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METHOD FOR VACUUM TUBE REJUVENATION

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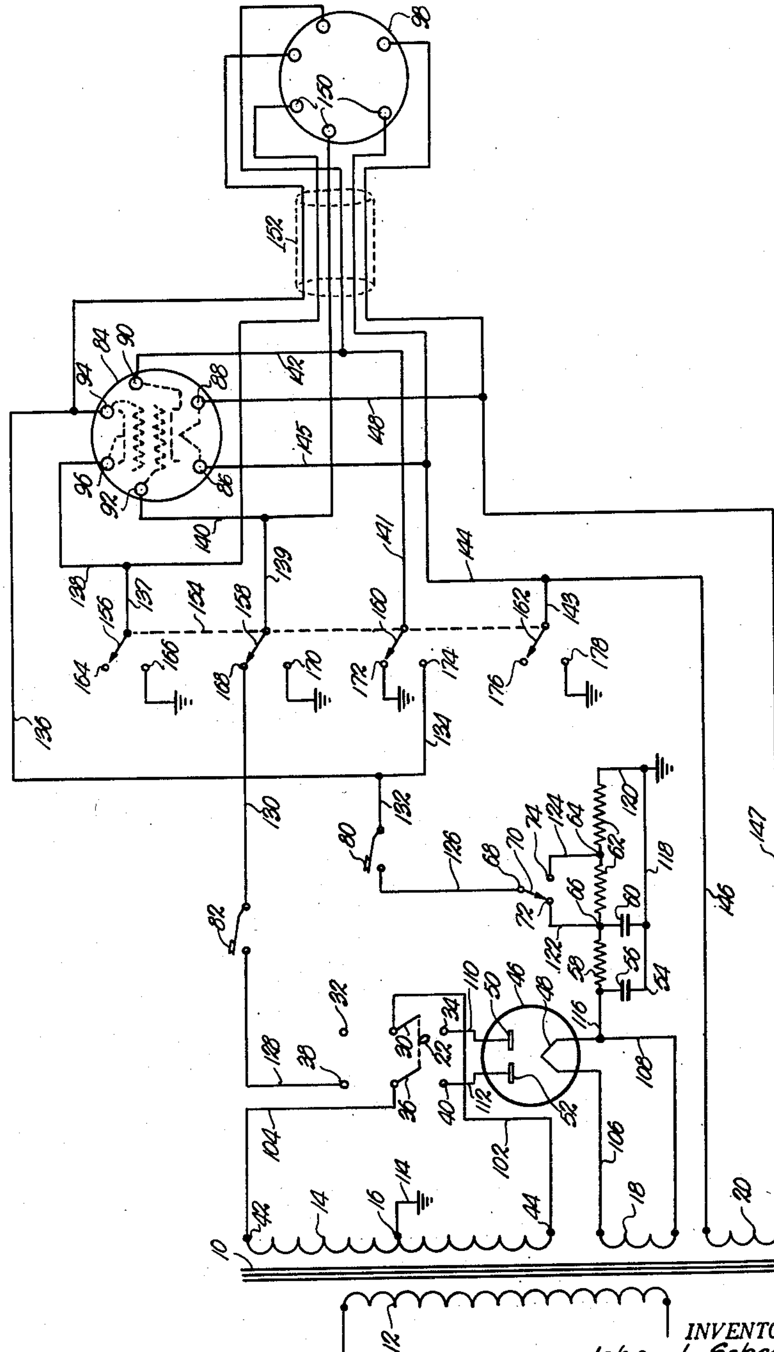

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METHOD FOR VACUUM TUBE REJUVENATION

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This invention relates to vacuum tube rejuvenation, and has for its primary purpose the provision of an improved method and apparatus for restoring old and defective vacuum tubes to usefulness by the removal of inter-element shorts therefrom and the reactivation of the cathode thereof to a level of emission capabilities satisfactory for efficient operation of the tube.

Previous methods of vacuum tube rejuvenation and the apparatuses therefor have all been subject to serious limitations and disadvantages, notably the inconsistency of results obtained therewith, as well as the markedly temporary nature of the restoration obtained even with tubes whose treatment initially appeared successful.

Accordingly, it is the most important object of this invention to provide a method and apparatus for vacuum tube rejuvenation which overcomes such limitations and disadvantages experienced with prior methods and apparatuses and is adapted for successfully restoring almost all of the previously untreated tubes subjected to the method to usefulness for a reasonable period following such treatment, thereby materially extending the operating life of the tube.

Another important object of this invention is to provide a method of vacuum tube rejuvenation whose practice will not result in damage to, or adverse changes in the operating characteristics of, the tube.

Another important object of this invention is to provide a method of vacuum tube rejuvenation particularly adapted for use with cathode ray and television type tubes.

Another important object of this invention is to provide simple inexpensive and fool-proof apparatus particularly adapted for use in practicing the method of the invention.

Still other important objects of this invention will become clear or be made apparent as the following specification progresses.

The single figure of the drawing is a schematic wiring diagram of a preferred form of apparatus for practicing the method of this invention.

The most common reasons for failure of vacuum tubes as a result of ordinary use are inter-element shorts and lowered cathode emission capabilities. As a tube is used, the active coating on the cathode thereof is gradually rendered less and less active, the cathode being the only part of the tube that actually "wears out." This effect is believed to be due to the gradual expenditure by the cathode of its active coating material by "blowing off" minute particles of same during periods of emission and the gradual building up on the cathode of a thin outer film of a relatively inactive material in covering relationship to the more active portion of the coating, which film prevents the remaining active portion of the cathode from effectively emitting the number of electrons required for satisfactory operation of the tube.

It is these occurrences that also cause the great majority of inter-element shorts, it being noted that many of such shorts appear only when the filament of the tube is carrying its normal operating voltage and thereby heating the various elements of the tube to expand the same to their normal operating dimensions. Since vacuum tube elements are commonly spaced apart by distances of only a few thousandths of an inch when cold, and often by only one or two thousandths when heated, it is clear that the gradual building up of particles of expended cathode material between elements, particularly between the cathode and the first or control grid adjacent thereto in view of the concurrent formation on the cathode of the above-mentioned film, will eventually result in inter-element shorts in a large number of cases.

Prior attempts at vacuum tube rejuvenation by efforts to overcome the effects of such conditions have resulted either in damaging the tube in other respects and changing its operating characteristics or in only partial rejuvenation of limited effectiveness for periods too short to justify the time and expense involved in treating the tube.

The majority, if not all, of such previous methds have involved applying to the filament of the tube, for some considerable period of time, a voltage substantially in excess of the characteristic or normal voltage at which the tube is designed to operate and is customarily operated in conventional applications, the purpose of this being to superheat the coating of material on the cathode to break up the outer film of relatively inactive material formed thereon. This type of treatment results however, in major surface irregularities and cracks in the cathode coating, with consequent "dead spots" in the emission pattern of the cathode, as well as in unduly shortening the ultimate possible useful life of the tube. In the case of cathode ray and television tubes particularly, such "dead spots" are intolerable for satisfactory performance.

The method of this invention overcomes such shortcomings of previous processes by uniformly removing or "blowing off" the objectionable outer film on the cathode in a manner that leaves the underlying active portion of the cathode coating exposed and in condition for further useful service in its function as an emitter of a substantially uniform pattern of electrons, without damaging the tube or changing its characteristics other than by restoring the emission capabilities of the cathode to a useful level.

Since that part of the method of this invention which is concerned with the restoration of the cathode emission capabilities of the tube is not effective in the presence of pre-existing inter-element shorts, the method hereof necessarily contemplates the elimination of such shorts. Further, since the removal of the objectionable inactive film from the cathode involves the liberation within the tube of minute particles of cathode material, inter-electrode shorts are occasionally caused by the cathode emission restoration itself, which necessitates the inclusion in the overall treatment of steps to remove such shorts after cathode restoration.

It will be understood that any of the conventional methods and means for testing the tube to be treated for shorts and cathode emission capabilities before, during and after treatment may be employed in connection with the method of tube rejuvenation contemplated by this invention.

Referring now, more specifically, to the steps included in our method, the first step is to apply to the filament of the tube a voltage and current equal to that characteristic voltage and current at which it is normally operated, that is, the standard operating voltage and current recommended by the manufacturer of the tube as being the proper values when the tube is used in the applications for which it was designed. The important thing is that such characteristic filament voltage not be substantially exceeded. It is likewise important that, whenever possible, although not necessarily, the tube being treated be disposed vertically with its base downwardmost, in order that the tube elements will be vertical with their open ends at the bottom to permit the escape from between elements of materials loosened from the elements during the "burning out" of shorts and the removal of the inactive cathode film.

Then, assuming that a short has been determined to exist between some adjacent pair of elements of the tube, a high voltage, direct current potential, preferably in the range of from 350 to 800 volts, is applied between the shorted elements for a period of preferably from one to five seconds, depending upon the seriousness of the short to be "burned out." It has been found that, if a potential having a minimum of ripple is used for this purpose, such as filtered, full wave rectified direct current, the necessary time of application and the chances of sparking between non-shorted tube elements are minimized. It has been further discovered that, although potentials down to slightly above 100 volts will burn out certain shorts if applied for a sufficient length of time, the higher voltages are to be preferred for quicker action and more complete removal of the material causing the short, around 400 volts being satisfactory for eliminating most shorts, although potentials above about 650 volts and sometimes as high as about 800 volts are required for the more serious cases. It may be noted that such potential may, if desired, conveniently be simultaneously applied between each pair of adjacent elements of the tube either to "burn out" more than one short at a time or to prevent any possibility of the formation of a new short between one pair of elements as a result of dislodging materials theretofore causing a short between another pair of elements. In any event, it is important in this step that the potential be so applied that the cathode is at a positive potential with respect to the first or control grid, in order to prevent excessive electron emission by the cathode as a result of undesirable conduction in the tube between non-shorted elements. It will be apparent that, if no short exists in the tube, this step may be omitted.

Next, assuming that conventional testing has revealed that the emission capabilities of the cathode of the tube are below the acceptable level for good performance, a high voltage alternating current potential, preferably in the range of 700 to 900 volts, is applied between the cathode of the tube and the first or control grid of the tube, with the cathode being grounded to prevent a discharge between the cathode and filament of the tube, for a period of preferably between $1/100$ and $1/10$ of a second, depending upon the seriousness of the cathode emission deficiency. Normally, the application of one such pulse, particularly if for a period approaching the preferred maximum limit of about $1/10$ of a second, is sufficient to restore the cathode emission capabilities of the tube to normal "new-tube" levels. In a few rare cases, repetition of this step a second or third time may be necessary and such is, of course, contemplated, although seldom required. It may be noted that application of the alternating current pulse in the manner of this step is attended by a visible discharge internally of the tube and having the general appearance characteristic of space discharges of electricity in evacuated containers. Such discharge is attended by momentary, extremely heavy electron emission by the cathode with the result that the outer, inactive film on the cathode is effectively and substantially uniformly "blown off," but without damage to the inner, active portion of the cathode coating which is thereby exposed. It is essential to this method that the potential used be at least in excess of about 500 volts and that the maximum length of the applied pulse in no event exceed one second, the shorter pulse lengths mentioned above being strongly preferred since longer pulses with the order of potential used can seriously damage the tube and virtually disintegrate the cathode coating thereof.

Finally, in the event that the cathode emission restoration shall have caused one or more inter-electrode shorts in the tube, the short "burn out" step described above is repeated in the same manner. It is notable that such shorts as are caused by cathode restoration are comparatively rare, particularly when the tube is positioned with its elements disposed vertically and the open ends thereof facing downwardly during the restoration step, and, in any event, are seldom serious or difficult to eliminate by the method of this invention.

Referring now to the apparatus shown in the drawing, the numeral **10** represents a transformer having a primary winding **12** adapted for connection to a source of alternating current line voltage, a high voltage secondary winding **14** provided with a center tap **16**, a rectifier filament secondary winding **18**, and a filament voltage secondary winding **20** adapted for heating the filament of a tube to be treated. It will become apparent to those skilled in the art that separate transformers having secondaries equivalent to windings **14**, **18** and **20** could be used, and further, that, where tubes having differing filament voltage requirements are to be treated, additional transformers or additional filaments **20** on transformer **10** could be provided together with suitable switching means for supplying the proper filament voltage to each type of tube to be treated.

A double pole, double throw switch **22** is provided, having a pole member **30** adapted to alternately engage a contact **32** and a contact **34** and a pole member **36** adapted to alternately engage a contact **38** and a contact **40**, members **30** and **36** being preferably ganged, as shown, for simultaneous respective engagement with either contacts **32** and **38** or contacts **34** and **40**. Winding **14** has end terminals **42** and **44**, which are respectively coupled with pole members **30** and **36** by conductors **102** and **104**, the center tap **16** of winding **14** being grounded through conductor **114**.

A full-wave rectifier tube **46** provided with a filament **48** and a pair of plates **50** and **52** has its filament **48** coupled with winding **18** by conductors **106** and **108** and its plates **50** and **52** respectively coupled with contacts **34** and **40** of switch **22** by conductors **110** and **112**. It is thus apparent that, when pole members **30** and **36** are in a position respectively engaging contacts **34** and **40**, the electrical output of winding **14** is applied to plates **50** and **52** of tube **46**, center tap **16** being grounded, and a full wave rectified, direct current potential with respect to ground is made available at conductor **108**.

The rectified, direct current output from conductor **108** is coupled by a conductor **116** with a filtering and voltage dividing circuit **54**, which includes an input filtering capacitance **56**, a resistance **58** forming a part of the filtering network and also serving as a series resistance for limiting the power drawn from tube **46**, a second filtering capacitance **60** and a voltage dividing, load resistance **62** having an intermediate tap **64**. Conductor **116** is connected in conventional manner with capacitance **56** and resistance **58**, resistance **58** being in turn coupled with capacitance **60** and voltage dividing resistance **62**, capacitors **56** and **60** being grounded through conductor **118** and resistance **62** being grounded through conductor **120**. Thus, a full wave rectified and filtered direct current potential of relatively high voltage is made available at the point of connection **66** between resistances **58** and **62**, and a similar potential of somewhat less voltage value is made available at tap **64** of resistance **62**.

A single pole, double throw switch **68** is provided having a shiftable pole member **70** and a pair of contacts **72** and **74**, contact **72** being coupled by a conductor **122** with point **66**, contact **74** being coupled by a conductor **124** with tap **64**, and member **70** being coupled with a conductor **126**. Obviously, resistance **62** and switch **68** could be replaced by a potentiometer, if desired, to make available ripple-free, direct current potentials of more than two values.

There is no connection to contact 32 of switch 22, but contact 38 is connected with a conductor 128. Thus, because of the grounding of center tap 16 of winding 14, an alternating current voltage of high potential with respect to ground is made available at conductor 128.

Manifestly, different types of power supply and filtering circuits and components from those shown could be used to produce the various direct and alternating current potentials required for the practice of the method of this invention. The virtue of the circuits illustrated, however, like the entire apparatus of this invention, lies in various details of construction resulting in an efficiently operating piece of equipment which may be manufactured with readily available and inexpensive components.

Suitable values for the various components will be obvious to those skilled in the art and need not be herein given. It may be noted, however, that the winding 14 should be capable of delivering voltage of sufficient level for use in practicing the method hereof with the preferred values of potential described above.

A normally open switch 80 is coupled with conductor 126, and a similar switch 82 is coupled with conductor 128, switches 80 and 82 being of a quick acting type and preferably, from the standpoint of economy, although not necessarily, manually operable. Conventional types of button operated, micro-switches capable of making and breaking a circuit in 1/100 of a second or less have been found well adapted for service as switches 80 and 82, it being understood that such micro-switches may be satisfactorily momentarily closed for an extremely short interval by a quick touch of the operator's finger and immediately reopened by the action of the switch itself, or the switch may be operated by other means for more accurate timing of its period of closure or may even be replaced by a timed switching mechanism, if desired.

A tube receiving socket 84 is provided for receiving a tube to be treated, socket 84 preferably being supported by any suitable means (not shown) in a position adapted for supporting the tube being treated with its elements in vertical disposition with their open ends downwardmost. Socket 84 has a plurality of terminals 86, 88, 90, 92, 94 and 96 respectively adapted for connection with one filament pin or lead, the other filament pin, the cathode pin, the first or control grid pin, the second or accelerator grid pin and the anode or plate pin of a tube placed in the socket for treatment in accordance with the method of this invention. Other sockets to accommodate tubes having different pin connections could obviously be supplied and have their terminals coupled in parallel with the terminals 86—96 inclusive of socket 84.

An auxiliary socket 98 is provided having a number of terminals 150 coupled in parallel with the corresponding terminals of socket 84 by means of an elongated, flexible, multi-conductor cable 152, the individual connections being obvious from the drawing. Socket 150 is particularly useful for performing the method of this invention upon television tubes without removing the same from the cabinet of the television receiver.

A multi-pole, double throw switch 154 is provided with four ganged poles 156, 158, 160 and 162, pole 156 having a pair of contacts 164 and 166 associated therewith, pole 158 having contacts 168 and 170, pole 160 having contacts 172 and 174, and pole 162 having contacts 176 and 178. It will hereinafter become obvious that switch 22 could be ganged with switch 154, if desired, but is herein illustrated as separate therefrom since such latter construction has been found slightly less expensive and to permit a more compact construction with little sacrifice in convenience. It will also be appreciated that suitable testing circuits may be integrated with the apparatus of this invention by the provision of additional contacts on switches 22 and 154.

Switch 82 is coupled with contact 168 of switch 154 by a conductor 130. Switch 80 is coupled with contact 174 of switch 154 by conductors 132 and 134, and with the second or accelerator grid terminal 94 of socket 84 by conductors 132 and 136. Contacts 164 and 176 of switch 154 have no connections, and contacts 166, 170, 172 and 178 are grounded.

Pole 156 of switch 154 is coupled with the anode or plate terminal 96 of socket 84 by conductors 137 and 138, pole 158 is coupled with the first or control grid terminal 92 by conductors 139 and 140, pole 160 is coupled with the cathode terminal 90 by conductors 141 and 142, and pole 162 is coupled with one filament terminal 86 by conductors 143, 144 and 145. Filament winding 20 is coupled with filament terminal 86 by conductors 146, 144 and 145, and with filament terminal 88 by conductors 147 and 148.

The operation of the above-described apparatus, when used in the practice of the method of this invention, should now be clear. It may be summarized as follows:

The primary winding 12 of the transformer 10 is coupled to a source of alternating current voltage. Switch 22 is shifted to place pole member 36 in engagement with contact 38 and switch 154 is shifted to place pole 160 in engagement with contact 172. The switch 82 is then operated for the required length of time to close the high voltage, alternating current circuit traceable from ground, through conductor 114, center tap 16 of secondary winding 14, a portion of winding 14, terminal 42, conductor 102, member 36 of switch 22, contact 38, conductor 128, switch 82, conductor 130, contact 168 of switch 154, pole 158, and conductors 139 and 140 to the first or control grid terminal 92 of socket 84, thence internally of the tube being treated to the cathode terminal 90 of socket 84, through conductors 142 and 141, pole 160 and contact 172 to ground. A high voltage, alternating current pulse of the desired potential is thereby applied between the cathode and the first or control grid of the tube being treated.

The switch 22 is then shifted to place member 36 in engagement with contact 40 and member 30 in engagement with contact 34, and switch 154 is shifted to place pole 156 in engagement with contact 166, pole 158 in engagement with pole 170, pole 160 in engagement with pole 174, and pole 162 in engagement with contact 178. Switch 68 is operated to place its pole 70 in engagement with the desired contact 72 or 74 thereof. Switch 80 is then closed for an appropriate period to impose a high voltage, ripple-free, direct current potential upon the cathode terminal 90 and the second or accelerator grid terminal 94 of socket 84 while the filament terminal 86, the first or control grid terminal 92 and the anode terminal 96 of socket 84 are each grounded. The circuit supplying the positive potential to the cathode terminal 90 may be traced from the secondary winding 14 of transformer 10, through conductors 102 and 104 to poles 30 and 36 of switch 22, thence through contacts 34 and 40 and conductors 110 and 112 to the plates 50 and 52 of the rectifier tube 46, then from the filament 48 of tube 46 through conductor 116, filter and voltage divider 54, switch 68, conductor 126, switch 80, conductors 132 and 134, contact 174 of switch 54, pole 160 and conductors 141 and 142 to the cathode terminal 90.

If required, switch 82 may again be closed with switches 22 and 154 in their first above described positions to repeat the short "burn out" step of the method.

It will be appreciated that many changes and modifications might be made in the method and apparatus of this invention without materially departing from the spirit thereof. Accordingly, we desire to be limited only by the scope of the appended claims.

Having thus described the invention what is claimed as new and desired to be secured by Letters Patent is:

1. A method for rejuvenating an old and defective vacuum tube of the kind provided with a number of ele-

ments including a grid, a cathode and a filament having a characteristic operating voltage, said method including the steps of applying across the filament of the tube an electrical potential equal to its characteristic operating voltage, whereby to heat the cathode of the tube to its normal operating temperature; and thereupon, applying an alternating current potential in excess of five hundred volts between the cathode of the tube and the grid of the tube for a period of less than one second with the cathode of the tube grounded, whereby to increase the electron emission capabilities of the cathode of the tube.

2. In the method as set forth in claim 1, wherein said alternating current potential is between seven hundred

and nine hundred volts, and said period is between one one-hundredth and one-tenth of a second.

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