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(71) Applicant: **Tacconi, Renato**
Via Milano, 238
I-20033 Desio Milan(IT)

Applicant: **Tacconi, Fulvio**
Via Roma, 120
I-20033 Desio Milan(IT)

(72) Inventor: **Tacconi, Renato**
Via Milano, 238
I-20033 Desio Milan(IT)
Inventor: **Tacconi, Fulvio**
Via Roma, 120
I-20033 Desio Milan(IT)

(74) Representative: **Luksch, Giorgio, Dr.-Ing. et al**
Ing. A. Giambrocono & C. S.r.l. Via Rosolino Pilo, 19/b
I-20129 Milano(IT)

(54) Improvements in frequency converter circuits for powering cold cathode fluorescent tubes.

(57) A frequency converter circuit for powering cold cathode fluorescent tubes comprising a circuit block (1) generating a square wave pulsed signal. This signal is used to power the primary winding (2) of a transformer (3) the secondary (4) of which is connected to at least one cold cathode fluorescent tube, said primary winding being connected to components (58, 63) connected to said circuit block (1), and which zero the mean value of said square wave pulsed signal.

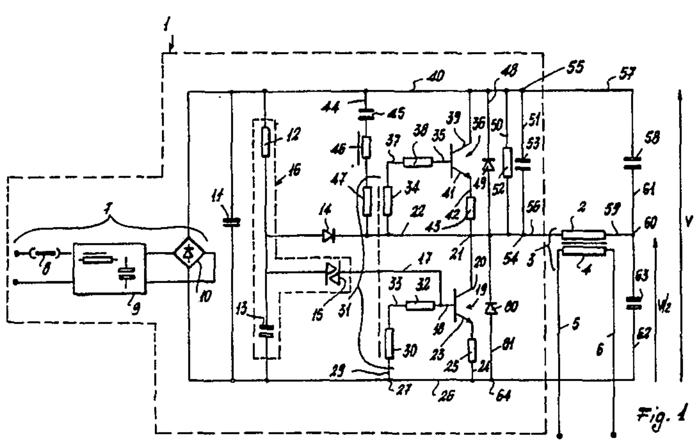

Fig. 1

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This invention relates to a frequency converter circuit for powering cold cathode fluorescent tubes.

Various types of frequency converters are already known and commercially available, their purpose being mainly to operate cold cathode fluorescent tubes at higher than mains frequency.

Although these circuits satisfy their purpose, they are often of complicated and costly construction. This is mainly due to the fact that they require control circuits with their own power supply, which on the average is 15 V.

An object of the present invention is therefore to provide a circuit of operating cold cathode fluorescent tubes which does not require independently powered control circuits, which is of simple construction and is of lower cost than corresponding known circuits.

These and further objects which will be apparent to the expert of the art are attained by a frequency converter circuit for powering cold cathode fluorescent tubes, characterised by comprising a circuit block generating a square wave pulsed signal, said signal being applied, with zero mean value, to a primary winding of a transformer, the secondary winding of which is connected to at least one cold cathode fluorescent tube.

The present invention will be more apparent from the accompanying drawing which is provided by way of non-limiting example and in which:

Figure 1 represents a frequency converter circuit for powering cold cathode fluorescent tubes constructed in accordance with the invention;

Figure 2 represents a modification of the circuit of Figure 1.

With reference to Figure 1, the circuit of the invention comprises a circuit block 1 operating as an oscillating circuit and generating a substantially square wave pulsed signal. According to the invention this signal is applied, with zero mean value, to a primary winding 2 of a transformer 3, the secondary winding 4 of which is connected via lines 5 and 6 to at least one cold cathode fluorescent tube.

Specifically, the circuit block 1 comprises a section 7 for connection to an external line by which the block 1 is fed with alternating voltage and for transforming and rectifying this voltage. This section comprises a fuse 8, an anti-interference filter 9 and a diode bridge 10. In parallel with the diode bridge 10 there is connected a capacitor 11 the purpose of which is to smooth the rectified mains voltage.

The circuit block 1 also comprises a resistor 12, a capacitor 13, a diode 14 and a trigger diode or diac 15. The resistor 12, the capacitor 13 and the diac 15 define a sawtooth generator 16 which triggers the oscillation generated by the circuit block 1 when the circuit is connected to the mains.

The diac 15 is connected in a line 17 terminating at the base 18 of a transistor 19, the collector 20 of which is connected to a node 21 in a line 22 containing the diode 14. The emitter 23 of said transistor 19 is connected to a line 24 containing a resistor 25 and terminating in a return line 26. From a node 27 of the line 26 there extends a line 29 terminating in a first secondary winding 30 of a transformer 31, said first secondary winding 30 being connected to the base 18 of the transistor 19 via a resistor 32 contained in a line 33.

The transformer 31 comprises a second secondary winding 34 with opposite polarity to the first winding 30. The second secondary winding 34 is connected to the line 22 and to a line 37 containing a resistor 28 and terminating at the base 35 of a transistor 36. The transistor 36 comprises a collector 39 connected to a line 40 and an emitter 41 connected to a line 42 containing a resistor 43 and terminating at the node 21.

Between the line 40 and the line 22 there is a first line 44 comprising a capacitor 45, an inductor 46 and the primary winding 47 of the transformer 31. A second line 48 runs parallel to the preceding 44 and contains a diode 49. A further two lines 50 and 51 run parallel to the preceding lines 44 and 48 and comprise a resistor 52 and a capacitor 53 respectively. The lines 22 and 40 terminate in nodes 54 and 55 at the ends of the capacitor 53. From these nodes there extend lines 56 and 57 terminating respectively at the primary winding of the transformer 3 and at a capacitor 58. From said winding 2 there extends a line 59 terminating in a node 60 to which a line 61 extends from the capacitor 58.

To the node 60 there is connected a capacitor 63 from which there extends a further line 62 terminating at a node 64, from which the line 26 extends.

It will now be assumed that a cold cathode fluorescent tube connected to the circuit of Figure 1 is to be powered. To do this, after connecting the tube to the lines 5 and 6, the circuit is powered by connecting the section 7 of the circuit block 1 to the mains. On making this connection, the capacitor 13 of the sawtooth generator 16 becomes charged via the resistor 12, and when the voltage across said capacitor reaches the breakdown voltage of the diac 15 (this voltage being generally 32 V ± 4V), the capacitor 13 discharges and a small current flows through the line 17 to the base 18 of the transistor 19. The transistor 19 therefore starts to conduct.

In the described situation, a current signal flows through the line 40 and from here through the line 44, charging the inductor 46 and capacitor 45. In this manner, said signal passes into the line 22 and from the node 21 passes to the transistor 19. Current thus circulates through the primary winding

47 of the transformer 31, with the result that voltage appears by induction across the secondary windings 30 and 34 of this transformer. As the secondary windings 30 and 34 are of opposite polarity, ie the winding 30 has the same polarity as the primary winding 47, current begins to circulate within the network formed by the lines 29, 33 and 24 and comprising the resistors 32 and 25, the transistor 19 and said secondary winding 30, and self-powers the transistor 19. In contrast, the transistor 36 does not conduct because its base 35 is polarized inversely as the current in the network comprising the secondary winding 34 and transistor 36 tends to circulate from the emitter 41 to the base 35. The transistor 19 is in a state of conduction, and this situation remains until the transformer 31 is saturated, with consequent zeroing of the voltages across its windings 47, 34 and 30. This results in blocking of the transistor 19, and the transient current in the inductor 46 flows through the diode 49 and returns to the line 44 via the line 40, its value being reduced until it becomes zero. During this stage the voltage across the primary winding 47 changes sign.

The polarity inversion of the voltage across the transformer 31 causes the transistor 36 to conduct and reinforce the blocking of the transistor 19.

In the described situation, the transistor 36 is self-powered by virtue of the current circulating in the network defined by the lines 22, 37 and 42, as described for the transistor 19. When the current through the inductor 46 ceases, a current signal is generated by the discharging capacitor 45 and flows through the line 40 towards the transistor 36. This signal flows to the collector 39 of the transistor 36, then through the lines 42 and 22, and returns to the line 44 through the primary winding 47 and inductor 46.

With the transistor 36 conducting, at a certain point the transformer 31 again becomes saturated with consequent zeroing of the voltages across its windings 47, 34 and 30. This results in blocking of the transistor 36, but current continues to flow through the inductor 46, originating from the line 26 via a diode 80 contained in a line 81. This current reduces in value to zero. During this phase the voltage across the primary winding 47 reverses to set the transistor 19 into conduction. Thus the aforesaid condition is restored and the cycle recommences.

Thus, with the alternating conducting states of the transistors 19 and 36, the circuit block 1 generates a square wave pulse which is fed to the primary winding 2 of the transformer 3.

Specifically, with the conduction of the transistor 19, a current signal corresponding to the lower crest of the wave generated by the block 1 and originating from the lines 40, 57 and 61 (via the capacitor 58) circulates through said winding 2 and, by induction, through the secondary winding 4 of the transformer 3 to enable this latter to power the fluorescent tube connected to the lines 5 and 6. The capacitors 58 and 63 are particularly chosen to halve the voltage V between the lines 26 and 57 of the circuit block 1 which is applied to the node 60 to which the transformer 2 is connected, this voltage thus being V/2. In addition, as soon as the circuit under examination is connected to the mains the capacitors 58 and 63 are exposed to circulating current. During the two conduction stages of the transistors 19 and 36 these capacitors are charged and discharged alternately via said transistors.

During the conduction of the transistor 36, a current signal corresponding to the upper crest of the wave generated by the circuit block 1 and originating from the line 42 circulates through the primary winding 2 of the transformer 3 so that by induction there is current circulation through the secondary winding 4 of said transformer with consequent powering of the fluorescent tube. Said current signal circulating through the primary winding 2 then passes to the capacitor 63, through the line 62 and to the return line 26.

The transformer 3 is therefore subjected to a square wave of zero mean value applied to its primary winding 2.

Figure 2 shows a different embodiment of the circuit according to the invention. In this figure, parts corresponding to those of Figure 1 are indicated by the same reference numerals plus 100. In Figure 2 the transformer 103 forms part of the circuit block 101 which generates a square wave pulsed signal. The transformer 103 comprises an auxiliary secondary winding 190 connected to a resistance 191 which is connected to the primary winding 147 of the transformer 131 (the secondary windings 130 and 134 of which are connected to the transistors 119 and 136). The primary winding 147 of the transformer 131 is connected via a line 192 to the auxiliary secondary winding 190 of the transformer 103. In this manner a network 200 is created by means of which the transformer 103, used for connecting the circuit to at least one fluorescent tube, "controls" the operation of the circuit via the connection between its auxiliary secondary winding 190 and the primary winding 147 of the transformer 131, the secondary windings of which are connected to the transistors 119 and 136. It will now be assumed that the circuit of Figure 2 is connected to the mains and the lines 105 and 106 are connected to a cold cathode fluorescent tube. Having made the connection to the mains, the transistor 119 enters into conduction in the manner described in relation to the operation of the circuit block 1 of Figure 1. Following this, a current signal flows through the line 140, through the line 157, through the capacitor 158, through the lines 161 and 158, and through the primary winding 102 of the transformer 103. This signal then passes to the line 156, and from the node 121 it enters the transistor 119, from which it emerges to terminate in the return line 126.

With the passage of the current signal into the primary winding 102 of the transformer 103, a voltage is induced in the secondary winding 104 and in the auxiliary secondary winding 190, to power the tube and, respectively, to generate in the network 200 a current which passes through the primary winding 147 of the transformer 131 to induce a voltage across the secondary windings 130 and 134. In the manner and for the reasons already described in relation to the operation of the circuit of Figure 1, the transistor 119 becomes self-powered whereas the transistor 136 remains blocked.

This situation remains until the transformer 31 reaches saturation, with consequent zeroing of the voltages across its windings 147, 34 and 130. As already described in relation to Figure 1, this leads to blockage of the transistor 119. During the saturation of the transformer 131 the voltage across the primary winding 102 and auxiliary secondary winding 190 of the transformer 103 is inverted and the current circulating through said primary winding 102, strongly reducing, discharges through the diode 149. The same happens for the auxiliary secondary winding 190, which releases a current which dissipates across the resistor 191. As the current in the primary winding 147 of the transformer 131 decreases until zero, as happens in the circuit of Figure 1 during the saturation of the transformer 31, the voltage across said primary winding 147 also changes sign. In this manner there is voltage across the secondary winding 134 of the transformer 131, which enables the transistor 136 to conduct while the transistor 119 remains blocked. In this situation, a current signal from the mains flows through the line 140, passes into the transistor 136, and flows through the line 156 and through the primary winding 102 of the transformer 103. It emerges from this latter and flows to the capacitor 163 and through the line 162, from which it passes to the return line 126.

During this stage, in the network 200 there is circulation of current induced in the auxiliary secondary winding 190 of the transformer 103.

As a result of this and of the passage of current through the primary winding 147 of the transformer 131, a current signal is induced in its secondary winding 134 and circulates through the network defined by the lines 122, 137 and 142. In this manner the transistor 136 is self-powered, as in the case of the transistor 36 of Figure 1. During this stage, the current induced in the secondary winding 104 of the transformer 103 powers the fluorescent tube connected to this secondary winding. The situation remains unchanged until the transformer 131 is saturated, with consequent blocking of the transistor 136. After this, the situation returns to that subsequent to the preceding saturation of said transformer as previously described, and on termination the transistor 119 returns to its conducting state whereas the transistor 136 remains blocked, so restarting the cycle.

During the various conducting stages of the two transistors 119 and 136, the capacitors 158 and 163 discharge through the transistor 136 and through the transistor 119 respectively. Again in the case of Figure 2 the transformer 103 is subjected to a square wave of zero mean value applied to its primary winding 2. It should be noted that after the triggering of oscillation in the circuit block 1 of Figure 1 or in the circuit block 101 of Figure 2, the sawtooth generator 16, 116 is neutralized by the diode 14, 114 through which the capacitor 13, 113 discharges.

Converter circuits provided with transistors 19, 119 and 36, 136 have been described. However, these components can be replaced by other components of field effect transistor or similar type.

It should also be noted that the resistor 52, 152 in the line 50, 150 and the capacitor 53, 153 in the line 51, 151 act as dampers and aid the switching of the transistors 19, 119 and 36, 136.

Finally, in a further embodiment a converter circuit can be provided substantially as that represented in Figure 2, but in which the primary winding 147 of the transformer 131 is connected in series with the primary winding 102 of the transformer 103. In this case the auxiliary secondary winding of the transformer 103 and the network 200 are not provided, so further simplifying the circuit of the invention.

A circuit formed in accordance with the invention is simple to construct and is of low cost compared with circuits of the state of the art for operating cold cathode fluorescent tubes. In particular, the transistor arrangement is of the half-bridge type and considerably limits the overvoltages generated during transistor switching.

Claims

1. A frequency converter circuit for powering cold cathode fluorescent tubes, characterised by comprising a circuit block (1, 101) generating a substantially square wave pulsed signal, said signal being applied, with zero mean value, to a primary winding (2, 102) of a transformer (3, 103) separate from or incorporated in said circuit block (1, 101), at least one secondary winding (4, 104) of said

transformer being connected to at least one cold cathode fluorescent tube.

2. A frequency converter circuit as claimed in claim 1, characterised by comprising means (58, 63; 158, 163) for zeroing the mean value of the square wave signal applied to the primary winding (2, 102) of the transformer (3, 103).

3. A frequency converter circuit as claimed in claim 2, characterised in that the means for zeroing the mean value of the square wave are capacitors (58, 63; 158, 163) connected by circuit lines (61, 62; 161, 162) to a line (59, 159) connected to the primary winding (2, 102) of the transformer (3, 103), said capacitors (58, 63; 158, 163) being connected to the circuit block (1, 101).

4. A frequency converter circuit as claimed in claim 1, characterised in that the transformer (103) comprises a secondary winding (104) for connection to the fluorescent tube and an auxiliary secondary winding (109) connected into a network (200) in which there is also present a primary winding (147) of a transformer (131) provided with secondary windings (130, 134) having opposite polarities and connected to transistors or similar means (119, 136) arranged to be alternately put into a conducting state in order to generate the pulsed signal applied to the primary winding (102) of the transformer (103) for operating the fluorescent tube.

5. A frequency converter circuit as claimed in claim 1, characterised in that the circuit block (1) comprises a sawtooth generator (16) with a resistor (12), a capacitor (13) and a trigger diode or diac (15), said block (1) also comprising elements (7, 11) for transforming and rectifying the mains voltage, transistor means (19, 36) for generating the square wave pulsed signal, transformer means (31) the secondary winding of which is divided into two portions (30, 34) in polarity opposition, said portions (30, 34) being connected to said transistor means (19, 36), and means (52, 53) for limiting short-duration overvoltages produced by the switching of the transistors during the various stages of the circuit operation.

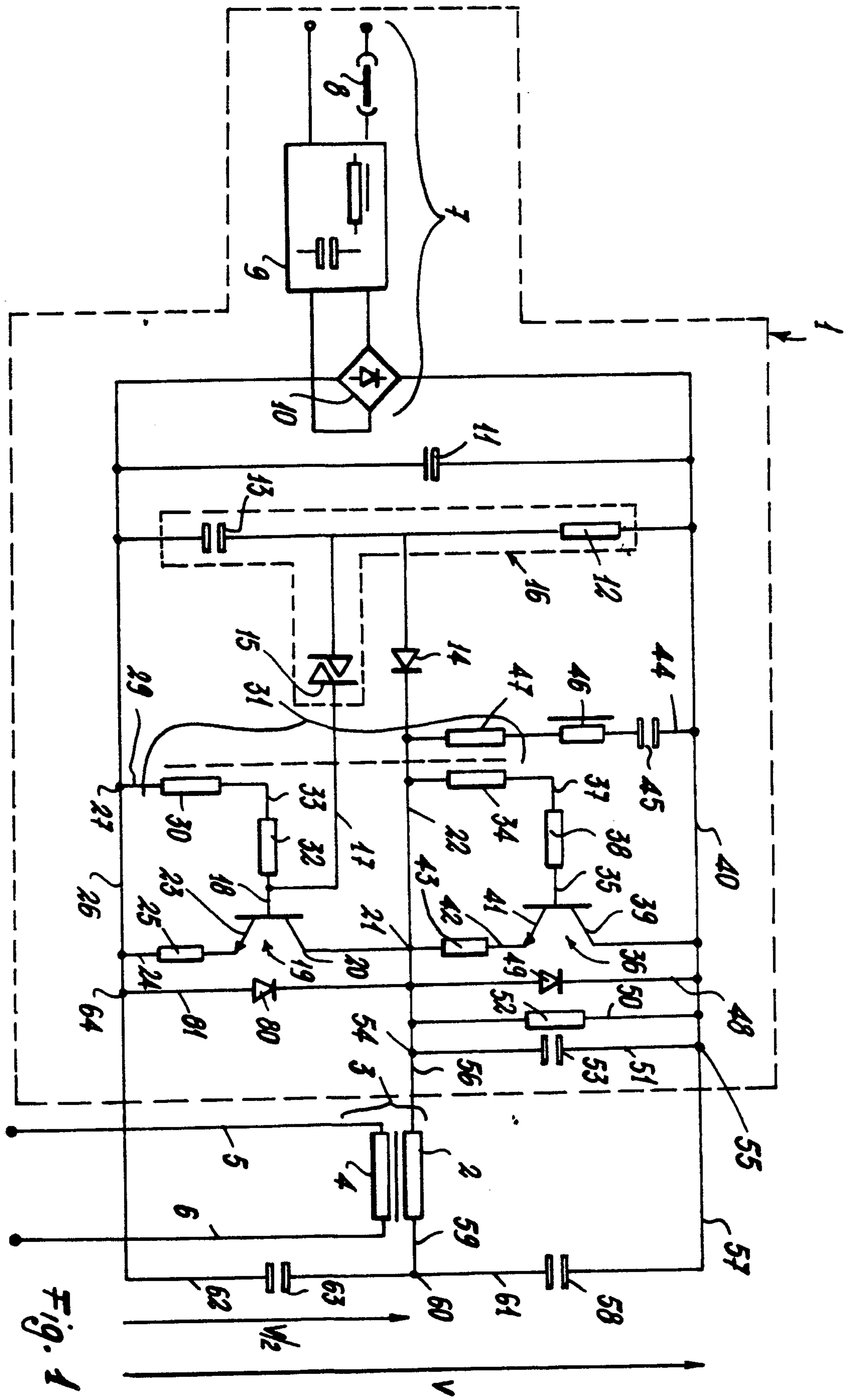

Fig. 1

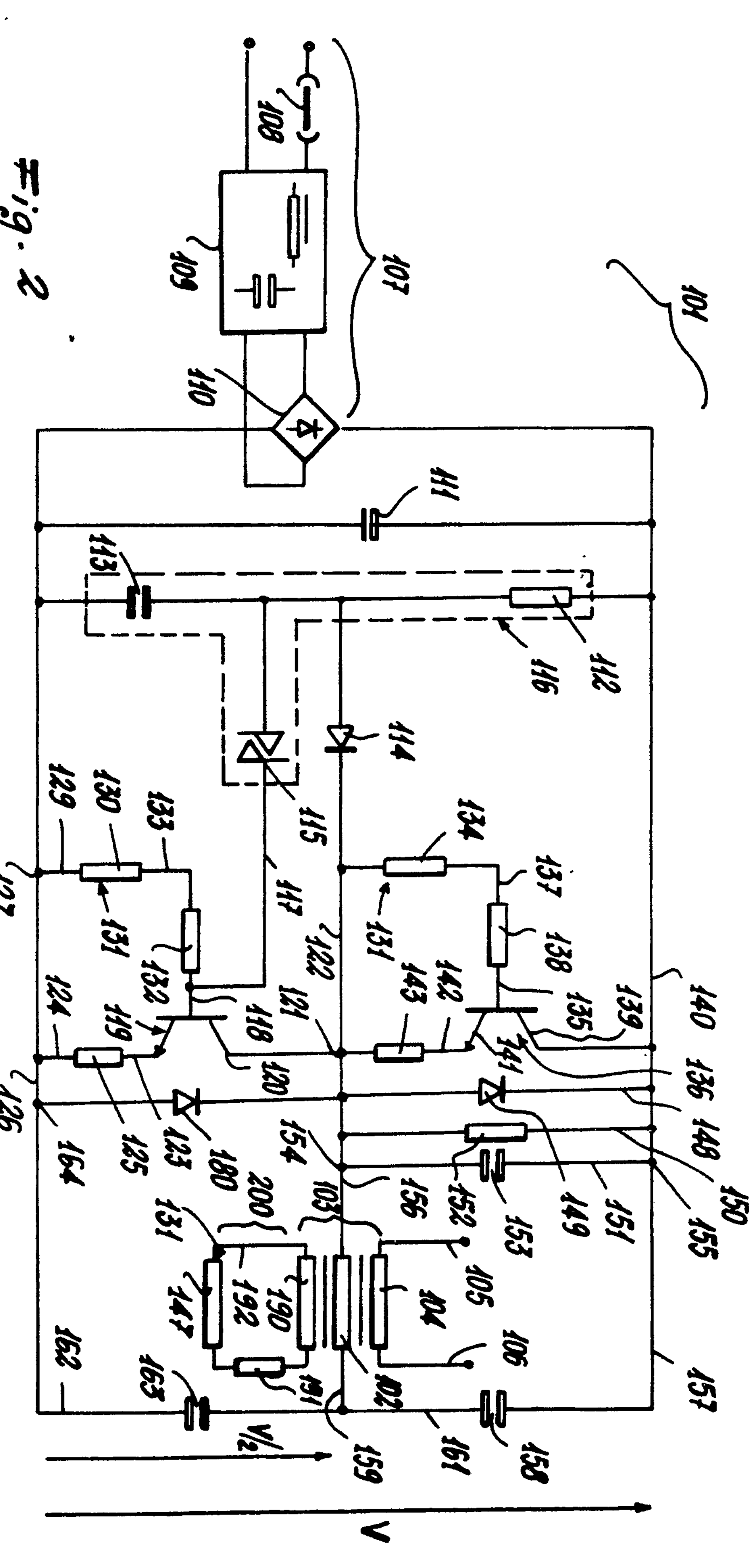

Fig. 2