

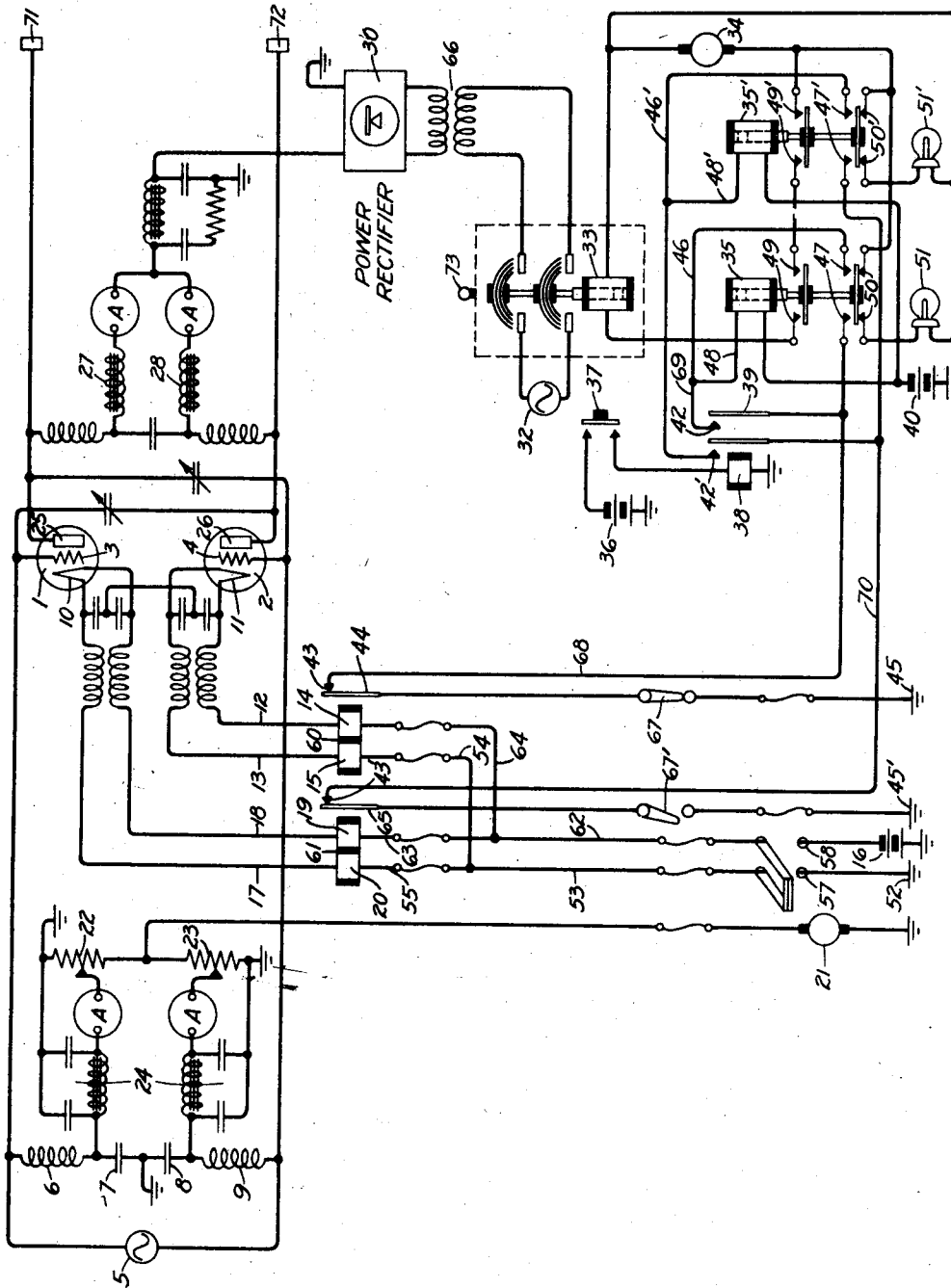
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PROTECTIVE CIRCUIT FOR VACUUM TUBES

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PROTECTIVE CIRCUIT FOR VACUUM TUBES

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This invention relates to protective devices and more particularly to those used in systems where overload surges of energy are to be guarded against.

5 One of the objects of the invention is to protect the electrodes of a space discharge device when current in the anode circuit exceeds a predetermined value.

10 Another object of the invention is to indicate immediately to an observer without the necessity of testing each individual tube, which of a group of parallel tubes is drawing an excess of plate current.

15 The invention is particularly applicable to high power radio installations which require the use of tubes whose power supply circuits may be in parallel, operating with direct current on the filament.

20 One of the features of the invention resides in placing a differential relay in the filament leads of each individual space discharge device which operates to disconnect the source of plate potential when the current exceeds a predetermined value but which
25 is unresponsive to any change in the filament current. A differential relay may be used comprising two windings so arranged that one winding is included in one filament lead and the second winding is included in the
30 second filament lead. The filament current passes through the two windings in series but the polarity of the windings is such that the resultant magnetic effect due to the filament current is zero or at least substantially
35 constant and is insufficient to attract the relay armature. However, the plate circuit is connected in such a manner that the plate current traverses the windings in parallel. The magnetic effect of the current under
40 these conditions is additive and when of sufficient value will attract the relay armature. A predetermined value is set beyond which an increase of plate current operates the relay which in turn controls means for discon-
45 necting the source of plate potential from the plate circuit.

A relay is associated with each parallel tube and can also be arranged to operate a signal to indicate which of the tubes is receiving the overload.

Some of the advantages of the system result from the positioning of the relays in the low voltage leads thus permitting the use of relays having light windings, which relays are comparatively cheap. This position is also desirable in high powered systems wherein tubes arranged in parallel have their anodes physically strapped together since each tube may have an individual indicator.

55 Other objects and features of the invention will be apparent on reading the following description in connection with the attached drawing which illustrates schematically the application of the invention to a pair of space discharge power amplifiers connected in push-pull relation for the purpose of amplifying the waves from a source which may generate either audio or radio frequency waves. While it has been necessary to show in considerable detail various arrangements for disconnecting the plate current and for indicating in which device the trouble has occurred, it is obvious that many changes may be made in the circuit connections and that the invention should not be limited to the specific arrangement of the drawing.

Referring to the drawing, the pair of space discharge vacuum tubes 1 and 2 are shown with their grids 3 and 4 connected in push-pull relation to a source of waves 5 which waves in this instance, are to be amplified, although the invention is not dependent upon any particular type of input or output connection. The input circuit of the amplifier tube 1 may be traced from the grid 3 of the tube 1 through the coil 6, the condenser 7 to ground and from ground at 52 through the parallel paths comprising leads 53 and 55 and 62 and 63, through windings 19 and 20 of relay 61, and leads 17 and 18 to the filament 10. The corresponding grid circuit for the vacuum tube 2 may be traced from the grid 4 to the coil 9, the condenser 8 to ground and from there through the parallel paths comprising leads 53 and 54 and 62 and 64, through windings 14 and 15 of relay 60, leads 12 and 13 to the filament 11. The source 5 is connected across the circuit branch 6, 7, 8 and 9.

The filaments of the tubes are connected in parallel to the source of direct heating cur-

rent 16. The filament circuit for the tube 1 may be traced from the ground 52, terminal 57, through the lead 53, lead 55, the relay winding 20, through lead 17, filament 10, lead 18, relay winding 19, back to the source 16 at terminal 58. The corresponding circuit for tube 2 also may be traced from the ground 52, terminal 57, through leads 53 and 54, relay winding 15, lead 13, filament 11, lead 12, relay winding 14 and back to the source 16 at terminal 58. The source 16 may be of any suitable type. The grids of the tubes are supplied with the required biasing voltage by adjustable resistances 22 and 23 which may be connected across a suitable source 21. The circuit through the resistance may be traced from ground through source 21, resistances 22 and 23 in parallel to ground. Filters 24 are provided to eliminate variations which may be present due to fluctuations in the source of grid potential 21. The alternating current output circuits of the tubes are arranged in push-pull relation and are shown connected to terminals 71 and 72. Another stage of amplification or a utilization circuit may be connected to these terminals.

Energy is supplied to the plate circuits of the tubes 1 and 2 in parallel. The direct current path of the plate circuit for tube 1 may be traced from the plate or anode 25, through coil 27, rectifier 30 to ground and back to the filament 10, through the pair of parallel paths one of which comprises leads 53, 55, relay winding 20 and lead 17 while the other comprises leads 62, 63, relay winding 19 and lead 18. The corresponding plate circuit for tube 2 may be traced from the anode 26 through the coil 28, rectifier 30 to ground and back to the filament 11 through a pair of parallel paths one of which comprises leads 53 and 54, relay winding 15 and lead 13 while the other comprises leads 62 and 64, relay winding 14 and lead 12.

The relays 60 and 61 have their windings differentially arranged so that magnetic fields which are produced by the filament current oppose each other so as to make the resultant force upon their respective armatures substantially zero. In other words, the filament current through the windings 14 and 15 in the case of relay 60, and 19 and 20 in the case of relay 61 flows in a series circuit and the windings are so poled as to produce the zero resultant magnetic force as mentioned above.

However, for current flowing in the plate circuit the windings 14 and 15 for relay 60 and windings 19 and 20 for relay 61 are in parallel and the flow of current in the respective pairs of windings is in the same direction. The windings are arranged in such a manner that current flowing therethrough in the same direction produces magnetic fields which are additive in effect. The relay armatures 44 and 65 may be arranged so that they do not

operate until a certain predetermined value of plate current is flowing through the relay coil. Thus, for normal operation the value of plate current is not sufficient to attract the armatures but if an overload occurs in either of the tubes the relays operate to interrupt the flow of plate current.

The type of circuit in which such a protective device could be used to great advantage is one in which the values of plate potential are very high, as for instance, in the order of 1,000 to 10,000 volts, or even higher. One arrangement by which the high voltage plate supply is interrupted is shown in the drawing.

The high voltage rectifier 30 is connected to the high side of a high voltage transformer 66, the low side of which is connected to a source 32 of alternating current. With such high potentials in the plate circuits it is desirable to place a protective circuit breaker in the primary or low voltage side of the transformer. Such a circuit breaker, provided with a handle 73 for manual operation, is shown in its open position at 33. The circuit breaker is maintained closed by the current through its solenoid from source 34, through contacts 49 and 49' of relays 35 and 35' during normal operation of the system.

Relay 35 is maintained in its closed position by current flowing in the circuit which may be traced from ground 45, through switch 67 in closed position, through the armature 44, through the contact 43, through lead 68, closed contacts 47 of relay 35, through the leads 46 and 48, the energizing winding of relay 35 back to grounded supply source 40. Relay 35' during normal operation is maintained in its closed position by current flowing through the circuit which may be traced from ground 45', through switch 67' and in its closed position through the armature 65, contact 43', through lead 70, contacts 47', leads 46' and 48', through the energizing winding of the relay 35' to grounded supply 40. By thus energizing the windings of the relays 35 and 35' the circuits through contacts 47 and 47', and 49 and 49' are maintained closed. During the normal operation of the circuit the contacts 50 and 50' of the relays 35 and 35' are open.

The operation of the circuit when an overload occurs in the plate circuit of either of the tubes will be readily understood from a description of the operation of either of relays 35 and 35', since the operation of either will open contacts 49 or 49' thereby opening the holding circuit of circuit breaker 33. For instance, when the current in the plate circuit of tube 2 reaches a certain predetermined value relay 60 operates attracting armature 44, thus opening the circuit by means of which relay 35 is energized. The plunger of relay 35 falls to the position shown in the drawing, causing contacts 50 to close an obvious circuit for energizing lamp 51 which

indicates that tube 2 is overloaded. When relay 35 is deenergized, contacts 49 are opened, thereby opening the holding circuit for circuit breaker 33. Source 32 is disconnected and the supply of plate current to tubes 1 and 2 ceases. As soon as plate current ceases to flow armature 44 of relay 60 falls back to its normal operating position, making contact with contact 43. A similar result would follow if an overload should occur in tube 1, but in this instance relay 35' would operate causing the lamp 51' to light.

In order to reset relays 35 and 35' it is necessary to reestablish the circuit through the winding of the one which has operated. This is accomplished by means of a reset button 37. On pressing the button a circuit is established from the grounded source 36 through the winding of relay 38 to ground. When the winding of relay 38 is energized its armatures are attracted to close contacts 42 and 42'. The circuit through the coil of the relay which has been opened (in this case relay 35) is reestablished which circuit may be traced from the source 40 through the winding of relay, contact 42 and its associated armature, lead 68, contact 43, armature 44, through the closed switch 67 to ground at 45. A similar circuit for the other relay may be traced from the source 40 through the winding of the relay 35', contact 42' and its associated armature, lead 70, contact 43', armature 65 and through the switch 67' to ground at 45'. When relay 35 or 35' or both are reset contact is again made at 49 or 49' or both as the case may be, thus completing the circuit through the coil of the circuit breaker 33, placing it in condition for closing by the operator.

It is to be understood that reset button 37 when operated causes current to flow through relay 38 only momentarily and after the circuit is established through relay 35 or 35' by the armatures and associated contacts 42 and 42' of relay 38, this reset circuit is broken and the holding circuit maintained through contacts 47 and 47'.

With the differential relays 60 and 61 in the circuits it is apparent that the filament emission of the tubes may be varied over a very wide range without causing the anode protecting circuits to operate since the resultant pull on the relay armature due to filament current is always zero. It is also obvious that these relays may be made much smaller and cheaper than those which would be necessary if individual relays were used in the high potential part of the plate circuit.

Further, when a large number of tubes are used in parallel the indication which is given by the invention also obviates the necessity of guessing at random which tube has received the overload current.

Other various forms will at once suggest themselves to those skilled in the art within the spirit of the invention, which is to be

limited therefore only by the scope of the appended claims.

What is claimed is:

1. In a space discharge system, a space discharge device having an anode and an electron emitting cathode, an anode circuit comprising leads from said cathode to a source of heating current, and indicating means in said leads operated by space current variations for indicating when said anode circuit is overloaded.

2. In a space discharge system, a space discharge device having an anode and an electron emitting cathode, an anode circuit comprising leads from said cathode to a source of heating current and indicating means in said leads comprising a differential relay operable when said anode circuit is overloaded.

3. An electron emitting cathode and a heating circuit therefor, an anode circuit comprising a portion of said heating circuit and indicating means in said heating circuit comprising a relay insensitive to changes in heating current, but operating to give an indication upon change of current in the anode circuit.

4. In a space discharge system, a space discharge device having an anode and an electron emitting cathode, a heating circuit therefor, an anode circuit comprising a portion of said heating circuit and anode protecting means in said heating circuit comprising a differential relay, insensitive to changes of heating current, but operating to interrupt the flow of anode current upon its reaching a predetermined value.

5. In a space discharge system, a space discharge device having an anode, an electron emitting cathode, having a heating circuit therefor, an anode circuit comprising a portion of said heating circuit and anode protecting means in said heating circuit comprising a differential relay having a pair of windings, said windings being in series in said heating circuit but in parallel in said anode circuit, said relay being sensitive only when current is flowing through said windings in parallel.

6. In a space discharge system, a space discharge device having an anode, and an electron emitting cathode, a heating circuit therefor, an anode circuit comprising a portion of said heating circuit and anode protecting means in said heating circuit comprising a differential relay having a pair of windings, said windings being in series in said heating circuit but in parallel in said anode circuit, said relay being insensitive to changes of current in said heating circuit, but operating to interrupt the current in said anode circuit upon its reaching a predetermined value.

7. In combination a plurality of space discharge devices having anode and individual cathode circuits, a source of potential for

impressing a high voltage upon said anodes and means, in each individual cathode circuit, controlled by an overload in any of the space discharge devices for disconnecting said source.

8. In combination a plurality of space discharge devices connected in parallel having anode and individual cathode circuits, a source of potential for impressing a high voltage upon said anodes and means comprising a plurality of relays associated with respective individual cathode circuits for disconnecting said source of high potential when the current in the anode circuit of any of said tubes exceeds a predetermined value.

In witness whereof, I hereunto subscribe my name this 25th day of May, 1928.

JOHN C. SCHELLENG.

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