ERBOTOM T 400 C

Electrosurgical Unit

SERVICE DOCUMENTS

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CONTENTS

MAINTENANCE OF THE ERBOTOM T 400 C

Maintenance of a unit including accessories is divided into preventative and corrective maintenance. Preventative maintenance involves regular testing of unit and accessories, while corrective maintenance deals with modifications and repairs.
All maintenance work must be documented in accordance with DIN 57751 Part 1/ IEC 601 Part 1. The maintenance record printed on page 4 is intended for this purpose.

1 Preventative maintenance

In order to avoid accidents resulting from faults due to age and wear and tear of the unit as well as the accessories, the unit along with its accessories must be tested at suitable intervals (at least once a year) by an authorized specialist in accordance with the following check list. The tests and measuring procedures required in this respect are described in IEC 601 Part 1/ VDE 0750 Part 1 and DIN 57751 Part 1/VDE 0751 Part 1.

In the interests of his own protection, the tester should carry out testing and maintenance of the unit in the sequence stated.

CHECK LIST FOR ROUTINE MAINTENANCE

Visual inspection

Check the electrosurgical unit including all its accessories for recognizable faults. The unit should thereby remain closed.

Electrosurgical unit

- Check unit cover, feet, switches and sockets for proper fastening and rotary controls for smooth operation.
- Check that the current rating and blow characteristic of the power supply fuses conform to the manufacturer's specifications.

Current rating:	6.3 A
Blow characteristic:	medium-blow

2 Corrective maintenance

Correchtive maintenance covers modifications and repairs to the electrosurgical unit and its accessories. It must not impair the safety of the unit for patients, users and the environment (DIN 57751 Part 1 / IEC 601 Part 1).

Modifications and repairs must therefore only be undertaken by the manufacturer or by third parties expressly authorized by him. If unauthorized persons carry out improper modifications or repairs to the unit or accessories, then the manufacturer accepts no responsibility in this respect. Claims under warranty are also hereby invalidated.
If any modification to the unit affects the rated data or range of application of the unit, inscriptions and accompanying documents must be altered accordingly.

Modification

A modification must not reduce the safety of the unit and accessories. Therefore, on completion of the modification, appropriate safety checks must be carried out (see check list for routine maintenance). If the modification affects the rated data or field of application of the unit, the inscriptions and accompanying documents must be amended accordingly.

Repairs

When repairs are made to the unit and accessories, only those components specified by the manufacturer may be used (see parts list).
Following repairs, the main constructional and functional features affecting safety must be tested to the extent that they can be affected by the repairs (DIN 57751 Part 1/ IEC 601 Part 1).

ERBOTOM T 400 C
HF SURGICAL UNIT

MAINTENANCE RECORD

Type No.: _____

Serial No.: _____

Name and address of operator: _____

The person undertaking the maintenance work or repair confirms with his signature that he has carried out the maintenance work / repair below with the required care and technical expertise and that he is familiar with the safety regulations, in particular the manufacturer's technical documentation and the IEC requirements currently valid at the time of maintenance work or repair.

Tests	Name, address, signature of the technician and date

Modifications	Name, address, signature of the technician and date

Repairs	Name, address, signature of the technician and dete

ERBE electro medical equipment

CIRCUIT DESCRIPTION

The ERBOTOM T 400 C electrosurgical unit consits of:

1 RF generator for the monopolar operating technique (monopolar generator) with oscillator, modulator, preamplifier, output stage and output circuit.

2 Safety circuit of the patient plate (NE monitor)

3 Finger switch monitor (AB monitor)

4 RF generator for the bipolar operating technique (bipolar generator)

5 Automatic actuating circuit for the bipolar surgical technique (bipolar monitor)

6 Control circuit

7 Optical and acoustical signal

8 Power unit

primary side which can endanger the output stage transistors. A protection circuit consisting of the two voltage-dependent resistors VDR1 and VDR2 in conjunction with D1, C4 and D2, C3 suppresses these voltage peaks.

Protection of the base of the transistors against positive voltages — P.c.board EE 156.7 P.c.board EE 156.9

In general, the two internal diode paths of a transistor must never conduct simultaneously, otherwise a short-circuit will be created which will destroy the transistor.

The power transistors of the output stage are in danger of short-circuit as soon as positive voltage peaks reach their base. As a result of their negative cathode bias of -2.2V DC, diodes D13 to D16 will suppress any positive voltage peaks occurring at the transistor base and thereby protect the base - collector diode paths against inverse operation.
The negative voltage of -2.2V DC required to protect the power transistors is produced by the power unit on p.c.board EE 156.7.

Output circuit — P.c.board EE 156.7

The output circuit of the monopolar generator transmits the high-frequency power from the output stage to the patient. It thereby carries out the following functions:

a) Matching of the impedance of the output amplifier to the load resistance. The load resistance is the sum of all electrical resistances in the field of application, e.g. resistance between active electrode and tissue
   resistance between patient plate and tissue
   resistance of the current paths through the patient.
b) Insulation of the field of application (patient) with respect to the operating voltage of the generator.
c) Protection of the field of application against low-frequency currents.
d) Circuit of the patient plate.

Re a)
The impedance of the output amplifier is very small compared with the load resistance as a result of the parallel connection of the 4 power transistors in each case. The output transformer Tr1 matches this low impedance of the output amplifier to the load resistance.
In most modes of operation, including TUR, the load resistance is around 200 ohm, but with special applications, e.g. cutting fatty tissue, it can also be high impedance.
In the standard version, the two monopolar output sockets Bu2 and Bu3 are connected to the secondary winding 12-14 of the output transformer Tr1. Their matching is 200 ohm.

If high-impedance matching is required, then the monopolar output socket for incisions and coagulation Bu2 can be connected to the secondary winding 1-12 of the output transformer by plugging the connecting leads into plugs St1 and St2 in accordance with the following table. Matching for socket Bu2 is then 350 ohm but remains at 200 ohm for Bu3.

Connection of the monopolar output socket Bu2 with high and low impedance matching

Plug	Low impedance matching	High impedance matching
St1	Contact 2	Contact 1, 3 or 4
St2	Contact 1	Contact 3 or 4

Re b)
Insulation of the field of application from the operating voltage of the generator is guaranteed by isolating the secondary from the primary winding of the output transformer Tr1.

Re c)
The sparking and arcing produced between active electrode and tissue produce low-frequency currents due to their rectifier effect, which can produce undesirable neuromuscular irritation in the patient. Capacitor C8

of the output circuit is used to suppress these low-frequency currents. For compliance with IEC 601 Part 2-2/ VDE 0750 Part 202, the DC resistance of capacitor C8 must be at least 2 Mohm.

Note ! In order to guarantee the safety of the patient, capacitor C8 must only be replaced by a capacitor of the same type (see parts list).

Re d)

The circuit of the patient plate can be fed out conductively or capacitively or insulated from earth (floating) according to the applicable national safety regulations.

Conductive earthing of the patient plate largely protects the patient against high-frequency voltages with respect to earth potential, since there is only a relatively small potential difference between the patient plate and the earthed operating table. This is caused by the inductance of the patient plate cable and is proportional to the current flowing through this cable. Conductive earthing does, however, have the disadvantage that low-frequency leakage currents can flow to earth. Conductive earthing of the patient plate corresponds to Type B of the classification in accordance with IEC 601 Part 1. While IEC 601 Part 2-2 no longer allows conductive earthing for electrosurgical units.

With a patient plate insulated from earth potential, the patient is protected against low-frequency leakage currents. But the disadvantage of this circuit is that the patient carries a high high-frequency voltage with respect to earth potential. Insulation of the patient plate from earth potential corresponds to Type CF of the IEC classification.

Capacitive earthing of the patient plate represents a compromise between conductive earthing and insulation from earth potential. The capacitor C_{NE} makes a high-

frequency connection between the patient plate and earth potential and protects the patient against high-frequency voltages. Capacitor C_{NE} represents a high resistance to low-frequency currents; it thus limits low-frequency leakage currents. Its capacitance is limited to max. 50 nF in accordance with IEC 601 Part 2-2/VDE 0750 Part 202.

Note : Capacitor C_{NE} must for safety reasons only be replaced by a capacitor of the same type (see parts list).

Capacitive earthing of the patient plate corresponds to Type BF of the IEC classification.

The ERBOTOM T 400 C electrosurgical unit is fitted as standard with capacitive earthing of the patient plate.

2 Safety circuit of the patient plate (NE monitor)

P.c.board EE 156.5

The NE monitor monitors the connection between patient plate and electrosurgical unit. If this connection is defective, the NE monitor signals this fault by emitting an acoustic signal and by lighting up a red pilot lamp and, at the same time, prevents the monopolar generator from being actuated.

The NE monitor consists of a modified Colpitts oscillator, with transistor T6 in the base circuit, whose frequency of approx. 20 kHz is determined by winding 5-6 of transformer Ü3 and by capacitor C16.

If the patient plate is not connected, the secondary winding 1-4 of transformer Ü3 is unloaded; the oscillator oscillates freely and generates a voltage in winding 7-8 of transformer Ü3 which turns on thyristor Ty1. Contact 6 of plug St6 and contact P of p.c.board EE 151.2 are thereby connected to chassis. If the attempt is now made

to actuate the unit monopolar generator, the monopolar outputs remain without power, since the transistors T1 and T3 on p.c.board EE 151.2 turn off (see 17.6 Control circuitry). Instead of which, an acoustic warning signal sounds (Su1 on p.c.board EE 151.2) and at the same time, the red pilot lamp La NE lights up.

When the patient plate is connected to plug St1, then the winding 1-4 of transformer Ü3 is loaded and the oscillator is intermitted Thyristor Ty1 insulates contact 6 of plug St6 from chassis and the monopolar generator can now be actuated without warning signals.
Voltage regulator IC1 on p.c.board EE 151.2 supplies the NE monitor with 24V DC.

Note ! Since the patient plate is not required in bipolar use, the safety circuit properly acts only on the monopolar outputs and does not prevent actuation of the bipolar generator. The surgeon can thus use bipolar coagulation without it being necessary for the patient plate to be connected to the electrosurgical unit.

Test button

The function of the NE monitor can be tested with the test button as follows:
If the patient plate is not connected to the electrosurgical unit, the red pilot lamp must light up and the acoustic warning signal must be heard when the test button is pressed.
The test button also allows the connection to be tested between electrosurgical unit and patient plate. When the button is pressed, the red pilot lamp will light up and the acoustic warning signal will be heard if there is a break.

3 Finger switch monitor (AB monitor) P.c.board EE 156.5

The AB monitor allows the monopolar generator to be actuated directly from the surgeon's handle. Since the cable of the electrode handle should be as light and flexible as possible, it contains only 2 conductors. Actuation of the monopolar generator by the buttons of the electrode handle therefore requires an internal monitor circuit, the AB monitor. In addition to the above function, this meets the requirement for electrical isolation of the patient from the unit electrical circuit and complies with the safety regulations with regard to leakage currents and insulating strength.

The AB monitor consists of a modified Colpitts oscillator with transistor T7 in the base circuit, whose frequency of approx. 20 kHz is determined by winding 5-8 of transformer U4 and capacitor C22.
When the buttons are not operated, winding 1-2 of transformer U4 is unloaded and the amplitude of the oscillation at the collector of transistor T7 is maximum. The outputs of the two voltage comparators of IC2 are low and transistors T8 and T9 isolate contact 1 (channel A) and contact 3 (channel B) of plug St6 from high potential. Neither of the two monopolar outputs is actuated.

On pressing the blue button, winding 1-2 of transformer U4 is damped by the resistor of 22 ohm located in the electrode handle. This damping causes a fall in the amplitude of the oscillation at the collector of T7 to a sufficiently low value, that the output of the voltage comparator B is switched to high potential. The output of voltage comparator A thereby remains on low. Transistor T8 conducts the high potential of comparator B to contact 3 of plug St6. This causes actuation of channel B via the control circuit. The monopolar generator now generates modulated high-frequency current for monopolar coagulation.

On pressing the yellow button, winding 1-2 of transformer U4 is short-circuited across resistor R36. The amplitude of the oscillation at the collector of T7 thereby drops to a sufficiently low value that the output of voltage comparator A is also held on high potential. Transistor T9 conducts the high potential of comparator A to contact 1 of plug St6. This causes actuation of channel A. The monopolar generator now generates high-frequency current for monopolar incisions.

Note ! On actuating channel A with finger switch, there is high potential both at contact 1 and contact 3 of plug St6. Simultaneous actuation of both channels is, in this case, excluded by the the control circuit located on p.c.board EE 151.2.

Alignment of the AB monitor is carried out with trimmer potentiometer TP2 (see Adjustment of the ERBOTOM T 400C).

The voltage regulator IC1 on p.c.board EE 151.2 supplies the AB monitor with 24V DC via plug St6.

4 Radio frequency generator for the bipolar operating technique (bipolar generator) P.c.board EE 150.3

The bipolar generator has been designed to meet the particular requirements of the bipolar operating technique.

- The output power of the bipolar generator amounts to a maximum of 50 Watt, since in contrast to the monopolar technique, the bipolar technique can operate with considerably less RF power.
- In bipolar applications, the impedance of the load resistor is around 75 ohm. The output circuit of the bipolar generator is matched to this impedance.

Bipolar generator

Since the maximum RF power required for the bipolar technique is 50 Watt and no modulation of the RF current is

required, the bipolar generator is designed as a single-stage, self-generating oscillator. The frequency of a self-generating oscillator is dependent on load. For this reason, the frequency of the output power fluctuates between 1000 kHz when loaded and 500 kHz with no-load conditions. But this effect is of no importance for the use of the bipolar generator.

The bipolar generator is made up of the two power transistors T1 and T2 operating in push-pull, the capacitors C2 and C3 and the primary winding of transformer Ü1. The transistors are used to generate the RF output power, while the two capacitors and the primary winding of the transformer Ü1 determine the fundamental frequency of the high-frequency current.
Fuse Si1 protects the transformer unit in the event of a fault and thereby switches off the bipolar generator where the supply voltage is too high. Choke Dr1 prevents the high frequency from interfering with the electronic circuitry connected in series. Diodes D1 to D4 suppress inverse voltage peaks at the bases of transistors T1 and T2.
The bipolar generator is supplied by the power unit on p.c.board EE 156.3 and can be actuated either by the bipolar automatic actuating circuit (p.c.board EE 156.4) or by footswitch.

Output circuit of the bipolar generator

The output circuit transmits the RF power from the bipolar generator to the patient. It thereby carries out the following functions:

a) Matching the impedance of the output amplifier to the load resistance.
b) Isolating the field of application (patient) from the generator operating voltage.

c) Protecting the field of application against low-frequency currents.

Re a)

The output transformer Ü1 matches the impedance of the bipolar generator to the impedance of the load resistance.

Re b)

Isolation of the field of application from the generator operating voltage is ensured by the isolation of the secondary from the primary winding of output transformer Ü1.

Re c)

Because of their rectifier effect, the sparks and arcing produced between the two active electrodes and the tissue produce low-frequency currents, which may cause undesirable neuromuscular irritation in the patient. Capacitor C5 is designed to suppress these low-frequency currents. To comply with IEC 601 Part 2-2, the DC resistance of capacitor C5 must be at least 2 Mohm.

Note ! To ensure the safety of the patient, capacitor C5 must only be replaced by a capacitor of the same type (see parts list).

5 Automatic actuation for the bipolar operating technique (bipolar monitor) P.c.board EE 151.4

Actuation of the RF power by footswitch

The bipolar RF generator on p.c.board EE 150.3 can be actuated either by the automatic actuating circuit or by footswitch.

Actuating the RF power by the automatic actuating circuit

The automatic actuating circuit allows actuation of the bipolar generator without additional control element, through the contact made by both tips of the bipolar coagulation forceps with the tissue. In order to prevent accidental coagulations through the actuation of the RF current with every accidental contact of the tips of the bipolar forceps with the tissue, a time delay is

used to switch on the bipolar coagulation current. Coagulation only begins when both forceps tips touch the tissue to be coagulated continuously for a specific period of time (switch-on delay). With every interruption in contact between the tips of the bipolar forceps and the tissue, the switch-on delay starts again from the beginning, so that preparation over any length of time is possible.

Before using the automatic actuating circuit, the button 15c on the front panel of the unit must be pressed. This button represents switch Sch3 in the circuit diagram.

When the surgeon brings the two forceps tips into contact with the tissue to be coagulated, a voltage U_{BE} is present at the base of the otherwise conducting transistor T1 and the transistor cuts off. At the end of the preset switch-on delay, transistor T2 conducts and energizes relay Re12, which closes the contact r2. Re11 is thereby supplied with 24V DC, the power unit starts and the bipolar generator is actuated.
The switch-on delay is normally 2 seconds. But it can be adjusted to between 1 second and 5 seconds with trimmer potentiometer TP3.
Transformer Tr1 of the transformer unit supplies the automatic actuating circuit with 18V AC.

Actuation of the RF power with the footswitch

Before switching on the bipolar generator with the footswitch, the button 15b on the front panel of the unit must be pressed. This button represents the switch Sch2 in the circuit diagram.
When the the bipolar generator is actuated with the blue pedal of the footswitch, 24V DC are present at contact J of p.c.board EE 151.4, relay Re11 is energized, relay contact r1 closes and the power unit on p.c.board EE 156.3 is thereby also actuated.

Transistor T5 isolates the bipolar generator from the power unit (p.c.board EE 156.3) and prevents actuation of the bipolar generator as long as the monopolar generator is switched on.
The output power of the bipolar generator can be adjusted at the two trimmer potentiometers TP1 and TP2:

- max. output power - TP1
- min. output power - TP2

Adjustment of the output power between minimum and maximum values is done with potentiometer PC (element 16).

6 Control circuitry P.c.board EE 151.2

The purpose of the control circuitry is the coordination of the following unit functions:

- monopolar incisions
- monopolar coagulation
- bipolar coagulation
- priorities
- all optical and acoustic signals

(see 7)

Control circuit for monopolar incisions (channel A)

When the monopolar generator (channel A) is actuated by footswitch or finger switch, contact V of p.c.board EE 151.2 is on high potential (18-24 V). If actuation is made by finger switch, then there is high potential at contact V as well as at contact T of p.c.board EE 151.2. This voltage is applied via diodes D5 and D6 to timer IC2, whose output 1 turns on transistor T1 via resistor R2. Relay Rel A thereupon comes on and switches on the power unit on p.c.board EE 156.3 via contact rA1; the modulation for the degree of coagulation (p.c.board EE 156.5) is switched on via contact rA2 and thus also the oscillator. The lamp LaA (element 9) in parallel with relay RelA lights up. The acoustic signal of signal generator Su1 sounds as a continuous tone, since transistor T6 is turned on via diode D4 and resistors R19 and R14. Both signals indicate actuation of the monopolar

generator (channel A).

Transistor T4 prevents actuation of the monopolar coagulation current (channel B) in the finger switching mode. It is turned on via diode D4 and in its turn cuts off transistor T3.

Control circuit for monopolar coagulation (channel B)

When the monopolar generator (channel B) is actuated by footswitch or finger switch, there is high potential (18-24V) at contact T of p.c.board EE 151.2. This voltage is fed via diodes D6 and D7 to the timer IC2, whose output 1 turns on transistor T3 via resistor R6. Relay RelB then comes on and switches on the power unit on p.c.board EE 156.3 via contact rB1; the modulation for the degree of coagulation (p.c.board 156.5) is switched on via contact rB2 and the oscillator is actuated. The lamp LaB (element 11) connected in parallel with relay RelB lights up. The acoustic signal from signal generator Su1 produces a modulated tone, which is switched on via the zener diode D10 and transistor T7 and is modulated by IC3. Both signals indicate actuation of the monopolar generator (channel B).

Control circuit for bipolar coagulation (channel C)

When the bipolar generator (channel C) is actuated by footswitch or automatic actuating circuit, there is high potential (24V) at contacts J of p.c.boards EE 151.2 and EE 151.4. This voltage actuates relay Rel1 on p.c.board EE 151.4 and switches on the power unit on p.c.board EE 156.3 via relay contact r1. At the same time, the lamp LaC lights up, which is directly switched on via contact J of p.c.board EE 151.2; and the acoustic signal generator Su1 switched on via diode D13, resistor R20 and transistor T6, produces a continuous tone. Both signals indicate actuation of the bipolar generator.

When the bipolar generator is switched on, then it must be ensured that the monopolar generator cannot also be switched on at the same time. In order to ensure this, the following components on p.c.board EE 151.2 block the two relays RelA and RelB:

- resistor R3
- transistor T2
- diode D3
- resistor R7
- transistor T4

Priorities

In order to prevent simultaneous actuation of different functions, the control circuitry on p.c.board EE 151.2 is coordinated so that the following priorities apply:

- First priority: warning signals for the patient plate
- Second priority: bipolar coagulation
- Third priority: monopolar incisions
- Fourth priority: monopolar coagulation

Control circuitry, p.c.board EE 151.2
(Schaltbild)

7 Optical and acoustic signals

The optical and acoustic signals of the ERBOTOM T 400 C identify the current operating mode of the unit and are used for fault signalling. All safety-related functions are signalled both optically and acoustically.

Pilot lamp of the power supply switch

The green pilot lamp in the power supply switch indicates the operational readiness of the electrosurgical unit as soon as the transformer unit receives mains voltage, when the power supply switch (element 1; switch Sch 1) is turned on.

Signals for monopolar incisions (channel A)

The lamp LaA (element 9) connected in parallel with relay RelA (p.c.board EE 151.2) and the acoustic signal generator Su1 signal actuation of the monopolar generator (channel A).

When the incision current is switched on, lamp LaA lights up; the acoustic signal generator Su 1 emits a continuous tone, since transistor T6 is turned on via diode D4 and resistors R19 and R14 (all components are located on p.c.board EE 151.2). The loudness of the tone is continuously adjusted on potentiometer Pt (element 19).

Signals for monopolar coagulation (channel B)

The lamp LaB (element 11) connected in parallel with relay RelB (p.c.board EE 151.2) and the acoustic signal generator Su1 signal actuation of the monopolar generator (channel B).

When the coagulation current is switched on, the lamp LaB lights up; the acoustic signal generator Su1 emits a modulated tone which is switched on via the zener diode D10 and transistor T7 and is modulated by IC3. The loudness of the tone can be continuously adjusted by potentiometer Pt (element 19).

Signals for bipolar coagulation (channel C)

While the bipolar generator is switched on, the white pilot lamp LaC (element 17) lights up and when the automatic actuating facility is used, the small white pilot lamp La1 (underneath element 15c) also lights up. The pilot lamp LaC is connected to contact J of p.c.board EE 151.2, while lamp La1 is connected to the 24V power unit on p.c.board EE 151.2. At the same time, these optical signals are accompanied by a continuous tone (as channel A) produced by the acoustic signal generator Su1 and this is actuated via diode D13, resistor R20 and transistor T6. The loudness of the tone is continuously adjustable on potentiometer PT (element 18/19).

to the inner ring of the toroidal-core transformer Tr 2.

The two secondary windings of transformer Tr 1 produce AC voltages of 18V and 27V respectively.
The AC voltage of 27V is rectified by the bridge rectifier BR1 on p.c.board EE 151.2 and stabilized on 24V DC by IC1 on p.c.board EE 151.2.
Transformer Tr2 produces a secondary voltage of 100V AC which is rectified by bridge rectifier BR 1.
The mains transformer Tr2 has 4 primary windings and can be adjusted to the appropriate mains voltage in accordance with the instructions on the circuit diagram at connector strip St3 of the transformer unit.

The primary winding of mains transformer Tr1 is connected in parallel with the primary winding 1-2 of transformer Tr2 and is thus always operated with 110V AC independently of the selected mains voltage.
When the power supply switch Sch1 is turned on, the transformer unit is supplied with mains voltage. At the same time, the lamps lights up inside the power supply switch.

Ancillary transformer Tr1

The ancillary transformer Tr 1 supplies the 2.2V DC power unit on p.c.board EE 156.7 with an input voltage of 6V AC. The primary winding of transformer Tr 1 is connected in parallel with the primary winding 1-2 of transformer Tr2 and is thus always operated with 110V AC independently of the selected mains voltage. The secondary winding 2-4 of transformer Tr1 generates the 6V AC voltage required to supply the 2.2V DC power unit; the second secondary winding is not connected.
Transformer Tr1 is protected against overcurrents by the fuse F1.

2.2V DC power unit P.c.board EE 156.7

The 2.2V DC power unit is used to supply power to the transistor protection circuit.
In the main, the power unit consists of the bridge rectifier BR1, smoothing capacitor C1, voltage regulator IC1 and trimmer potentiometer TP1.
Transformer Tr1 supplies the bridge rectifier Gl1 with an input voltage of 6V AC. The output voltage of the voltage regulator IC1 can be adjusted to the required voltage of -2.2V DC at potentiometer TP1.

24V DC power unit P.c.board EE 151.2

The 24V DC power unit supplies its output voltage to:

- footswitch
- control circuit
- oscillator.
- modulator
- NE and AB monitors
- Rel1 and the through-switching of the power supply for the bipolar generator on p.c.board EE 151.4

The power unit consists of the bridge rectifier BR 1, the smoothing capacitor C1, the fixed-voltage regulator IC1 and a filter capacitor C2.
The bridge rectifier BR1 receives 27V AC from transformer Tr1 of the transformer unit, which is rectified and then smoothed by capacitor C1 and fed to the fixed-voltage regulator IC1. This produces a DC voltage of 24V at its output.

Power unit P.c.board EE 156.3

The power unit on p.c.board EE 156.3 controls the output power of all three channels of the ERBOTOM T 400 C (monopolar incisions, monopolar and bipolar coagulation) by adjusting the operating voltage which is taken from it.

Transformer Tr2 of the transformer unit produces 100V AC on its secondary side and supplies the power unit via the bridge rectifier Br1 of the transformer unit.

The operating voltage adjusted at the power unit is present at the electrolytic capacitor C1. This acts as a smoothing capacitor and is connected via connections RN and AB to p.c.board EE 156.3. At these connections, the phase control of the power pack supplies the charging voltage of capacitor C1. Depending on the output power selected, the thyristor switches part of the applied pulsating DC voltage to the monopolar or bipolar generator. Triggering of the thyristor is actuated by the unijunction transistor T1 according to the blocking period set by the RC network. The RC network consists of the capacitor C2, the resistor R5 and the resistors switched in according to the channel selected.

Channel	Potentiometer	Function
A monop. incis.	TP3	Adjustment of minimum output power A_{MIN}
	TP4	Adjustment of minimum output power A_{MAX}
	PA	Continuous power adjustment between A_{MIN} and A_{MAX} at element 7
B monop. coag.	TP1 on p.c.board EE 156.1	Adjustment of minimum output power B_{MIN}
	TP2	Adjustment of maximum output power B_{MAX}
	PB	Continuous power adjustment btween B_{MIN} and B_{MAX} at element 10
C coag	TP2 (EE 151.4)	Adjustment of minimum output power C_{MIN}
	TP1 (EE 151.4)	Adjustment of maximum output power C_{MAX}
	PC	Continuous power adjustment between C_{MIN} and C_{MAX} at element 15 16

Footnote

1) The trimmer potentiometer TP1 (B_{MIN}) on p.c.board EE 156.3 has no function in the ERBOTOM T 400 B and ERBOTOM T 400 C versions. On the ERBOTOM T 400 A , TP1 is used to adjust the minimum coagulation current and is therefore still required for servicing purposes on these units.

Power unit, p.c.board EE 156.3

Note ! The power adjustment of channel A at potentiometer PA is effected by amplitude control of the RF output voltage, compared with which the output voltage of channel B is adjusted at potentiometer PB through variation in the pulse interval of the modulated coagulation current and thus the mean power generated.

The zener diode D4 limits the voltage required for triggering to 15V.

In order to prevent error triggering of thyristor Ty1 during the charging time of C1, thyristor Ty3 is triggered at the same time as Ty1 cuts off transistor T1.

Relay board P.c.board 30103-159

The output voltage of the ERBOTOM T 400 C is determined by its supply voltage present at electrolytic capacitor C1. The relay board discharges C1 after every actuation of the unit. This prevents the generation of a high output peak due to the residual charge on capacitor C1 when the unit is switched on again. This is particularly important when switching from monopolar to bipolar coagulation and on turning back the output power from a high to a low output stage.

The relay is energized during incisions by diode D3, during monopolar coagulation by diode D2 and during bipolar coagulation by diode D1, which thereby opens relay contact r1. After each actuation, relay contact r1 closes and discharges capacitor C1 via resistors R1 and R2.

Relay board, 3C103-159

ADJUSTING THE ERBOTOM T 400 C

Before delivery, all ERBE units are correctly adjusted and then subjected to an endurance test followed by a final test. All spare parts are also tested and adjusted as necessary.
Repairs, replacement of p.c.boards, considerably varying operating conditions or special requests may under cer - tain conditions require readjustment of the unit.

The instructions given below for adjusting the ERBOTOM T 400 C electrosurgical unit enable the servicing technician to carry out all adjustment work.

Measuring instruments required:

- 1 digital voltmeter with more than 1 Mohm input resistance.
- 1 RF power meter, e.g.:
  ERBE power meter or
  Dempsey Electrosurgical Analyzer

Instructions for adjusting the ERBOTOM T 400 C

Finger switch monitor

- Connect electrode handle with two buttons.
- Connect the digital voltmeter to the measuring point on the right of p.c.board EE 156.5 (to the anode of D11 or to R20) and to chassis.
  Set the voltmeter to DC voltage.

Note ! The connecting cable of the patient plate must not yet be connected to the unit. Only in this way can damage to the digital voltmeter from high frequency be reliably avoided.

- Actuate channel B of the monopolar generator with the blue button of the electrode handle and, using trimmer potentiometer TP2 on p.c.board EE 156.5, set the following voltage at the measuring point:

ERBOTOM T 300 C / T 400 C Series C: 6 ±0.2V DC

ERBOTOM T 300 C / T 400 C Series D and E: 7 ±0.2V DC

Note ! When the monopolar generator is actuated, the acoustic warning signals of the patient plate safety circuit sounds and the red pilot lamp La NE (element 5) lights up. This does not affect the measuring procedure.

. Remove the digital voltmeter
. Connect the patient plate to the electrosurgical unit.
. Actuate the monopolar generator with the buttons of the electrode handle and check that the correct channels are switched on:

yellow button = channel A (incisions)
blue button = channel B (coagulation)

. The optical and acoustic signals assigned to the individual channels must correctly indicate the particular channel switched on.
. In the event of unreliable switching (relay chattering), correct the setting of the trimmer potentiometer TP2 so that only definite operating conditions occur.

Switch-on delay and output power of the bipolar generator

. Connect the bipolar forceps to the electrosurgical unit via the connecting cable.
. Connect the RF power meter to the tips of the forceps.
. Switch on the automatic delay circuit (blue button 15c on the unit front panel).
. Connect the Dempsey power meter to 125 ohm (heavy load) and select sensitive measuring range (high sense). The measuring resistor of the ERBE power meter is already 125 ohm and does not need to be switched.

Switch-on delay of the bipolar generator

. Determine the switch-on delay as follows: Connect the forceps tips to the power meter and using a stop watch, measure the time up to automatic switching on of the bipolar generator.

. Turn the "DEGREE OF COAGULATION" control to position 0.
. Turn the "INCISION POWER" control to position 10.
. Actuate channel A of the monopolar generator by pressing the yellow button of the electrode handle.
. Set the maximum output power in monopolar incisions (max. cutting power) on trimmer potentiometer TP4 (A_{MAX}) on p.c.board EE 156.3 to 400 W. This represents an output of 370 W measured on the power meter.

. Turn back the "INCISION POWER" control to position 1.
. Switch the power meter to 60 W or the Dempsey power meter to "high sense".
. Set the minimum cutting power at trimmer potentiometer TP3 (A_{MIN}) on p.c.board EE 156.3 to 2.5 W.
. Check that the incision power rises steadily when the power control is turned from position 1 to position 10.
. Turn the "DEGREE OF COAGULATION" control and the "INCISION POWER" control to position 10.
. Set the degree of coagulation on trimmer potentiometer TP1 on p.c.board 30103/100 so that the maximum incision power is 200 W. This represents an output of 190 W measured on the power meter.

Output power in monopolar coagulation (coagulation power)

. Connect the patient plate to the power meter.
. Connect an electrode handle with two buttons to the monopolar output socket.
. Fit a knife or small ball electrode in the electrode handle and connect to the appropriate socket of the power meter.
. Switch the ERBE power meter to the 600 W range or the Dempsey power meter to "heavy load", "normal sense".
. Turn the "COAGULATION POWER" control to position 10.
. Turn the trimmer potentiometer TP1 on p.c.board EE 156.5 fully clockwise.

. Set the maximum coagulation power on trimmer potentiometer TP2 (B_{MAX}) on p.c.board EE 156.3 to 400 W. This represents an output measured on the power meter of 380 W (see Chapter 14, Physical principles of power measurement).
. With the same setting, adjust the coagulation power with trimmer potentiometer TP1 on p.c.board EE 156.5 to 300 W. This represents an output of 285 W / 165 W measured on the power meter.
. Turn back the "COAGULATION POWER" control to position 1.
. Set the minimum coagulation power (B_{MIN}) on trimmer potentiometer TP1 on p.c.board EE 156.1 to 2.5 W.

Note ! With the ERBOTOM T 400 B and ERBOTOM T 400 C versions, trimmer potentiometer TP1 (B_{MIN}) on p.c.board EE 156.3 has no effect. On the ERBOTOM T 400 A version, TP1 is used to adjust the minimum coagulation power and is therefore still needed for servicing purposes on these units.

. Check that the coagulation power rises steadily when the power control is turned from position 1 to position 10.

Output voltage of the 2.2V DC power unit

. Connect the digital voltmeter to measuring point MP on one of the two boards EE 156.9 and to chassis.
. Set the output voltage of the voltage regulator IC1 (p.c.board EE 156.7) on trimmer potentiometer TP1 on p.c.board EE 156.7 to -2.2 V DC.

PARTS LIST

ERBOTOM T 400 C

Code	Designation	Specification	Pces.	Manufacturer	EE-Parts-Nc
	Components				-
T1 - T4	Transistor				50200-007
	Centering socket	Delrin	16		30103-012
	Heat sink	104 511/472/SE,	1		40103-018
C NE	Capacitor	0.22 µF, PME 271 Y 522	2		51106-010
PA, PC	Potentiometer	100 k	2		51031-003
PT (Ton)	Potentiometer	200 R	1		51031-001
	Resistor	27 R, 5%, 0.5 W	1		51002-003
)	Rotary switch	0 21, antitwist	1		51501-007
	Cover		1		51501-008
	Pointer		1		51501-009
	Rotary switch	0 28, antitwist	3		51501-001
	Cover		3		51501-002
	Pointer		3		51501-003
	Rotary switch	0 15	1		51501-010
	Cover		1		51501-011
	Screw cover		1		51501-012
F1, F2	Fuse	M 6.3 A, 250 V, 5x20 mm	2		51611-012
La NE	Cover	red opal	1		50604-008
LaA,LaB LaC	Cover	opal	3		50604-009
La 1)	Signal lamp	white, 24 V	1		50604-049
	Lamp	24 V, 23 mA	4		50604-005
	Lamp holder		4		51610-005
Su1	Buzzer		1		50610-000
Sch1	Power switch	2 WiXII/1308	1		50502-000
TEST	Push button	white	1		50502-027
Bu1	Socket NE	Neutral Electrode, 2-poles	1		30102-039
Bu2	Socket AE	Active Electrode, 2-poles	1		30102-004
Bu3	Socket TUR	1-pole	1		30103-016
Bu4	Socket FS	Footswitch, 4-poles	1		30102-109
Bu5	Socket BIP	2-poles	1		30102-016

ode	Designation	Specification	Pces.	Manufacturer EE-Parts-No.
	Components	**(Cont.)**		
	Mounting board	Alu, 2 mm	1	30101-016
	Knurled nut	M3, plastics, white	2	55102-001
Bu6	Contact pin	Potential equalization	1	51601-025
	Socket	for APP-Plug, black 8843-2SP.Fl.4/3.60	1	51603-000
	Pin base	6-pins, for connection to St1 of power transformer	1	51602-019
	Pin base	6-pins, for connection to St2 of power transformer	1	51602-018
)	Socket housing	2-poles	3	51602-013
	Socket housing	3-poles	4	51602-014
	Socket housing	6-poles	2	51602-015
	Socket housing	8-poles	3	51602-030
	Multiple connector	31-poles	2	51602-003
	Power cable	3 x 0.75 mm^2, 3 m, gray	1	51704-000
	Power Amplifier Unit			**30103-045**
	Capacitor	2200 µF, 160 V,	1	51100-015
	Knurled nut	M3	1	55102-001
	Wiring Board	**Assembly**		**30103-050**
	Widerstand	15 K, 5 %, 2 W	1	51006-002
	Multiple connector	22-poles	4	51602-000
	Multiple plug	31-pins	2	51602-002

Code	Designation	Specification	Pces.	Manufacturer	EE-Parts-No
	HF-Board	**Assembly**			**30103-048**
IC1	Timer	NE 555 V	1		50000-000
IC2	OP-Amplifier	µA 747, DIL-Housing	1		50001-004
Ty1	Thyristor	EC 103 M	1		50210-005
T1, T2, T6, T7	Transistor	BC 546 B	4		50200-001
T3, T8, T9	Transistor	BC 547 B	3		50200-002
T4, T5	Transistor		2		50200-007
D1	Zener-Diode	BZX 55 C 15	1		50222-003
D2, D8 D10, D19	Diode	1 N 4148	6		50222-000
D3, D5	Diode	NS 2004	2		50220-003
D4, D6	Diode	BYV 95 C	2		50220-001
D7	Diode	BY 227	1		50220-005
D11	Zener-Diode	BZX 55 C 30	1		50222-008
C1	Capacitor	680 pF	1		51103-011
C2, C7, C15, C16, C22	Capacitor	0.015 µF	5		51102-012
C3	Capacitor	470 pF	1		51103-002
C4, C5, C28-C30	Capacitor	0.15 µF	5		51102-004
C6	Capacitor	330 pF	1		51103-001
C8, C10 C13	Capacitor	0.1 µF	3		51103-007
C9	Capacitor	100 µF	1		51100-017
C11, C12	Capacitor	820 pF	2		51103-012
C14	Capacitor	100 pF	1		51103-000
C17, C18 C21, C31	Capacitor	1.5 µF	4		51102-002
C19	Capacitor	0.68 µF	1		51102-026
C23-C25	Capacitor	3.3 nF, 5 %, 2 kV	3		51103-004
R1, R29	Resistor	1.8 k, 5 %, 0.33 W	2		51000-024
R2, R23	Resistor	18 k, 5 %, 0.33 W	2		51000-021
R3, R4	Resistor	22 k, 5 %, 0.33 W	2		51000-022
R5- R7	Resistor	3.3 k, 5 %, 0.33 W	3		51000-015
R8	Resistor	22 R, 5 %, 0.33 W	1		51000-001
R9	Resistor	1 M, 5 %, 0.33 W	1		51000-023

Code	Designation	Specification	Pces.	Manufacturer	EE-Parts-No.
	HF-Board	**Assembly (Cont.)**			**30103-048**
R10	Resistor	5.6 k, 5 %, 0.33 W	1		51000-018
R11, R13- R15	Resistor	10 R, 5 %, 0.5 W	4		51002-001
R12, R16	Resistor	82 R, 5 %, 0.5 W	2		51002-053
R17	Resistor	36 R, 10 %, 11 W	1		51011-001
R18	Resistor	68 k, 5 %, 0.5 W	1		51002-060
R19	Resistor	5.6 k, 10 %, 11 W	1		51011-000
R20, R26, R27, R34, R35, R41	Resistor	10 k, 5 %, 0.33 W	6		51000-019
R21	Resistor	270 R, 5 %, 0.33 W	1		51000-052
R22	Resistor	820 R, 5 %, 0.33 W	1		51000-013
R24	Resistor	1 k, 5 %, 0.33 W	1		51000-014
R25	Resistor	390 R, 5 %, 0.33 W	1		51000-011
R28	Resistor	6.8 k, 5 %, 0.33 W	1		51000-025
R30	Resistor	2.2 k, 5 %, 0.33 W	1		51000-034
R31	Resistor	4.7 k, 5 %, 0.33 W	1		51000-017
R32	Resistor	680 R, 5 %, 0.33 W	1		51000-012
R33	Resistor	120 R, 5 %, 0.33 W	1		51000-009
R36, R37	Resistor	22 R, 5 %, 0.5 W	2		51002-058
R38	Resistor	4.7 R, 5 %, 0.5 W	1		51002-061
R42	Resistor	330 R, 5 %, 0.33 W	1		51000-010
TP1	Trimmpot	100 k	1		51030-004
TP2	Trimmpot	10 k	1		51030-006
Ü1	Transformer	Oscillator	1		30102-030
Ü2	Transformer	Preamplifier	1		30103-024
Ü3	Transformer	Monitor	1		30103-120
Ü4	Transformer	Monitor	1		30101-013
St1, St3 St4	GS-Plug	3-pins	3		51602-009
St2	GS-Plug	2-pins	1		51602-008
St5	GS-Plug	8-pins	1		51602-031
St6	GS-Plug	6-pins	1		51602-012

Code	Designation	Specification	Pces.	Manufacturer	EE-Parts-No
	Power Amplifier	**Assembly**			**30103-238**
D1-D16	Diode	NS 2004	32		50220-003
D17-D20	Diode	BYV 95 C	8		50220-001
C1	Capacitor	0.1 µF	2		51103-007
R1-R3	Resistor	8.2 R, 5 %, 4 W	6		51008-001
R4-R7	Resistor	5.6 R, 5 %, 4 W	8		51008-002
R8-R11	Resistor	10 R, 5 %, 0,5 W	8		51002-001
	Socket	AP 91, black	16		51610-010
	Output Circuit	**Assembly**			**30103-242**
BR1	Bridge rectifier		1		50224-002
IC1	Voltage regulator	LM 317 T	1		50002-009
D1, D2	Diode	NS 2004	2		50220-003
C1	Capacitor	1000 µF, 40 V	1		51100-005
C2	Capacitor	100 µF, 40 V	1		51100-003
C3-C7, C9,C12	Capacitor	0.1 µF			51103-007
C8	Capacitor	3300 pF	1		51103-004
C10	Capacitor	0.1 µF	1		51102-014
C11	Capacitor	100 pF	1		51104-019
	Coil		1		30103-241
R1	Wiring strap	O R	1		51607-008
R2, R3	Resistor	V 250, LA, 15 A	2		51013-003
R4	Resistor	150 R, 5 %, 0.5 W	1		51002-051
TP1	Trimpot	4.7 k	1		51030-002
Tr1	Transformer	Output	1		30103-025
St1, St2	GDS-Plug	8-pins	2		51602-031
St3	GDS-Plug	6-pins	1		51602-012
St4, St5	GDS-Plug	3-pins	2		51602-009

Code	Designation	Specification	Pces.	Manufacturer EE-Parts-No.
	BIP-HF-Generator	**Assembly**		**30101-008**
T1, T2	Transistor		2	50200-007
D1 -D6	Diode	BYV 95 C	6	50220-001
C2, C3	Capacitor	2200 pF	2	51103-003
C5	Capacitor	3300 pF	1	51103-004
R1, R2	Resistor	1.2 R, 5 %,	2	51006-001
R3, R4	Resistor	8.2 k, 10 %,	2	51004-005
Dr1	Choke		1	51302-001
Ü1	Transformer		1	30101-014
Sil	Fuse	F, 1.6 A, 250 V	1	51611-000
	Fuse holder		1	51610-003
	Heat sink		2	40101-002
	Bipolar Monitor	**Assembly**		**30102-036**
T1, T2	Transistor	BC 517	2	50200-003
T3	Transistor	BF 398	1	50201-001
T4	Transistor		1	50200-011
T5	Transistor		1	50200-007
D1, D6- D8	Diode	BYV 95 C	4	50220-001
D2	Zener-Diode	BZX 55 C2 V7	1	50222-000
D3, D4	Diode	1 N 4148	2	50220-000
D5	Zener-Diode	5ZX 55 C5 V6	1	50222-001
C1, C2, C5, C10	Capacitor	0.15 µF	4	51102-004
C3	Capacitor	100 µF, 40 V	1	51100-003
C4	Capacitor	47 µF, 40 V	1	51100-002
C6	Capacitor	0.015 µF	1	51102-012
C7, C8	Capacitor	1000 µF	2	51106-012
C9	Capacitor	680 pF	1	51103-011
Dr1,Dr2	Choke		2	51302-000

Code	Designation	Specification	Pces.	Manufacturer	EE-Parts-Nc
	Bipolar Monitor	**Assembly (Cont.)**			**30102-036**
R1	Resistor	150 k, 5 %, 0.5 W	1	Allen Bradley	51002-069
R2	Resistor	39 k, 5 %, 0.5 W	1		51002-030
R3	Resistor	27 R, 5 %, 0.5 W	1		51002-003
R4	Resistor	270 k, 5 %, 0.5 W	1		51002-023
R5	Resistor	27 k, 5 %, 0.5 W	1		51002-020
R6	Resistor	1.5 M, 5 %, 0.5 W	1		51002-026
R7	Resistor	510 R, 5 %, 0.5 W	1		51002-007
R8, R9	Resistor	3.3 k, 5 %, 0.5 W	2		51002-013
TP1,TP3	Trimming-potentiometer	47 k	2		51030-003
TP2	Trimming-potentiometer	100 k	1		51030-004
Rel1,Rel2	Relay		2		50400-002
	Logic	**Assembly**			**30103-171**
IC1	Voltage regulator	MC 78 24 CT	1	Motorola	50002-000
IC2, IC3	Timer	NE 555 V	2	Signetics	50000-000
BR1	Bridge rectifier		1		50224-001
T1 - T7	Transistor	BC 547 B	7		50200-002
D1-D6, D8, D9,D11-D13	Diode	1 N 4148	11		50220-000
D7	Zener-Diode	BZX 55 C 5 V6	1		50222-001
D10	Zener-Diode	BZX 55 C 15	1		50222-003
C1	Capacitor	1000 µF, 40 V	1		51100-005
C2	Capacitor	0.68 µF, 100 V	1		51102-005
C3 - C7	Capacitor	0.15 µF, 100 V	5		51102-004
C8, C9	Capacitor	68 nF, 10 %, 50 V	2		51104-025
R1,R4,R5 R8, R12	Resistor	1.8 k, 5 %, 0.5 W	5		51002-011
R2, R6	Resistor	12 k, 5 %, 0.5 W	2		51002-016
R3, R7, R11,R17	Resistor	18 k, 5 %, 0.5 W	4		51002-018

Code	Designation	Specification	Pces.	Manufacturer EE-Parts-No.
	Logic	**Assembly (Cont.)**		**30103-171**
R9	Resistor	1.5 M, 5 %, 0.5 W	1	51002-026
R10	Resistor	330 k, 5 %, 0.5 W	1	51002-024
R13	Resistor	180 R, 5 %, 0.5 W	1	51002-054
R14	Resistor	390 R, 5 %, 0.5 W	1	51002-006
R15	Resistor	330 R, 5 %, 0.5 W	1	51002-056
R16	Resistor	6.8 k, 5 %, 0.5 W	1	51002-
R18	Resistor	100 k, 5 %, 0.5 W	1	51002-045
R19	Resistor	820 R, 5 %, 0.5 W	1	51002-008
R20	Resistor	10 k, 5 %, 0.5 W	1	51002-031
RelA,RelB	NF-Relay		2	50400-000
	Power Transformer	**Universal, Assembly**		**30103-043**
BR1	Bridge rectifier		1	50224-004
Tr1	Power transformer		1	30102-028
Tr2	Transformer	Special type	1	51300-004
F3	Fuse	T 0.125 A, 250 V	1	51611-057
Th1	Thermo switch		1	50505-000
Th2, Th3	Thermal cut-off		2	51611-024
	Additional Transformer Tr1			**30103-246**
	Power Transformer Universal		1	30103-240
F1	Fuse	T 0.125 A, 250 V	1	51611-057
	Fuse holder		1	51610-031
	Socket housing	6-poles	1	51602-016

Code	Designation	Specification	Pces.	Manufacturer	EE-Parts-N
	Power Supply Unit				**30103-046**
Ty1	Thyristor	S 2016 L	1		50210-002
Ty3	Thyristor	EC 103 M	1		50210-005
T1	Unijunction-Transistor	2 N 4871	1		50202-000
D1, D3	Diode	1 N 4148	2		50220-000
D4	Zener-Diode	BZX 55 C15	1		50222-003
C1, C2	Capacitor	0.15 µF	2		51102-004
C3	Capacitor	0.47 nF	1		51102-024
C5	Capacitor	0.1 µF	1		51103-007
R1	Resistor	6.8 k, 5 %, 1 W	1		51004-004
R2	Resistor	3.3 k, 5 %, 0.5 W	1		51002-013
R3, R5, R7	Resistor	1.2 k, 5 %, 0.5 W	3		51002-010
R4	Resistor	4.7 k, 5 %, 0.5 W	1		51002-029
R6	Resistor	180 R, 5 %, 0.5 W	1		51002-054
R8	Resistor	27 k, 5 %, 0.5 W	1		51002-020
R9	Bridge	50 mm, insulated	1		51702-009
R11	Resistor	eliminated	-		-
TP1-TP4	Trimming-potentiometer	47 k	4		51030-003
	Heat sink		1		30103-020
	Relay Board	**Assembly**			**30103-159**
D1-D4	Diode	1 N 4148	4		50220-000
R1,R2	Resistor	470 R	2		51011-015
Rel 1	Relay		1		50400-002

Code	Designation	Specification	Pces.	Manufacturer	EE-Parts-No.
	Adjustment Board	**Assembly 1**			30103-100
TP1	Trimming-potentiometer	1 M	1		51030-017
PM	Potentiometer	100 k	1		51031-022
	Adjustment Board	**Assembly 2**			30103-097
TP1	Trimming-potentiometer	1 M	1		51030-017
PB	Potentiometer	1 M	1		51032-000
R	Resistor	470 k, 5 %, 0.33 W	1		51000-028
	Double Push-Button	**Assembly**			30103-166
Sch2	Double push-button	assembly, Isostat	1		50503-027
	Button	blue, Type 4354-1063	2		30102-085
	Push-Button	**Assembly**			30103-167
D1	Diode	1 N 4148	1		50220-000
Sch3	Push-button assembly, Isostat		1		50503-004
	Button	gray	1		51501-098