March 11, 1952 H. G. PRATT 2,589,029

AUTOMATIC VARIABLE COUPLER

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Fig. 1.

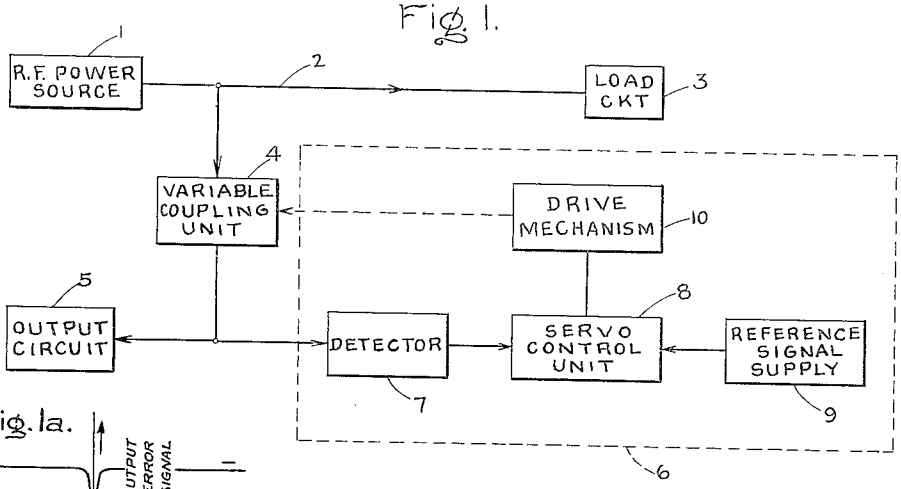


Fig. 1a.

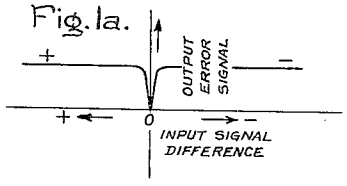
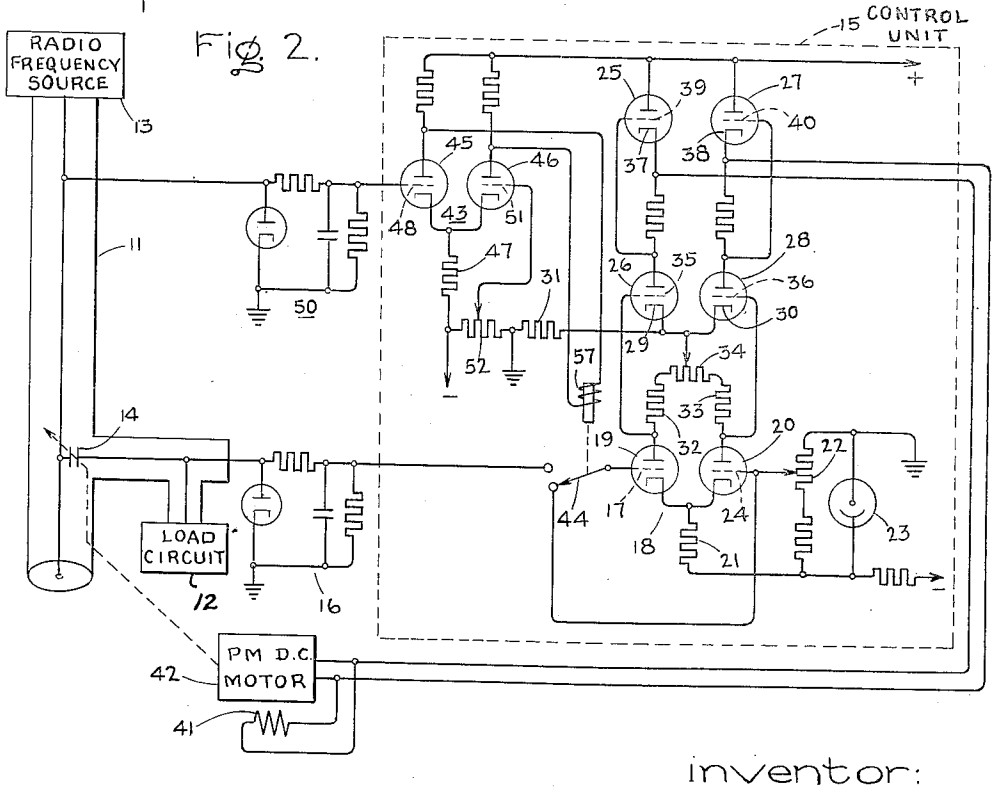


Fig. 2.



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AUTOMATIC VARIABLE COUPLER

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7 Claims. (Cl. 323—7)

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This invention relates to coupling circuits for electrical signals and particularly to the type automatically controlling the degree of coupling.

It is often desirable in electrical energy transmission systems, especially of the type employing an unstable source whose output varies in intensity over a wide range, to extract a fixed amount of energy for calibration or control purposes. Several techniques are available for obtaining a fixed amount of energy from a source of variable intensity energy. This invention is directed particularly to the technique employing a calibrated reference signal for comparison with the extracted signal in order to obtain a measure of the amount of control necessary to achieve the fixed amount of extracted energy. One of the requirements of such a system is that control of the intensity of the extracted signal be possible over a wide range of fluctuations of the intensity of the signals at their source. It is also highly desirable that these be insured a fast and faithful response of the control circuit to fluctuations of the source.

It is an object of my invention to provide an improved arrangement for extracting a fixed amount of signal from a variable intensity signal source.

It is a further object of my invention to provide a method and apparatus for extracting an adjustable predetermined amount of electrical energy from an energy source of fluctuating intensity.

It is a further object of my invention for providing an improved method and apparatus for comparing a normally variable electrical signal with a fixed reference signal to obtain control signals useful in stabilizing said variable signals.

The novel features which I believe characteristic of my invention are set forth with particularity in the appended claims. My invention, 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 drawings in which Fig. 1 shows my invention in block diagram form, Fig. 1*a* shows in graphical form the desired output error signal-input signal difference characteristic achieved in accordance with my invention, and Fig. 2 is a circuit diagram disclosing a particular embodiment of my invention.

Fig. 1 shows a source of variable intensity energy as, for example, the radio frequency stage

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of a radio receiver coupled by means of a transmission line 2 to a load circuit 3 which may comprise the low frequency stages of a receiver. In order to derive a constant intensity signal from the output of source 1, as, for example, a detected radio frequency energy of substantially constant wattage and useful for controlling circuits 1 or 3 or for controlling an exterior mechanism, a portion of the output of source 1 is coupled by means of a variable coupling unit 4 to the output circuit 5. In order to maintain the input to circuit 5 constant over a wide range of energy intensity variation of the source 1, a control circuit 6 is employed for adjusting the degree of coupling of circuit 4. Control circuit 6 comprises a detector 7 for detecting a portion of the variable coupling output supplied to circuit 5 and for applying the detected output to a servo control unit 8 which is also provided with a highly regulated reference signal from supply 9. The control unit 8 serves to compare the intensity of signals from sources 7 and 9 to derive an error signal indicative of the difference of intensity between these two signals. This error signal is coupled from the output of control unit 8 to a drive mechanism 10 as, for example, a servo motor which is employed to control the degree of coupling of circuit 4. Circuit 8 is arranged such that variation of the intensity of the output of coupling 4 in either direction from a given intensity results in a control signal being applied to mechanism 10 to adjust the coupling circuit 4 in a proper direction to maintain a constant output thereof. When the signals supplied to control unit 8 from circuits 7 and 9 are substantially equal, however, the adjustment of the degree of coupling of circuit 4 is held fixed.

The degree of control achieved with applicant's arrangement is clearly shown by the steep null characteristic of Fig. 1*a*, where the abscissa refers to the difference between the reference and variable coupling output signals, and the ordinate refers to the intensity of output signal obtained for application to the circuit 10.

Briefly, an embodiment of applicant's invention comprises the use of several groups of electron discharge devices having their electron discharge paths serially connected across a source of direct voltage. The devices are arranged into pairs, each comprising a device from each group. The variable intensity and reference signals are applied to the input circuits of respective devices of an initial pair of devices, and the amplifier versions of these signals are successively coupled through the remaining pairs of devices.

Certain of the pairs of devices are intercoupled to render the system more sensitive to input signal differences. The final pair of devices are arranged to have a signal difference indicator coupled between the cathode output circuits thereof. This arrangement is desirable to obtain a suitable indicator driving voltage permitting prompt and sensitive response to input signal differences.

Fig. 2 shows an embodiment of applicant's invention in circuit diagram form comprising an arrangement for maintaining the amplitude of detected radio frequency voltage supplied over a coaxial transmission line 11 to a load circuit 12 from a radio frequency source of fluctuating voltage 13 constant over a wide range of fluctuations. An adjustable coupling condenser 14 is coupled between the coaxial transmission line 11 and the input of the voltage control unit 15. In a preferred form, condenser 14 comprises a plate movable with respect to the inner conductor of coaxial line 11. By varying the coupling of the movable plate with respect to the inner conductor, the amount of voltage applied to control circuit 15 may be regulated. Detector circuit 16 detects the output of condenser 14 and couples it to an input electrode 17 of comparator circuit 18. Comparator circuit 18 comprises a pair of cathode coupled triodes 19 and 20 having a common unbypassed cathode load resistor 21 and operating as a form of push-pull circuit. A source of adjustable amplitude reference voltage is available from the movable arm of potentiometer 22. Potentiometer 22 is coupled at one end to a source of negative potential and at the other end to ground. A voltage regulating tube 23 is coupled across the potentiometer 22 to maintain a substantially constant source of negative voltage from which a predetermined amount may be coupled by adjustment of potentiometer 22 to the input electrode 24 of tube 20. The plate voltage of tubes 19 and 20 is supplied from a positive voltage source, +, through the plate-cathode circuits of series connected tubes 25, 26 and 27, 28 respectively. Tubes 26 and 28 have their cathodes 29 and 30 tied together and coupled by means of a common current bypass resistor 31 to ground. This is necessary since in the particular embodiment disclosed tubes 26 and 28 draw considerably more plate current than do the voltage amplifiers 19 and 20. The cathode electrodes 29 and 30 of tubes 26 and 28 are also coupled through load resistors 32 and 33 to respective plate electrodes of tubes 19 and 20. Potentiometer 34 is provided for adjusting the relative amount of load resistance contained in tube circuits 19 and 20. The output of tube 19 is coupled to the input electrode 35 of tube 26 while the output of tube 20 is coupled to the input electrode 36 of tube 28. Cathodes 37 and 38 of tubes 25 and 27 are coupled by means of resistors to the plate electrodes of 26 and 28 respectively. The input electrodes 39 and 40 of tubes 25 and 27 are coupled to the output of tubes 26 and 28.

During operation of circuit 15, tubes 19, 20, 25, 26, 27 and 28 are conducting all the time. If the input signals to electrodes 17 and 24 are equal, no voltage is developed between cathodes 37 and 38. Potentiometer 34 is provided to adjust for the no voltage condition. If the negative signal from diode 16 applied to electrode 17 is more negative than the negative signal available at electrode 24, tube 20 will conduct more heavily than tube 19 thereby making the voltage available at electrode 35 more positive with respect to that at 36, hence lowering the positive voltage at electrode 39 with respect to electrode 40 whereby the voltage at cathode 37 is more negative than that at cathode 38. Across cathodes 37 and 38 is provided the field windings 41 of a permanent magnet D. C. motor 42 whose output shaft is coupled by appropriate gearing to the movable plate of condenser 14. Thus it is seen that for a lowering in voltage of electrode 17 with respect to electrode 24, a negative voltage is available at cathode 37 with respect to cathode 38 thereby driving motor 42 in a direction to reduce the degree of coupling of condenser 14 and hence the amount of voltage available at electrode 17. The control voltage is developed across winding 41 until the voltages at electrodes 17 and 24 have once again become substantially equal. By adjusting the movable arm of potentiometer 22, the voltage stabilization level may be varied in either direction.

Should the input voltage at electrode 17 become less negative than the reference voltage at electrode 24, a lower positive voltage is developed at cathode 37 than at cathode 38 thereby driving the motor 42 in an opposite direction to control the degree of coupling of condenser 14 and hence increase the input voltage at electrode 17 to be substantially equal to the reference voltage. By providing a common cathode unbypassed load resistor for tubes 19 and 20, small voltage differences may be detected and hence a finer degree of adjustment may be obtained since greater conduction of one section as, for example, tube 19 due to a more positive signal at electrode 17 relative to electrode 24 results in a biasing voltage developed across resistor 21 reducing the discharge current flow through tube 20. A similar action on the part of tubes 26 and 28 further amplifies this signal difference such that upon application to the winding 41 coupled across the outputs of devices 25 and 27, sufficient power will have been developed to adjust condenser 14 to equalize the signals applied to electrodes 17 and 24.

In the event of failure of source 13 such that no voltage is available in coaxial line 11, control unit 15 would normally attempt to operate to raise the zero voltage available at electrode 17 to that of the reference level, thereby running the motor 42 needlessly. Hence, it is desirable to prevent operation of the control circuit 15 until a given minimum level of signal voltage is available in transmission line 11. To this end, a switching circuit 43 is provided for connecting the output of detector circuit 16 by means of switch 44 to input electrode 17. For no signal on the transmission line 11, switch 44 couples the input electrodes 17 and 24 together, thereby maintaining motor 42 fixed at its last position. Circuit 43 comprises a pair of triodes 45 and 46 having a common unbypassed cathode resistor 47 coupled to a source of negative potential. The input electrode 48 of tube 45 is supplied with available detected radio frequency energy from transmission line 11 by means of detector circuit 50. The input electrode 51 of tube 46 is coupled to an adjustable source of negative voltage available at potentiometer 52. Between the output electrodes of tubes 45 and 46 is coupled the field coil 57 of the relay controlling the position of switch 44. The output electrodes of tubes 45 and 46 are coupled by load resistors to a source of positive potential. When no radio frequency energy is available in line 11 enough static or

contact potential is developed across the output of 50 to provide negative bias at 48 balancing negative bias applied from 52 to 51. Tubes 45 and 46 therefore conduct substantialy equally, hence producing no voltage drop across winding 57 and thereby maintaining switch 44 in its lower position to prevent operation of motor 42. If the input signal at electrode 45 rises, as upon arrival of radio frequency energy, a resultant voltage is developed across winding 57 to raise switch 44 to its other position thereby coupling radio frequency voltage from circuit 16 to input electrode 17 of the control circuit 18. Thus, it is seen the switching circuit functions such that for no radio frequency input voltage, a bias voltage is developed balancing the reference voltage established by potentiometer 52 at electrode 51, and winding 57 is inoperative to raise 44 to couple input voltage to the control circuit 18. However, when radio frequency voltage is available, the balance is destroyed and relay winding 57 operates 44 to apply input voltage to circuit 18.

The arrangement set forth in Fig. 2 has been found to operate satisfactorily over a wide range of input voltage frequencies and intensity variations in providing a substantially constant output to very close tolerances for application to a load circuit 12.

While I have shown only certain preferred embodiments of my invention by way of illustration, many modifications will occur to those skilled in the art and I therefore wish to have it understood that I intend in the appended claims to cover all 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 system for regulating the supply of signal voltage from a source to a load, a source of operating voltage, two pairs of electron discharge devices, each electron discharge device having an anode, a cathode, and a control electrode, the devices of each pair being connected in series across said source with a resistance in series between the anode of one device and the cathode of the other device, means to vary the potential of the control electrode of said other device with the anode potential of said one device of each pair, and means to supply to the control electrodes of said one device of each pair a voltage varying on said electrodes in opposite sense with variations in voltage on said load, and means responsive to the difference in potentials of the cathodes of said other devices of said pairs to control the voltage supplied to said load.

2. An arrangement for comparing the intensity of a variable signal with a reference signal comprising two groups of electron discharge devices, a source of unidirectional voltage, means for respectively coupling the electron discharge paths of the devices in each group in series across said source, each of said devices comprising an input and an output circuit, means for coupling said signals to respective input circuits of an initial device in each group, an indicator for indicating the intensity difference of said signals, means for coupling said indicator between an output circuit of the final devices in said groups, and means for coupling the remaining output circuit of each device to a respective remaining input circuit of a succeeding device in a respective series coupled group.

3. An arrangement according to claim 1 further comprising means for intercoupling a selected pair of devices, one from each group, to achieve push-pull operation.

4. An arrangement for comparing the intensity of a variable signal with a reference signal comprising two groups of electron discharge devices, a direct voltage source, means for respectively coupling the electron discharge paths of the devices in each group in series across said source, each of said devices comprising an input circuit, an output circuit and a cathode electrode, said devices being arranged into a first, second and third pair of devices, each comprising a device in each group, a common cathode impedance intercoupling said first and second pair of devices, means supplying said signals to respective input circuits of said first pair of devices, means coupling the output circuits of said first and second pairs of devices to the input circuits of said second and third devices respectively, and an indicator for indicating the intensity difference of said signals coupled between the output circuits of said third pair of devices.

5. An arrangement for comparing the intensity of a variable signal with a reference signal comprising two groups of electron discharge devices, a direct voltage source, means for respectively coupling the electron discharge paths of the devices in each group in series across said source, each of said devices comprising an input circuit, an output circuit, a cathode and an anode, said devices being arranged into a first, second and third pair of devices, each pair comprising a device in each group, a respective common cathode load impedance intercoupling the respective devices of said first and second pair of devices, means supplying said signals to respective input circuits of said first pair of devices, means coupling the output circuits of said first and second pair of devices to the input circuits of said second and third devices respectively, and an indicator for indicating the intensity difference of said signals coupled between the output circuits of said third pair of devices, the devices of said first and second pair of devices each comprising anode load impedances, said first and second load impedances also comprising the cathode load impedances of a respective device of said second and third pair of devices respectively.

6. A variable coupling arrangement for applying a predetermined amount of signal from a variable intensity signal source to a load comprising a source of reference signal, two groups of electron discharge devices, a direct voltage source, means for respectively coupling the electron discharge paths of the devices in each group in series across said source, each of said devices comprising an input circuit, an output circuit, and a cathode electrode, said devices being arranged into a first, second and third pair of devices each comprising a device in each group, separate means providing a push-pull intercoupling of the respective devices of said first and second pair of devices, means normally supplying said signals to respective input circuits of said first pair of devices, means coupling the output circuits of said first and second pair of devices to the input circuits of said second and third devices respectively, coupling means for applying signals from said source to said load, means coupled between the output circuits of said third pair of devices for controlling the degree of coupling of said coupling means, and means responsive to the intensity of variable signals falling below a minimum level for coupling said sig-

nals to a common input circuit of one of the devices of said first pair of devices.

7. An arrangement for controlling the degree of coupling of coupling means supplying signals from a variable intensity signal source comprising a reference signal source, two groups of electron discharge devices, a direct voltage source, means for respectively coupling the electron discharge paths of the devices in each group in series across said source, each of said devices comprising an input circuit, an output circuit, a cathode and an anode, said devices being arranged into a first, second and third pair of devices each comprising a device in each group, a respective common load impedance intercoupling the respective devices of said first and second pair of devices in push pull, means supplying said signals to respective input circuits of said first pair of devices, means coupling the output circuits of said first and second pair of devices to the input circuits of said second and third devices respectively, an indicator for indicating the intensity difference of said signals coupled by the output circuits of said third pair of devices, the devices of said first and second pair of devices each comprising

anode load impedances, said first and second load impedances also comprising the cathode load impedances of a respective device of said second and third pair of devices respectively, means coupled between the cathodes of said third pair of devices for controlling the degree of coupling of said coupling means.

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