Nov. 26, 1940. N. F. SHOFSTALL 2,223,188

SIGNALING SYSTEM

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Fig. 1.

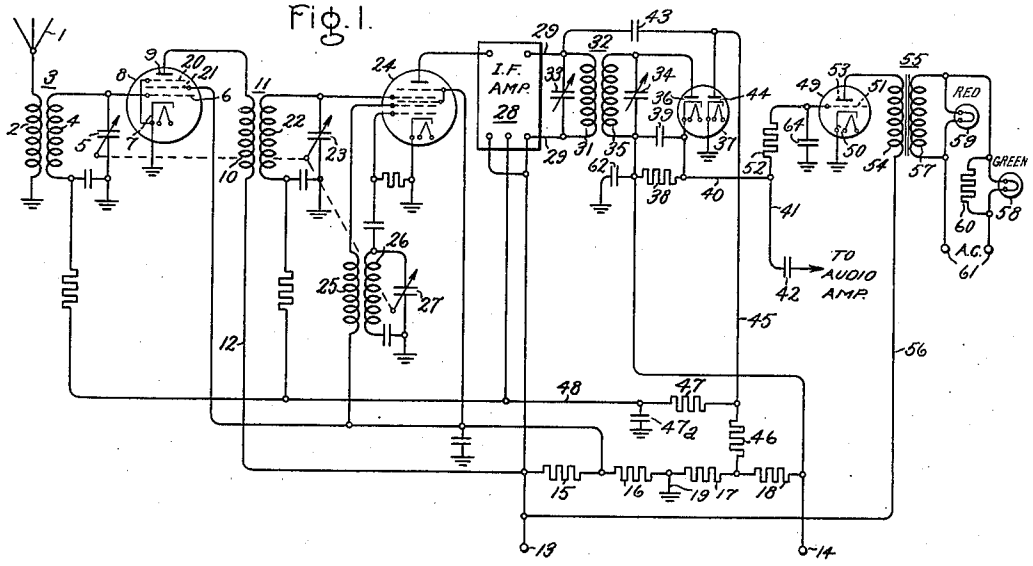
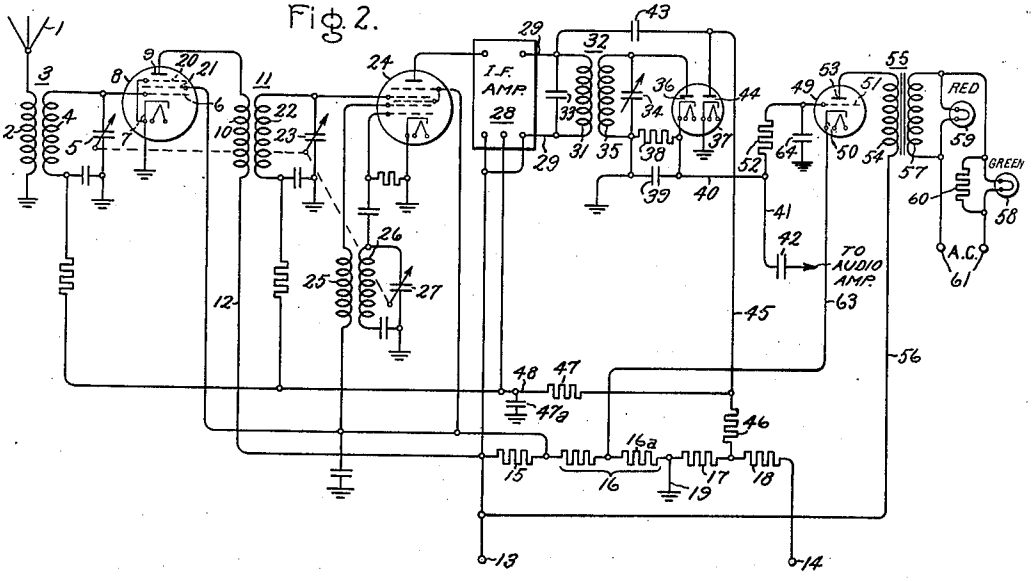


Fig. 2.



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SIGNALING SYSTEM

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13 Claims. (Cl. 250—27)

My invention relates to signaling systems and more particularly to an arrangement for regulating the voltage supplied thereto. In greater particularity, my invention relates to a method of an arrangement for maintaining constant the voltage supplied to thermionic devices employed in a signaling apparatus.

It is highly desirable and often quite indispensable in the operation of signaling apparatus utilizing thermionic devices that the voltage of the several energizing sources shall remain substantially constant. This is especially true with regard to the space current source for thermionic devices which perform certain functions, typical of which are oscillators and converters where it has been found that a change in anode potential of one volt results in a change in frequency of two hundred cycles at fifteen megacycle operation. Certain types of signaling arrangements, as, for example, radio receivers employing automatic volume control, experience during a period of normal operation a comparatively large fluctuation in the space current consumed by certain of the thermionic tubes. If the radio receiver has in addition to automatic volume control a thermionic frequency converter tube operating at high frequencies, this fluctuation is likely to create a corresponding variation in the anode voltage, caused by an inherently poor regulation of the anode supply, which may seriously impair the operation of the converter and thereby greatly impair the usefulness of the receiver.

It is accordingly an object of my invention to overcome these undersirable fluctuations in the terminal voltage of the space current supply by the provision of a regulating system which will maintain substantially constant the space current consumption of the thermionic devices and thereby maintain correspondingly constant the terminal voltage of the energizing source.

A further object of my invention is to attain this result by utilizing to a large extent apparatus already present in the signaling system whereby a minimum of additional equipment is required and a greatly improved operation results.

A still further object of my invention is so to arrange the circuit and the bias of an electronic tuning indicator control device that decreasing values of received signal intensity will result in decreasing values of space current in this device equal in amount to the increasing values of current consumed by certain of the other thermionic devices caused by the same change in signal intensity.

A further object of my invention is so to arrange the circuit of a radio receiver provided with automatic volume control and thermionic tuning indication that the change in space current of certain of the thermionic tubes caused by the operation of the automatic volume control is compensated by an opposite change of equal or proportionate amount in space current consumption by the thermionic tuning indication device.

An additional object of my invention is to maintain the potential of an energizing source constant by an arrangement which operates entirely automatically to control the value of current consumed by two or more of the thermionic devices whereby a changing condition which produces an increase in the current consumption by one device will produce a corresponding and opposing change of equal or proportional amount in the current consumption of another device.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawing in which Figure 1 represents an embodiment of my invention, and Figure 2 represents a modified embodiment thereof.

Referring to the drawing, I have illustrated in Fig. 1 a radio receiving system having an antenna 1 connected to ground through the primary 2 of a radio frequency transformer 3. The secondary 4 of the transformer, tuned by a variable condenser 5 to the frequency of a desired signal, is connected to the control grid 6 and the cathode 7 of a radio frequency amplifier tube 8. The anode 9 of this amplifier is connected through the primary 10 of a radio frequency transformer 11 and a conductor 12 to the positive pole 13 of the space current source connected between the terminals 13 and 14. Bleeder resistors 15, 16, 17 and 18 are connected between the terminals 13 and 14 to supply reduced potentials to various portions of the set in conventional manner. A connection 19 to ground is made between the resistors 16 and 17. The suppressor grid 20 of the amplifier tube 8 is connected to the cathode 7 while the screen grid 21 is connected to a point of reduced space current supply potential between the bleeder resistors 15 and 16.

The secondary 22 of the transformer 11 is tuned

to the desired signal frequency by a variable condenser 23 arranged for uni-control with the condenser 5, and signal oscillations appearing across this tuned circuit are impressed between the cathode and the control grid of a converter stage 24. The converter 24 has connected to an oscillator and anode grids therein in conventional manner a circuit comprised by the inductively coupled windings 25 and 26. The winding 26 is tuned by a variable condenser 27, arranged for uni-control with the condensers 5 and 23, to a frequency differing by a fixed amount from the frequency of the signal oscillation. The converter 24 operates to change the frequency of the signal oscillation appearing across the tuned circuit 22, 23 to an intermediate frequency oscillation and supplies these oscillations to an intermediate frequency amplifier represented conventionally at 28 which may consist of any desired number of stages of amplification. The intermediaite frequency amplifier 28 terminates in a channel 29 connected to the primary 31 of an output transformer 32 which is tuned by the respective variable condensers 33 and 34 to the intermediate frequency.

Intermediate frequency oscillations appearing in the secondary 35 of the transformer 32 are rectified by the diode elements 36 of an electron discharge device 37 to provide a unidirectional electromotive force across a resistor 38 and parallel connected condenser 39. This electromotive force, which is the audio frequency component of the signal oscillation, is connected through the conductors 40 and 41 and through a coupling condenser 42 to the input of a conventional audio frequency amplifier, not shown, where it is amplified and reproduced in a manner well known.

A second portion of the intermediate frequency oscillations appearing in the signal channel 39 is coupled through a condenser 43 to the diode elements 44 of the electron discharge device 37 and through a conductor 45 and a resistor 46 to a point between the bleeder resistors 17 and 18. The resistors 46 and 17 are thus connected in parallel with the diode elements 44 and have built up thereacross a pulsating unidirectional electromotive force for purposes of automatic volume control. This electromotive force is connected through a filter comprised by a resistor 47 and a condenser 47a and through the control circuit 48 to the control grid of such radio frequency and intermediate frequency stages of amplification as may be desired to provide with conventional automatic volume control.

The operation of the arrangement thus far described will now be evident. Signal oscillations appearing in the antenna 1 are coupled through the transformer 3 to the radio frequency amplifier 8 where they are amplified and coupled through the transformer 11 to the converter stage 24. The signal oscillations are here changed to an intermediate frequency oscillation and are then passed to the intermediate frequency amplifier 28 for further amplification. The amplified intermediate frequency oscillations are coupled through the transformer 32 to the diode elements 36 where they are rectified and the audio frequency components of rectification are transferred through the condenser 42 to the audio frequency amplifier for further amplification and reproduction. A second portion of the intermediate frequency oscillations are rectified by the diode elements 44 to provide an automatic volume control voltage in the conductor 48. This control voltage operates in a manner well known in the art to maintain the intermediate frequency oscillations appearing in the output of the intermediate frequency amplifier 28 of substantially constant amplitude.

The action of the automatic volume control circuit in variably biasing the grid element of those amplifier stages to which it is connected results in a variation of the space current in these stages with variation of received signal intensity. If the supply connected to the terminals 13 and 14 is such as to have a relatively poor regulation, this variation in space current consumption causes a corresponding and opposite variation in the terminal potential appearing between the terminals 13 and 14. Any change in terminal voltage of this nature has a detrimental effect on the operation of the signaling apparatus and is undesirable.

In accordance with my invention, this detrimental fluctuation of supply potential is eliminated by an arrangement which maintains the current drain on the space current supply substantially constant. To this end, I utilize an auxiliary electronic discharge device such as the electronic tuning indicator control tube 49. The tube 49 has a grounded cathode 50, a control grid 51 connected through a resistor 52 to that end of the resistor 38 which is connected to the diode element, and an anode 53 connected through the saturating winding 54 of a saturable core reactor 55 and conductor 56 to the space current supply terminal 13. The other end of the resistor 38 is at ground potential for alternating currents by virtue of the capacitor 62 but is maintained below ground potential for direct currents by its connection to a point on the bleeder having a sufficiently negative potential from ground to bias the electron discharge device 49 to cut-off. Alternating current from a source 61 is supplied through the winding 57 of the saturable reactor 55 to an incandescent lamp 58 having a distinctive color, as for example the color green. A second incandescent lamp 59 is connected across the winding 57, this lamp also having a distinctive color, as for example the color red, different from that of lamp 58. A voltage limiting resistor 60 is connected across the terminals of the incandescent lamp 58 for a purpose shortly to become apparent. This arrangement of the electronic device 49, the reactor 55, and the lamps 58 and 59 operates in a manner as follows.

In the absence of signal oscillations in the signal channel 29, the electronic device 49 is biased to cut-off as explained above, and no anode current therefore flows in the saturating winding 54. The impedance of the winding 57 under this condition is a maximum with the result that a potential drop occurs across the terminals of the lamp 59 which, by proper selection of the value of the resistor 60, may be a large proportion of the total voltage impressed across the terminals 61. The illumination from the red lamp 59 then predominates over that from the green lamp 58. Upon the occurrence of a signal oscillation in the signal channel 29, a unidirectional pulsating voltage is developed by the diode elements 36 across the resistor 38 with a polarity tending to decrease the negative bias on the control grid 51 of the device 49. Space current now begins to flow in the device 49 and the core of the reactor 55 is saturated to a degree depending upon the magnitude of the space current. An increase in the core saturation results in a decrease in the value of the impedance of the winding 57 which, by its shunting effect on the lamp 59, in turn

causes a greater proportion of the potential drop of the source connected to the terminals 61 to be impressed across the terminals of the green colored lamp 58. The illumination of the green lamp now increases and may, with a sufficient space current flowing in the device 49, eventually predominate over that of the red lamp 59, the illumination of which is decreasing as the reactance of the winding 57 decreases. This arrangement of the lamps 58 and 59 constitutes an indicator for indicating the presence and relative strength or the absence of a signal in the signal channel.

A little further reflection will make evident the fact that I have accomplished by the arrangement of Figure 1 a regulation of the supply source connected between the terminals 13 and 14 such that the terminal potential of this source tends to remain substantially constant. A signal oscillation appearing in the channel 29 produces in the automatic volume control circuit 48 a control potential which operates to reduce the space current in the various electronic discharge devices to which this circuit is connected in proportion to the amplitude of the signal oscillation. The same signal likewise and simultaneously causes a control potential in the control circuit 40 which operates to increase the space current of the electronic discharge device 49 in proportion to the amplitude of the signal oscillation. If the space current in the device 49 increases as rapidly as the space currents in the several amplifying stages to which the automatic volume is connected decrease, the space current load on the source connected between the terminals 13 and 14 remains constant and the potential across the terminals 13 and 14 also remains constant irrespective of the regulation of the supply source. The suitable choice of an electronic discharge device 49 to accomplish this result in practice depends in large part upon a choice of the other thermionic devices used for radio and intermediate frequency amplification and upon the number of stages automatically controlled. A proper choice may be made by one skilled in the art.

The potential of a point on the bleeder resistor may be maintained constant in similar manner by connecting the conductor 56 to that point and by suitably adjusting the bias on the operating grid 51 of the device 49 to cut-off. Thus the potential applied to the screen grid of the several electronic discharge devices used in the signaling apparatus may be maintained substantially constant by connection of the conductor 56 to a point between the resistors 15 and 16 and by suitably choosing a value for the resistors 17 and 18 to bias the device 49 to cut-off.

A modification of my invention is shown in Figure 2 wherein I have indicated elements corresponding to like elements of Figure 1 by like numerals. This modified arrangement, which provides an alternative method for biasing the control grid 51 of the device 49, allows the low potential end of the secondary winding 35 of the intermediate frequency transformer 32 to be at ground potential both for direct and alternating currents. The cathode 50 of the device 49, shown grounded in Figure 1, is connected through a conductor 63 to a positive point on the bleeder resistor 16 so chosen that the potential drop across the portion 16a will bias the discharge device 49 to cut-off. The operation and regulatory action of this modification are in all respects the same as that of the arrangement shown in Figure 1 and will not be again described.

In addition to accomplishing the regulation of a supply source, my invention has the further advantage that the operation of the tuning indicator arrangement under control of the device 49 is materially improved. The operating grid of the device 49 is biased to cut-off, as previously explained, with the result that the positive potentials additionally applied to the control grid by the drop across the resistor 38 cause the device initially to operate upon the lower non-linear portion of its grid-voltage anode-current characteristic curve. This characteristic curve has a sharp bend or knee near the cut-off point which insures that small unidirectional potentials developed across the resistor 38 by noise oscillations appearing in the signal channel 29 do not produce a material change in the anode space current of the device 49. The indication of the lamps 58 and 59 is therefore not changed by noise in the signal channel, as would be the case were the tuning indicator control tube so biased that a small anode space current flowed during the period when no signal is being received, and false indications from this source are thereby greatly reduced or eliminated.

I wish it clearly understood that wherever the expression "radio frequency amplifier" shall appear in the claims appended to this description, the expression shall include those amplifiers which amplify frequencies above the range of audibility as, for example, amplifiers of intermediate frequencies.

While I have shown particular embodiments of my invention, it will, of course, be understood that I do not wish to be limited thereto since different modifications may be made both in the arrangement of the circuit and of the apparatus described. I, of course, contemplate by the appended claims to cover any such modifications as fall 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. The combination, in a signaling system, of a source of signal impulses, means connected to said source and including an electron discharge device for amplifying said signal impulses, a second electron discharge device, means connecting said second discharge device to said first device to operate said second device in response to the output of said first device, a source of potential having a terminal electromotive force for supplying space current individually to said discharge devices, means individually connecting said devices to said source, means responsive to the average strength of said signal impulses for controlling the gain and the average space current of said amplifying means, and means for additionally controlling said last-named discharge device by said last-named means in a manner to vary equally but in opposite sense the magnitude of the space currents consumed by each of said devices from said second-named source whereby said terminal electromotive force is maintained substantially constant.

2. The combination, in a radio receiver, of a radio frequency amplifier having an input and an output circuit, a source of radio frequency electromotive force connected to said input circuit, an auxiliary electron discharge device, a source of current connected to supply individual space currents to said amplifier and to said device and having a terminal electromotive force,

and means for maintaining said terminal electromotive force substantially constant, said means including a pair of rectifiers associated with the output circuit of said amplifier and arranged to simultaneously change in opposite sense the magnitude of the space currents of said amplifier and said device in response to a change in the strength of the radio frequency electromotive force of said first-named source.

3. In combination, a radio frequency amplifier having an input circuit including a control grid and having an output circuit, a source of radio frequency electromotive force connected to said input circuit, an auxiliary electron discharge device having an input circuit including a control grid, a source of current connected to supply individual space currents to said amplifier and to said device and having a terminal electromotive force, and means for maintaining said terminal electromotive force substantially constant, said means including a pair of rectifiers connected to the output circuit of said amplifier and arranged to develop individually unidirectional electromotive forces from the radio frequency current appearing in said output circuit, said unidirectional electromotive forces being applied to bias respectively the control grid of said amplifier and said device in a manner simultaneously to change in opposite sense the magnitude of the space current of said amplifier and said device in response to a change in strength of the radio frequency electromotive force of said first-named source.

4. In a signaling system having electron discharge devices individually receiving space current from a source having a terminal potential variable upon variations in current flowing therefrom, the method of maintaining substantially constant the terminal potential of said source which consists in individually supplying said devices with currents from said source, converting a signal potential to a control potential, applying said control potential to the control grid of a first of said electron discharge devices in a manner to bias the control grid of said device toward cut-off, converting another portion of said signal potential to a second control potential, and applying said second control potential to the control grid of a second of said electron discharge devices in a manner to bias the control grid of said second device away from cut-off, whereby the total current taken from said source by said device, and consequently said terminal potential, tends to be more constant.

5. The combination, in a signal receiver, of a plurality of amplifiers connected in succession with respect to signal currents transmitted through said receiver, a source of operating potential for said amplifiers, each of said amplifiers drawing varying amounts of current from said source in accordance with the intensity of signals received in said receiver, the output potential of said source being subject to undesired fluctuations with variations of current drawn therefrom, and means to reduce the current drawn by certain of said amplifiers when the current increases in other of said amplifiers with changes in the intensity of received signals thereby to maintain constant the current drawn from said source.

6. The combination, in a tunable radio receiver, of a signal amplifier, an additional amplifier, a source of operating current, means individual to each of said amplifiers for supplying operating current thereto from said source the output potential of said source being variable in response to variations in current supplied thereby, and means responsive to changes in the average strength of received signals for effecting variations in the average operating current supplied by said source to each of said amplifiers, said last-named means effecting a change in the operating current supplied to a first of said amplifiers substantially equal and opposite to that supplied to the other of said amplifiers whereby the output potential of said source is maintained substantially constant.

7. In a signaling system, the combination of a source of signals having a varying average strength, means including an electron discharge device for amplifying said signals, means including a second electron discharge device for indicating a condition of said amplified signals, means connecting said second device for operation in response to the output of said first device, a source of space current having a terminal potential subject to variation upon variation in current flowing from said source, means for supplying space currents from said source to said devices, and means for maintaining substantially constant said terminal potential, said last-named means being responsive to the average strength of amplified signals to vary the magnitude of the space current flowing in each of said discharge devices, the space current of a first of said devices varying substantially equally and oppositely to that of the other of said devices.

8. The combination, in a signaling system, of a source of signals having varying average strength, means including an amplifier connected to said source for amplifying said signals, means responsive to the average strength of amplified signals for controlling and maintaining substantially constant the output of said amplifier as said signals vary in strength, said control means producing variations in the space current of said amplifier in proportion to changes of signal strength, means for supplying space current to said amplifier, the potential at which said space current is supplied being subject to undesired variations dependent upon the magnitude of said space current supplied, an electron discharge device, means for connecting said device to operate in response to the output of said amplifier, and means for maintaining substantially constant the space current supplied by said space current supply means thereby to maintain said potential constant, said last-named means including said electron discharge device, and means responsive to the average strength of amplified signals for varying the space current of said discharge device substantially equally with but in a direction opposite to changes in the space current of said amplifier.

9. In a radio receiving system, the combination of tunable means for receiving signals having a varying average strength, means including an electron discharge device for amplifying said signals, means for controlling the gain of said amplifying means to maintain substantially constant the output of said amplifying means as said signals vary in strength, means including a second electron discharge device for indicating the average strength of amplified signals, means connecting said indicating means to operate in response to the output of said amplifying means to provide an indication of the accuracy of tuning of said tunable means to said signal, means having a terminal potential for supplying space current through separate individual paths to said

devices, said potential being subject to variation upon variation in current flow from said last means and means for maintaining said terminal potential substantially constant, said last-named means being responsive to the strength of amplified signals for changing the space current of said last-named device equally with but in a direction opposite to changes in space current of said first-named device.

10. The combination in a radio receiver, of a number of signal stages and a tuning indicating stage, a source of operating potential common to all of said stages and subject to voltage variations upon variations in current flowing therefrom, means to vary the bias of all of said stages in response to the intensity of received signals, said means tending to vary the current in each of said stages, certain of said signal stages tending to operate undesirably upon voltage variations of said source, and means to prevent such undesired operation comprising means to increase current in said tuning indicating stage in response to said bias variation when current in said signal stages decreases, whereby variations in total current flowing from said source are reduced and the constancy of potential of said source is increased sufficiently to eliminate said undesired operation.

11. The combination, in a superheterodyne radio receiver having signal stages and a tuning indicating stage, one of said signal stages including a local oscillator, of a source of operating potential common to all of said stages including said oscillator and subject to voltage variations upon variations in current flowing therefrom, the operating frequency of said oscillator being subject to variation upon variation in voltage supplied thereto from said source, means to vary the bias of certain of said stages in response to the intensity of received signals, said means tending to vary the current in each of said certain stages, and means to prevent said frequency variation comprising means to increase current in said tuning indicating stage in response to said bias variation when current in said signal stages decreases, whereby variations in total current flowing from said source are reduced and the constancy of potential of said source is increased sufficiently to eliminate said frequency variation.

12. The combination in a radio receiver, of a number of signal stages and a tuning indicating stage, a source of operating potential common to all of said stages and subject to voltage variations upon variations in current flowing therefrom, certain of said signal stages tending to operate undesirably upon said voltage variations, means to operate said tuning indicating stage from a signal stage to indicate maximum intensity of a received signal, means to vary the bias and the amplification of said signal stages in response to intensity of received signals, said last means tending to vary the current in said stages, and means to prevent such undesired operation comprising means to increase current in said tuning indicating stage in response to said bias variation when current in said signal stages decreases, whereby variations in total current flowing from said sources are reduced and the constancy of potential of said source is increased sufficiently to eliminate said undesired operation.

13. The combination in a radio receiver, of a number of signal stages and a tuning indicating stage, a source of operating potential common to all of said stages and subject to voltage variations upon variations in current flowing therefrom, means connecting said tuning indicating stage through an individual path to said source, certain of said signal stages tending to operate undesirably upon voltage variations of said source, means to vary the bias of all of said stages in response to the intensity of received signals, said last means varying the current and amplification in said signal stages, and means to prevent such undesired operation comprising means to increase the current flowing individually to said tuning indicating stage in response to said bias variation when current in said signal stages decreases, whereby variations in total current flowing from said source are reduced and the constancy of potential of said source is increased sufficiently to eliminate said undesired operation.

NORTON F. SHOFSTALL.