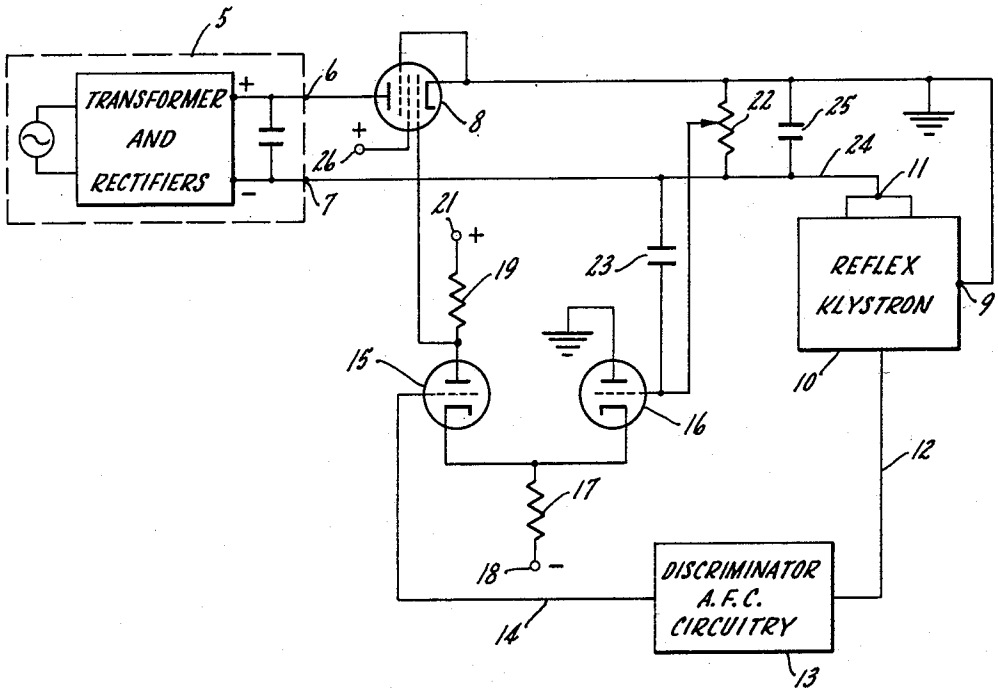
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AUTOMATIC FREQUENCY CONTROL CIRCUITRY
FOR HIGH VOLTAGE KLYSTRON TUBES
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AUTOMATIC FREQUENCY CONTROL CIRCUITRY FOR HIGH VOLTAGE KLYSTRON TUBES

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The present invention relates to control circuitry for electron tubes and more particularly to a power supply-frequency stabilization circuit for the reflector electrode of a high voltage klystron tube.

A problem long prevalent in the design of reflector (or repeller) automatic frequency control (A.F.C.) circuitry for high voltage klystron oscillator systems of the prior art has been the necessity of providing a direct current (D.C.) path from the final stage of the discriminator circuit to the reflector electrode. In equipment which utilizes a relatively low voltage klystron tube, such tube is usually operated with its resonant cavity (or metal shell) at a positive potential and its reflector at a negative potential, with respect to its grounded cathode; this arrangement usually has the advantage of permitting the use of a power supply already being utilized for associated circuitry in the equipment to also supply the klystron, since the magnitudes of the necessary klystron operating voltages will be relatively low with respect to ground potential. However, this arrangement has disadvantages in that the metal shell of the klystron is at a positive potential with respect to ground thus presenting a shock hazard to personnel in the area and an insulation problem in coupling the output of the klystron tube to associated mixer circuitry. As it becomes necessary to utilize klystron tubes requiring higher and higher resonant cavity (positive with respect to the cathode) and reflector (negative with respect to the cathode) voltages, in association with, for example, such circuitry as parametric amplifiers, these disadvantages become increasingly important. For example, a high voltage klystron oscillator tube requiring a resonant cavity voltage of 2300 v. D.C. positive and a reflector voltage of 600 v. D.C. negative (both with respect to the cathode) operated in this manner, that is, with the cathode at ground potential, has its complete outer shell at a positive potential of 2300 v. D.C. with respect to ground, constituting a very dangerous shock hazard thus necessitating its enclosure within a safety shield; also the removal of dissipated power in the form of heat becomes difficult because conduction cooling is impossible due to the high positive potential of the outer shell with respect to ground and convection cooling, either forced or free, is greatly restricted by whatever safety shield is used. In addition, radio frequency interference (RFI) is introduced by the necessity to insulate the waveguide structure from the high potential metal shell.

These disadvantages may be overcome by operating the klystron in such a way that the metal shell thereof is at ground potential. This can be accomplished by placing the cathode at a negative 2300 v. D.C. with respect to the grounded resonant cavity (or metal shell) and placing the reflector at a negative 2900 v. D.C. with respect to the resonant cavity (that is, the cavity still remains 2300 v. D.C. positive, and the reflector 600 v. D.C. negative, with respect to the cathode which is the common reference element). However, if a high voltage klystron is operated in this manner, the problem of the necessity of a D.C. coupling between the last stage of the reflector discriminator-A.F.C. circuitry and the reflector becomes the important restriction.

The present invention overcomes this problem of the prior art by the creation of novel control circuitry to

enable a conventional discriminator circuit to control the regulation of the reflector power supply voltage for correcting frequency deviations in the klystron, thus obviating the need for, and problem of, a D.C. coupling between the last stage of the reflector A.F.C. circuit and the reflector electrode, and at the same time permitting the discriminator circuitry to take advantage of the inherent voltage gain of the reflector voltage supply which in effect considerably reduces the gain necessary from the discriminator-A.F.C. circuitry.

An object of the present invention is the provision of automatic frequency control circuitry for klystron tubes.

Another object is to provide circuitry to enable electronic frequency stabilization of high voltage klystron tubes.

A further object of the invention is the provision of a single electronic frequency stabilization circuit to compensate the reflector electrode of a reflex klystron tube for both changes in power supply voltage and frequency drift due to thermal variation in the elements of the tube itself.

Still another object is to provide an automatic frequency stabilization circuit for the reflector electrode of a high voltage reflex klystron tube which does not require a direct current path therebetween.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description of a preferred embodiment of the invention as schematically illustrated in the accompanying figure of drawing.

Referring now to the figure of drawing, there is shown a specific embodiment of the invention in which block **5** contains the common elements of a power supply for providing a high negative potential, filtered direct current voltage across output terminals **6** and **7** thereof, and is not considered to be a part of the invention. The positive terminal **6** of power supply **5** is coupled to the anode of a pentode electron tube **8**, which has its cathode grounded. The resonant cavity (or metal shell) terminal **9** of reflex klystron tube **10**, whose frequency of oscillation is to be controlled, is also coupled to ground potential. Negative terminal **7** of power supply **5** is coupled to reflector electrode **11** of klystron **10**. Thus it can be seen that a high negative D.C. potential exists between reflector electrode **11** and ground, which potential is dependent upon and controlled by the voltage drop across pentode **8**. A sample of the energy from the klystron **10** is supplied via conductor **12** to a discriminator circuit **13** which may be of any suitable type well known in the art which produces a D.C. output voltage whose magnitude and polarity are determined by the frequency deviation or error of the klystron **10**. Several such discriminator circuits are described and shown in chapter 7 of Microwave Mixers, volume 16, M.I.T. Radiation Laboratory Series, McGraw-Hill Book Company, Inc. (1948). This D.C. control voltage from the discriminator-A.F.C. circuit **13** is coupled via conductor **14** to the grid of control triode tube **15** which has its cathode coupled, in common with the cathode of a second control triode tube **16**, through a cathode resistance **17** to a source of constant negative D.C. potential **18**, and its anode coupled via a resistance **19** to a source of positive D.C. potential **21**. The control grid of pentode regulating tube **8** is coupled to the anode of triode **15**, the screen grid is coupled to a source of positive D.C. potential **26**, and the suppressor grid is coupled to the grounded cathode thereof. The control grid of triode **16** is coupled to an adjustable voltage dividing potentiometer **22**, and via capacitance **23** to conductor **24**, which couples high negative potential terminal **7** to reflector electrode **11**. Filter

capacitance 25 is coupled between conductor 24 and ground potential.

Operation

The operation of the invention occurs in the following manner. Power supply 5 provides a filtered high negative potential D.C. voltage across its output terminals 6 and 7. This high negative potential at terminal 7 is applied to reflector electrode 11 of klystron 10 via conductor 24 while terminal 6 is coupled via regulating pentode 8, which acts as an electronically variable impedance, to ground potential. Since the operating frequency of a reflex klystron is directly dependent upon the value of its reflector potential, the desired degree of frequency control can thus be obtained by controlling this potential, which is accomplished in the present invention in the following manner. The potential applied to reflector 11 is protected against changes in the source voltage of power supply 5, and is varied when necessary to compensate for tendencies toward frequency change due to variations in temperature of the elements of klystron 10. With regard to the source voltage of power supply 5, any variation therein would be detected by the grid of control triode 16 through voltage dividing potentiometer 22 and conveyed via the common cathode coupling to control triode 15. This change in cathode potential of control triode 15 causes a change in its level of conduction and thus a change in its anode voltage which is conveyed to the control grid of pentode 8 resulting in a change in the level of conduction, or effective impedance, of that tube in a direction so as to maintain the reflector voltage between terminal 11 and ground relatively constant. In addition, any change in the frequency of oscillation of klystron 10, whether caused by slight changes in supply potential at reflector terminal 11 or by variations in operating temperature of the electrodes of klystron 10, will be detected by discriminator 13 which provides a control voltage proportional to the frequency deviation to the control grid of triode 15 via conductor 14. This control voltage varies the level of conduction of control tube 15 causing a change in its anode potential which is conveyed to the control grid of regulating pentode 8 causing a change in its level of conduction and the voltage drop thereacross, and thereby varying the negative D.C. potential present at reflector electrode 11 in such manner as to cause klystron 10 to return to the desired frequency of oscillation.

Thus it becomes apparent from the foregoing description and annexed drawing that the invention, a voltage and frequency sensitive voltage control circuit, is a useful and practical device having application in the area of frequency control of klystron oscillator tubes. The usefulness of the device is enhanced by the fact that the gain or amplification requirement of the discriminator circuitry is unusually low to be utilized for controlling such a high voltage which is a consequence of the utilization of the reflector power supply and its inherent gain as an integral part of the overall control circuitry of the invention.

Many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

I claim:

1. An electrical circuit for controlling the frequency of oscillation of a klystron tube comprising:

a source of high potential direct current voltage having a positive and a negative terminal means;

a reflex klystron oscillator tube having a reflector electrode terminal coupled to said negative terminal means of said source of direct current voltage, and

having a resonant cavity coupled to ground potential;

a pentode electron tube having an anode, a cathode, and a control grid, said anode being coupled to said positive terminal means of said source of direct current voltage and said cathode being coupled to ground potential;

a frequency sensing and discriminating means having an input and an output terminal means, said input terminal means thereof being coupled to said oscillator tube for constantly receiving energy samples therefrom; and

an electronic control means having an input terminal coupled to said output terminal means of said frequency sensing and discriminating means for receiving a voltage proportional to the frequency deviation of said oscillator tube, and having an output means coupled to said control grid of said pentode electron tube for providing a control voltage thereto for varying the potential applied to said reflector electrode in such a manner as to cause the frequency generated by said klystron tube to remain constant.

2. A combined reflector power supply and frequency stabilization circuit for a high voltage reflex klystron oscillator tube comprising:

a source of high potential direct current voltage having a positive and a negative terminal means;

a reflex klystron oscillator tube having a reflector electrode coupled to said negative terminal means of said source of direct current voltage and a resonant cavity coupled to ground;

a pentode electron tube having an anode coupled to said positive terminal means of said source of direct current voltage, a cathode coupled to ground potential, a screen grid coupled to a source of positive direct current potential, a suppressor grid coupled to said cathode thereof, and a control grid for receiving a potential to control the voltage drop across said electron tube;

a frequency sensing and discriminating means having an input and an output terminal means, said input terminal means thereof being coupled to said oscillator tube for constantly receiving energy samples therefrom;

a first triode control tube for detecting variations in the supply potential from said source of direct current voltage, having an anode coupled to ground potential, a cathode coupled through a resistance means to a source of constant negative direct current potential, and a control grid coupled across said supply potential by means of a voltage dividing potentiometer; and

a second triode control tube having a cathode coupled in common with said cathode of said first triode control tube, a control grid coupled to said output terminal means of said frequency sensing and discriminating means, and an anode resistively coupled to a source of constant positive direct current potential and directly coupled to said control grid of said pentode electron tube for providing a control voltage thereto to enable said pentode tube to vary the potential applied to said reflector electrode in such manner as to cause the frequency generated by said klystron tube to remain constant.

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