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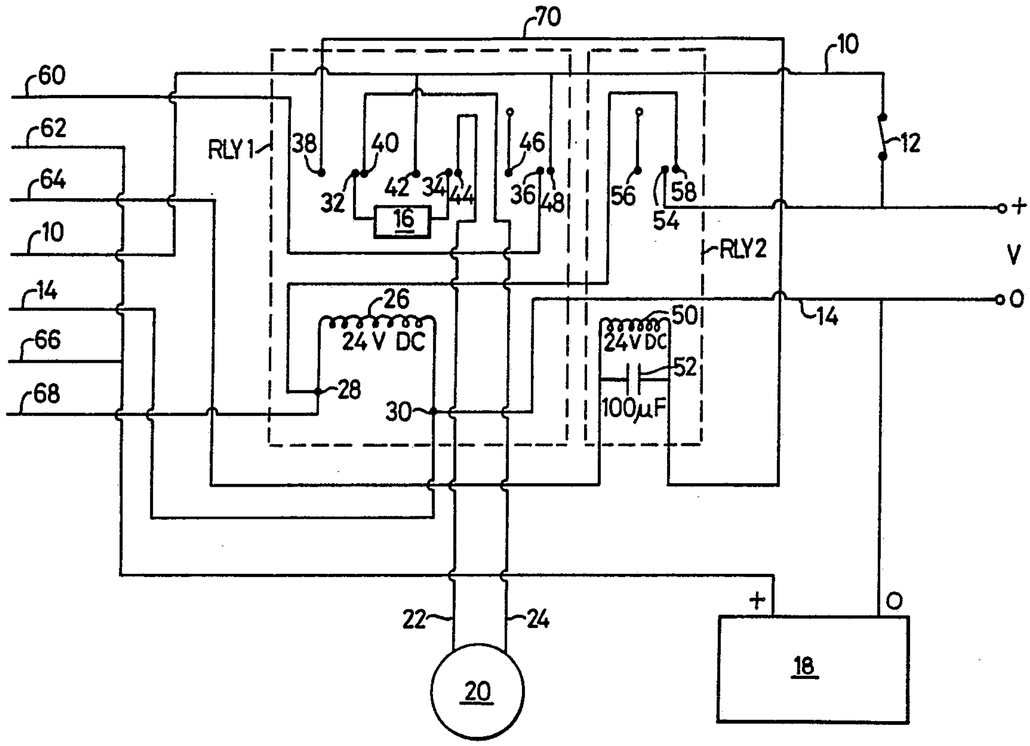
(54) Title: IMPROVEMENTS IN OR RELATING TO D.C. to A.C. INVERTERS



(57) Abstract

A portable A.C. power supply comprises D.C. to A.C. inverter means, including a chopper circuit (18) and transformer (22), connected to D.C. storage cells (at V). The supply includes control means responsive to the current being drawn by the load (16) (such as a power tool) which de-activates the supply if the alternating current drawn by the load (16) falls below a predetermined level, e.g. if the tool is switched off, and re-activates the supply automatically when the tool is switched on again. The supply also allows the storage cells to be re-charged via the windings of the output transformer (22).

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"IMPROVEMENTS IN OR RELATING TO D.C. TO A.C. INVERTERS"

The present invention relates to D.C. to A.C. inverters and is particularly, but not exclusively, concerned with portable A.C. power supplies powered by a storage cell or cells.

D.C. to A.C. inverters are used in conjunction with rechargeable storage cells to provide a portable alternating current supply enabling A.C. appliances to be operated remote from mains supply outlets. The use of such portable power supplies is restricted, however, by the limited amount of energy available before the cells have to be recharged. Additionally, the life of the cells is reduced if they become excessively discharged in use prior to recharging. It is also desirable to avoid overcharging the cells and to reduce the overall weight and size of the supply as far as possible.

It is an object of the present invention to obviate or mitigate the aforesaid disadvantages and to enhance the portability of a rechargeable A.C. power supply.

According to a first aspect of the invention, an A.C. power supply comprises at least one storage cell and D.C. to A.C. inverter means connected to said cell, including means for monitoring the current being drawn by a load connected to the supply and first control means responsive to said monitoring means, said control means being adapted to activate or deactivate the power supply in response to the current being drawn by the load.

Preferably, said first control means deactivates the power supply if the alternating current drawn by the load falls below a predetermined threshold level.

Preferably also, said inverter means includes transformer means to which said load may be connected and said first control means includes first switching means adapted to disconnect said load from said transformer means and to disconnect said inverter means from said cell when said alternating current falls below the predetermined threshold level.

Preferably also, said first control means further includes second switching means responsive to said first switching means and which, in a first condition connects said load to said transformer means and in a second condition connects said load to said storage cell.

Preferably also, said second switching means switches from said first condition to said second condition when the alternating current drawn by the load falls below the predetermined threshold level, said second switching means being further adapted to return to said first condition in response to a direct current being drawn from the storage cell by the load.

The invention is preferably further provided with means for monitoring the D.C. voltage output from the cell and second control means responsive to said D.C. voltage monitoring means and adapted to deactivate the supply if the D.C. voltage falls below a predetermined threshold level.

Preferably, the power supply is provided with means for monitoring the D.C. voltage output from the cell and second control means responsive to said D.C. voltage monitoring means and adapted to deactivate the supply if said voltage falls below a predetermined threshold level.

According to a second aspect of the invention, an A.C. supply comprises at least one storage cell, D.C. to A.C. inverter means connected to said cell and transformer means having a first winding connected to said inverter means and a second winding connected to the output terminals of the supply, wherein said first winding is adapted to apply a charging current to said cell in response to an input current applied to said second winding.

Preferably, said supply is further provided with switching means whereby said inverter means may be isolated from said first winding.

An embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:-

Fig. 1 is a circuit diagram of the main supply circuit of a rechargeable A.C. supply embodying the invention;

Fig. 2 is a circuit diagram of sensing and control circuitry for connection to the circuit of Fig. 1;

Fig. 3 is a circuit diagram of a chopper circuit for use in the circuit of Fig. 1;

Fig. 4 is a circuit diagram of a transformer circuit for use in the circuit of Fig. 1; and

Fig. 5 is a circuit diagram of a charging circuit for connection to the transformer circuit of Fig. 4.

Referring now to Fig. 1 of the drawings, a rechargeable storage cell, or cells, (not shown) applies a D.C. voltage, V (say, 24 V) across a positive voltage rail 10, via a main power switch 12, and a zero voltage rail 14. The storage cell powers an A.C. supply to a load 16 (such as a power tool) by means of a D.C. to A.C. inverter including a chopper circuit 18 and transformer means 20, and the connection of the load 16 to the transformer means 20 (via lines 22, 24) is controlled by a first relay RLY 1 comprising a coil 26, having a positive terminal 28 and a negative terminal 30, first and second movable contacts 32 and 34 and a third movable contact 36. The movable contacts 32, 34, 36 co-operate selectively with stationary contacts 38 or 40, 42 or 44 and 46 or 48 respectively, and the circuit is illustrated with the coil 26 energised and the load 16 connected to the transformer means 20. RLY 1 is controlled firstly by a second relay RLY 2 (comprising a coil 50, a delay capacitor 52 connected in parallel with the coil 50, a single movable contact 54 and first and second stationary contacts 56, 58) and secondly, during operation of the supply, by control circuitry illustrated in Fig. 2 and described below. The circuit of Fig. 1 is connected to the control circuit by lines 60, 62, 64, 66 and 68 and by the voltage rails 10 and 14. In normal operation line 60 is shorted to line 62, line 64 is shorted to rail 14 and line 66 is shorted to line 68.

The initial operation of the circuit when the switch 12 is closed is as follows. With the switch 12 open and the circuit de-energised, contacts 32, 34 and 36 of RLY 1 engage contacts 38, 42, 46 and contact 54 of RLY 2 engages contact 56. When the switch 12 is closed and the load 16 is switched on, the coil 50 of RLY 2 is energised (via rail 10, contacts 42, 34, the load 16, contacts 32, 38 and line 70). Contact 54 thus engages contact 58, energising the coil 26 of RLY 1 and causing contacts 32, 34, 36 to engage contacts 40, 44, 48 (as illustrated). RLY 2 is then de-energised, however RLY 1 remains energised since the positive terminal 28 of coil 26 is now connected to the applied voltage V via lines 68, 66, 62, and 60 and contacts 36 and 48.

Once operational, the circuit of Fig. 1 is controlled by the sensing and control circuit of Fig. 2 which serves to monitor both the A.C. current being drawn by the load 16 and the output voltage V of the storage cell. Firstly, the circuitry of Fig. 2 deactivates the circuit of Fig. 1 if the load 16 ceases to draw current (eg. if an appliance powered by the supply is switched off). This is desirable since the D.C. to A.C. inversion circuitry of Fig. 1 consumes a significant amount of power even when "idling", so that the running time of the supply between recharging is increased if the circuitry is deactivated when the load is disconnected. Secondly, the circuitry of Fig. 2 deactivates the circuit of Fig. 1 if the amplitude of voltage V falls below a predetermined threshold level so as to prevent excessive discharging of the storage cell.

Referring now to Fig. 2, the A.C. current being drawn from the supply by the load is monitored by a current transformer 74. The output signal from the current transformer 74 is rectified by a full-wave rectifier 76 and applied to a first input terminal 78 of a first comparator (type LM324) 80. The comparator 80 compares the rectified current signal with a reference level (set by potentiometer 82) applied to its second input terminal 84, and the output from terminal 86 is applied to the base of a first transistor TR 1 (TIP121) which controls the flow of current through a coil 88 of a third relay RLY 3. In normal use, when the load 16 is drawing current, coil 88 is energised and contact 90 of RLY 3 engages contact 92, connecting line 66 to line 68 and so maintaining RLY 1 and the copper circuit 18 energised as previously described. If the load 16 ceases to draw current, the coil 88 is de-energised, contact 90 engages open-circuited contact 94 (as illustrated) and RLY 1 and chopper circuit 18 are also de-energised, so de-activating the power supply. When the load 16 is switched on again RLY 1 is re-energised as in the initial start-up and the power supply resumes normal operation.

A second comparator (also type LM324) 96 monitors the output voltage V from the storage cell. A voltage divider network comprising resistors 98 and 100 connected between rails 10 and 14 applies a voltage proportional to voltage V to a first input terminal 102 of the comparator 96 and this voltage is compared with a reference level (set by potentiometer 104) applied to a second input terminal 106. The output terminal 108 of the comparator 96 is connected to the base of a second transistor TR 2 (TIP121) which controls the flow of current to a coil 110 of a fourth relay RLY 4. In normal operation the coil 110 is de-energised and contacts 112, 114 of RLY 4 are connected to contacts 116 and 118 respectively, connecting line 60 to line 62 and line 64 to the zero voltage rail 14. When the voltage V on rail 10 falls below the predetermined threshold level, coil 110 is energised and contacts 112 and 114 engage contacts 120 and 122 respectively (as illustrated). Line 60 is thus connected to open-circuited contact 120 and the negative terminal 124 of coil 110 is shorted to the zero voltage line 14, latching RLY 4.

The disconnection of line 62 from line 60 de-energises the chopper circuit 18 of Fig. 1. Consequently, the current transformer 74 will cease to sense any A.C. current, so that RLY 3 and hence RLY 1 will become de-energised and the circuit of Fig. 1 will again be deactivated. In the circuit of Fig. 2, a terminal 125 may provide the power supply for the comparators 80 and 96.

Fig. 3 shows the chopper circuit 18 of Fig. 1. The circuit includes output transistors TR 3 and TR 4 (both TIP121) having their collectors 126, 128 connected (via resistors 162, 164) to the bases of transistors TR 5 and TR 6 (both 2N3771) of the power stage of the transformer circuit 20 illustrated in Fig. 4. The chopped output from transistors TR 3 and TR 4 alternately enables transistors TR 5 anad TR 6 so that an alternating current flows in a first winding 130 of a transformer 132.

The second, output, winding 134 of the transformer 132 may be provided with switchable tappings 136, 138 and 140 to provide a choice of output A.C. voltages; eg. 240 V, 220 V or 110 V. The frequency of the A.C. output may also be continuously varied by means of potentiometer 142 (Fig. 3), but would normally be switchable between pre-set values (eg. 50 Hz and 60 Hz). The potentiometer 142 may thus be replaced by switchable fixed resistances.

The transformer 132 is advantageously of the toriodal type, having windings 130 and 134 wound on top of one another, which, having high efficiency and low bulk, is well suited to use in a portable power supply pack. The windings 134 and 130 may also be utilised to apply a charging current to the rechargeable storage cell, the input charging current being applied to the second winding 134 and hence to the cell via the first winding 130, lines 144 and 146 and a suitable charging circuit (see Fig. 5, described below). Switching means 148 are provided to isolate the first winding 130 from the D.C. to A.C. inversion circuitry while the cell is being charged so as to avoid interference problems.

Fig. 5 shows a regulated charging circuit which may be incorporated into a rechargeable power supply. The A.C. charging current from lines 144 and 146 is rectified by a full wave rectifier 150 and the rectified output applied to the cell via a regulating network including a variable voltage regulator (type LM338K) 152 and a 2200 µF electrolytic smoothing capaciutor 154. The regulator 152 automatically disconnects the charging current when the cell is charged to a predetermined level set by potentiometer 156. Additionally the output resistances 158, 160 may be switchable to vary the output charging voltage; eg. from 24 V to 12 V.

The circuitry of Figs. 1 to 5 may be incorporated into a portable, rechargeable A.C. power supply contained in a water-proof carrying case. The case may be hand held or in the form of a back or shoulder pack. The storage cell may be a sealed, rechargeable battery of 10 to 14, 24 to 28 or 34 to 38 volts D.C., and the supply will give an A.C. output in excess of 500 watts at 110, 220 or 240 volts A.C. The supply may also be provided with D.C. output terminals giving a D.C. supply and provision may be made for the connection of additional storage cells.

It will be appreciated that various modifications or variations of the device may be made which fall within the scope of the invention. For example, the chopper circuit 18 may be replaced by a quartz oscillator circuit generating pulse trains having a highly accurate frequency and 1:1 mark-space ratio, which have to be set manually in the chopper circuit 18. This does not, however, allow easy switching of the output frequency. It is also important, for reasons of safety, that the drive transistors TR 5 and TR 6 are never both enabled at the same time. In the case of a quartz oscillator circuit, which applies anti-phase pulse trains to the drive transistors, this may be done by delaying the rising edge of each pulse of each train by a short period (say fifty microseconds) so that there is a dead period between the pulses applied alternately to the transistors. This compensates for switching delays or residual charge effects. Additional protection may include means adapted to force the drive transistors off in the event that they are enabled simultaneously.

The charging arrangement allows the cell to be recharged by any suitable means such as an A.C. mains supply, a vehicle charging system, another battery or battery charger, solar power or any power source producing a D.C. supply such as windmills, waterwheels, turbines or the like. It is particularly desirable that the supply be rechargeable from a vehicle battery, eg. via a cigar lighter socket. Where the supply uses two 12 V cells, the charging circuit may be adapted to automatically switch the cells from parallel to series connection depending on whether the charging voltage is 12 V (eg. from a private car) or 24 V (from a heavier vehicle).

The supply is preferably provided with two A.C. outlet sockets: a standard 13 amp socket for 220 V/240 V operation and a regulation industrial type for 110 V. It may also include cell charge level indicating means and A.C. power-on indicating means.

The invention thus provides improved D.C. to A.C. inverter means which may be incorporated into a portable rechargeable, A.C. power supply having reduced bulk, increased running time between charges and enhanced battery life.

CLAIMS

1. An A.C. power supply comprising at least one storage cell and D.C. to A.C. inverter means connected to said cell, including means for monitoring the current being drawn by a load connected to the supply and first control means responsive to said monitoring means, said first control means being adapted to activate or deactivate the power supply in response to the current being drawn by the load.

2. An A.C. power supply as claimed in claim 1 wherein said first control means deactivates the power supply if the alternating current drawn by the load falls below a predetermined threshold level.

3. An A.C. power supply as claimed in claim 2 wherein said inverter means includes transformer means to which said load may be connected and said first control means includes first switching means adapted to disconnect said load from said transformer means and to disconnect said inverter means from said cell when said alternating current falls below the predetermined threshold level.

4. An A.C. power supply as claimed in claim 3 wherein said first control means further includes second switching means responsive to said first switching means and which, in a first condition connects said load to said transformer means and in a second condition connects said load to said storage cell.

5. An A.C. power supply as claimed in claim 4 wherein said second switching means switches from said first condition to said second condition when the alternating current drawn by the load falls below the predetermined threshold level, said second switching means being further adapted to return to said first condition in response to a direct current being drawn from the storage cell by the load.

6. An A.C. power supply as claimed in any preceding claim further including means for monitoring the D.C. voltage output from the cell and second control means responsive to said D.C. voltage monitoring means and adapted to deactivate

the supply if the D.C. voltage falls below a predetermined threshold level.

7. An A.C. power supply as claimed in claim 6 wherein said second control means includes third switching means adapted to disconnect the inverter means from the cell and to switch said second switching means to its second condition if the D.C. voltage falls below said threshold level, and to prevent direct current being drawn from the cell by the load when said second switching means is in its second condition.

8. An A.C. power supply as claimed in claim 7 wherein said first, second and third switching means each comprise electromagnetic relays, the first and second relays being energised and the third relay being de-energised in normal operation.

9. An A.C. power supply comprising at least one storage cell, A.C. to D.C. inverter means connected to said cell and transformer means having a first winding connected to said inverter means and a second winding connected to the output terminals of the supply, wherein said first winding is adapted to apply a charging current to said cell in response to an input current applied to said second winding.

10. An A.C. power supply as claimed in claim 9 and further provided with switching means whereby the inverter means may be isolated from said first winding.

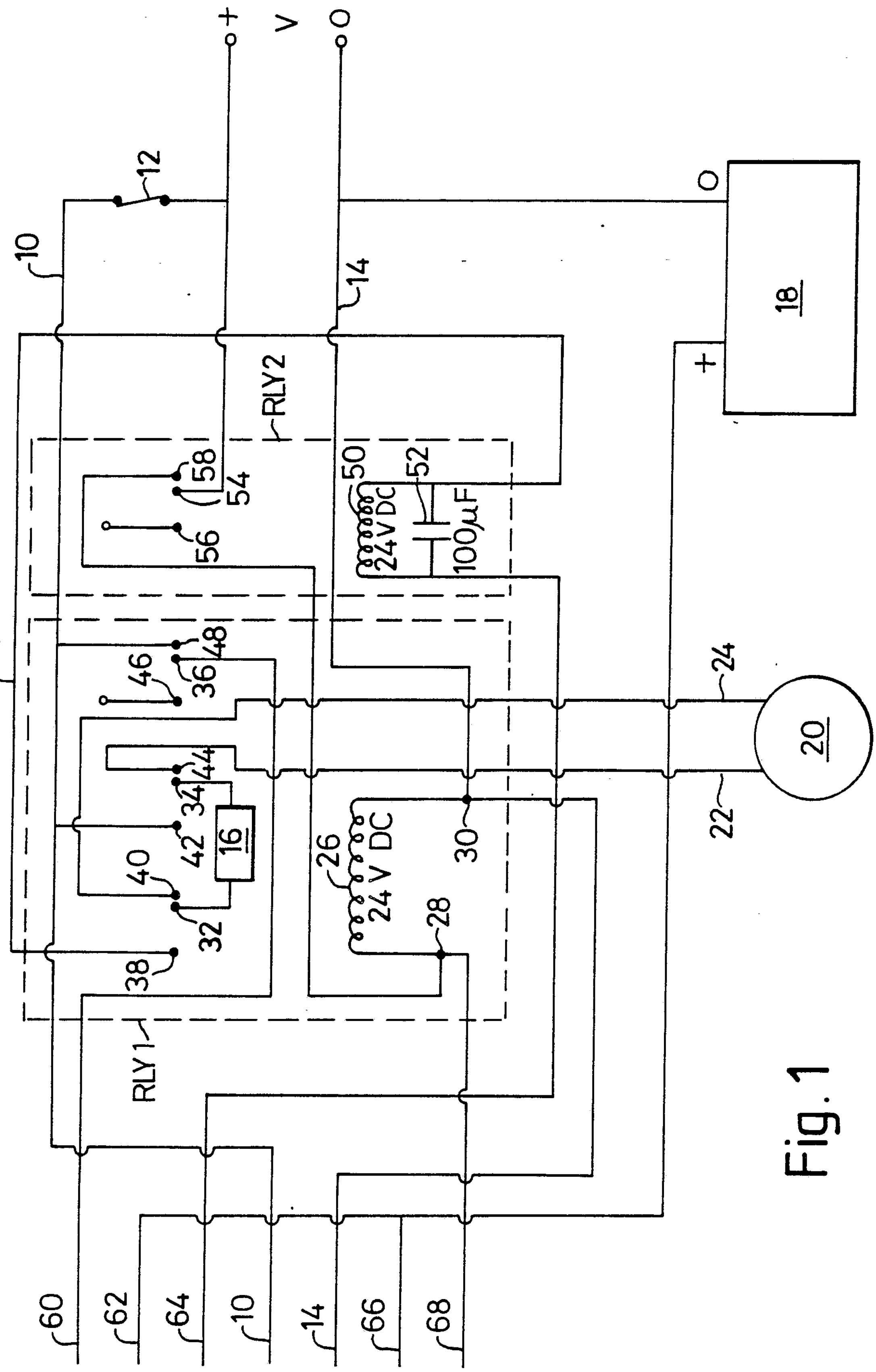
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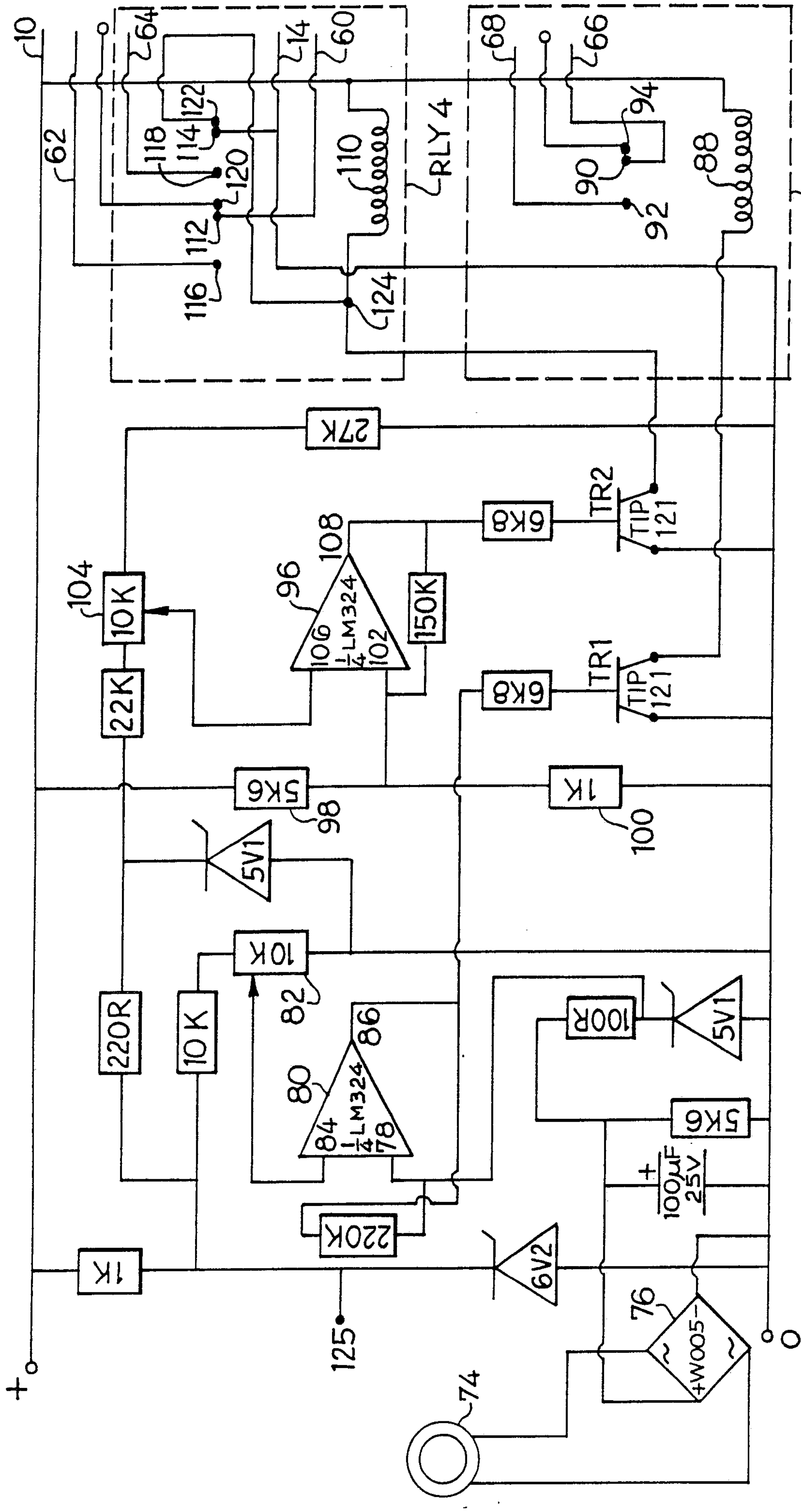
Fig. 1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22K
5K6
98
1K
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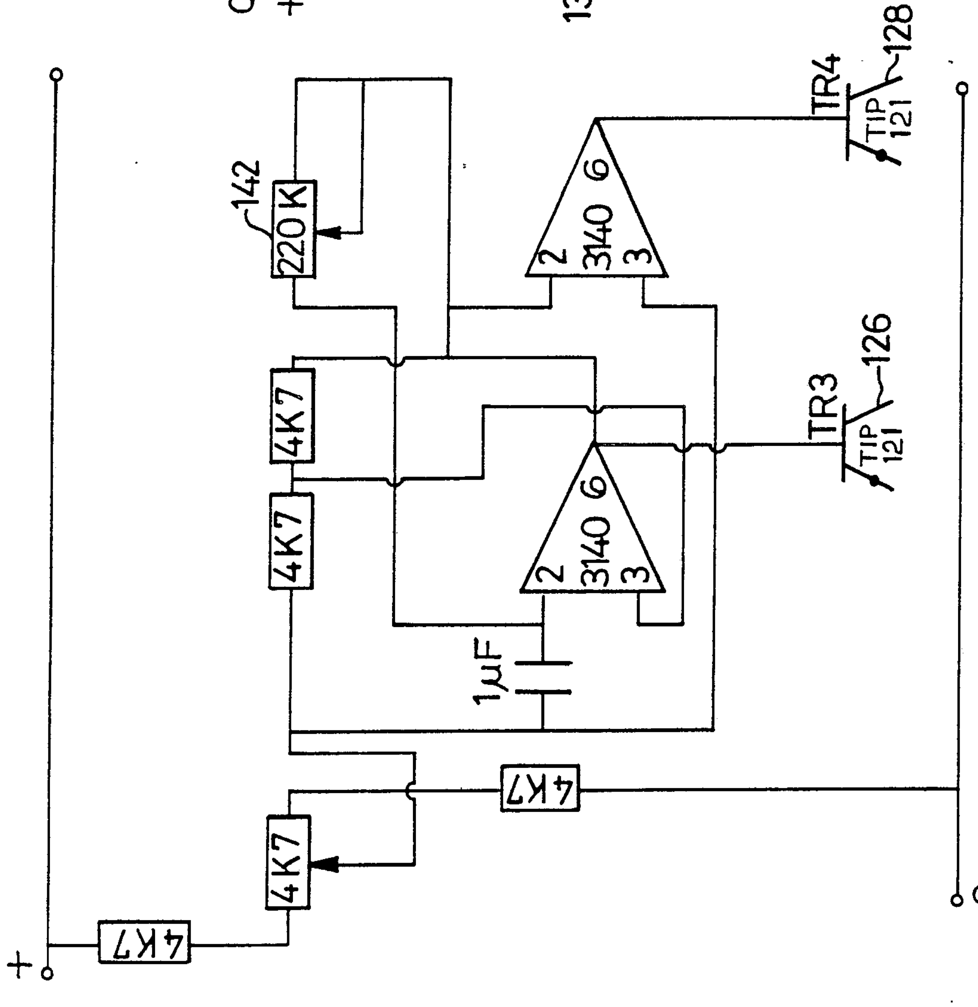
+

Fig. 2



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TR3
TIP 121
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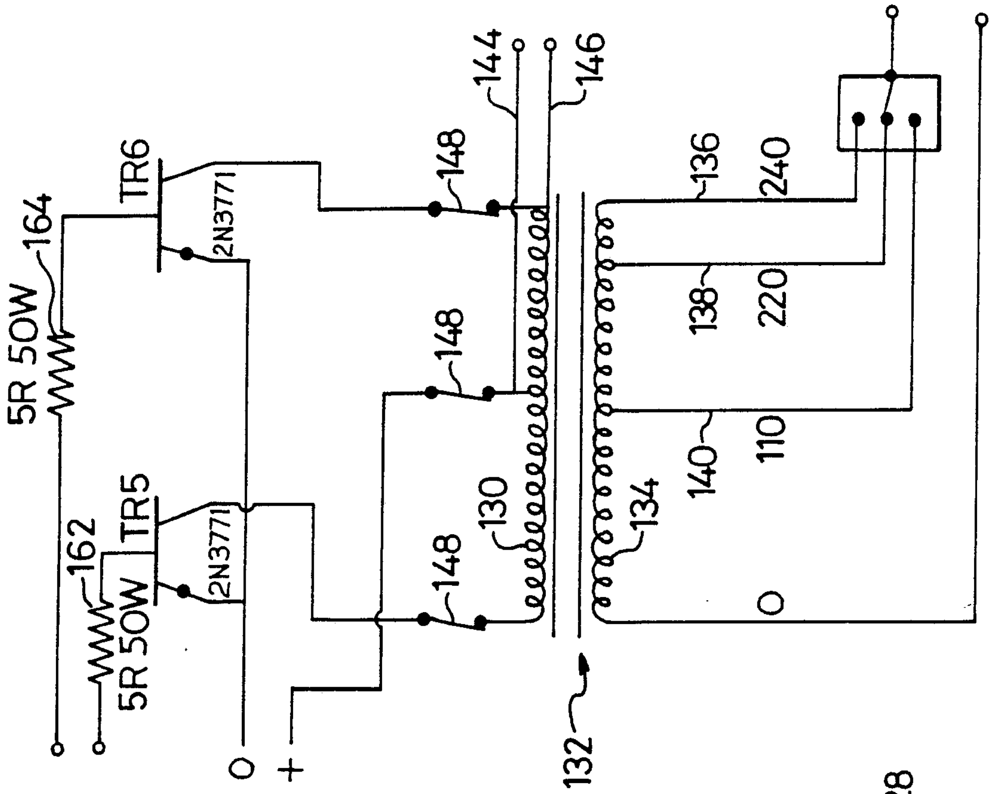
TR4
TIP 121
128

Fig. 3



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TR6
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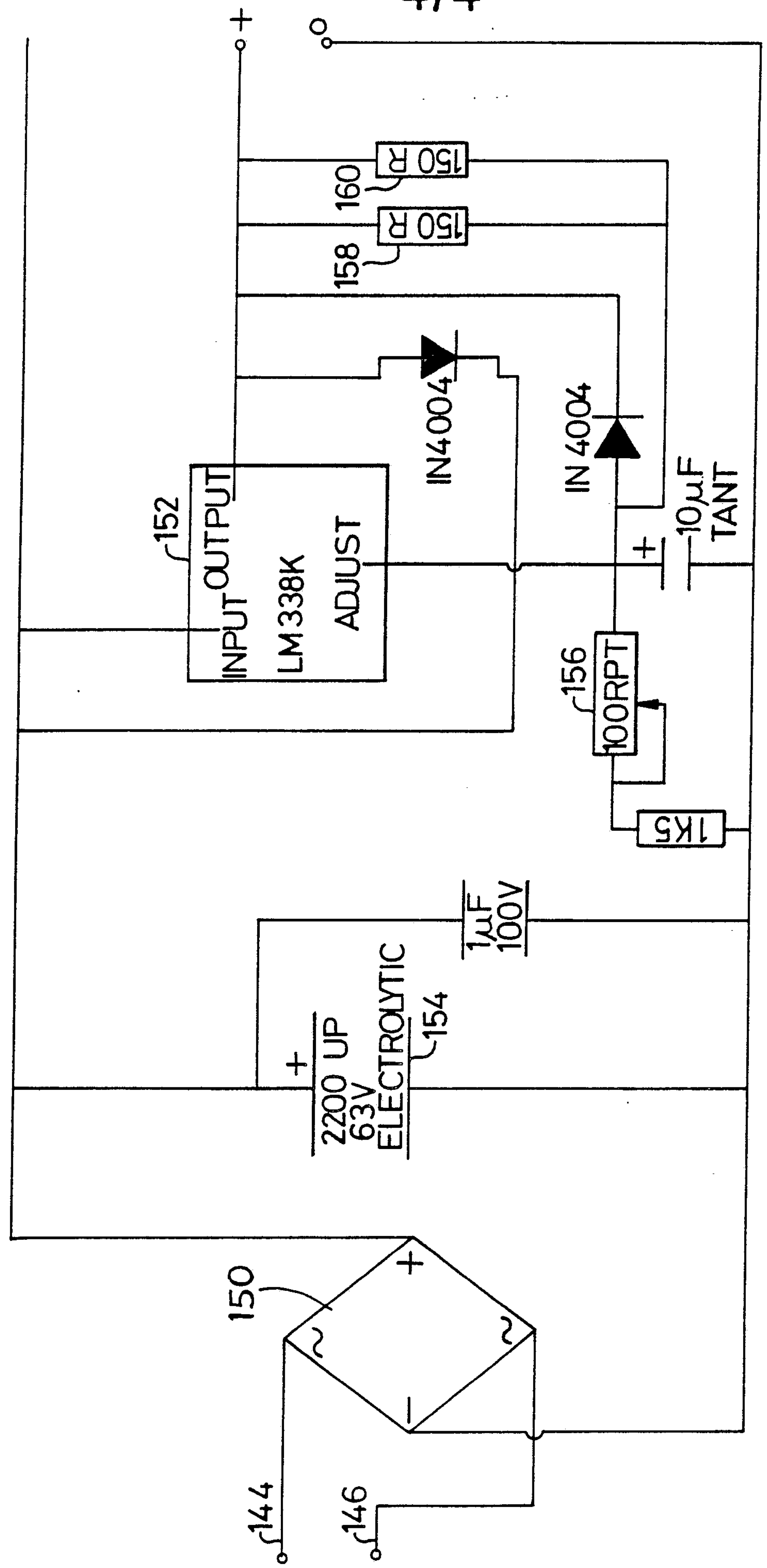
Fig. 4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154
150
+
144
146

Fig. 5

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 88/00140

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC^4: H 02 H 7/18; H 02 J 7/00; H 02 M 7/48

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC^4	H 02 H; H 02 J; H 02 M; H 02 P

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [*]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
A	GB, A, 2010028 (G.R. JURGENS) 20 June 1979 see page 1, lines 123-126, 89-98; figure 1 --	1,2
A	US, A, 4493001 (L.J. SHELDRAKE) 8 January 1985 see abstract; column 1, lines 52-59 --	1
A	US, A, 3771012 (W.M. NIEDERJOHN) 6 November 1973 see abstract; column 1, lines 46-49, 54-60; figures --	1
A	US, A, 4137557 (G. CIARNIELLO et al.) 30 January 1979	

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* Special categories of cited documents: [10]

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
19th May 1988	21 JUN 1988
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	P.C.G. VAN DER PUTTEN

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.

GB 8800140
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB-A- 2010028	20-06-79	DE-A- 2846799	10-05-79
		JP-A- 54075049	15-06-79
		AU-A- 4126778	17-05-79
		US-A- 4237385	02-12-80
		AU-B- 523071	08-07-82
US-A- 4493001	08-01-85	CA-A- 1222283	26-05-87
US-A- 3771012	06-11-73	DE-A,C 2325853	06-12-73
		CA-A- 963524	25-02-75
		GB-A- 1414052	12-11-75
US-A- 4137557	30-01-79	LU-A- 72458	28-08-75
		NL-A- 7505678	18-11-75
		BE-A- 829065	01-09-75
		FR-A,B 2271691	12-12-75
		DE-A- 2521462	20-11-75
		US-A- 4088940	09-05-78
		GB-A- 1513812	07-06-78
		SE-A- 7505410	17-11-75

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