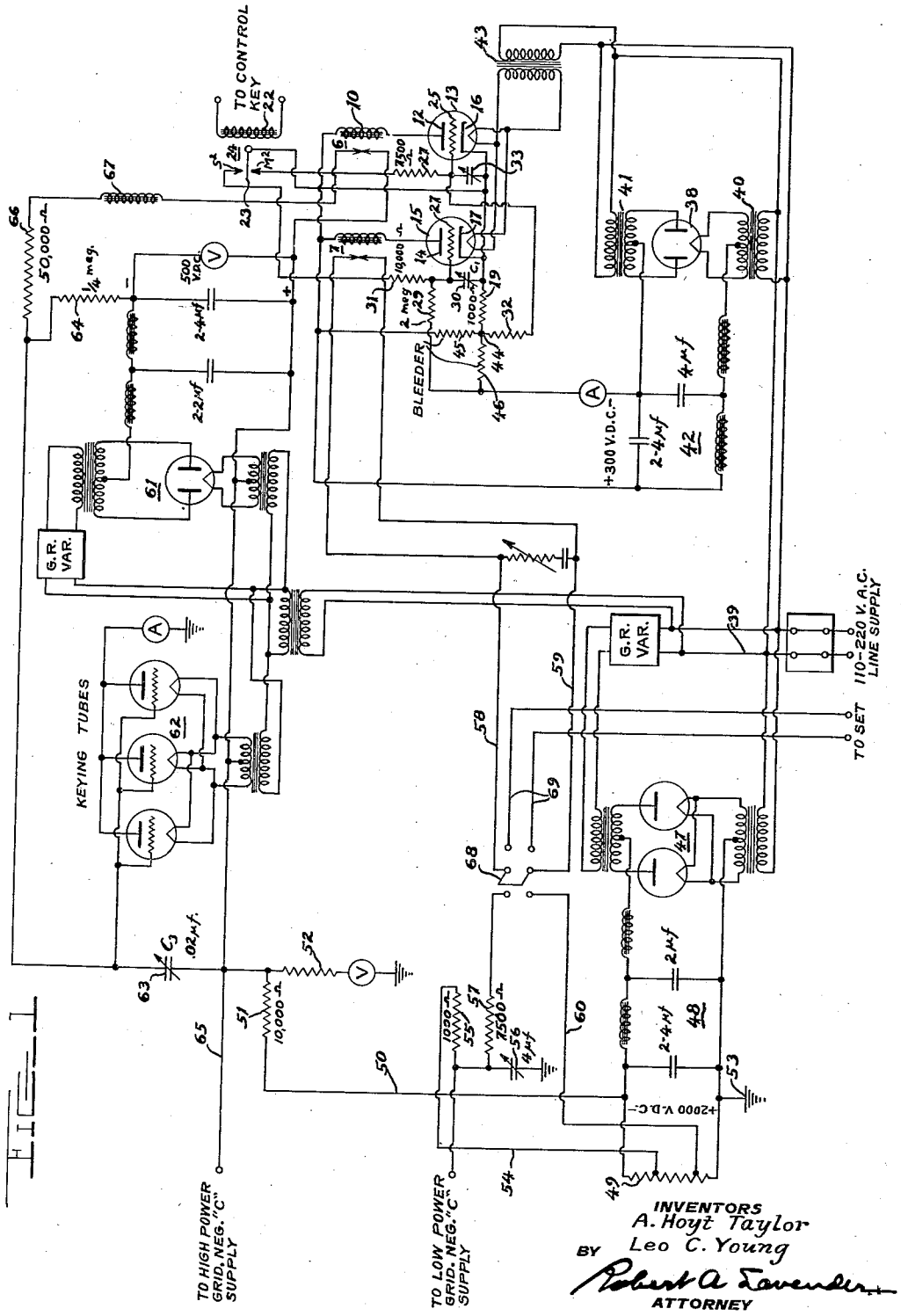
March 14, 1939. A. H. TAYLOR ET AL 2,150,193

KEYING RADIO TRANSMITTER

Filed Feb. 23, 1937 3 Sheets-Sheet 1



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FIG. 2

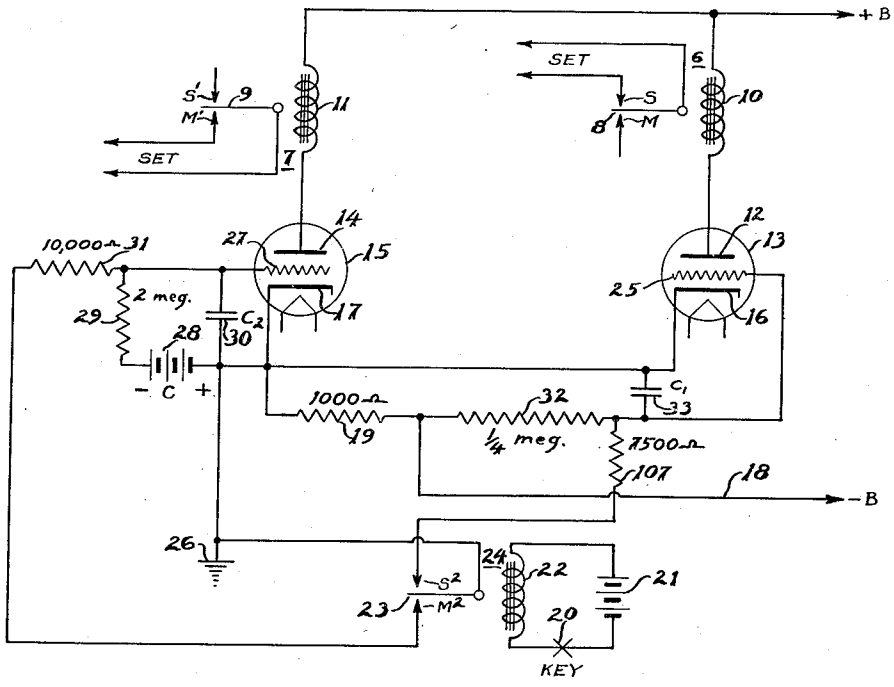
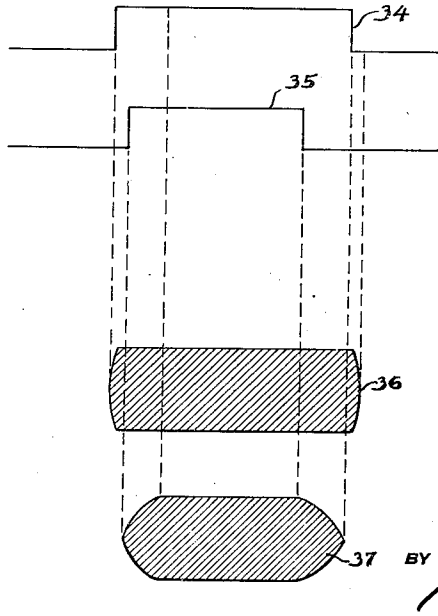


FIG. 3



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FIG. 4

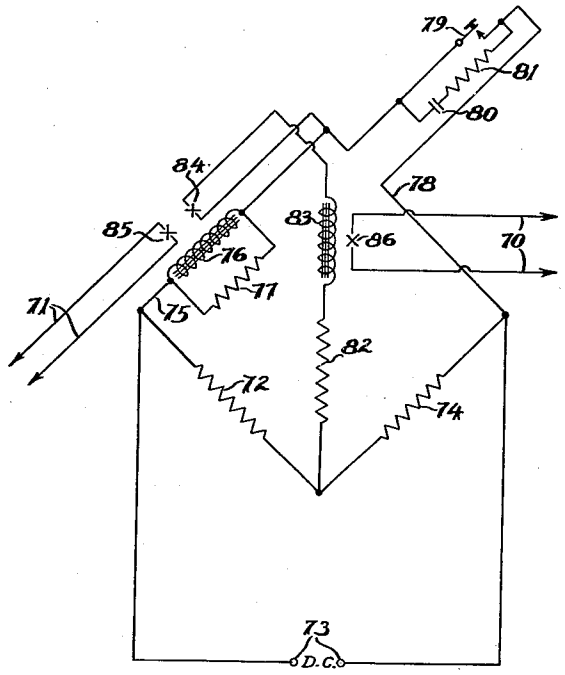
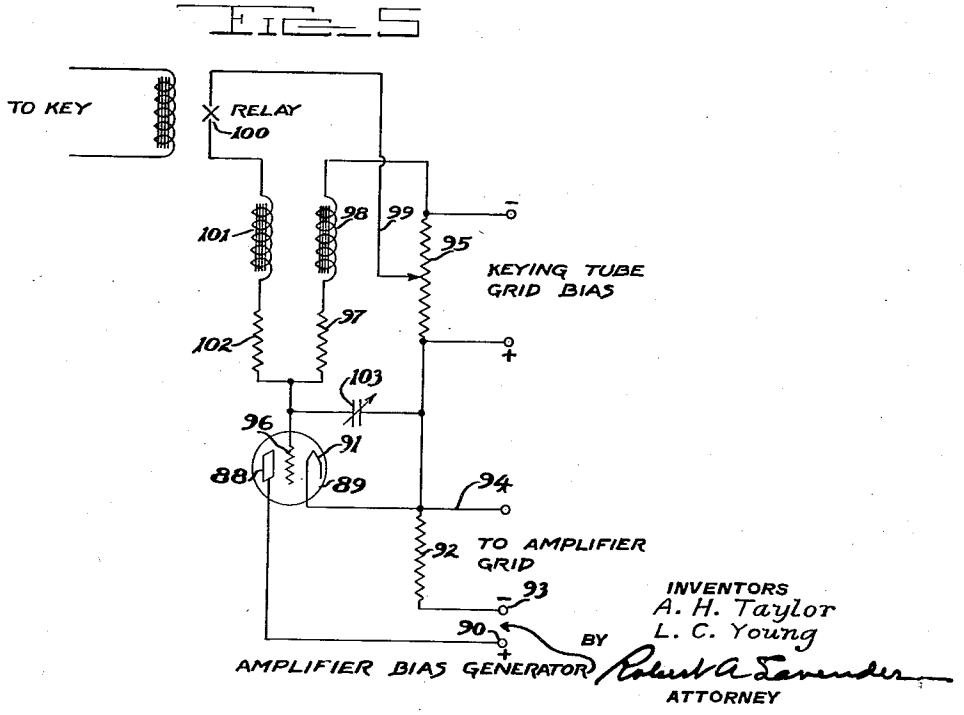


FIG. 5



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KEYING RADIO TRANSMITTER

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Application February 23, 1937, Serial No. 126,960

21 Claims. (Cl. 178—66)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

This invention relates broadly to means for interrupting the output of a radio transmitter for the purpose of signaling and more particularly to means for preventing the disturbances known as key clicks that have heretofore been present in signals so transmitted.

It is an object of our invention to provide a means for keying radio transmitters without giving rise to key clicks or to noises that may be due to bouncing relays. A further object is to prevent the abrupt growth and decay of the current in the transmitting antenna. A still further object is to cause the signal current to increase and decrease gradually so that the ends of the envelope of the signal are rebounded. An additional object is to key the transmitter system at two different stages thereof and to prevent interaction between the circuit elements affecting the keying at such two stages to eliminate interfering effects or inefficient operation arising from such interaction.

In the drawings:

Fig. 1 is a schematic representation of one successful arrangement for practicing our invention;

Fig. 2 is a fragmentary diagram illustrating the underlying principle of our invention;

Fig. 3 shows the relative times of closing the circuits at the two stages in the transmitter and the effect thereof upon the shape of the envelope;

Fig. 4 illustrates schematically a bridge arrangement for effecting the objects above enumerated; and

Fig. 5 depicts a type of bias forming circuit that depends upon the time constants of the circuit to secure the desired timing.

It is well-known to those skilled in this art that key clicks are a source of interference to reception of continuous wave signals, particularly where several channels of communication are used simultaneously with transmitters, receivers and antennae in close proximity to each other. The nature of the impulses transmitted by a keyed transmitter was carefully investigated by means of an oscillograph in connection with a relatively low frequency system.

These studies showed that key clicks were in general traceable to two faults, both of them lying in the transmitter; first, the presence of transients due to the rapid rise and rapid decay of the radio frequency currents in the antenna; and second, the presence of transient direct current voltages in the antenna. In the first category are included not only those transients that might be due to the normal rise and fall of current in the stages keyed but also any transients due to bouncing relays or to effects arising in subsequent frequency multipliers due to the use of circuits with the high bias that is necessary for frequency multiplication. In the second category it was found that the abrupt turning on of current in the last stage, even though the last tubes were not oscillating, resulted in very vicious transients set up by the rapid rise and fall of the plate current of the last stage, through values of the same order of magnitude as those obtaining during normal operation, even though no radio frequency excitation was applied to any of the grids.

It was at first believed that the problem could be solved by keying the last stage of the transmitter and smoothing out the operation, which would avoid the transients arising in the multiplying circuits when the usual practice of keying a low power stage is followed. However, it was found that although the key clicks might be suppressed in this manner, it would still leave the intermediate stages and the master oscillators with their very disturbing sub-harmonics all in operation when the key is open, resulting not only in undesirable transients but also in wastage of power. It was therefore apparent that not only must the last stage be keyed but the first stage as well.

Keying two stages required that the timing of the last stage with respect to the first be properly and automatically adjusted since, no matter how effective may be the smoothing out in the first stage, the intermediate stages are capable of undoing all that has been done. Therefore, all keying transients in the earlier stages must have ceased completely before the final stage begins its smoothing out process, and in addition to that, the final stage must cease its smoothing out process before the first stage breaks. In other words, the operation of the first stage must overlap slightly in time on both ends of the operation of the last stage and the adjustment must not be critical. Another desirable feature was a system that could be built in as an integral part of a new transmitter or could be used as an adjunct to existing transmitters. The apparatus shown in the drawings and now to be described has been found completely satisfactory. In fact, the smoothing out on the last stage is so effective that even a relay bounce in the earlier stages does not affect the signal transmitted.

Reference will now be made to Fig. 2 to explain the underlying theory of operation of the present invention. In this figure are represented two relays 6 and 7 that respectively control the operation of the high power stage and the low power stage of a radio transmitter by varying the grid biasing voltage. These relays are biased so that the respective armatures 8 and 9 are in contact with the respective spacer contacts S and S' when the respective co-acting solenoids 10 and 11 are not energized, and are moved to the marker contacts M and M' when the respective

solenoids are energized. It will be noted that the circuit to the set is closed through relay 6 when armature 8 is against contact S whereas the armature 9 closes the circuit to the set when against contact M'. That is, the circuit through relay 6 is broken when solenoid 10 is energized and is closed through relay 7 when solenoid 11 is energized. Solenoid 10 is connected in the circuit of plate 12 of the vacuum tube 13 and solenoid 11 is likewise connected to the plate 14 of vacuum tube 15, the respective cathodes 16 and 17 of these tubes being connected to the negative B supply 18, through the thousand ohm resistive impedance 19. It is to be understood that the values for the various circuit elements herein stated are illustrative and not limiting, the essential feature being that they shall be so chosen as to give the time constants desired in any particular application.

The controlling key is indicated at 20 and is shown in circuit with a battery 21 and a solenoid 22 that actuates armature 23 of biased relay 24 having a spacer contact S^2 against which armature 23 lies when solenoid 22 is not energized and a maker contact M^2 against which that armature is drawn by solenoid 22. When key 20 is open armature 23 is against contact S^2 and connects the grid 25 of tube 13 to ground at 26 through resistance 107, having a value of 7500 ohms, which results in a low bias on grid 25 and consequently tube 13 will pass current which energizes solenoid 10, and holds armature 8 against contact M, thus keeping open the circuit to the high power stage and allowing a blocking bias to be applied thereto as will be fully set forth hereafter. At the same time, the grid 27 of tube 15 is connected to biasing battery 28 through the two megohm resistance 29 and condenser 30, connected between cathode 17 and grid 27 of tube 15, and acquires a high negative potential whereby tube 15 is blocked and armature 9 of relay 7 is against contact S', which keeps open the circuit to the low power stage of the set.

When key 20 is closed the armature 23 of relay 24 is drawn against contact M^2 to connect condenser 30, having a capacity of 0.07 microfarad, to ground through the relatively low resistance 31 of 10,000 ohms, which quickly unblocks tube 15 and allows current to pass, thus energizing solenoid 11 and drawing armature 19 against contact M' to close the circuit to the low power stage of the set and unblock that stage, whereby that stage is set in operation. Closing of the key 20 breaks the connection of grid 25 to ground through resistance 107 and causes condenser 33, of 0.01 microfarad, that is connected between cathode 16 and grid 25 to charge through the ¼ megohm resistance 32, which slowly blocks the tube 13, de-energizes solenoid 10 and permits armature 6 to be moved against contact S and thereby close the circuit to the high power stage and so render the whole transmitter operative. When key 20 is opened relay 24 is de-energized, armature 23 is moved against contact S^2 and condenser 33 is quickly discharged through resistance 107, the low capacity of the condenser and the low resistance giving a small time constant, the tube 13 again passes current and breaks the circuit to the high power stage by way of relay 6. The action of relay 24 when the key is opened breaks the low resistance path to ground of condenser 30 and this condenser is slowly charged through high resistance 29 to block tube 15 which de-energizes solenoid 11 and breaks the circuit to the low power stage. It will be noted from the foregoing that the low power stage goes into action before the high power stage and continues in action after the high power stage has ceased to operate. It is obvious that the time interval between the keying of the low power stage and of the high power stage may be made of any suitable value by proper choice of the circuit elements to give the time constants sought and the same applies to the interval between the cessation of operation of the high power stage and that of the low power stage.

In Fig. 3 line 34 indicates the time of operation of the low power stage while line 35 indicates the similar value for the high power stage and the resulting envelope shapes are indicated at 36 and 37 respectively in this figure. Due to certain circuit elements that will be hereinafter set forth, the action of the low power stage does not begin or end abruptly, which somewhat rounds the ends of the envelope as indicated at 36 while the additional smoothing out and rounding off arising from the rate at which the high power stage is activated and rendered inactive is shown at 37.

Referring now to Fig. 1, the disclosure of our invention is further developed. Inasmuch as certain parts therein have the same functions and equivalent values as do parts above described in connection with Fig. 3, they will be given the same reference characters and no detailed explanation will be made thereof. However, it is to be noted that the B supply is derived from a rectifier 38 connected to alternating current supply 39 by transformers 40 and 41, the output of the rectifier 38 being smoothed by a filter 42, and the filaments of tubes 13 and 15 being supplied from a filament transformer 43. The positive and negative sides of the output circuit of rectifier 38 are respectively connected to the common point 44 by the bleeder resistances 45 and 46.

The grid negative bias potentials for the transmitter high power and low power stages are supplied by the rectifier 47, whereof the output is smoothed by filter 48 and passes through a voltage divider 49. The high voltage for the high power stage is taken from the negative side of the output circuit of rectifier 47 by a conductor 50 that is connected through 10,000 ohm resistance 51 and resistance 52 to ground, the positive side of the rectifier output being also grounded at 53. The grid negative bias potential for the low power stage of the transmitter is taken from the lead 54 which is connected through 1000 ohm resistance 55 and 4 microfarad condenser 56 to ground. Connected between resistance 55 and condenser 56 is 7500 ohm resistor 57 that may be connected through wire 58, relay 7, and wires 59 and 60 to the voltage divider 49.

Still referring to Fig. 1, the relay 6 controls the negative grid bias on the high power stage through the apparatus now to be described. Rectifier 61 supplies the grid biasing potential for the keying tubes 62. When solenoid 22 is not energized armature 23 of relay 24 is against contact S^2, tube 13 is passing current and the circuit to the set is broken at relay 6. This causes the condenser 63 to charge through the ¼ megohm resistance 64 and block the tubes 62 which makes their impedance practically infinite and results in the filaments of the tubes 62 having impressed upon them the full negative voltage from rectifier 47 and therefore applies the full negative grid potential to the high power stage through lead 65 and blocks that stage. When solenoid 22 is energized the tube 13 is blocked as above described and relay 6 is actuated to

close the circuit and permit condenser 63 to discharge through 50,000 ohm resistance 66 and inductors 67, the effect of resistance 66 and inductors 67 being to prevent the abrupt unblocking of the keying tubes 62 with the consequent rapid decrease in negative grid potential on the high power stage, which smooths out the action of that stage when it begins to operate. Likewise, when solenoid 22 is not energized, tube 15 is blocked and the circuit to the low power stage is broken at relay 7 which results in applying to the low power stage a negative potential determined by the point of connection of lead 54 to voltage divider 49 and the charging of condenser 56 through the resistance 55, thereby blocking the low power stage. However, when the solenoid 22 is energized the relay 7 closes the circuit before the circuit controlled by relay 6 is closed, as above explained, and the condenser 56 discharges through resistance 57 and so decreases the biasing potential on the low power stage that this stage is brought into action prior to the action of the high power stage, the effect of the discharge of condenser 56 through resistance 57 being to prevent abruptness of beginning action by the low power stage. It is to be understood that normally the conductors 58 and 59 are connected to resistance 57 and conductor 60 respectively by the double-pole, double-throw switch 68 which may, however, be thrown to connect relay 7 to the leads 69 that are connected to the keying devices usually provided in the set, thereby permitting utilization of the keying apparatus provided by the manufacturer for the low power stage in connection with the high power stage control of our invention, or the switch 68 may be so connected for testing purposes.

It is apparent from the foregoing that tubes 62 are in effect a portion of a grid negative bias voltage divider whereof the voltage dividing ratio can be shifted gradually and as desired between the required limits. Also, the time delay devices governing the rise and fall of grid potential of the high power tube of the transmitter are associated not with the grid of the high power tube but with the grids of the keying tubes 62, which operate solely under direct current conditions with no radio frequency in them or the circuits associated therewith and therefore can be easily handled.

When solenoid 22 is again de-energized the action of relays 6 and 7 is as above described in connection with Fig. 2. This results in again charging the condenser 63 to block the keying tube 62 and also to charge the condenser 56, whereby blocking potentials are applied first to the high power stage and then to the low power stage, but the time constants of the various circuit elements involved prevent abrupt changes in the biasing potentials. It will be observed that the lead 65 is connected between resistance 51 and the keying tubes 62 and therefore resistance 51 and tubes 62 act as a variable ratio potentiometer to control the negative bias applied to the high power stage of the transmitter.

In Fig. 4 we show a modified means for actuating the relays 6 and 7, wherein the leads 70 constitute a portion of the circuits associated with the keying tubes 62 and the leads 71 are likewise connected to leads 58 and 59 of Fig. 1. This part of our invention consists of a bridge having a resistance 72 in one arm connected at one end to one side of a source 73 of direct current and at its other end to an arm having in it a resistance 74 whereof the second end is connected to the other side of source 73. Arm 75 is connected to the common point of the arm 72 and the first mentioned side of source 73 and includes a solenoid 76 in shunt with a resistance 77, the other end of this arm being connected to the fourth arm 78 of the bridge that includes a key 79 bypassed by a condenser 80 in series with a resistance 81. Connected between the common point of arms 75 and 78 and the common point of the respectively opposite arms is a resistance 82 in series with a solenoid 83 and a relay armature and co-acting contact designated by 84, the said relay mechanism 84 being disposed to have the armature thereof moved to close the circuit through solenoid 83 and resistance 82 when solenoid 76 is energized, the armature thereof being biased in accordance with the usual practice to break the circuit when solenoid 76 is not energized. Relay devices 85, also operated by solenoid 76 control the circuit through the conductors 71. At 86 is disposed a relay device that closes the circuit through conductors 70 when solenoid 83 is energized and is biased to break the circuit at that point when the solenoid 83 is not energized. With key 79 open there is no flow of current through solenoid 76 and therefore the relay mechanism at 84 keeps open the circuit through solenoid 83 and the circuits through the conductors 70 and 71 are broken at 86 and 85 respectively. Upon closing key 79 the circuit through conductor 71 is closed by the action of solenoid 76 upon relay 85 and likewise the circuit through solenoid 83 is closed at 84 which results in the operation of relay 86 to close the circuit through conductors 70. It is thus seen that the low power amplifier controlled through conductors 71 is set in operation prior to the operation of the high power stage through the conductors 70 and also that when key 79 is opened the action of resistance 77 and solenoid 76 is to delay the opening of the relay 85 but the impedance of solenoid 83 and resistance 82 is so great that the circuit through conductor 70 is broken at 86 before the circuit through conductors 71 is broken at 85. Relay 76 is of the quick closing, slow opening type, while relay 83 is both quick closing and quick opening.

Fig. 5 illustrates schematically a circuit for forming and controlling the grid bias of the keyed amplifier tube of a transmitter. The plate 88 of keying tube 89 is connected to the positive terminal 90 of the amplifier bias generator and the cathode 91 of this tube is connected through resistance 92 to the negative terminal 93 of the bias generator, the conductor 94 connecting the grid of the keyed tube (not shown) to that terminal of resistance 92 that is at a high negative potential when the tube 89 is not passing plate current. The full grid bias for keying tube 89 is applied across resistor 95 whereof the positive end is connected to cathode 91 and the negative end is connected to grid 96 of tube 89 through inductance 98 and resistance 97 in series. Some suitable point on resistance 95 is connectible to grid 96 through conductor 99, key-controlled relay 100, inductance 101 and resistance 102 in series. Grid 96 and cathode 91 are connected through variable condenser 103. When relay 100 is open the full potential across resistance 95 is applied to grid 96, blocking tube 89 and impressing upon the amplifier grid, through conductor 94, the full value of the amplifier negative bias from 93, which blocks the amplifier. Actuation of the key (not shown) energizes solenoid 104 and closes relay 100, which connects grid 96 to

a point on resistance 95 having a potential which permits plate current to flow through tube 89, thus lowering the negative potential impressed upon conductor 94 by the value of the IR drop through resistance 92, which unblocks the keyed tube in the amplifier and sets the amplifier in operation. The values of the various elements of this circuit are so chosen as to give time constants that cause gradual building up and decay of the currents in the amplifier, thus rounding off the ends of the wave train.

It will be apparent from the foregoing that we have provided means not only for effecting gradual increase and decrease of the wave trains, but also to prevent interaction between the several control circuits and so have eliminated the detrimental effects mentioned as being heretofore present in radio transmitters.

As used in the appended claims the term "signal pulse" refers to that part of a signal, such as a dot or dash, that is transmitted as a single wave train of short duration.

The invention described herein may be manufactured and/or used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

We claim:

1. A system of the class described, comprising a source of grid-biasing potential, means associated therewith to derive therefrom two potentials of different magnitudes; means for applying the higher of said potentials, including a resistive impedance and vacuum tube means with its grid terminal connected to said impedance, a capacitive element connected between the grid terminal of said vacuum tube means and said impedance, the anode terminal of said vacuum tube means being grounded, a grid-biasing lead connected to a point between said impedance and said element, a source of potential connected to impress a grid-biasing potential on said vacuum tube means and to charge said capacitive element, a relatively high resistance in the connection between the negative side of said last mentioned source and said grid terminal, and means connecting the opposite terminals of said last mentioned source including a resistive impedance, an inductive reactance, and a first, normally open relay; means for applying the lower of said potentials, including two resistive impedances in series, a grid-bias lead connected between said impedance, a capacitive element connected at one side between said series impedances and at the other side to ground, and a second, normally open relay; a vacuum tube circuit connected to operate said first relay, a second vacuum tube circuit connected to operate said second relay, and a double-acting relay connected to control said vacuum tube circuits having a normal position to maintain both said first and second relays in open position and a second position to cause the closing of said first and second relays, the elements in said vacuum tube circuits having such time constants that when said double-acting relay is moved to said second position said second relay is closed quickly and said first relay is closed more slowly and upon returning said double-acting relay to its normal position said first relay is opened quickly and said second relay is opened more slowly.

2. A system of the class described, comprising a source of grid-biasing potential, means associated therewith to derive therefrom two potentials of different magnitudes; means for applying the higher of said potentials, including a resistive impedance and vacuum tube means with its grid terminal connected thereto, a capacitive element connected between the grid terminal of said vacuum tube means and said impedance, the anode terminal of said vacuum tube means being grounded, a grid-bias lead connected to a point between said impedance and said element, a source of potential connected to impress a grid-biasing potential on said vacuum tube means and to charge said capacitive element, a relatively high resistance in the connection between the negative side of said last mentioned source and said grid terminal, and means connecting the opposite terminals of said last mentioned source including delay elements and a first, normally open relay; means for applying the lower of said potentials, including two resistive impendances in series, a grid-bias lead connected between said impedances, a capacitive element connected at one side between said series impedances and at the other side to ground, and a second, normally open relay; a vacuum tube circuit connected to operate said first relay, a second vacuum tube circuit connected to operate said second relay, and a double-acting relay connected to control said vacuum tube circuits having a normal position to maintain both said first and second relays in open position and a second position to cause the closing of said first and second relays, the elements in said vacuum tube circuits having such time constants that when said double-acting relay is moved to said second position said second relay is closed quickly and said first relay is closed more slowly and upon returning said double-acting relay to its normal position said first relay is opened quickly and said second relay is opened more slowly.

3. A system of the class described, comprising a source of grid-biasing potential, means associated therewith to derive therefrom two potentials of different magnitudes; means for applying the higher of said potentials, including a resistive impedance and vacuum tube means with its grid terminal connected thereto, a capacitive element connected between the grid terminal of said vacuum tube means and said impedance, the anode terminal of said vacuum tube means being grounded, a grid-bias lead connected to a point between said impedance and said element, a source of potential connected to impress a grid-biasing potential on said vicuum tube means and to charge said capacitive element, a relatively high resistance in the connection between the negative side of said last mentioned source and said grid terminal, and means connecting the opposite terminals of said last mentioned source including a resistive impedance, an inductive reactance, and a first, normally open relay; means for applying the lower of said potentials, including two resistive impedances in series, a grid-bias lead connected between said impedances, a capacitive element connected at one side between said series impedances and at the other side to ground, and a second, normally open relay; and manually controllable means to operate said relays, including elements automatically acting to close said first relay a predetermined interval after closing said second relay when said controllable means is actuated and to open said first relay a predetermined interval before opening said second relay when such actuation of said controllable means ceases.

4. A system of the class described, comprising a source of grid-biasing potential, means asso-

ciated therewith to derive therefrom two potentials of different magnitudes, means for applying the higher of said potentials including devices constituting in effect a potentiometer with one portion of fixed value and the other portion of variable value, a grid bias lead connected to a point between said portions, means associated with said devices to change the value of said other portion and having inherent characteristics to make any such change gradual, said associated means including a first, normally open relay; means for applying the lower potential including series resistive impedances, a capacitive element connected to a point between said impedances and to ground, a grid bias lead connected to a point between said impedances, and a second, normally open relay; a vacuum tube circuit connected to operate said first relay, a second vacuum tube circuit connected to operate said second relay, and a double-acting relay connected to control said vacuum tube circuits having a normal position to maintain both said first and second relays in open position and a second position to cause the closing of said first and second relays, the elements in said vacuum tube circuits having such time constants that when said double-acting relay is moved to said second position said second relay is closed quickly and said first relay is closed more slowly and upon returning said double-acting relay to its normal position said first relay is opened quickly and said second relay is opened more slowly.

5. A system of the class described, comprising a source of grid-biasing potential, means associated therewith to derive therefrom two potentials of different magnitudes; means for applying the higher of said potentials including devices constituting in effect a potentiometer with one portion of fixed value and the other portion of variable value, said other portion including vacuum tube means, a grid bias lead connected to a point between said portions, means associated with said devices to change the value of said other portion and having inherent characteristics to make any such change gradual, said associated means including a first, normally open relay; means for applying the lower potential including series resistive impedances, a capacitive element connected to a point between said impedances and to ground, a grid bias lead connected to a point between said impedances, and a second, normally open relay; a vacuum tube circuit connected to operate said first relay, a second vacuum tube circuit connected to operate said second relay, and a double-acting relay connected to control said vacuum tube circuits having a normal position to maintain both said first and second relays in open position and a second position to cause the closing of said first and second relays, the elements in said vacuum tube circuits having such time constants that when said double-acting relay is moved to said second position said second relay is closed quickly and said first relay is closed more slowly and upon returning said double-acting relay to its normal position said first relay is opened quickly and said second relay is opened more slowly.

6. A system of the class described, comprising a source of grid-biasing potential, means associated therewith to derive therefrom two potentials of different magnitudes; means for applying the higher of said potentials including devices constituting in effect a potentiometer with one portion of fixed value and the other portion of variable value, a grid bais lead connected to a point between said portions, means associated with said devices to change the value of said other portion and having inherent characteristics to make any such change gradual, said associated means including a first, normally open relay; means for applying the lower potential including series resistive impedances, a capacitive element connected to a point between said impedances and to ground, a grid bias lead connected to a point between said impedances, and a second, normally open relay; a manually controllable double-acting relay, a first triode, means connecting the plate of said triode to actuate said first relay, a capacitance connected between the grid and the cathode of said triode, a resistance connected to said grid and connectible to said cathode through said double-acting relay and normally so connected when said double-acting relay is not actuated, and a relatively large resistance connected between said grid and a source of negative potential, whereby said capacitance is gradually charged when said double-acting relay is actuated; a second triode, means connecting the plate thereof to actuate said second relay, a capacitance connected between the grid and the cathode of said second triode, a resistance connected to said grid of the second triode and connectible to the cathode thereof when said double-acting relay is actuated, and a high resistance connected to said grid and to said source of negative potential through which the condenser connected to the second triode is charged when said double-acting relay is not actuated; the values of the resistances and capacitances associated with said two triodes being respectively of such values that when said double-acting relay is not actuated there is small negative bias on the grid of the first triode and large negative bias on the grid of the second triode, that when said double-acting relay is actuated the first triode blocks slowly while the second triode unblocks rapidly, and when such actuation ends the first triode unblocks quickly and the second triode blocks slowly.

7. A system of the class described, comprising a source of grid-biasing potential, means associated therewith to derive therefrom two potentials of different magnitudes; means for applying the higher of said potentials, including elements inherently acting to cause any changes in said applied potential to be made gradually, and also including a normally open first relay; means for applying the lower of said potentials including elements to smooth out changes thereof and also including a normally open second relay; a manually controllable double-acting relay, a first triode, means connecting the plate of said triode to actuate said first relay, a capacitance connected between the grid and the cathode of said triode, a resistance connected to said grid and connectible to said cathode through said double-acting relay and normally so connected when said double-acting relay is not actuated, and a relatively large resistance connected between said grid and a source of negative potential, whereby said capacitance is gradually charged when said double-acting relay is actuated; a second triode, means connecting the plate thereof to actuate said second relay, a capacitance connected between the grid and the cathode of said second triode, a resistance connected to said grid of the second triode and connectible to the cathode thereof when said double-acting relay is actuated, and a high resistance connected to said grid and to said source of negative potential through which the condenser connected to the second triode is

charged when said double-acting relay is not actuated; the values of the resistances and capacitances associated with said two triodes being respectively of such values that when said double-acting relay is not actuated there is small negative bias on the grid of the first triode and large negative bias on the grid of the second triode, that when said double-acting relay is actuated the first triode blocks slowly while the second triode unblocks rapidly, and when such actuation ends the first triode unblocks quickly and the second triode blocks slowly.

8. A system of the class described, comprising a source of grid-biasing potential, means associated therewith to derive therefrom two potentials of different magnitudes; means for applying the higher of said potentials, including elements inherently acting to cause any changes in said applied potential to be made gradually, and also including a normally open first relay; means for applying the lower of said potentials including elements to smooth out changes thereof and also including a normally open second relay; a vacuum tube circuit connected to operate said first relay, a second vacuum tube circuit connected to operate said second relay, and a double-acting relay connected to control said vacuum tube circuits having a normal position to maintain both said first and second relays in open position and a second position to cause the closing of said first and second relays, the elements in said vacuum tube circuits having such time constants that when said doube-acting relay is moved to said second position said second relay is closed quickly and said first relay is closed more slowly and upon returning said double-acting relay to its normal position said first relay is opened quickly and said second relay is opened more slowly.

9. Means for keying a radio transmitter by controlling the grid bias on a tube in a high power stage and also on a tube in a low power stage, comprising means for controlling the grid bias on a tube in the high power stage including a first relay normally in open circuit position, means for controlling the grid bias on a tube in the low power stage including a second relay normally in open circuit position; a manually controllable double-acting relay, a first triode, means connecting the plate of said triode to actuate said first relay, a capacitance connected between the grid and the cathode of said triode, a resistance connected to said grid and connectible to said cathode through said double-acting relay and normally so connected when said double-acting relay is not actuated, and a relatively large resistance connected between said grid and a source of negative potential, whereby said capacitance is gradually charged when said double-acting relay is actuated; a second triode, means connecting the plate thereof to actuate said second relay, a capacitance connected between the grid and the cathode of said second triode, a resistance connected to said grid of the second triode and connectible to the cathode thereof when said double-acting relay is actuated, and a high resistance connected to said grid and to said source of negative potential through which the condenser connected to the second triode is charged when said double-acting relay is not actuated; the values of the resistances and capacitances associated with said two triodes being respectively of such values that when said double-acting relay is not actuated there is small negative bias on the grid of the first triode and large negative bias on the grid of the second triode, that when said double-acting relay is actuated the first triode blocks slowly while the second triode unblocks rapidly, and when such actuation ends the first triode unblocks quickly and the second triode blocks slowly.

10. Means for keying a radio transmitter by controlling the grid bias on a tube in a high power stage and also on a tube in a low power stage, comprising means for controlling the grid bias on a tube in the high power stage including a first relay normally in open circuit position, means for controlling the grid bias on a tube in the low power stage including a second relay normally in open circuit position, a vacuum tube circuit connected to operate said first relay, a second vacuum tube circuit connected to operate said second relay, and a double-acting relay connected to control said vacuum tube circuits having a normal position to maintain both said first and second relays in open position and a second position to cause the closing of said first and second relays, the elements in said vacuum tube circuits having such time constants that when said double-acting relay is moved to said second position said second relay is closed quickly and said first relay is closed more slowly and upon returning said double-acting relay to its normal position said first relay is opened quickly and said second relay is opened more slowly.

11. A system of the class described, comprising a source of grid-biasing potential, means associated therewith to derive therefrom two potentials of different magnitudes; means for applying the higher of said potentials, including elements inherently acting to cause any changes in said applied potential to be made gradually, and also including a normally open first relay; means for applying the lower of said potentials including elements to smooth out changes thereof and also including a normally open second relay; a bridge circuit having a first arm including an impedance connected at one end to one side of a direct current supply, a second arm including an impedance having one terminal connected to the other side of said direct current supply, the other terminals of said impedances being connected together, a third arm connected to the first mentioned terminal of said first arm and including a solenoid disposed to actuate said second relay and an impedance in shunt with said solenoid, a fourth arm including a key connected between said third arm and said first mentioned terminal of said second arm, and a connection between the common point of said first and second arms and the common point of said third and fourth arms, said connection including a relay disposed to be actuated by the solenoid in said third arm, a solenoid disposed to actuate said first relay, and an impedance, all in series, the total impedance of said connection being much greater than the total impedance of said third arm.

12. A system of the class described, comprising a source of grid-biasing potential, means associated therewith to derive therefrom two potentials of different magnitudes; means for applying the higher of said potentials, including elements inherently acting to cause any changes in said applied potential to be made gradually, and also including a normally open first relay; means for applying the lower of said potentials including elements to smooth out changes thereof and also including a normally open second relay; manually operable means, and a network con-

trolled by said manually operable means to actuate said relays, the said network including elements having time constants chosen to close said second relay before and open it after the effecting of the corresponding operations of said first relay.

13. A system of the class described, comprising a source of grid-biasing potential, means associated therewith to derive therefrom two potentials of different magnitudes; means for applying the higher of said potentials, including elements inherently acting to cause any changes in said applied potential to be made gradually, and also including a normally open first relay; means for applying the lower of said potentials including elements to smooth out changes thereof and also including a normally open second relay; a vacuum tube network operatively connected respectively to actuate each of said relays, the circuit parameters of said networks being chosen to close said second relay before the closing of said first relay and to open said first relay before the opening of said second relay, and common means to control both of said networks.

14. A system of the class described, comprising a source of grid-biasing potential, means associated therewith to derive therefrom two potentials of different magnitudes; means for applying the higher of said potentials, including elements inherently acting to cause any changes in said applied potential to be made gradually, and also including a normally open first circuit closing means; means for applying the lower of said potentials including elements to smooth out changes thereof and also including a normally open second circuit closing means; a vacuum tube network operatively connected respectively to actuate each said circuit closing means, the circuit parameters of said networks being chosen to close said second circuit closing means before the closing of said first circuit closing means and to open said first circuit closing means before the opening of said second circuit closing means and common means to control both of said networks.

15. A system of the class described comprising a source of keying potential, an impedance connected to said source, space discharge means effectively in series with said impedance, means to apply said potential connected between said impedance and said discharge means; means gradually to apply a blocking potential to said discharge means and means selectively operable to decrease gradually said blocking potential and permit said discharge means to pass current, whereby said keying potential is gradually varied between a first predetermined value when said discharge means is blocked and a second predetermined value when said discharge means passes current.

16. A system of the class described comprising a source of keying potential, an impedance connected to said source; space discharge means effectively in series with said impedance, said discharge means and the operating circuits therefor carrying no radio frequency current; means to apply said potential connected between said impedance and said discharge means; means gradually to apply a blocking potential to said discharge means and means selectively operable to decrease gradually said blocking potential and permit said discharge means to pass current, whereby the keying potential is gradually varied between a first predetermined value when said discharge means is blocked and a second predetermined value when said discharge means passes current.

17. A method of keying a radio transmitter having at least a low voltage stage and a high voltage stage, both of which are normally blocked between the transmission of any two successive signal pulses, comprising the steps of gradually unblocking the said low voltage stage, gradually unblocking the said high voltage stage for an interval equal to the duration of full amplitude of the pulse to be transmitted, gradually blocking said high voltage stage and then gradually blocking said low voltage stage.

18. A method of keying a radio transmitter having at least an initial amplifying stage and a final amplifying stage, both of which are normally blocked between the transmission of any two successive signal pulses comprising the steps of gradually unblocking the said initial stage, gradually unblocking the said final stage for an interval equal to the duration of full amplitude of the pulse to be transmitted, gradually blocking said final stage and then gradually blocking said initial stage.

19. A method of keying a radio transmitter having at least a first amplifying stage and a subsequent amplifying stage, both of which are normally blocked between the transmission of any two successive signal pulses comprising the steps of gradually unblocking the said first amplifying stage, gradually unblocking the said subsequent stage for an interval equal to the duration of full amplitude of the pulses to be transmitted, gradually blocking said subsequent stage and then gradually blocking said first amplifying stage.

20. A method of keying a radio transmitter stage by apparatus including normally blocked space discharge means that in effect constitutes part of a voltage divider for a control potential applied to said stage, neither said means nor any circuits for operating the same carrying radio frequency current, comprising the steps of applying to said stage a control potential to block said stage, said potential also being impressed upon a portion of the discharge path through said spaced discharge means, gradually unblocking said space discharge means to permit current to pass therethrough whereby the potential on the said transmitted stage is changed to permit said stage to operate and then after an interval gradually restoring the blocking potential on said discharge means to cause the full blocking potential again to be impressed upon said stage.

21. A method of keying a radio transmitter stage by apparatus including a normally blocked electron stream and a path therefor that are effectively a portion of voltage divider for the control potential applied to said stage, comprising the steps of applying to said stage control potential to block the stage, said control potential being also applied to a portion of said path, permitting said electron stream to flow with gradually increasing strength whereby the control potential on said stage is changed to permit said stage to operate, and then after an interval gradually decreasing the strength of said electron stream to cause the full blocking potential to be again applied to said stage.

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