INTERNATIONAL ATOMIC ENERGY AGENCY
UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION

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College on Medical Physics
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IAEA DROP-OUT RELAY WITH DELAYED SWITCH-ON AND RESET

IAEA, Vienna, Austria

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IAEA DROP-OUT RELAY

WITH DELAYED SWITCH-ON AND RESET

TO PROTECT YOUR INSTRUMENTS

AGAINST

POWER FAILURES AND LIGHTNING STROKE

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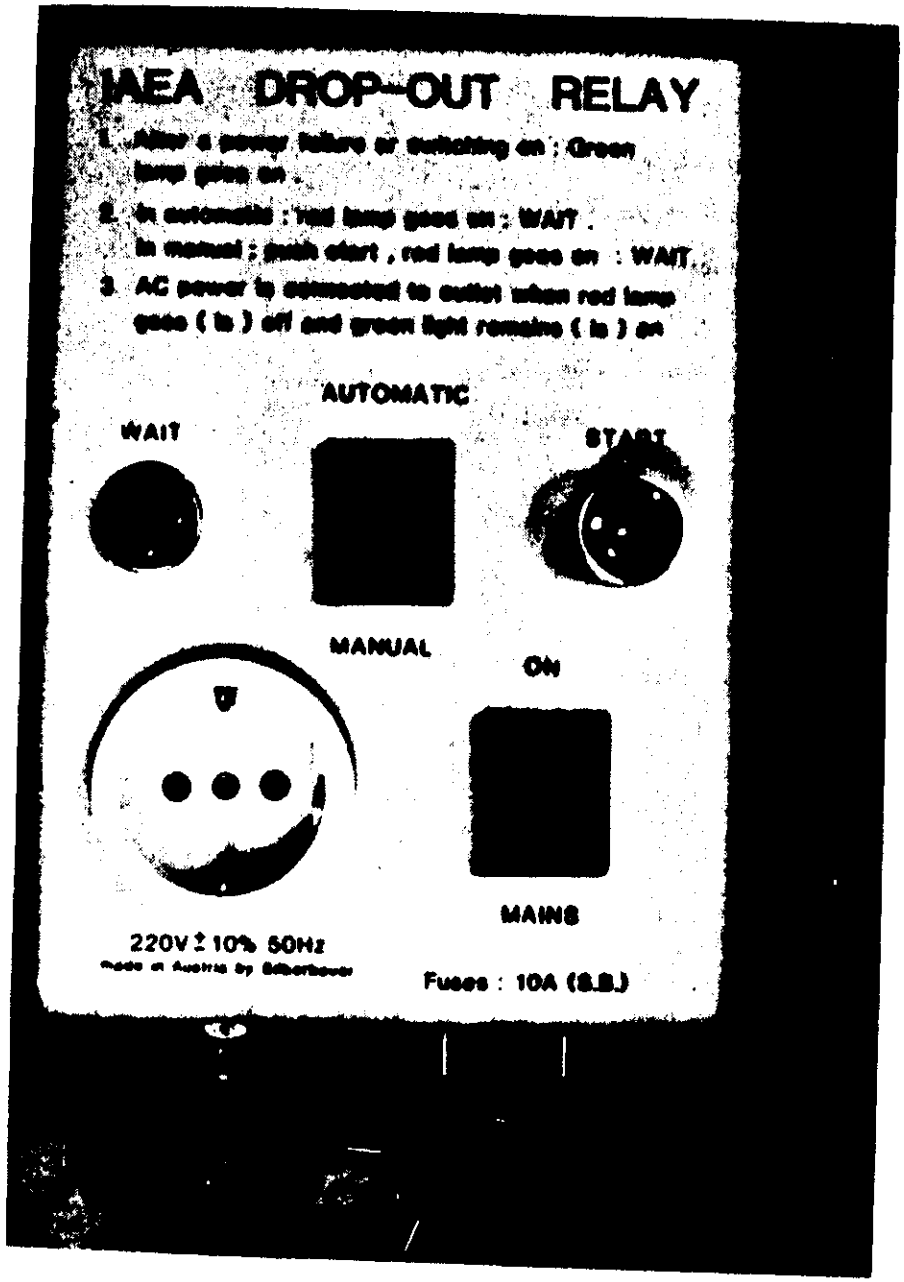
CONTENTS

THIS UNIT PREVENTS INSTRUMENT DAMAGE

CAUSED BY POWER FAILURES AND LIGHTNING STROKE



I. PRINCIPLE OF PROTECTION

A power failure is often accompanied at its very beginning by a high transient. After the power is restored heavy surges, sags and transients (see VIII. Glossary) occur during one to two minutes. A lightning stroke on nearby power lines or earth lines may cause high energy transients on AC mains lines. Instruments are often damaged by these disturbances. To protect instruments against them a drop-out relay is used. It consists of transient clippers (varistors) and a circuit which disconnects the instrument from the mains supply lines at the beginning of the power failure and reconnects it approximately 2.5 minutes after pushing the start button (mannual mode) or after the last power interruption lasting longer than approximately 15 ms (automatic mode).

II. INSTALLATION

1. Unpack the box and check that it contains:

   a. Manual,
   b. Drop-out relay,
   c. Plug fitting to outlet of drop-out relay,
   d. 10 spare fuses.

2. Check for any transport damage.

3. Verify that AC voltage and frequency of your mains outlet correspond to values printed on drop-out relay (220 V, 50Hz or 115 V, 60Hz).

4. Mount on the cable of the drop-out relay a plug which fits to the mains outlets of the laboratory. (Brown = live, blue = neutral, yellow-green = earth).

5. Check the function of the drop-out relay in manual and automatic mode (See IV. Instructions for use.) without an instrument connected to it.

6. Mount the plug delivered with the drop-out relay on the AC input cable of your instrument and plug your instrument into the drop-out relay.

7. The drop-out relay can be positioned on a table or the floor, or it can be hanged on a wall (See VII.f.).

III. SPECIFICATIONS

The drop-out relay is made in two versions. One is for 220 V $\pm$ 10% and 50Hz, the other is for 115 V $\pm$ 10% and 60Hz. The units are marked accordingly.

For all drop-out relays:

Current rating of relay contacts: 16A resistive load/6A inductive load

Fuses: 10 A slow blow

Delay time: between 2 and 3 minutes
When the voltage is lower than nominal this time is longer, and when the voltage is higher it is shorter.

All parts of the drop-out relay and its delay circuit are over-dimensioned and have been chosen so that it can be reasonably expected that they can withstand the mains disturbances to which they are exposed. The relay contacts are made for higher currents than they are actually carrying. The voltages and/or currents which the diodes, triac, and capacitors can withstand are several times larger than those to which they are exposed. Furthermore, they are protected by capacitors C3 and C4 and the varistors. The varistors may develop failures when exposed to high energy transients or to continuous AC overvoltage. They have therefore to be checked regularly (See Chapter VI.7.).

The construction of this drop-out relay is in accordance with the safety standards of the ÖVE (Oesterreichiser Verband für Elektrotechnik - Austrian Union for Electrotechnology).

IV. INSTRUCTIONS FOR USE

1. Connect the drop-out relay to the mains outlet.

2. Connect the instrument to the outlet of the drop-out relay.

3. Switch on your instrument at the start of work or after a power failure in one of the two following ways:

a. manual mode:

This mode is used for instruments which require manual control after power return.

1. Set "manual/automatic" switch S3 to manual.

2. Switch on the drop-out relay with the main switch S1. The green lamp in the switch will light up when there is AC power.

3. Push start button S2; the red light "WAIT" lights up. After approximately 2.5 minutes the red light will go out. At the same time the mains is connected to the output socket.

4. Switch on the connected instrument.

NOTE: Keep the main switch S1 in the on position if you do not want to push the start button and to wait 2.5 minutes each time you switch on your instrument.

b. automatic mode:

This mode is used for instruments which have to start functionin automatically after power return.

1. Set the main switch S1 in the on position.

2. Set the "manual/automatic" switch S3 in the automatic position.

3. Set the mains switch of the connected instrument in the o position.

4. When the green lamp in the main switch is on and the red lam is off the mains is connected to your instrument.

5. When a power failure occurs the instrument will be disconnecte from the mains supply lines and the green lamp goes off.

6. At the end of a power failure the green and red lamps wil light up.

7. After approximately 2.5 minutes the red lamp will go off and your instrument will be switched on.

V. OPERATION OF CIRCUIT

NOTE: See circuit diagram on page 11.

1. The fuses interrupt the mains supply when one of the varistors is damaged by a mains disturbance and makes a short circuit or when the connected instrument develops a short circuit.

2. Varistor 1 serves to protect the drop-out relay against normal mode transients.

3. Varistors 2, 3 and 4 serve to protect connected instruments against normal and common mode transients and lightning strokes.

4. When the main switch (S1) is in the off position the drop-out relay circuit and the output are not connected to the mains.

5. When the main switch (S1) is in the on position and switch S3 set to manual, pressing the pushbutton "manual start" (S2) will cause the delay circuit to be connected to the mains through the self-holding relay d1. After a delay of approximately 2.5 minutes, the output will also be connected to the mains through the selfholding relay d2.

6. When the main switch (S1) is in the on position and switch S3 set to automatic, relay d1 comes on automatically at every restoration of the mains power. As a consequence, the output will be connected to the mains approximately 2.5 minutes after the power is restored.

7. When the power fails the relay d2 disconnects the output from the mains supply lines. When switch S3 is in the manual position, the relay d1 disconnects the delay circuit at the same time from the mains supply lines.

8. When the power is switched on or is restored and the manual start push-button is pressed, or S3 is in the automatic position, C1 is charged through the diodes D1-D4 and resistor R1. The voltage across C2 follows nearly simultaneously the voltage across C1 ($R1C1 \gg R2C2$).

9. When the trigger point of the diac is reached (approximately 32 V) a short trigger pulse (less than 1 ms) fires the triac which energises relay d2. The mains will now be connected to the output through the contacts 1-2 and 3-4 of relay d2.

10. From the moment the mains is connected to the output the relay d2 is kept energised through its contacts 5-6. When any power failure longer than the release time of the relays occurs d1 closes its contacts 4-12 and C1 is discharged through a small current limiting resistor R4 in approximately 3 ms. Thus, the full delay time is provided after power failures lasting longer than the sum of the release time of the relay and discharge time of C1.

11. If the diac were to be connected directly to C1 the large charge $Q = V_{C1}$. C1 of C1 would damage the diac. On the other hand the large capacity of C1 is needed to get a long delay time with a suitable charging resistor R1. Therefore, R2 protects the diac and C2 delivers the current necessary to fire the triac.

12. The delay time T can be calculated from the formula:

$$T = R_1 C_1 \ln \left(\frac{U_{MP}}{U_{MP} - U_{DIAC}} \right)$$ where: U_{MP} = mains peak voltage;
U_{DIAC} = diac breakover voltage.

Since the actual values of R1 and C1 and the trigger point of the diac differ according to the manufacturer's tolerances the delay time of an individual drop-out relay may lay in between 2 and 3 minutes.

3. Each relay has an inherent mechanical delay, so the triac must be on for at least two AC cycles. Since the trigger pulse of the diac is much shorter than this period the triac is clamped to the voltage of C1 via diode D5 and resistor R3. This ensures that relay d2 will be switched on properly and hold itself by its contacts 5-6. The whole electronic delay circuit is then bypassed.

4. Resistor R5 and capacitor C3 avoids false triggering of the triac by voltage spikes. R3 limits the discharge current of C1 through the triac. C4 is for transient suppression.

VI. TROUBLE SHOOTING:

1. A fuse has blown:

   a. One of the varistors has developed a short circuit.
   b. There is a short circuit in the delay circuit.
   c. There is a short circuit in the instrument connected to the drop-out relay.
   d. The instrument connected draws too long a too high current when switched on (starting current) or when in normal use ($>10^A$).

2. The green lamp in the main switch does not light up when the dropout relay is switched on:

   a. There is no AC power (red lamp doesn't light either).
   b. One of the fuses has blown (red lamp doesn't light either) (See 1.)
   c. The lamp has burned out (red lamp lights up at manual or automatic start).

3. The red lamp "wait" does not light up after manual or automatic start.

   a. There is no AC power (See 2.a.).
   b. One of the fuses has blown (See 1.).
   c. The relay contacts 5-6 of d2 do not disconnect (In this case the output is connected to the mains when mains switch S1 is closed.).

4. After the manual or automatic start the red lamp doesn't go off.

   a. Relay d1 is not energised or contacts 12-4 of d1 do not open.
   b. There is a loose contact of one of the wires connected to the delay circuit board.
   c. There is a fault in the electronic circuit such as: C1 or C2 has short circuit, the diac or triac has open circuit, one of the diodes has open circuit.

5. After manual or automatic start the mains is connected (almost) immediately to the output.

   a. See 3.c.
   b. There is a fault in the electronic circuit such as C1 has open circuit, the triac has short circuit, the diac has short circuit, diode D5 has a short circuit.

6. Failures on the delay board can be found by observing the voltages and resistances between the test points A, B and C. The trigger voltage of the diac is 32V $\pm$ 10%. The voltage remaining on C1 just after d2 energires is approximately 9V.

7. Varistor break down:

Three varistor failures may occur:
Due to one heavy or many less heavy disturbances they may

a. produce a short circuit (This can be measured with an ohm meter, and the fuses will blow.);

b. produce an open circuit;

c. develop other resistance/current-voltage characteristics than specified by the factory.

To check the last two cases disconnect the drop-out relay from the instrument and the mains supply. Set the mains switch in on position. With the help of a variable DC-power supply, a mA-meter and a voltmeter current-voltage relations can be measured at the input cable (Varistor 1) and at the out- put socket (varistors 2, 3 and 4). At a current of 1 m A the voltage over the varistor should be 350 $\pm$ 10% V (or 200 $\pm$ 10% V).

For more precise test descriptions see databooks on varistors supplied by the manufacturers.

IMPORTANT: Varistors loose their characteristics by absorbing the energy of high-energy transients which would otherwise have damaged the electronic circuits of the connected instruments. It is therefore necessary to check them regularly at intervals the duration of which depends on the seriousness of the occurring mains disturbances. Especially after periods of heavy thunderstorms checks should be carried out.

8. The delay time is too short or too long.

a. Check the AC input voltage. High AC voltage causes short delays, low voltage long delays.
b. When C1 or C2 leak the delay time may be long.
c. When R1 becomes smaller due to humidity or deposited dust the delay time will be too short.

VII. HOW TO OPEN THE DROP-OUT RELAY

a. Before opening disconnect AC mains supply.

b. Take off the four rubber feet which are stuck on the screw holes at the back.

c. Unscrew four screws holding the back cover and take off the cover.

d. The delay board (printed circuit board) can be taken out for test purposes without disconnecting the four wires with which it is connected to the switches, relay d2 and the mains lines.

e. When replacing the board put it back in the two groves. Th rubber stuts in the cover will then keep it fixedly on its plac when the cover is fixed.

f. To permit hanging the drop-out relay on a wall take off the bac cover. Open carefully the keyhole which is the furthest fro the circuit diagram visible at its inside and replace th cover. The unit can now be hanged up on a short nail or scre fixed in the wall.

VIII. GLOSSARY

Sag: A short (0,1s to a few seconds) lasting undervoltage of th AC mains. Sags occur usually when electromotors (eleva tors) or compressors of air-conditioners and refrigerators or X-ray equipment are switched on. They cause electri lights to dimm for a short moment.

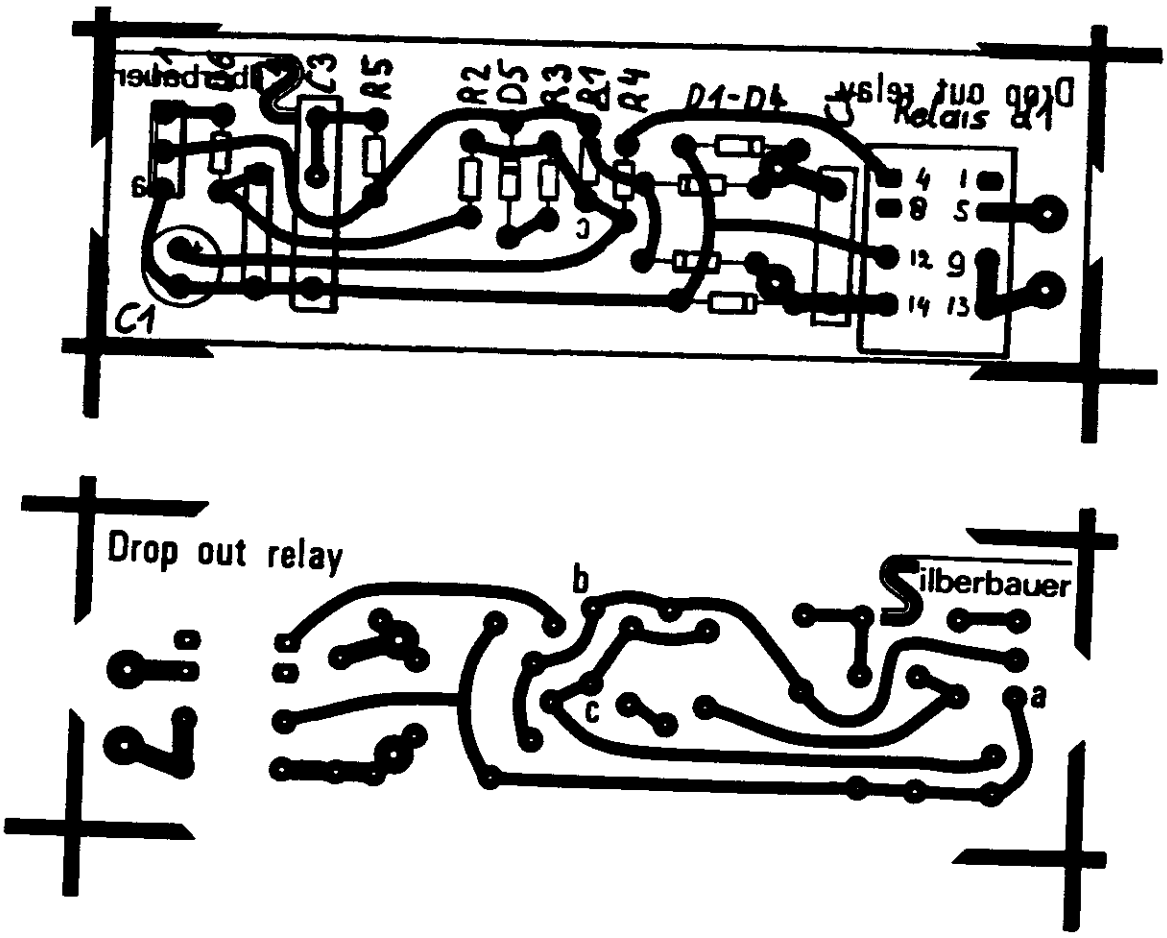
Surge: A short (0.1s to a few seconds) lasting overvoltage of th AC mains. They cause electric lights to flare up for short moment.

Transient: Pulse like energetic disturbances followed occasionally by a decaying wave. Their duration is from a few micro-seconds to a few milliseconds. They may have an amplitude up to ten thousand volts. They occur when inductive loads, such as electromotors, are switched off and when the lightning strikes supply lines. They can only be detected by sophisticated equipment but are present on each mains supply line and cause frequently instrument malfunction and damage.

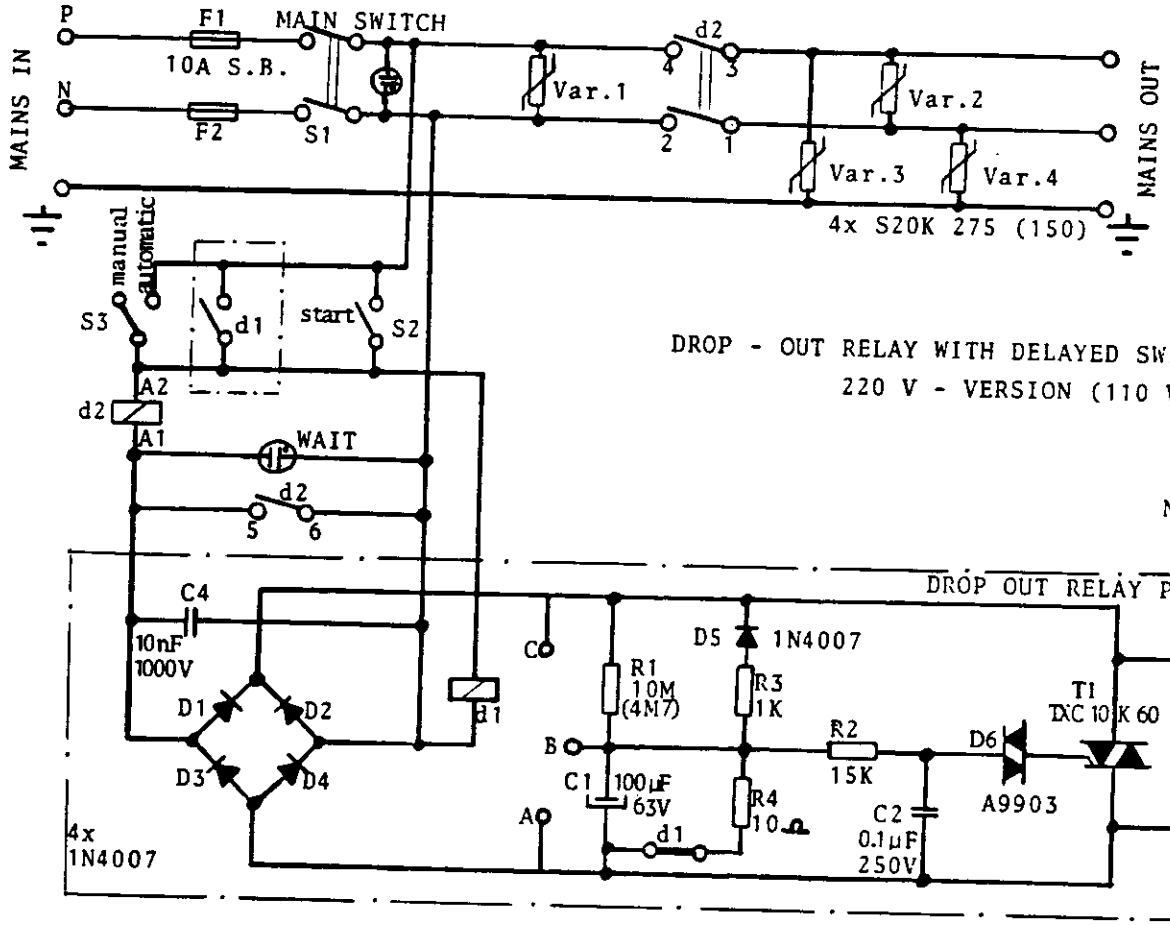
Transient clipper: Device which clips the amplitude of transients and absorbs a part of their energy.

Varistors: Voltage dependent resistor made from metal oxide with symmetric voltage current characteristics. They can absorb in single events large quantities of energy (up to 400 Joule depending on type) but small amounts of power (up to 1 W). They are used as transient clippers.

Power failure: Interruption of the AC mains supply. Power failures may last from a few milliseconds to hours or days. At their beginning they may be accompanied by a high transient. When the power is restored heavy sags, surges and transients may occur.



Component lay-out and printed circuit



DROP - OUT RELAY WITH DELAYED SWITCH ON OR RESET
220 V - VERSION (110 V)

November 1984

IX. PART LIST

Item	Comp No.	Qty.	Description
1.	Case	1	Case Type: 94 14 121 Manufacturer: ODENWAELDER
2a.*)	S1a	1	Main switch with indicator lamp; 10/16A 250V Type: T 1553 VQN 250V double pole Manufacturer: ARCO
2b.*)	S1b	1	Main switch with indicator lamp; 10/16A 130V Type: T1553 VQN 130V double pole Manufacturer: ARCO
3.	S3	1	Switch; 10/16A 250V Type: T1450 SPV QN single pole Manufacturer: ARCO
4a.	d2a	1	Relay; contact ratings 16A/250V; coil 220V/50Hz Type: LS07/10E 910 302 003 00 Manufacturer: AEG
4b.	d2b	1	Relay; contact ratings 16A/250V; coil 115V/60Hz Type: LS07/10E 910 302 003 86 Manufacturer: AEG
5.	FH1, FH2	2	Fuse holders (central hole mounting) Size: 6,3 x 32mm Type: KSH56051605
6.	F1, F2	2	Fuse Size: 6,3 x 32mm; Type: 10A slow blow
7a.	Var1a-Var4a	4	Varistors; 275V 1W Type: S20K275 Manufacturer: SIEMENS
7b.	Var1b-Var4b	4	Varistors; 150V 1W Type: S20K150 Manufacturer: SIEMENS
8.	PB	1	Printed board Type: drop-out relay
9.	D1-D5	5	Diodes 1N4007

*) Suffixe a for 220V version
Suffixe b for 115V version

Item	Comp. No.	Qty.	Description
10.	D6	1	DIAC 32V Type: A9903 Manufacturer: SIEMENS
11.	T1	1	TRIAC Type: TXC 10K 60 Manufacturer: SIEMENS
12.	C1	1	Electrolytic capacitor; 100µF/63V Manufacturer: PHILIPS
13.	C2	1	Plastic film capacitor; 0.1µF/250V Type: 2222352 Manufacturer: PHILIPS
14a.	C3a	1	Plastic film capacitor; 0.1µF/630V Type: MMKO Manufacturer: EVOX
14b.	C3b	1	Plastic film capacitor; 0.1µF/400V Type MMKO Manufacturer: EVOX
15.	C4	1	Plastic film capacitor; 0.01µF/1000V Type: MKS 4 Manufacturer: WIMA
16a.	R1a	1	Resistor; 10M/400V 0.25W 5%
16b.	R1b	1	Resistor; 4M7/400V 0.25W 5%
17.	R2	1	Resistor; 15k/0.25W 5%
18.	R3	1	Resistor; 1k/0.25W 5%
19.	R4, R5	2	Resistor; 10R/0.25W 5%
20a.	MOa	1	Mains outlet; 10/16A 250V Type: Schuko Manufacturer: SIEMENS
20b.	MOb	1	Mains outlet; 10/16A 115V
21a.	MPa	1	Mains plug; 10/16A 250V Type: Schuko Manufacturer: SIEMENS
21b.	MPb	1	Mains plug; 10/16A 115V Manufacturer: CROUSE-HINDS

Item	Comp. No.	Qty.	Description
22a.	d1a	1	Relay; 220V/50Hz Type: V23100-V7128-F104 Manufacturer: SIEMENS
22b.	d1b	1	Relay; 115V/60Hz Type: V23100 - V7127 - F104 Manufacturer: SIEMENS
23.	S2	1	Spring return push button switch Type: S936 K Manufacturer: ARCO
24a.	NIa	1	Neon indicator Type: SL 69 NC 250V Manufacturer: ARCO
24b.	NIb	1	Neon indicator Type: SL 69 NC 130V Manufacturer: ARCO
25.	W	1	Wire; multi-strand, 1.5mm^2 with PVC or silicon rubber
26.	TS	1	Terminal strip connector Type: EKL2 EPADS (5-pole) Manufacturer: Electroterminal

Possible replacement parts should be requested from:

IAEA
Medical Applications Section
P.O.B. 100
A-1400 VIENNA
Austria

or

Ing. G. Silberbauer
Hieszgasse 15
A-1030 Vienna
Austria

When ordering parts please give serial number of the drop-out relay printed at the inside of the cover.

1332M/P.H. Vuister/85-03-06

85-01306