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COMPLETE SPECIFICATION

Transistor Signal-translating Apparatus for Line Voltage Operation

We, RADIO CORPORATION OF AMERICA, a Corporation organized under the laws of the State of Delaware, United States of America, of 30, Rockefeller Plaza, City and State of New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to semiconductor signal-translating apparatus of the type which is adapted for energization from an alternating current mains supply source.

Some types of power line operated signal-translating apparatus, such as those of the electron-tube type, require relatively high supply voltages for the operation thereof. Such apparatus thus operate effectively on line voltage and stepped-up line voltage power. Other types of power line operated apparatus incorporate signal-translating devices of the transistor type which require relatively low supply voltages.

The problem with transistorized signal-translating apparatus and equipment for power line operation, therefore, is to provide low cost and efficient means for reducing the relatively high line voltage, as supplied directly or by rectification from a wall outlet for example, to the much lower voltage or voltages which may be useful to energize the various transistor circuits and elements thereof.

It will be appreciated that conventional voltage reducing means may include a step-down transformer or one or more series resistor elements in a supply circuit through which the line current may be directed to flow. Thus a line voltage or 117 volts a-c, for example, may be reduced sufficiently, for instance to a

direct current at 12 volts, for transistor circuit operation. However, suitable power-supply transformer or resistor means of required wattage and size for such wide voltage reduction may be relatively costly. Furthermore, the use of resistor means for voltage dropping in power supply circuits always introduces undesirable energy loss and the added problem of heat dissipation. In addition to the foregoing, to produce the requisite power output, the power supply must provide low voltage at high current levels so that the power supply filtering requires large and expensive filter capacitors to remove the ripple components from the rectified voltage.

It is, therefore, the object of this invention to provide a low cost transistor signal-translating apparatus for operation from an alternating current mains supply source, which eliminates the use of relatively costly step-down supply transformer, as well as voltage dropping supply resistor means which are heat producing and wasteful of energy, and must be filtered with relatively large and costly capacitor means.

According to the present invention there is provided a transistor signal-translating apparatus for operation from an alternating current mains supply source comprising a transistor power-output amplifier stage and at least a transistor driver amplifier stage, coupling means for coupling said driver stage to said output stage, utilization means coupled to the output of said output stage, and power supply means including a rectifier for furnishing power from said mains supply source to said transistors, the transistor in said output stage being a high voltage silicon transistor which has a collector-to-emitter breakdown voltage higher than the mains supply source peaks and being connected through said utilization means

[Price 4s. 6d.]

and said rectifier to said alternating current mains supply source, and the transistor in said driver stage being a low voltage transistor which has a collector-to-emitter breakdown voltage which is low with respect to the collector-to-emitter breakdown voltage of said silicon transistor, said low voltage transistor deriving its operating potential by being connected to said power supply through a low wattage series resistor which is shunted to a point of reference potential by a shunt filter capacitor of low voltage rating.

The silicon transistor may be of a commercial mesa type, that has a high reverse or breakdown voltage between the collector and emitter higher than the supply line voltage peaks. This transistor presently reaches safe peak collector currents of over 100 milliamperes, and yet may be driven by a low voltage transistor stage which may require an operating current of only a few milliamperes.

The high voltage output transistor may thus be energized at line voltage directly from rectified line current. Thus it does not require either a step-down transformer or power-dissipating voltage dropping resistor means in its supply circuits. The first stage or driver transistor, and other low level signal-translating stages or elements of the apparatus, may be energized from the supply line through low wattage and low cost R-C filter means inserted in circuit between the high voltage power supply circuit and the low level operating circuits. The series resistor elements of the filter means are at the same time effective to reduce the line voltage to the required low values for the low voltage, low level, transistor operating circuits.

The invention will now be described with reference to the accompanying drawing, in which

FIGURE 1 is a schematic circuit diagram of a transistorized radio receiver provided with a high level signal amplifier and power supply means embodying the invention, and

FIGURE 2 is a schematic circuit diagram of a phonograph record player showing a modification of the amplifier and power supply means of FIGURE 1, in accordance with the invention.

Referring to FIGURE 1, the radio receiver represented by the circuit is adapted to operate with 115 volts line-voltage power supplied economically and effectively to the transistor signal-translating elements thereof. By way of example, the receiver comprises suitable conventional signal translating circuits of which the first is a transistorized signal mixer stage 5.

The mixer stage is coupled on its input side of the usual conventional ferrite rod antenna 6 for signal reception, and is coupled on its output side through a tuned intermediate-frequency input transformer 7 with a tran-

sistorized intermediate-frequency amplifier comprising a single stage 8. The intermediate-frequency amplifier, in turn, is coupled through a tuned output transformer 10 with the second or audio-frequency detector 11. This is represented as a diode coupled to an output potentiometer-type load resistor 12 from which is derived the audio-frequency output signal through a variable volume control contact 15. The latter is controlled by the usual volume control knob indicated at 16. The receiver is manually tunable by suitable means indicated by a tuning dial 17 connected with variable tuning capacitors, indicated at 18 and 19, for the antenna and oscillator circuits of the input or mixer stage 5.

The receiver is provided with a common ground or chassis element 20 having a common ground or circuit return lead 21. This operates also as one lead of the power supply circuitry of the receiver and in conjunction with a low voltage positive supply lead 22. The ground lead 20 thus operates as the negative side. The leads 21 and 22 provide a low voltage operating current or power supply source for the low level signal-translating stages of the receiver, including the low level audio-frequency amplifier stages which follow the detector and volume control means as will be described.

The specific construction or operation of the signal input end of the receiver preceding the volume control device, except for the low voltage power supply circuit 21-22, will not be further described. The receiver shown represents any electronic signal-translating apparatus or equipment of the plug-in power line operated type which may effectively use transistor signal-translating elements therein and operate directly on line voltage power.

The volume control means 12-15 is followed by a transistorized audio-frequency amplifier which may comprise two or more cascade-connected stages terminating in a high level power output stage 24 coupled to a signal output utilization device, such as a loudspeaker 25, through suitable output coupling means such as a transformer 26. The output stage 24 is driven by a low level amplifier stage 28 and may be preceded by additional low level amplifier stages in any particular apparatus. In the present example the stage 28 is coupled directly to the volume control means, or audio-frequency signal source, as the first stage of the two-stage audio-frequency amplifier provided for the receiver.

The output stage 24 comprises a high voltage silicon power transistor 30 of the NPN type having a base 31, a collector 32, and an emitter 33. This transistor may be considered to be of a mesa type (TA-2301) which has a relatively high reverse or breakdown voltage between the collector and emitter. This breakdown voltage must be greater than

the supply or line voltage peaks, which, in the United States of America, are usually about 150 volts, and with present developments the breakdown voltage may be considered to be about 300 volts for the transistor referred to. This transistor operates with peak collector currents of over 100 milliamperes (ma) but may be driven effectively by a low voltage transistor 35 in the driver stage 28. By way of example, the average current drawn by the transistor 30 may be about 30 ma.

A suitable low voltage driver transistor 28 may be of the commercial high-beta 2N2614 type having a base 36, a collector 37 and an emitter 38 as indicated. Low voltage transistors generally operate with a supply voltage of the order of 25 volts. For example, low voltage transistor receivers are transistors which operate efficiently on voltages of 4.5 volts or less. The transistor 35 provides a high gain transistor stage of the low voltage, low level type, and may be of like or opposite conductivity with respect to the high level output stage 24. In the present example, it is of the opposite or PNP conductivity type as indicated, and requires an operating current of only a few milliamperes (such as 2 ma) as compared with the output stage.

As will be seen from the circuit diagram, both transistors operate with a common-emitter circuit configuration. The base 36 of the first stage of driver transistor is connected to the volume control contact 15 and, through the signal supply resistor or potentiometer element 12, to the detector low voltage output lead 40. The latter is connected with a bias supply terminal 41 on a series voltage-divider network or circuit comprising three series resistors 42, 43 and 44 connected between the positive low level supply lead 22, in connection with the resistor element 42, and the negative or ground supply lead 21 in connection with resistor element 44 at a terminal 45.

An intermediate supply terminal 46 on the voltage divider circuit, between the resistor elements 43 and 44, is connected through a lead 47 with the emitter 33 of the output transistor 30 and also, through a collector or direct-coupling resistor 48, with both the base 31 of the voltage transistor 30 and the collector 37 of the low voltage driver transistor 35. The emitter 38 of the driver transistor 35 is connected, through a lead 49 and an emitter circuit resistor 50, with the positive supply lead 22, thereby completing the emitter-collector and emitter-base circuits of the driver stage with the low voltage supply circuit 21—22. An audio frequency coupling capacitor 51 completes the audio frequency supply circuit from the detector 11 to the emitter 38, and decouples the bias network resistors 42, 43 and 44 to eliminate audio frequency feedback and maintain high gain. The capacitor

51 may have a capacity of 50 mfd at the low voltage and thus be of relatively low cost.

The transformer 26, by which the high level output stage 24 is coupled to the sound-reproducing speaker means 25, is provided with a primary winding 53 connected in the output or collector circuit 54 of the transistor 30 as the load element therein. The winding is supplied with operating current for the collector circuit through an intermediate tap or terminal 55 from a positive d-c supply lead 56. The latter is connected with a power supply rectifier 57 of the simple diode type having an input filter capacitor 58 connected between the supply lead 56 and the ground or common return lead 21 of the system at the terminal 45. Line voltage a-c or d-c power is applied to the receiver through the usual line-cord connection comprising a line or wall-plug 59 having one line-cord connection 60 with the ground or common return lead 21 and a second line-cord connection 61, through a power switch 62 and a protective series resistor 63, with the rectifier 57.

Thus, when the line switch 62 is closed and the plug 59 is connected with a conventional wall outlet or like current source (not shown), the high voltage transistor 30 is energized with high voltage direct current through the rectifier 57 across the input filter capacitor 58. Thus, the high voltage transistor 30 receives substantially full rectified line voltage without step-up or reduction, and this circuit may provide a peak voltage of substantially 140 volts d-c across an input capacitor 58 of 20 mfd. and with supply or line voltage of 117 volts a-c, for example. Some voltage is lost across the protective line resistor 63.

In the present example the portion of the output transformer primary winding, between the tap 55 and an end terminal 65, is utilized for hum-bucking or cancellation in the output circuit in accordance with known practice for the supply circuits of such receivers. For this purpose the rectified supply current for the low voltage circuit 21—22 is taken from the terminal 65 through a series low wattage filter resistor 66 and applied to a low voltage shunt filter capacitor 67 connected between a supply terminal 68 on the positive supply lead 22 and terminal 45 on the ground lead 21. By way of example, the filter resistor may have a resistance of 22,000 ohms as indicated and the filter capacitor 67 may have a capacity of 50 mfd. at 15 volts.

The rectified direct current supplied to the transformer primary terminal 55 thus flows mainly through the primary winding 53 and the collector circuit 54 of the output stage 24. A relatively low current flows from the terminal 55 through the hum-cancellation section between that terminal and the terminal 65. The filter means 66—67 connected with the terminal 65, thus provides substantially ripple-free, low voltage, operating current at



the supply leads 21—22 for the low level input stages of the receiver and for the input or driver stage of the output amplifier.

In operation, the collector current of the PNP input or driver transistor 35 flows through the direct coupling resistor 48 and thus provides a positive forward operating bias for the base of the NPN high voltage output transistor 30. Bias voltage for the input or driver-stage transistor 35 is obtained from the voltage divider circuit. Due to the polarity of the conductors 22 and 21 and the respective connections of the base and collector of the driver transistor 35 with the terminals 41 and 46 respectively, the base 36 is negatively biased as is the collector 37. The emitter 38 is positively biased through its circuit connection with the positive lead 22 of the low voltage supply circuit. Bias stability is achieved by negative feedback of the emitter current of the high voltage transistor through the resistor 44 of the network.

The low voltage provided at the supply circuit 21—22 is thus derived through a series filter resistor 66 of low wattage and low cost in connection with a low cost low voltage filter capacitor 67. This filter means thus effectively provides reduction of the relatively high output-stage operating voltage to a safe and much reduced operating voltage for all lower level amplifier stages. The series resistor means thus effectively provided for the low level low voltage stages is in a different branch of the operating current supply circuit from the high level high voltage output stage and thus is not required for voltage dropping at high current levels.

From the foregoing description, it will be seen that the two direct coupled low voltage and high voltage transistor amplifier stages provide a low cost, high gain audio-frequency power amplifier which may operate from line voltage power supply means without using a power transformer or any high power dissipating resistor element for reducing the input voltage for the lower level stage supply.

The circuit of FIGURE 2, to which attention is now directed, shows a modification of the two-stage power amplifier of FIGURE 1, wherein the high level high voltage output transistor stage is driven by a low voltage transistor stage of similar conductivity type, and in a phonograph record-playing system as the audio-frequency signal source. In this circuit, like elements as appear in FIGURE 1 are designated by like reference numerals.

In this amplifier circuit, the high level output stage 24 is substantially the same as in FIGURE 1 and comprises the high voltage silicon mesa transistor 30 coupled through the output transformer 26 to the loudspeaker signal-translating device 25 for sound reproduction. The collector circuit 54 is connected through the full primary winding 53 to the terminal 65 to which rectified supply

current is directly applied through the power rectifier 57, instead of to the tap 55 as in the preceding example. The hum-cancellation feature provided by the transformer connection between the tap 55 and terminal 65 is not provided in this supply circuit. Therefore, the input filter capacitor 58 may be increased from 20 mfd to 50 mfd. to compensate. The series protective resistor 63 and the power switch 62 are provided in the input circuit lead 61 for the power plug 59. The opposite power supply lead 60 is connected with the common circuit return lead 21. In the present example this lead 21 is coupled to chassis or ground 20 through a suitable bypass capacitor 70.

The low level low voltage supply circuit 21—22 is provided with operating current through the low wattage series filter resistor 66 and across the low voltage filter capacitor 67 connected between the terminals 68 and 45. The emitter 33 of the output transistor 30 is connected through the lead 47 and the feedback resistor 44 to the terminal 45 thereby providing the same collector and emitter biasing or polarization as in the preceding example. However, as the two transistors are of similar conductivity types, the coupling or collector resistor 48 provided in circuit with the base 31, is connected to the positive low voltage supply lead 22 through the connection lead 72. This places a proper (reverse) positive bias on the collector 73 of the NPN driver transistor 74 and the connection lead 49 for the emitter 75 is connected to the negative supply lead 21, thereby providing a proper negative bias on the emitter.

The base 76 of the driver transistor 74 is, as in FIGURE 1, connected to the volume control contact 15, and, through the volume control resistor 12, to a terminal 77 bypassed to common lead 21 through an audio-frequency by-pass capacitor 78. Positive bias potential is provided at the terminal 46 in response to emitter current flow through the resistor 44 and is applied to the base through a feedback supply resistor 79 connected between the terminals 46 and 77. As in FIGURE 1, signals applied to the volume control resistor 12 are applied to the driver transistor 74 and, through the direct coupling, to the output power transistor 30 for driving the loudspeaker 25. This amplifier circuit is of the common emitter type as FIGURE 1, and operates in the same manner except for the fact that the transistors are of the same conductivity types.

In FIGURE 2 the applied signals are derived from a low voltage phonograph pickup 80, and an amplifier stage 81 of the low level low voltage type is provided in the amplifier circuit preceding the volume control means 12—15 to attain proper overall gain. The pickup device 80 is connected with the first

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stage 81 through an output circuit comprising the leads 82, and the amplified signals from the stage 81 are applied to the volume control resistor 12—15 through an output circuit indicated by the leads 83 and 84. The lead 83 is connected directly with the high volume end of the resistor 12 as indicated, and the lead 84 is connected to the common or ground lead 21, and thence through the bypass capacitor 78 with the terminal 77 of the volume control resistor 12.

The low voltage amplifier stage 81 is supplied with low voltage operating current through a supply lead 85 connected with the positive supply lead 22, and the lead 84 which is connected with the negative supply lead 21. The low level stages 28 and 81 are thus supplied with operating current at low voltage from the supply circuit 21—22 through the voltage-dropping, low wattage, filter resistor 66 in conjunction with the filter capacitor 67, thereby producing low voltage hum free operating current without power dissipating resistors or transformer means, and at relatively low cost, as in FIGURE 1.

The pickup 80 is shown in operative relation to the usual phonograph record 87 which is carried by rotary turn-table 88 driven by a conventional turn-table motor indicated at 89. The motor is energized, through the circuit connections indicated, from the supply leads 60 and 61 upon closure of the operating switch 62.

The phonograph circuit shown is adapted for low cost high volume production. As in FIGURE 1, the amplifier circuits comprise direct-coupled low voltage and high voltage transistors, involving a minimum of filtering in the power supply circuits, while the series resistor means for the driver and other low level low voltage circuits are of the filter resistor type and thus are not used for voltage reduction at high current levels.

The high voltage power output transistor stage, in each of the circuits shown, is driven by a low voltage transistor stage directly coupled thereto, without any voltage reducing means being required for the power transistor, while the operating voltages for the driver as well as any other low voltage signal-translating devices in the system or apparatus involved, are provided by the drop attained in low cost filtering circuits, without substantial power dissipation or loss.

The improved electronic signal translating system using the transistorized power amplifier and power supply circuits of the present invention is, therefore, suitable for operation directly from a commercial supply line or wall outlet. This eliminates the necessity for transformer or other voltage reducing power conveying means for transistor operation in a supply-line or power-operated system and results in savings in weight, cost and

power consumption. Low-voltage power supply and hum reduction in the low level signal-translating stages of the system are attained with substantially no power loss.

WHAT WE CLAIM IS:—

1. A transistor signal-translating apparatus for operation from an alternating current mains supply source comprising a transistor power-output amplifier stage and at least a transistor driver amplifier stage, coupling means for coupling said driver stage to said output stage, utilization means coupled to the output of said output stage, and power supply means including a rectifier for furnishing power from said mains supply source to said transistors, the transistor in said output stage being a high voltage silicon transistor which has a collector-to-emitter breakdown voltage higher than the mains supply source peaks and being connected through said utilization means and said rectifier to said alternating current mains supply source, and the transistor in said driver stage being a low voltage transistor which has a collector-to-emitter breakdown voltage which is low with respect to the collector-to-emitter breakdown voltage of said silicon transistor, said low voltage transistor deriving its operating potential by being connected to said power supply through a low wattage series resistor which is shunted to a point of reference potential by a shunt filter capacitor of low voltage rating.

2. Apparatus according to Claim 1, wherein additional low voltage transistor stages for said apparatus also derive their operating potential from the same point in said power supply from which the transistor in said driver stage obtains its operating potential.

3. Apparatus according to Claim 1, wherein said low voltage transistor in addition to including said series resistor in its connection to said power supply also includes in series therewith a hum-bucking portion of said utilization means.

4. Apparatus according to Claim 1, comprising a voltage divider resistor circuit connected between the low voltage operating potential and said point of reference potential, said voltage divider resistor circuit having intermediate terminals thereon for applying low voltage operating current to base, emitter and collector electrodes of said driver transistor and to the base electrode of said power output transistor, the collector of the driver transistor and the base of the output transistor having a common coupling impedance element in circuit therewith.

5. A transistor signal-translating apparatus substantially as herein described with reference to FIGURE 1 of the accompanying drawing.

6. A transistor signal-translating apparatus

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stage 81 through an output circuit comprising the leads 82, and the amplified signals from the stage 81 are applied to the volume control resistor 12—15 through an output circuit indicated by the leads 83 and 84. The lead 83 is connected directly with the high volume end of the resistor 12 as indicated, and the lead 84 is connected to the common or ground lead 21, and thence through the bypass capacitor 78 with the terminal 77 of the volume control resistor 12.

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The phonograph circuit shown is adapted for low cost high volume production. As in FIGURE 1, the amplifier circuits comprise direct-coupled low voltage and high voltage transistors, involving a minimum of filtering in the power supply circuits, while the series resistor means for the driver and other low level low voltage circuits are of the filter resistor type and thus are not used for voltage reduction at high current levels.

The high voltage power output transistor stage, in each of the circuits shown, is driven by a low voltage transistor stage directly coupled thereto, without any voltage reducing means being required for the power transistor, while the operating voltages for the driver as well as any other low voltage signal-translating devices in the system or apparatus involved, are provided by the drop attained in low cost filtering circuits, without substantial power dissipation or loss.

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2. Apparatus according to Claim 1, wherein additional low voltage transistor stages for said apparatus also derive their operating potential from the same point in said power supply from which the transistor in said driver stage obtains its operating potential.

3. Apparatus according to Claim 1, wherein said low voltage transistor in addition to including said series resistor in its connection to said power supply also includes in series therewith a hum-bucking portion of said utilization means.

4. Apparatus according to Claim 1, comprising a voltage divider resistor circuit connected between the low voltage operating potential and said point of reference potential, said voltage divider resistor circuit having intermediate terminals thereon for applying low voltage operating current to base, emitter and collector electrodes of said driver transistor and to the base electrode of said power output transistor, the collector of the driver transistor and the base of the output transistor having a common coupling impedance element in circuit therewith.

5. A transistor signal-translating apparatus substantially as herein described with reference to FIGURE 1 of the accompanying drawing.

6. A transistor signal-translating apparatus



substantially as herein described with reference
to FIGURE 2 of the accompanying drawing.

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