receiver (not shown) to constitute mobile communications equipment and is supplied with operating power from a battery in the vehicle. In order to reduce the total battery drain, the filaments of the transmitter tubes 1, 2 and 3, as well as those of the remaining transmitter tubes, are turned off during receiving periods, but are arranged to be turned on in response to the removal of the microphone (not shown) from its hook preparatory to the use of the microphone for transmitting a message by way of the transmitter. The removal of the microphone from its hook actuates the hook switch 11 to its closed position as illustrated. The contacts of the hook switch 11 are connected in series with the operating winding 12 of a relay 13 and the car battery 14, one terminal of the battery and relay being grounded as indicated. Thus, when the hook switch 11 is closed the relay 13 is energized, closing its normally-open contacts 15 (these contacts are illustrated in the closed position, since no microphone is shown on the hook 11). One end of the filament in each of the tubes 1, 2 and 3 (and also of the filament in each of the remaining transmitter tubes) is connected to ground, while the other end of the filament in each of the tubes in the transmitter is connected through the contacts 15 to the ungrounded or "hot" terminal of car battery 14. Thus, when contacts 15 are closed, the filament in each of the transmitter tubes 1, 2 and 3 (and also the filament in each of the remaining transmitter tubes) is connected directly across battery 14, so that the removal of the microphone from its hook energizes relay 13 and turns on all of the filaments of the transmitter tubes.

The multiplier (frequency doubler) tube 2, which is dormant during receiving periods, is used as a control

tube for the interlocking circuit arrangement of this invention. The anode 7 of tube 2 is connected through the inductance of the LC tuned anode circuit 16 to the positive terminal of the transmitter anode supply 17, which is illustrated as a battery but which may be any suitable type of D. C. power supply, such as a vibrator-type supply energized from the car battery 14. The screen grid 18 of tube 2 is connected through a fixed resistor 19 and an adjustable resistor 20 to the positive terminal of power supply 17, to provide a positive polarizing potential on screen grid 18.

The cathode 21 of tube 2 is connected through the energizing winding 22 of the antenna-changeover-relay 23 to ground, so that the anode current of tube 2 flows through the winding 22. Relay 23 has a pair of normally-open or "make" contacts 24, a pair of normally-open or "make" contacts 25, a pair of normally-open or "make" contacts 26, and a pair of normally-closed or "break" contacts 27. The contacts 27 connect the antenna 28 (when relay 23 is deenergized) to the receiver input circuit, and the contacts 26 connect the antenna 28 (when relay 23 is energized) to the transmitter output circuit. Thus, relay 23 may be termed an antenna-changeover-relay, and this relay is illustrated in the open or deenergized position.

A circuit extends from the positive terminal of power supply 17 through contacts 25 (when these contacts are closed) to the common junction point of resistors 19 and 20, so that when relay 23 is energized to close its contacts 25, the resistor 20 is short-circuited. The tube 2 is the only tube in the transmitter that is supplied with positive anode voltage directly from power supply 17. All the other transmitter tubes (1, 3, and others not shown) receive their anode voltage by way of a connection extending from the positive terminal of anode supply 17 through the normally-open contacts 24 of relay 23 to a bus 29, and thus anode voltage is applied to these tubes only when relay 23 is energized to close contacts 24 and energize the bus 29. The anodes and screen grids of all of such other transmitter tubes (1, 3, etc.) are supplied with positive potential only by way of bus 29. For example, the anode 30 of tube 1 is connected through the inductance of the LC tuned anode circuit 31 to bus 29, and the screen grid 32 of tube 1 is connected through a resistor 33 to bus 29.

In order to complete the circuit from anode supply 17 to tube 2, to thereby apply polarizing potential between the anode 7 and the cathode 21 of this tube, a microphone push-to-talk switch 34 is provided, this switch preferably being mounted on the microphone handle or handgrip in the conventional manner. Switch 34 is normally open and is spring-biased to open position, but when closed by manual pressure completes a circuit between the negative terminal of the D. C. anode supply 17 and ground and thus applies anode potential to tube 2, it being recalled that anode 7 of tube 2 is connected to the positive terminal of the anode supply 17 and that the cathode 21 of this tube is connected to ground through the operating winding 22 of relay 23. The drawing shows (for simplicity of illustration) the switch 34 directly in the battery circuit. In actual practice, this switch would energize a relay (not shown) whose contacts would in turn close the circuit from the negative side of battery 17 to ground.

It has previously been stated that the removal of the microphone from its hook, in preparation for the transmission of a message, actuates the hook switch 11 which closes relay 13, thereby turning on all the transmitter tube filaments. After the lapse of a sufficient time interval following the energization of the filaments, the temperature of the emitter of the control tube 2 will be sufficiently high to allow anode current to flow through this tube when the microphone push-to-talk switch 34 is depressed to supply anode voltage to said tube.

Only after sufficient anode current flows through the winding 22 of relay 23 (which winding is connected into the anode-cathode circuit of tube 2) will this relay be energized to close its normally-open contacts 24 and thereby connect all of the remaining transmitter tubes 1, 3 etc. to the anode voltage supply 17, thereby to supply anode voltage to such tubes.

If the push-to-talk switch 34 is pressed before sufficient filament warm-up time has elapsed, tube 2 will not be capable of passing enough anode current to energize relay 23, and in this case relay contacts 24 will remain open and anode voltage will not be applied to transmitter tubes 1, 3 etc. This unenergized condition of relay 23 will then obtain until the filaments have warmed up sufficiently so that tube 2 is capable of passing enough anode current to energize relay 23 and close its contacts 24, thereby applying anode voltage to all of the transmitter tubes. Since relay 23 will not be energized to apply anode voltage to transmitter tubes 1, 3 etc. until the filament of tube 2 has heated sufficiently, and since the filaments of all of the transmitter tubes are turned on simultaneously, the anode voltage cannot be applied prematurely to tubes 1, 3 etc., and possible damage to these tubes is thus avoided.

A signal lamp or pilot lamp 35 is connected in series in the anode-cathode circuit of tube 3, directly between the cathode 36 of this tube and ground. This lamp is lighted in response to the flow of anode current through tube 3 and through the lamp filament, which flow occurs when relay 23 is energized to apply anode voltage to tube 3, since at this time the filament of tube 3 is at a temperature sufficient for full anode current through this tube. Since relay 23 does not close until all of the transmitter tubes are at a sufficiently high temperature for full transmitter output, the lighting of signal lamp 35 (in response to the application of anode voltage to tube 3) indicates to the operator that full transmitter power output is available. If the push-to-talk switch 34 is pressed before sufficient warm-up time has elapsed, the relay 23 will not be energized (as previously described), anode voltage will then not be applied to tube 3, and the lamp 35 will not light. This unlighted condition of lamp 35 indicates to the operator that he has no transmitter power output. The lamp 35 thus provides a clear, positive indication of full transmitter output and communications are made certain.

By the utilization in the tube 2 circuit of an adjustable screen grid resistor 20, the anode current of the tube 2 (which tube functions during transmission as a frequency doubler tube operating at, say, 152 mc. and functions during transmitter energization periods as a control tube) can be adjusted to the exact value necessary, after the tube filament warm-up time, to energize or pull in the relay 23. When normal transmitter operation is ready to take place, the relay 23 is energized as previously described, closing its contacts 25 and short-circuiting the resistor 20, the screen grid current of tube 2 then flowing through contacts 25 and resistor 19. Resistor 19 is the normally-used screen grid resistor used for transmission. This arrangement of the extra resistor 20 short-circuited when contacts 25 are closed, means that the doubler tube 2 circuit can be designed for optimum RF operation, with no concern as to its other function as a control tube for the interlock circuit. Alternatively, resistor 20 could be omitted if proper control action could be obtained without it, in the tube 2 circuit.

Relay 23 closes, as previously stated, only when all of the transmitter tubes are at a sufficiently high temperature for full transmitter output, and this relay then closes its contacts 24 to apply anode voltage to all of the transmitter tubes. The transmitter may then be operated for communication purposes as desired, that is, for the transmission of a message, and tube 2 (used as a control tube for the interlock circuit, to effect proper energization of the transmitter tubes) then enacts its

other role, the frequency multiplication of the input thereto. It is enabled to properly carry out this function because of the short-circuiting of resistor **20** by the contacts **25** of the changeover relay **23**.

When relay **23** operates as described to complete the enabling of the transmitter, contacts **27** are opened to disconnect the antenna **28** from the receiver input circuit and contacts **26** are closed to connect the antenna to the transmitter output circuit. Then, the anenna **28** is changed over and is properly connected for transmission.

It will be noted that this invention provides a transmitter interlock circuit without requiring any additional parts. The tube **2**, used as the control tube, is one of the transmitter tubes already present and is dormant during receiving periods. The extra sets of contacts on the antenna changeover relay **23** are usually already present. The signal light **35** is not an extra or additional component. Thus, the cost of the equipment is not increased by the incorporation of this invention.

Light **35**, alternatively, can be in series with any other of the remaining tubes (such as tube **1**) or in series with any combination of, or even all of, the remaining tubes.

The control tube **2** is illustrated as a pentode. However, this tube could be a triode or a tetrode, equally well. If a triode were used, the contacts **25** of relay **23** could be utilized to control some combination of grid or anode voltage, thereby to obtain proper operation when this tube acts in its role of control tube.

What is claimed is:

1. A radio transmitter energization circuit comprising a transmitter having a plurality of electron discharge devices coupled together for the transmission of signals therethrough, each of said devices having at least an anode electrode and a cathode electrode, means for heating the cathode electrodes of all of said devices to electron-emitting temperature, a controllable circuit for energizing the heating means of all of said devices simultaneously, a source of unidirectional energizing voltage for the anode-cathode circuits of said devices, means for applying the voltage of said source between the anode electrode and the cathode electrode of one only of said devices, and means acting in response to the flow of a predetermined current through said one device to apply the voltage of said source between the anode electrode and the cathode electrode of each of the remaining devices.

2. A radio transmitter energization circuit comprising a transmitter having a plurality of electron discharge devices coupled together for the transmission of signals therethrough, each of said devices having at least an anode electrode and a cathode electrode and one of said devices also having a control electrode, means for heating the cathode electrodes of all of said devices to electron-emitting temperature, a controllable circuit for energizing the heating means of all of said devices simultaneously, a source of unidirectional energizing voltage having a positive terminal and a negative terminal, means for applying the voltage of said source between the anode electrode and the cathode electrode of only said one device, and means acting in response to the flow of a predetermined current through said one device to apply the voltage of said source between the anode electrode and the cathode electrode of each of the remaining devices and to vary the value of an impedance in series circuit between said positive terminal and said control electrode.

3. A radio transmitter energization circuit comprising a transmitter having a plurality of electron discharge devices coupled together for the transmission of signals therethrough, each of said devices having at least an anode electrode and a cathode electrode and one of said

devices also having a control electrode, means for heating the cathode electrodes of all of said devices to electron-emitting temperature, a controllable circuit for energizing the heating means of all of said devices simultaneously, a source of unidirectional energizing voltage having a positive terminal and a negative terminal, means for applying the voltage of said source between the anode electrode and the cathode electrode of only said one device, means acting in response to the flow of a predetermined current through said one deveice to apply the voltage of said source between the anode electrode and the cathode electrode of each of the remaining devices and to vary the value of an impedance in series circuit between said positive terminal and said control electrode, and an indicating lamp connected in series in the anode-cathode circuit of one of the said remaining devices.

4. In a mobile radio communications system including a vehicle-mounted transmitter, said transmitter having a plurality of electron discharge devices coupled together for the transmission of signals therethrough and each of said devices having at least an anode electrode and a cathode electrode: means for heating the cathode electrodes of all of said devices to electron-emitting temperature, a controllable circuit for energizing the heating means of all of said devices simultaneously, a source of unidirectional energizing voltage for the anode-cathode circuits of said devices, means for applying the voltage of said source between the anode electrode and the cathode electrode of one only of said devices, an antenna, and means acting in response to the flow of a predetermined current through said one device to apply the voltage of said source between the anode electrode and the cathode electrode of each of the remaining devices and also to connect said antenna to the output circuit of said transmitter.

5. In a mobile radio communications system including a vehicle-mounted transmitter, said transmitter having a plurality of electron discharge devices coupled together for the transmission of signals therethrough, each of said devices having at least an anode electrode and a cathode electrode and one of said devices also having a control electrode: means for heating the cathode electrodes of all of said devices to electron-emitting temperature, a controllable circuit for energizing the heating means of all of said devices simultaneously, a source of unidirectional energizing voltage having a positive terminal and a negative terminal, means for applying the voltage of said source between the anode electrode and the cathode electrode of only said one device, an antenna, means acting in response to the flow of a predetermined current through said one device to apply the voltage of said source between the anode electrode and the cathode electrode of each of the remaining devices, to vary the value of an impedance in series circuit between said positive terminal and said control electrode, and also to connect said antenna to the output circuit of said transmitter, and an indicating lamp connected in series in the anode-cathode circuit of one of the said remaining devices.

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