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POWER SUPPLY FOR TRANSFORMERLESS RECEIVERS

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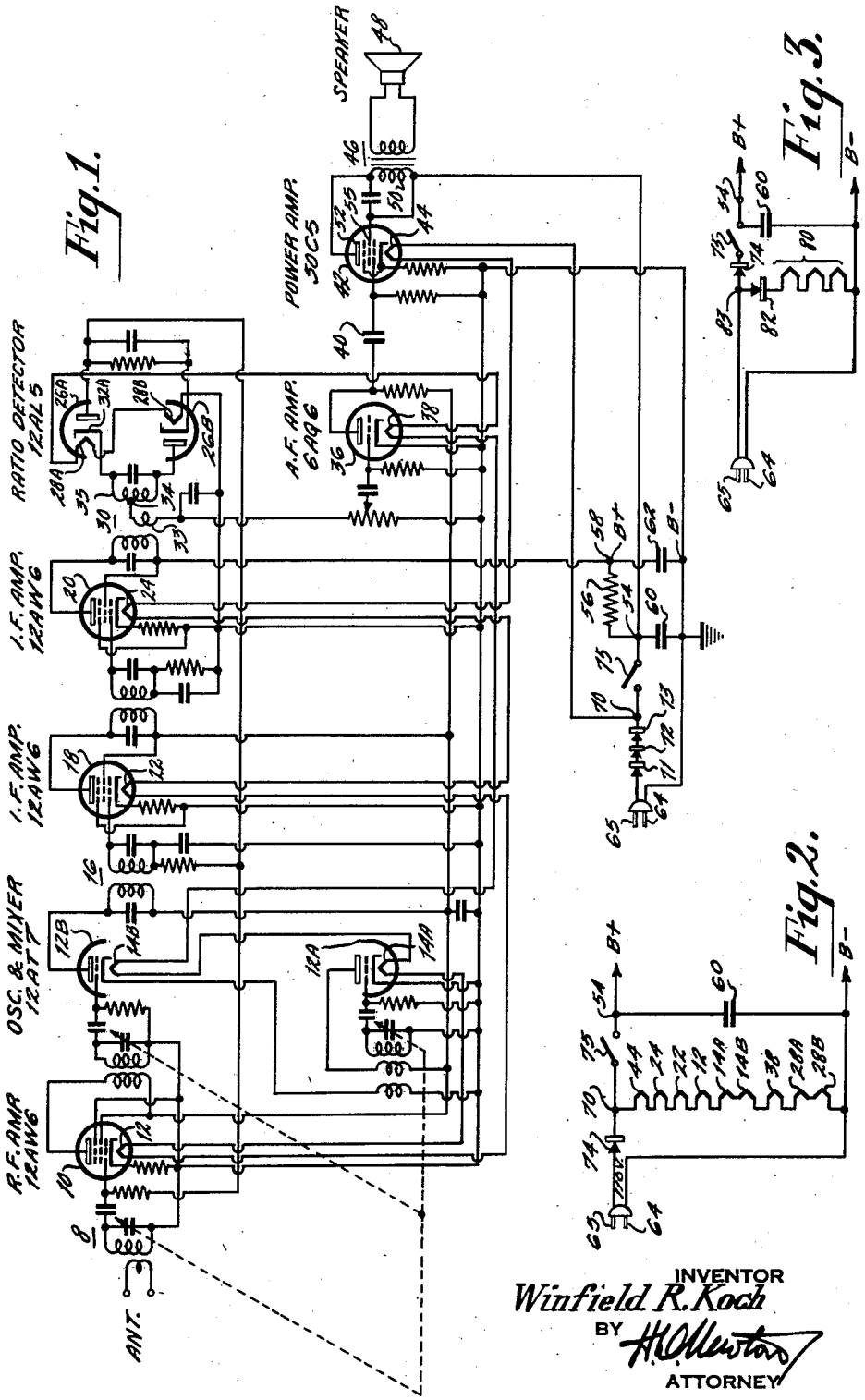


Fig. 1.

Fig. 3.

Fig. 2.

INVENTOR
Winfield R. Koch
BY H. O'Neill Stevens
ATTORNEY

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POWER SUPPLY FOR TRANSFORMERLESS RECEIVERS

Winfield R. Koch, Marlton, N. J., assignor to Radio Corporation of America, a corporation of Delaware

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This invention relates to power supply circuits. It relates more particularly to voltage supply circuits for transformerless receivers, of the A. C.-D. C. type, using series connected electronic tube heaters or filaments.

Tungsten or similar metallic type filaments or heaters in thermionic or hot-cathode type electronic tubes have a positive temperature coefficient of resistance. That is, the resistance increases as the temperature is raised. Accordingly, there is an initial surge of current when the low resistance filament is first connected to a current source. This surge may, and often does, exceed the rated current capacity of the filament and is therefore detrimental to tube life. An initial surge current of this type may exceed the normal operation current by six or seven times.

The surge current is particularly detrimental when a thermal lag of any one heater in a plurality of series connected heaters or series string, is substantially shorter than that of the rest. This means that excess current will flow through the heater for a substantial time period, until all the heaters are sufficiently warmed up. If one heater of a series string has a lower voltage rating, its thermal lag is generally shorter than that of the heaters having a higher voltage rating. This is true in many present receiver circuit designs which employ a series filament string having rated heater voltages to correspond to the power line supply voltage. A five tube set may have heater voltages somewhat in the following order: 50, 25, 12.6, 12.6, 12.6, thus totaling 112.8 volts which very nearly corresponds to the average voltage of a 110 volt supply line.

A continuous operation of heaters while the set is off would give increased tube life because of the reduction of temperature strains due to the initial current surge through the heaters when the set is turned on. In such operation the differences in thermal lag are minimized. Furthermore, by this means moisture is kept out of the set accordingly preventing fungus growths or other deterioration of the parts.

The time interval required for warming up an indirectly heated cathode to produce normal electron emission is generally of the order of several seconds and is therefore objectionable. As a result, several methods have been used to hasten the warm up period of systems using such heaters. Many of these methods have in themselves been detrimental to tube life. By continuous operation of the heaters, such warm up delay is either entirely precluded or at least substantially eliminated without adversely affecting the tube life.

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Means for continuously operating heaters at reduced voltage in a stand by condition, while the associated radio circuit is inoperative or the radio receiver is off, have been known in the prior art. As a general rule, however, such means include a ballast or voltage dropping resistor to reduce the voltage across the heaters. This type of resistor dissipates a large amount of heat which is objectionable, particularly in a small receiver cabinet when parts are crowded. Efficiency of such a means is therefore very low.

It is also, at times, a problem to reduce power frequency hum in receivers having alternating current heater supply voltages. This is particularly true in frequency-modulated signal receivers. In the ratio detectors or discriminators, used in the latter type receiver, the cathode of one detector tube is generally at high audio frequency impedance above ground. When this is so and an alternating heater supply voltage is used, leakage current from the essentially grounded heater to the cathode may cause a hum in the audio frequency output. The hum frequency is related to the power line frequency and is therefore generally either 60 or 120 cycles. In many cases also, because of the A. C. heater supply voltage, the heterodyne oscillator is frequency modulated at the power line frequency, again causing hum in the audio frequency output signal. A direct current heater supply voltage system has therefore been used in some of the more expensive receivers in order to eliminate these problems. Such a system in the past, however, has generally been limited to high-price equipment.

Oscillator frequency drift with the warm up of a receiver will cause an erratic tuning. This is due to thermal expansion of parts in the frequency determining circuits of the receiver. By keeping the tubes warm or at reduced power when the receiver is turned off, the temperature changes and therefore the thermal expansion of the parts is lessened. As a result, the oscillator frequency drift and the general receiver mistuning is minimized.

It is therefore a primary object of this invention to provide a low cost improved plate and heater supply system which will correct inadequacies of the prior art systems.

It is another object of the invention to provide a low cost power supply system which will minimize hum in the receiver output.

It is a further object of the invention to provide a system whereby warm up time is reduced to a minimum, yet in which improved tube life results.

Still further objects of the invention are to provide systems in which erratic tuning due to thermal expansion of parts is minimized and in which a transformerless or A. C.-D. C. type power supply circuit is used.

In accordance with the invention, there is provided a power supply system for transformerless or A. C-D. C. type receivers having electronic tupe cathode heaters or filaments connected in series. Continuous heater operation is provided with the heaters at reduced voltage when the receiver is off. A system is provided wherein a single switch is used to apply full operating voltage to the heater. There is simultaneously applied to the receiver, the high potential direct current supply voltage. A further feature of the invention provides versatility in the connection of receiver heaters and the provision of a direct current for the energization of the heaters.

Although this invention is particularly useful with respect to filamentary heaters generally used with cathode type tubes, it may readily be applied with equal advantage to filament type tubes. For purposes of simplification, therefore, the term heater is used in this discussion in its generic sense to include any hot-cathode heating means, either self-heated filament type or indirect cathode heater means.

The novel features that are considered characteristic of this invention are set forth with particularity in the appended claims. The operation itself, however, both as to its organization and mode of operation, as well as additional objects and advantages will best be understood from the following description when read in connection with the accompanying drawing. In the drawing, like reference numerals refer to like parts throughout the respective figures. In the drawing:

Figure 1 is a schematic circuit diagram of a receiver system embodying the invention;

Figure 2 is a simplified schematic diagram of a portion of a power supply circuit as embodied in the system of Figure 1, arranged in accordance with the invention; and,

Figure 3 is a simplified schematic diagram of an alternate modification of a portion of a power supply system, also arranged in accordance with the invention.

Referring now to the drawing, Figure 1 is a schematic diagram of a frequency modulation receiver circuit which embodies the power supply system of the invention. This circuit is used to illustrate some of the many advantages of the invention. Certain improved functions, which will be discussed in detail hereinafter, are possible when operation of the improved power supply system is combined with that of such a receiver. The mode of operation of frequency-modulated signal receivers of this type is well known to those skilled in the art. Therefore, a detailed description of the entire system is not necessary for an understanding of the present invention. However, a general description of the circuit follows. A detailed description is made of the circuit portions which are related to the present invention.

An antenna or other source of signal energy is coupled by an input circuit 8 to a radio frequency amplifier tube 10. This tube preferably has a

heater type filament 12. Such a tube may be, for example, a 12AW6. This radio frequency amplifier and its associated circuit is in turn coupled to a mixer circuit. One portion 12B of a double triode such as a 12AT7 type tube, having the other triode section 12A connected in an oscillator circuit, is used in the mixer circuit. This section is recognized as the first detector stage of a superheterodyne type receiver. The twin triode oscillator and mixer tube 12 has a common heater element 14 having separate portions associated with each triode section.

A transformer 16 is used to couple the output circuit of the mixer to an intermediate frequency section utilizing a pair of intermediate frequency amplifier tubes 18 and 20. In the present embodiment, 12 volt heaters 22 and 24 are used in each of the intermediate frequency amplifier tubes which may be of the 12AW6 type. Coupled to the I.-F. amplifier is a dual diode ratio detector 12AL5 tube 26 and its associated circuit. Any FM detector may be used here, such as for example, one of those fully disclosed in the Patents 2,497,840 and 2,497,841, issued to S. W. Seeley, for improvements in Angle Modulation Detectors, on February 14, 1950. The presently shown circuit has an FM signal detector tube 26 with a 12 volt heater divided into two separate portions 28A and 28B, one portion being for each of the respective diodes. A ratio detector transformer 30 is used as the coupling means between the final I.-F. amplifier circuit and the ratio detector circuit.

The secondary of the ratio detector transformer 30 has the high potential terminal connected to the cathode 32A of the ratio detector tube 26. Therefore, the cathode 32A is at a high audio frequency impedance with respect to ground. Since the cathode heater 28A is nearly at ground potential in general, as shown by the particular described embodiment, the cathode 32A is at a high audio potential with respect to its heater 28A. When an alternating current is applied to the heater in such a case, it is difficult to prevent a leakage current at the power line frequency between the heater 28A and the cathode 32A. This, of course, will produce a hum in the audio output of the receiver. The second detector audio output signal is taken from a tertiary winding 33 connected to a tap 34 on the secondary 35 of the ratio detector transformer 30. This signal is applied to the audio frequency amplifier tube 36, which may be a 6AQ6 or similar type tube. This tube is provided with a cathode and a 6.3 volt heater 38.

The output circuit of the A.-F. amplifier stage is coupled by means of a capacitor 40 to a power amplifier stage using a 50C5 type tube 42. This tube has a 50 volt heater 44 connected in series with the heaters of the above described tubes. In order to prevent heater overload, all the described heaters must have the same rated operating current capacities. This necessary condition for series heater strings is met by the particular tube types hereinbefore described.

In this particular circuit the rated heater voltages of the seven tubes in the series string will total 119.3 volts. Although this is more voltage than that supplied by an ordinary 110 volt power line, in accordance with the present invention a heater string of rated voltage in excess of the rated power line voltage may be used, as will be later described in detail.

An output transformer 46 couples the power amplifier stage to a speaker 48. Through the

primary 50 of this output transformer 46 the B+ power amplifier tube supply terminal 54 is connected to the anode 52 of the power amplifier tube 42. Operating voltage is connected to the screen grid 55 of the power amplifier tube directly from the junction of the output transformer 50 and the power supply terminal 54. These connections are typical of those conventionally used to supply operating potentials to the power amplifier tubes in receivers of this type.

A power supply filter resistor 56 is connected between the B+ power amplifier tube supply terminal 54 and a common B+ supply terminal 58 for the remainder of the receiver circuit. Power supply filter capacitors 60, 62 are connected to ground from each side of the filter resistor 56, thereby being connected to one of the power line terminals 64, which is also grounded. The series heater string is connected at one end to this grounded power supply terminal 64. The other power supply line plug or terminal 65 is connected to a power supply connection 70 by means of a series rectifier, which is preferably of the dry disc or blocking layer type, such as copper oxide. Three series connected dry disc rectifier sections 71, 72, 73 are provided to meet the rated current requirements of this embodiment. Any other type rectifier may be used in this circuit, but it should be selected to have a sufficient current rating for the needs of the receiver circuit. An on-off receiver switch 75 of the single-pole single-throw type, to provide for the application of high voltage to the receiver, is connected between the power amplifier tube high voltage terminal 54 and the power supply connection 70. The other end of the series heaters is also connected through the rectifiers to the other power line terminal 65 by medium of this power supply connection 70, and therefore the switch in addition provides for the application of full operating current to the heaters.

Operation of the power supply circuit will be more easily understood from a consideration of the simplified circuit diagram shown in Figure 2. This circuit diagram is identical with the similar portion of that of Figure 1 except that for purposes of simplicity, a single rectifier 74 is connected between the power line terminal 65 and the power supply connection terminal 70. All parts not necessary for the following description of the invention have been eliminated from the circuit diagram so that the operation of the heater supply and high voltage power supply circuits of the invention will be more easily understood.

It is seen from a consideration of this figure that the heaters are connected directly across the line terminals through the rectifier 74 at all times. When the power line is connected to the terminals 64 and 65 therefore, there will be supplied to the heaters a rectified current. Since the dry disc rectifier 74 is connected in circuit as a half wave rectifier, the effective current flowing to the filaments will be reduced to approximately half of what would be the unrectified line current. The rectifier 74 therefore provides the same function as a dropping resistor in the series heater circuit. There is, however, in the rectifier an efficient reduction of the heater power, since the current is kept to a required value without the power waste associated with a voltage dropping resistor of the same current limiting capacity. There is in reality a voltage drop and a resulting power waste across the rectifier 74 but it is so small that it may essentially be neglected in the following discussion.

As explained in the foregoing discussions, the continuous operation of the heaters at a reduced voltage provides improved operation of the receiver circuit. Not only is the heater and cathode temperature strain minimized by such operation, but also the change in tuning characteristics of the receiver, due to thermal expansion of the tuning elements upon the change of the heater temperature.

When normal operation is required, the off-on switch 75 may be closed. At this time the first power supply filter capacitor 60 is connected in shunt with the series filaments. This capacitor 60 should have a large capacity rating for providing proper filtering and storage action. The voltage across the filaments, because of the storage action of the filter capacitor, will then tend to approximately equal the peak line voltage. The peak voltage in case of a 110 volt power line is about 156 volts. There is, of course, a small voltage drop across the rectifier 74 and there is a power supply load circuit tending to discharge the capacitor 60, but the resulting voltage across the heaters will be enough to very nearly supply their rated full operating current. The series heater string therefore may have a total voltage rating higher than the normal rated line voltage, such as that of 119.3 in the presently described embodiment.

In addition, when the set is turned on, there is available at the power amplifier high voltage terminal 54 the normal D.-C. plate voltage available in this type of power supply circuit. With the present circuit, therefore, stand by operation is provided without the provision of any additional parts, since the rectifier 74 is necessary to normally provide the D.-C. high voltage supply. A rectifier of more current carrying capacity, however, is required in order to additionally supply the rated heater current.

In the presently described receiver, the rated voltage requirement of the series heater string is only slightly greater than that of the line voltage. However, should only three or four tubes be used in a receiver, an additional heater ballast or voltage dropping means may be required. Such means is shown in Figure 3, wherein an alternate simplified power supply circuit is shown.

The filament circuit consists of three heaters 80 connected in series with a heater current limiting dry disc rectifier 82. In this manner the rectifier 82 provides a simple and efficient means of obtaining a rated heater current from a power line having voltage of a value higher than that of the rated voltage of the heater string. In this embodiment, the heater string is continuously connected across the line and the rectifier 82 is used to provide essentially half the normal effective current. The three shown heaters 80 then should have a total rated voltage of approximately half the power line voltage, minus any voltage drop across the rectifier. Any appropriate number of heaters may be connected in circuit with the rectifier as long as the current requirements are the same and the total voltage rating is correct. The three heaters 80, shown for purposes of illustration, may have rated heater voltage of 35, 12.6 and 12.6 if the power line supplies 120 volts. The heater series voltage requirement of 60.2 volts will then be very near the effective voltage across the heaters if the small voltage drop across the rectifier 82 is neglected.

It is important in this embodiment to connect the plate supply rectifier 74 between the junction of the power line and the filament string 83 and the capacitor 60. Otherwise the heater current limiting rectifier 82 would not be effective in reducing the current tending to flow through the heaters from the charged capacitor 60 when the line switch 75 is closed. This current would be of such a large value that the heaters would soon open. In addition, both the plate supply rectifier 74 and the heater current limiting rectifier 82 must be in the same sense. Otherwise the heater current limiting rectifier 82 would not block the direct current across the filter capacitor 60 from flowing through the heaters. This would result in effectively causing the peak line voltage to be applied directly to the heaters, rather than half the rated line voltage, which of course would overrate the heaters causing them to open.

As heretofore explained, there are many advantages in using a direct current supply for the heaters. By this means, the leakage current from the heater 28A to the cathode 32A in the ratio detector will not cause a hum at the alternating current power line frequency. Also, there will be no tendency for power line frequency modulation in the oscillator or any of the other lower level receiver stages.

There is therefore provided in accordance with the invention a simplified and efficient power supply for transformerless receivers, which provides standby operation of the heaters at reduced voltage without the addition of any new circuit elements. The present power supply circuit in addition supplies a direct current for operation of the heater string.

Although in this specific embodiment, filamentary heaters of cathode type tubes have been described for purposes of illustration, it is to be recognized that any other type of thermal cathode heaters or filaments might be used in a similar manner. Also, the preferred type rectifier may be any one of the dry disc or blocking layer types known to those skilled in the art, such as selenium or copper oxide.

Although there is hereinbefore described particular embodiments of the invention, it is to be understood that the invention is not necessarily limited to the particular adaptations set forth and that modifications may be made which will not depart from the spirit and scope of the invention. Novel features which are clearly indicated in the foregoing full description of the nature, construction and operation of the invention are contained in the appended claims.

What is claimed is:

1. A radio circuit for providing hum-free operation comprising in combination, a pair of power line terminals for connection to power supply lines, a plurality of electronic hot-cathode type tubes having heaters connected in series, a rectifier connected in series with said heaters, said rectifier and heaters being connected to said terminals, and heater current control means for selectively changing voltage applied across said heaters through said rectifier from said power lines, said control means comprising a series combination of a switch and a capacitor connected in shunt with said heaters.

2. In an electronic tube signal conveying system, a plurality of thermionic tube cathode heater elements connected in series, a rectifier element, a pair of power line terminals, a circuit connecting said heater elements and said rectifier element in series to said terminals whereby direct current may be supplied to said heater elements by said rectifier, switch means and a capacitor connected in series, said switch means and said capacitor being connected across said heaters so that, upon said power line terminals being connected to an alternating current power line source and said switch means being closed, substantially peak power line voltage will be applied to said heater elements, and means for connecting an external direct current power supply lead to the junction of said capacitor and said switch means.

3. A power supply system for providing a lowered voltage to electronic tube heaters in standby operation comprising a plurality of series connected electronic tube heater elements, a dry disc rectifier connected with a heating current supply circuit in series with said elements, means for connecting said supply circuit to a source of operating current, and a series combination of a switch and a capacitor connected in shunt with said heater elements.

4. A standby heater supply system for transformerless radio systems comprising in combination, tubes having serially connected thermionic heaters, rectifier means serially connected with said heaters, means connecting the series combination of said heaters and said rectifier means to a current supply circuit for supplying current below the normal rated current directly to said heaters, and heater current control means shunting said serially connected heaters and including a single-pole single-throw switch for increasing the current to said heaters to normal rated value.

5. In an electronic tube system, a series string of tube heaters, a rectifier in series with said heaters, means connecting said rectifiers and heaters for current supply from a common source, and heater current control means comprising a capacitor and a switch connected in series and shunting said heaters for selectively increasing the voltage across said heaters.

WINFIELD R. KOCH.

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