

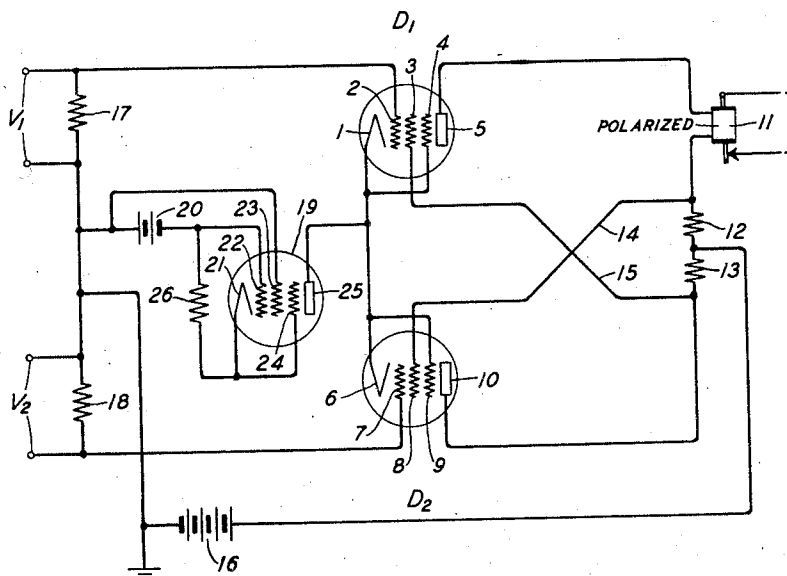
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ELECTRIC DISCHARGE TUBE CIRCUITS

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ELECTRIC DISCHARGE TUBE CIRCUITS

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The invention relates to detector circuits and particularly to detector circuits employing electric space discharge tubes.

5 An object of the invention is to distinguish between voltages of different magnitudes.

A related object is to detect small differences between a plurality of different electrical voltages over a wide range of absolute values of the individual voltages, and to utilize the detected differences to control the operation of electrical apparatus.

10 The circuit of the invention in one form is a differential detector which will respond quickly and positively to very small differences between different applied electrical voltages, the direction of operation depending upon which applied voltage is the greater and the operation being independent of the absolute magnitude of the individual applied voltages. In one embodiment, the differential detector consists of two pentode vacuum tubes connected in push-pull arrangement, the screen grid-plate circuits of the two tubes being connected in mutually regenerative relation, means for impressing two separate signal voltages respectively on the individual portions of the input circuits of the two tubes, a mechanical relay having its operating winding connected in the individual plate-cathode circuit of one of the tubes, so as to be differentially responsive to the direction of flow of plate current through the winding and a "constant current" tube common to the control grid-cathode and plate-cathode circuits of the two tubes, for controlling the differential sensitivity of the detector.

15 There are in general two disadvantages in the usual differential detector circuit. The first relates to the speed of operation. With a differential input which is just great enough to operate a differential relay in the output of the detector, for instance, the time of operation may become inordinately great. The second disadvantage relates to the variation in differential sensitivity as the magnitudes of the input voltages become great.

20 In the circuit of the invention, the first disadvantage is eliminated by the regenerative connections. The circuit is in an unstable condition once it starts to operate, with the current rapidly building up to a value high enough to insure quick operation of the relay. The second disadvantage is eliminated in the circuit of the invention by the constant current tube which maintains the proper adjustment of the detector tubes so that proper operation will be obtained for the

same small differences in input voltage independent of the absolute magnitudes of the input voltages.

The objects and advantages of the circuits of the invention will be better understood from the following detailed description thereof when read in connection with the accompanying drawing, the single figure of which shows schematically a differential detector circuit embodying a preferred form of the invention.

Referring to the drawing, the differential detector circuit of the invention comprises the two pentode detector vacuum tubes D_1 and D_2 , connected in push-pull relation. The detector tube D_1 comprises in an evacuated envelope, a filament or cathode 1, a control electrode or grid 2, a screen grid 3, a suppressor grid 4 connected directly to the cathode 1, and a plate or anode 5, and the detector tube D_2 comprises in an evacuated envelope, a filament or cathode 6, a control electrode or control grid 7, a screen grid 8, a suppressor grid 9 connected directly to the cathode 6, and a plate or anode 10.

The plate 5 of the tube D_1 is connected to the plate 10 of the tube D_2 through the operating winding of the polarized mechanical relay 11 and the resistances 12 and 13 in series. The plate 5 of the detector tube D_1 is also connected directly to the screen grid 8 of the detector tube D_2 through the winding of mechanical relay 11, and conductor 14, and the plate 10 of detector tube D_2 is connected directly to the screen grid 3 of the detector tube D_1 through the conductor 15. Plate current is supplied from the plate battery 16 to the plate 5 of tube D_1 and to the plate 10 of tube D_2 , through resistance 12 and the winding of mechanical relay 11 in series, and the resistance 13, respectively.

A control voltage V_1 is applied to the input of the detector tube D_1 across the terminals of a series resistance 17, in the individual portion of its control grid-cathode circuit, and a control voltage V_2 is applied to the input of the detector tube D_2 across the terminals of a series resistance 18 in the individual portion of the cathode-control grid circuit of the latter tube.

A pentode vacuum tube 19 acting as a "constant current" device, that is, as a device in which the voltage drop varies over wide limits as the current through it varies over narrow limits, in series with a direct current battery 20, is connected in common to the common portions of the cathode-control grid circuits and the common portions of the plate-cathode circuits of the detector tubes D_1 and D_2 . The pentode tube 19

comprises in an evacuated envelope, a cathode 21, a control grid 22, a screen grid 23, a suppressor grid 24 connected directly to the cathode 21 and a plate or anode 25. The plate 25 is connected to a common point in the cathode energizing circuit for the tubes D₁ and D₂. The control grid 22 is connected to the negative terminal of battery 20, the positive terminal of which is connected through resistance 17 to the control grid 2 of detector tube D₁, and through the resistance 18 to the control grid 7 of the tube D₂. The screen grid 23 of tube 19 is connected directly to the positive terminal of the battery 20. A resistance 26 is connected directly across the cathode 21 and the control grid 22 of tube 19. The negative terminal of plate battery 15 is connected to ground, and to the positive terminal of the battery 20, as indicated.

The relative values of the elements of the circuit shown in the drawing, and their purpose in accordance with the invention will be brought out in the following detailed description of operation of the circuit.

In order to properly describe the operation of the circuit, the functions of the tube 19 and the series battery 20 will be disregarded for the moment. The particular interconnection of the plates and screen grids of tubes D₁ and D₂, indicated in the drawing and described above, are such as to make the plate-screen grid circuits of the tubes D₁ and D₂ mutually regenerative. To illustrate, let it be assumed that current is flowing through the tube D₂ only. Then, the resultant drop in potential across the resistance 13 reduces the potential on the screen grid 3 of detector tube D₁ tending to make the plate current of the tube D₁ small or zero. This leaves the screen grid 8 of the detector tube D₂ at full potential, since there is no large drop in potential across the resistance 12 and hence the current through the detector tube D₂ is at a maximum.

Now let it be assumed that voltage V₂ is applied to the input of the detector tube D₂ across the resistance 18 in its control grid-cathode circuit. This voltage is in the negative direction, and therefore tends to reduce the plate current of the detector tube D₂. As the plate current of the tube D₂ decreases so also does the voltage drop across the resistance 13. Hence, the voltage on the screen grid of the tube D₁ increases, which in turn causes the plate current of the tube D₁ to increase. This increase of current in tube D₁ produces an increase in potential across the resistance 12 and a subsequent drop in potential on the screen grid 8 of detector tube D₂. The reduction of the potential of the screen grid 8 of detector tube D₂ causes a further decrease in the plate current of the tube D₂, and hence a further increase of plate current in tube D₁.

The process just described is a regenerative one with the amount of regeneration dependent upon the values of the series resistances 12 and 13. Enough regeneration should be provided by means of resistances 12 and 13 so that the action is discontinuous, that is, once the action starts taking place it continues until it reaches its full value. If these are too small, no proper action can take place, while if they are too large a "D. C. sing" will be produced, that is, the detector circuit will lock up on one side or the other. With the proper values for resistances 12 and 13, however, the regenerative action can be made to proceed with a very small input voltage. If the resistance 13 is made slightly

larger than the resistance 12, current will flow through the detector tube D₂ but not through the detector tube D₁ when both input voltages V₁ and V₂ are removed. If the resistance 13 is made slightly smaller than the resistance 12, current will flow through the detector tube D₁ but not through the detector tube D₂ when both input voltages are removed. Either method of operation can be used. In a practical circuit set up and satisfactorily operated, the resistance 13 was made greater than the resistance 12. Another method of operation could be had by making the two resistances 12 and 13 equal, in which case, the current will continue to flow through the detector circuit in the direction last assumed.

To return to the differential action, assume a voltage V₂ is applied to the input of a detector tube D₂ across the resistance 18 such that the current through the tube D₂ is small and the current through the detector tube D₁ is large. Now, let it be assumed that a voltage V₁ is applied to the input of the detector tube D₁ across resistance 17. If the voltage V₁ is larger than the voltage V₂ applied to the input of the detector tube D₂, the currents in the two tubes will reverse, that is, the current through the tube D₂ will be large and the current through the tube D₁ will be small. Now, if the value of the applied voltage V₁ is maintained constant, a further increase in the applied voltage V₂ will again decrease the current through the tube D₂ and hence increase the current through the tube D₁.

All this time, of course, the absolute magnitudes of the control grid biases for the tubes D₁ and D₂ have been getting more and more negative, thus reducing the absolute magnitudes of the plate currents of these tubes more and more. This results in (1) a lack of sensitivity in the tubes, and (2) may result in insufficient current to operate the relay 11 in the plate-cathode circuit of tube D₁. To overcome these defects, use is made of the tube 19 in the common portion of the control grid-cathode and plate-cathode circuits of the tubes D₁ and D₂ as a "constant current" device, that is, as a device in which the voltage drop varies over wide limits as the current through it varies over narrow limits. This is a well-known characteristic of pentode vacuum tubes. To help this action further, use is made of the resistance 26 connected between the control grid and cathode of the tube 19. A decrease in plate potential on the tube 19, which tends to produce a small current decrease therein, also tends to decrease the negative bias on the control grids of the detector tubes D₁ and D₂, which in turn tends to increase the plate current of the latter tubes. The decrease in plate current through tube 19 which produces a decrease in potential drop across resistance 26, also tends to increase the plate current of tube 19 by virtue of the reduction in its grid bias.

As indicated, the space path of the tube 19 is connected in series with the battery 20 in the common cathode leads of the tubes D₁ and D₂. The purpose of the battery 20 is to reduce the high negative potential on the control grids of the detector tubes D₁ and D₂, since for best operation, the voltage drop across the tube 19 should be of the order of 50-60 volts.

With the addition of the tube 19 and battery 20 to the circuit, as the input voltages V₁ and V₂ increase in magnitude, a slight decrease in the total plate currents of tubes D₁ and D₂ produces a relatively large decrease in the voltage drop across tube 19. This, in turn, tends to decrease

the negative bias effect of the supply voltages V_1 and V_2 , and hence large variations in the input voltage will result in only a small change in the total plate current of the tubes D_1 and D_2 .

5 The differential sensitivity of the detector circuit remains unaffected, however, since the tube 19 tends to hold only the total plate current constant independent of the particular tube in which it flows. However, the actual direction of flow of plate current through the winding of the relay 11 is still determined by the difference between 10 the two input voltages V_1 and V_2 , the flow in the case of V_1 being larger than V_2 being such as to cause operation of the relay 11 to open its normally closed armature and contact, whereas in 15 the case of input voltage V_2 being larger than the input voltage V_1 the flow is in such direction as to maintain the relay in the unoperated condition in which the relay armature and contact 20 remain closed.

The circuits of the invention as shown in the drawing have been used successfully with a differential type of echo suppressor in connection with a four-wire telephone circuit. When so 25 used, the signal waves flowing in opposite sides of a four-wire signaling circuit cause rectified signaling voltages V_1 , V_2 to be applied respectively across the resistance 17 in the input circuit of the detector tube D_1 and across the resistance 18 in 30 the input circuit of the detector tube D_2 , the rectified voltage V_1 , when it is stronger than V_2 , through the detector tube D_1 causing the operation of the relay 11 to remove a normal short circuit in the corresponding side of the four-wire 35 circuit, and V_2 , when it is stronger, through the detector tube D_2 , biasing the relay 11 in the unoperated direction so that the normal short-circuit across the first side of the four-wire circuit will be maintained.

40 The differential detector circuit of the invention, however, is not limited to echo suppressors or even to voice-operated switching circuits, but may be used in any situation where it is desired to obtain positive and quick directional operation of switching apparatus for small differences 45 between two or more given voltages.

Various other modifications of the circuits illustrated and described which are within the spirit and scope of the invention will occur to persons 50 skilled in the art.

What is claimed is:

1. A differential detector circuit comprising two space discharge detector tubes each including a cathode, an anode, a control grid and a 55 screen grid, and circuits therefor, the control grid-cathode circuits and the cathode-anode circuits respectively being connected in push-pull relation, the screen grid-anode circuits of the two detector tubes being connected in mutually regenerative relation, means for impressing separate 60 variable voltages respectively on the individual portions of the control grid-cathode circuits of the two detector tubes, and means in the individual portion of the cathode-anode circuit 65 of one of said tubes directionally responsive to the flow of plate current therethrough to indicate which of said variable voltages is the greater.

2. A differential detector circuit comprising two space discharge detector tubes each including a 70 cathode, an anode, a control grid and a screen grid, and circuits therefor, the cathode-anode and cathode-control grid circuits of the two tubes respectively being connected in push-pull rela-

tion, the screen grid-anode circuits of the two tubes being connected in mutually regenerative relation, means for impressing different voltages respectively on the individual portions of the 5 cathode-control grid circuits of the two tubes, means in the individual portion of the cathode-anode circuit of one tube differentially responsive to flow of plate current therethrough in opposite 10 directions, and means for maintaining the magnitude of the resultant plate current in the individual portion of the cathode-anode circuit of one tube substantially constant over a wide range of magnitudes of the voltages impressed on the 15 cathode control grid-cathode circuits of the two tubes.

3. The system of claim 2, in which the last-mentioned means comprises a pentode space discharge tube having its space path common to the common portions of the cathode-control grid 20 circuits and the common portions of the cathode-anode circuits of the two detector tubes.

4. The system of claim 2, in which the last-mentioned means comprises a third space discharge tube having its discharge path in series 25 with a source of positive biasing potential for the control grids of the two detector tubes, in common to the individual portions of the cathode-control grid circuits and the cathode-anode circuits of both detector tubes, said third tube including a cathode, an anode, a control grid and 30 a screen grid, the screen grid of said third tube being maintained at positive potential with respect to the control grid thereof, and a resistance connected directly between the control grid 35 and cathode of said third tube.

5. A switching circuit comprising two space discharge detector tubes each including a cathode, an anode, a control grid and a screen grid, control grid-cathode and cathode-anode circuits 40 for the two tubes respectively connected in push-pull relation, the screen grid of each tube being connected to the anode of the other tube so that the two tubes are mutually regenerative, a polarized relay having a winding connected in the individual portion of the cathode-anode circuit of 45 one tube, means for impressing separate voltages on the individual portions of the control grid-cathode circuits of the tubes, a resistance in each individual portion of the cathode-anode circuit for each tube, the relative values of the resistances in the individual portions of the cathode- 50 anode circuits of the two tubes being such that when the input voltage to one tube exceeds the input voltage to the other tube by a given amount, said relay will be operated in one direction and 55 when the input voltage to the other tube exceeds that to said one tube by a given amount said relay will be operated in the opposite direction, and means for preventing undue reduction in sensitivity of said switching circuit during operation. 60

6. The switching circuit of claim 5 in which the last-mentioned means comprises a constant current space discharge device and a source of positive biasing potential for the control grids of said detector tubes, the discharge path of said 65 constant current device and said source of positive biasing potential in series being connected in common to the common portion of the control grid-cathode circuits and the common portion of the cathode-anode circuits of the two detector 70 tubes.

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