

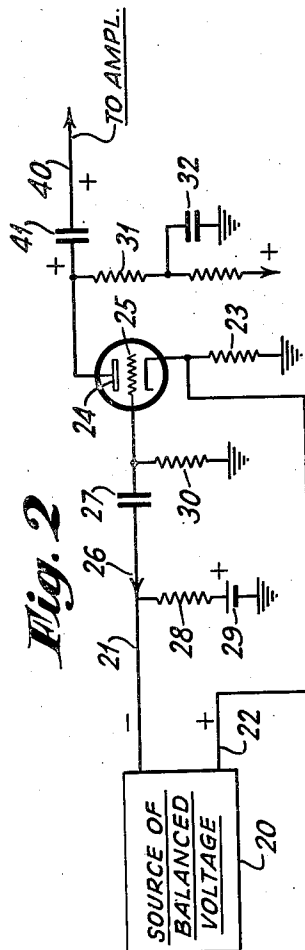
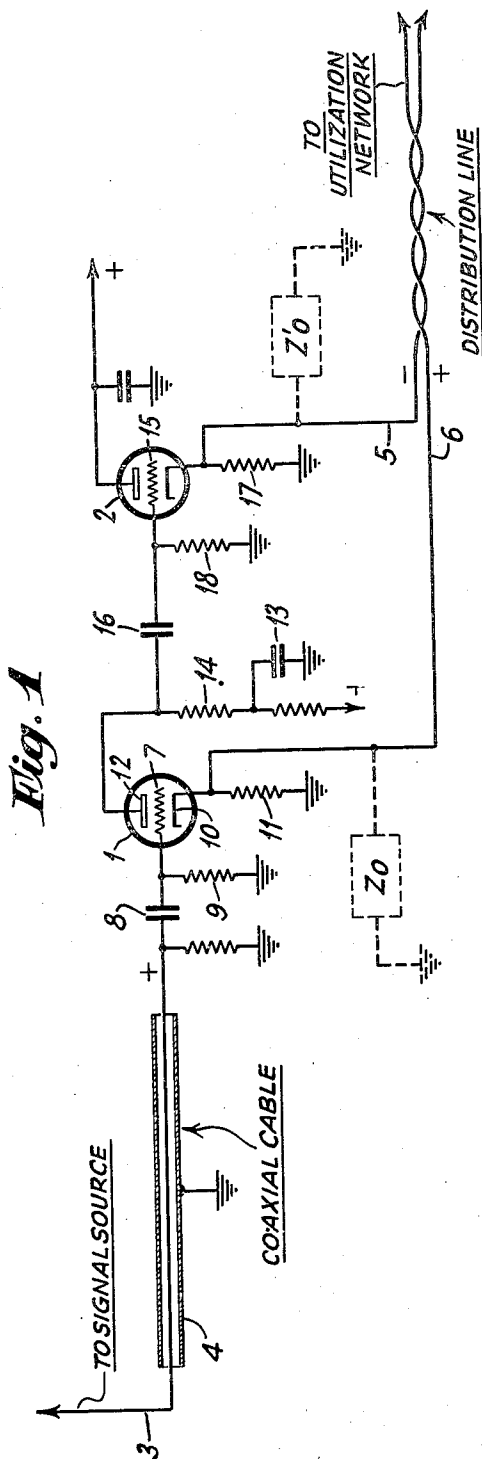
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COUPLING CIRCUITS

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COUPLING CIRCUITS

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5 Claims. (Cl. 178—44)

Our present invention relates to coupling circuits generally adapted to transfer alternating current voltage from unbalanced to balanced lines, or from balanced to unbalanced lines.

In the past it has generally been known how to couple an unbalanced circuit to a balanced circuit. An unbalanced circuit is, of course, one which has one side thereof at a given polarity with respect to ground, while the other side thereof is ground itself; on the other hand, a balanced circuit is one wherein the two sides of the circuit are at opposite polarity with respect to ground. In the prior art it has been customary to employ three electron discharge tubes to couple an unbalanced circuit to a balanced circuit when using a cathode-coupled output for direct connection to the balanced lines. In this last instance, one of the tubes is used to secure phase reversal of the unbalanced voltage, while the other two tubes are utilized to provide cathode coupling to the balanced lines. It is, also, known to secure a balanced output with a signal tube, and in this case one of the output connections has a low direct current potential, while the other output connection has a high direct current potential. In this case, condensers are required to eliminate the direct current potential coupling. Working into a low impedance load it is practically impossible to obtain an output which is constant at low frequencies. It would require extremely large coupling condensers, and might seriously limit the maximum frequency obtainable due to the large capacity of each coupling condenser to ground which is in parallel with the output of the tube.

Accordingly, it may be stated that it is one of the important objects of our present invention to provide a coupling arrangement, adapted for use in coupling an unbalanced circuit to a balanced circuit, wherein the arrangement avoids the necessity of utilizing coupling condensers to the balanced lines, and gives an output at low impedance suitable for direct connection to the balanced lines; the coupling arrangement, further, having very low direct current potentials at the points of connection of the balanced lines to the coupling tubes.

In the case of the coupling of balanced circuits to unbalanced circuits, it has been customary in the past to employ three electron discharge tubes. Cancellation of longitudinal voltage effects is produced in the plate circuits of the coupling tubes, and there is a strong possibility that large longitudinal voltages might drive the

5 grids of the coupling tubes positive and damage them.

It is, therefore, another important object of our present invention to provide a coupling network adapted to connect a balanced circuit to an unbalanced circuit, wherein but a single tube is employed, and the effect of longitudinal voltages being eliminated in the input circuit of the single tube.

10 Another object of our invention may be stated to reside in the provision of a coupling network, adapted to connect an unbalanced line to a pair of balanced lines, wherein there are employed a pair of electron discharge tubes; one of the tubes having its input electrode coupled to the unbalanced line and having a cathode coupling connection to one of the balanced lines, while the second tube has its input electrode connected to the output electrode of the first tube, and the second balanced line is connected to the cathode load of the second tube.

15 Another object of the invention may be stated to reside in the provision of a single tube coupling network, adapted to couple a pair of balanced lines to an unbalanced line, one of the balanced lines being connected to the input electrode of the tube, while the other balanced line is connected to the cathode load of the tube, and the unbalanced line being connected to the output electrode of said coupling tube.

20 Still other objects of our present invention are to improve generally the simplicity and efficiency of coupling networks of the cathode-coupled type, and more especially to provide such networks in an economical and reliable manner.

25 The novel features which we believe to be characteristic of our invention are set forth in particularity in the appended claims; the invention itself, however, as to both its organization and method of operation will best be understood by reference to the following description taken in connection with the drawing in which we have indicated diagrammatically several circuit organizations whereby our invention may be carried into effect.

30 In the drawing,

Fig. 1 illustrates a circuit arrangement adapted to couple an unbalanced line to a pair of balanced lines.

35 Fig. 2 shows a circuit adapted to couple a pair of balanced lines to an unbalanced line.

Referring now to the accompanying drawing, wherein like reference characters in the two figures designate similar circuit elements, there is shown in Fig. 1 a pair of electron discharge

tubes 1 and 2 which are included in the coupling network adapted to provide the coupling circuit between an unbalanced line and a pair of balanced lines. The unbalanced line is shown, by way of illustration, as a coaxial cable whose inner lead 3 is at a positive potential with respect to the grounded outer conductor 4. The lead 3 may have one end thereof connected to a source of signal energy of any desired frequency. For example, the signal energy source may be in a signal range of 60 cycles to 8 megacycles; the signals may be included in the video or normal sound broadcast range. Regardless of the frequency of the signal energy, or the frequency band width of the signal energy, the lead 3 is shown, by way of illustration, as having a positive alternating current voltage with respect to ground. It is for this reason that the term "unbalanced" is applied to line 3—4. Assuming, now, that it is desired to transmit the signal energy from the line 3—4 to a distribution line comprising a pair of leads 5 and 6, attention is directed to the fact that the leads 5 and 6 are "balanced." In other words, at any given instant the leads 5 and 6 are of opposite polarity with respect to ground. Such a distribution line, for example, may be a twisted pair of leads adapted to transmit a wide band of television signal energy through an apartment house, or the like, to one or more television receivers.

It is to be clearly understood, however, that the specific example shown in Fig. 1 involving the transmission of energy from an unbalanced coaxial cable to a balanced distribution line is merely illustrative. The unbalanced and balanced circuits may be of any other specific type. For example, the unbalanced circuit may consist of an iconoscope, whereas the balanced circuit may comprise a push-pull picture signal amplifier. Those skilled in the art will readily perceive other uses for the unbalanced and balanced circuits respectively. Considering the coupling network specifically, the control grid 7 of tube 1 is connected to the lead 3 and by a coupling condenser 8, while the grid side of condenser 8 is connected to ground through the grid-leak resistor 9. The cathode 10 of tube 1 is connected to ground through a cathode load resistor 11. The plate 12 is connected to a source of positive potential through an impedance, an intermediate point of the impedance being bypassed to ground through the high frequency bypass condenser 13. The section of the impedance between the plate and the bypassed point is denoted by numeral 14. By way of illustration the impedance 14 is shown as a resistor.

The resistor 11 is unbypassed, and there is signal frequency voltage developed across the resistor. This voltage is applied to control grid 7 in degenerative phase to the signal frequency voltage applied through condenser 8. As a result the impedance across resistor is low. The signal frequency voltage developed across the plate load resistor 14 is applied to the control grid 15 of tube 2 through condenser 16. The cathode of tube 2 is connected to ground through a resistor 17, the grid leak resistor 18 providing a negative bias path between grid 15 and the grounded end of the resistor 17. The plate of tube 2 is energized from a source of direct current which is not shown. The cathode end of the resistor 17 is connected to lead 5. The unbypassed resistor 17 develops signal frequency voltage thereacross which is applied to grid 15 in degenerative phase. At any given instant the

polarities of leads 5 and 6 are opposite with respect to ground. In Fig. 1 there is shown, by way of illustration, that when lead 3 is positive to ground, then lead 6 is positive and lead 5 is negative relative to ground.

The impedance of each lead 5 and 6 to ground is denoted by the symbol Z_0 , and is shown by the dotted rectangles so labelled. The magnitude of Z_0 is equal to the expression

$$\frac{R_{11}}{1 + R_{11}S_{m-1}}$$

where S_{m-1} is the transconductance of tube 1; the magnitude of Z_0' is equal to

$$\frac{R_{17}}{1 + R_{17}S_{m-2}}$$

where S_{m-2} is the transconductance of tube 2.

A constant signal level is applied to the grid 7 of tube 1. The output from the cathode of tube 1 is constant, up to several megacycles, and reduced in magnitude by the efficiency of the cathode-coupled stage. The resistor 14 causes a signal voltage to be applied to grid 15 of tube 2 which is equal to the voltage applied to grid 7, but is 180 degrees out of phase. Similarly the output from the cathode load of tube 2 will be constant, up to several megacycles, and can be made equal in magnitude to that of the first tube 1 but reversed in phase. Consequently, there is had a balanced output, at tubes 1 and 2, at low impedance and low direct current potential suitable for direct connections to the transmission lines. By inserting a battery in the ground side of the cathode resistors the direct current potentials can be cancelled out.

To convert a balanced input to an unbalanced output, the arrangement shown in Fig. 2 may be employed. Here the source of balanced voltage is generally represented by the box 20; and the leads 21 and 22 are shown as respectively at negative and positive potentials relative to ground. The source 20 can be any push-pull amplifier, for example; it can also comprise the type of distribution line shown in Fig. 1. The lead 22 is connected to the cathode end of the grounded resistor 23 disposed in the space current path of tube 24. The control grid 25 is connected to the slidable contact arm 26 through condenser 27. The lead 21 is connected to ground through a series path consisting of resistor 28 and positive voltage source 29. The contact arm 26 is slidable along resistor 28. The grid leak resistor 30 provides the usual bias path for grid 25. The signal voltage is developed across resistor 31, and one end of the resistor is bypassed to ground through condenser 32 for signal frequency currents. The signal voltage developed across load resistor 31 is applied to lead 40 through the coupling condenser 41. As shown in Fig. 2, when the leads 21 and 22 are respectively at negative and positive potentials, the lead 40 assumes a positive potential. The lead 40 may be connected to an amplifier, transmission cable or other utilization apparatus.

In the circuit of Fig. 2, the opposite polarity signal effects on the grid and cathode of tube 24 are additive in the plate circuit thereof. The potentiometer 28—26 is inserted in the grid side of the tube to equalize the gain from the two sides of the circuit. The resistor 28 acts as a termination for one side of the input circuit, while the parallel combination of the cathode resistor 23 and the reciprocal of the transconductance of

tube 24 acts as the other side of the input circuit of tube 24. A positive potential, derived from source 29, equal to the cathode to ground direct current potential of the resistor 23 is inserted in the ground end of the terminating resistor 28. This is done in order that the direct current potential at the point where the line is connected to resistor 28 shall be the same as that at the point where the line 25 is connected to the cathode of tube 24. Of course, if the source of signal voltage 20 has no direct current potentials, the source 29 may be dispensed with; resistor 28 would then be grounded. If the source 20 is the output of the circuit shown in Fig. 1, then source 29 causes the direct current potentials at the ends of lines 21 and 22 (or 5, 6) to be equal, and no direct current flows. Any longitudinal voltages induced onto the line 21—22 would be cancelled out in the input circuit of tube 24. This is a decided advantage in cases where longitudinal voltages are appreciable.

While we have indicated and described several systems for carrying our invention into effect, it will be apparent to one skilled in the art that our invention is by no means limited to the particular organizations shown and described, but that many modifications may be made without departing from the scope of our invention, as set forth in the appended claims.

What we claim is:

1. In a coupling network between an unbalanced voltage source and a balanced voltage network, a pair of cascaded tubes, means for impressing the unbalanced voltage between the input electrodes of the first tube, means for impressing the output voltage of the first tube upon the input electrodes of the second tube, a resistive impedance individual to and connected to the cathode of each of said tubes, each of said impedances being in the space current path of its respective tube, means degeneratively applying to the input electrode of each tube voltage developed across its respective cathode impedance, and a direct current voltage connection between the cathode end of each impedance and said balanced network.

2. In combination, an electron discharge tube provided with at least a control grid, a cathode and a plate, a resistor connected between the cathode and ground and being disposed in the space current path of the tube, a source of unbalanced high frequency voltage coupled between ground and said control grid, means for applying to said control grid in degenerative phase high frequency voltage developed across said resistor, a second tube including at least a cathode,

a control grid and a plate, means for impressing high frequency voltage developed in the plate circuit of the first tube upon the control grid of the second tube, a second resistor connected between the cathode of the second tube and ground, means for applying to the control grid of the second tube in degenerative phase high frequency voltage developed across said second resistor, a direct current voltage connection to the cathode end of said second resistor, and a second direct current voltage connection to the cathode end of said first resistor whereby the high frequency voltages on said two connections are balanced with respect to ground.

3. In combination with a source of balanced voltage and an unbalanced voltage network, an electron discharge tube provided with at least a cathode, a control grid and a plate, a resistor connected between the cathode and ground and being disposed in the space current path of the tube, a direct current voltage connection between said source and the cathode end of said resistor, a second connection between said source and the control grid of said tube, means for applying in degenerative phase to said control grid a voltage developed across said resistor, and means for applying to said network voltage developed in the plate circuit of said tube.

4. In combination with a pair of leads which are at opposite polarities with respect to ground and which carry voltages of high frequency, a tube including at least a cathode, a control grid and a plate, a resistive impedance connected between the cathode and ground and being located in the space current path of the tube, one of said leads being connected to the cathode end of said resistive impedance, a connection from the other lead to the control grid of said tube, means for applying the high frequency voltage of said impedance to said control grid in degenerative phase, and a lead connected to the plate of said tube for transmitting high frequency voltage which is unbalanced with respect to ground.

5. In combination, cascaded signal transmission tubes each tube having a load impedance in the space current path thereof which develops signal voltage, means degeneratively applying the signal voltage of each impedance to its respective tube input electrode, means applying signals to the first of said tubes, and an independent signal output connection to a point on each impedance which has a variable signal potential.

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