OPERATING INSTRUCTIONS

BALZERS

BB 800 095 BE

Automatic deposition unit ADU 100

A product of BALZERS AG, Balzers

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1. APPLICATION

In order to replace a separate rate and film thickness measuring system in most applications of the electron beam evaporation (e.g. a quartz crystal measuring device), the electron beam evaporation source ESQ 110 (including the ESQ 200 in an analogous fashion) has been modified so as to integrate the measuring system in the evaporation source in its entirety. Especially in continuous plants (source permanently under vacuum) or when very thick films are produced, the extensive endurance of the measuring system is utilized. In many cases, a continuous rate and film thickness measuring procedure in the evaporation of dielectrics is also possible.

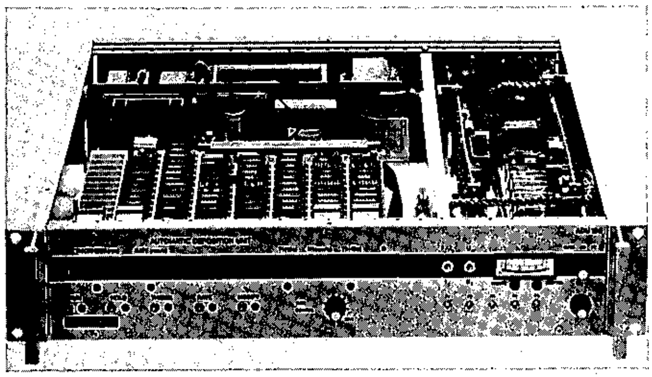


Fig. 1

2. FUNCTION

The vapor ions generated by the electron beam of the evaporation source above the crucible in the vapor chamber are deflected to an ion collector (ion detector) by the deflecting magnetic field of the beam gun. From this detector (potential to ground: –50 V to –200 V) the ion current reaches the control unit ADU 100, where it is used for measuring the rate and film thickness (actual value of the rate). By means of the data input on the ADU 100 (nominal values), the gun control unit EKS 110 A is triggered in such a way that on the one hand a constant coating rate is obained to the maximum possible extent, and on the other hand the electron beam of the evaporation source is turned off and the shutter, mostly located above the evaporation, is closed when the desired film thickness is reached.

Since frequently the ion current generated by the electron beam in the vapor chamber and collected by the detector is not directly proportional to the condensation rate on the substrate, the ion current signal in the ADU 100 is converted in a suitable manner. In this respect, special reference is made to the "product control" repeatedly mentioned in the ensuing information.

For high evaporation power (e.g. in the aluminium evaporation of > 8 kW), the ion current does not increase as fast as the condensation rate on the substrate. Among other things, this is caused by the fact that the longer detention period of the ions (due to their shorter path, partly under 1 mm) in an area where secondary electrons of low energy are located contributes to a rapid increase of the recombination of ion and electron. If an ion escapes the recombination process, it is always focussed virtually on the collecting detector by the magnetic field of the electron beam gun (focussing action of the heterogeneous magnetic field). In order to achieve now an accurate rate control against the condensation rate even though the ion current has the tendency to level off, the product of the ion current signal and the emission current signal (from the gun control unit EKS 110 A) is used as the actual value of the rate control. By this non-linear control path, the anomalous behavior (short-time fluctuations) of the evaporation source is highly improved, especially at an increased beam power. If the beam output is low (< 5 kW), the product control may be less accurate (non-linear) than the mere ionic current control, however.

2.1. Block diagram of the evaporation control unit ADU 100

(refer to the separate sheet BG 241 500 -S in the final section of these instructions)

The block circuit diagram has been subdivided into two sub-groups:

I. the digital control section (incl. data input)

II. the analog regulating and control section of the evaporation rate

By means of the digital control section I, the coating process is automated. Control functions are generated only (no regulating functions are carried out).

By means of the analog regulating and control section II, the evaporation speed is readjusted to a nominal value.

In automatic operation, this nominal value is furnished by the digital control section I (function of time, refer to fig. 2), in manual operation by the potentiometer RATE CONTROL (fig. 3, item 20) on the front panel of the control unit ADU 100. The optimum setting of the regulating parameters as well as the calibration of the rate and film thickness display is achieved with the potentiometers P1 ... P5 (analog) (fig. 3, items 15 - 19), as well as the digital switches (D) (fig. 3, item 7).

The control unit ADU 100 can be triggered by a master computer in such a way, that the function of the digital control section I including the data input and output is taken over by the external computer control. This switch position is actuated by means of a toggle switch (REMOTE LOCAL) on the rear panel of the unit and indicated on the front panel by the corresponding light-emitting diode (REMOTE) (fig. 3, item 11).

Further integration of the ADU 100 in a control system on a higher level may be accomplished if the starting pulse is furnished externally with the control unit ADU 100 providing for a back indication after the coating program has been completed (THICKNESS REACHED). In this case, the "positioning" of the coating process in the coating cycle is taken over by the control system on a higher level; the actual coating control is performed, however, by the control unit ADU 100.

2.2. Program flow of the coating operation

After the data required for a coating operation have been fed on the front panel of the ADU 100 (film thickness, rate, first rise time T1, second rise time T2, digital factor D), the function S (t) of the nominal value plotted in fig. 2 is furnished to the analog regulating and control section II by the digital control section I. The automatic rate control system in the regulating and control section now controls the electron beam power of the evaporation source in the gun control unit EKS 110 A so that the voltage drop of the ion current (actual value), collected by the detector, coincides with the function of the nominal value generated by the digital section I as accurately as possible. At the "corners" of the function indicating the nominal value (START, after expiration of T1, after expiration of T2, at THICKNESS REACHED) an appropriate multiple-pole power relay in the analog section II (relay circuit board E3) is triggered across the contact NC of a reed relay on the digital section I in each case.

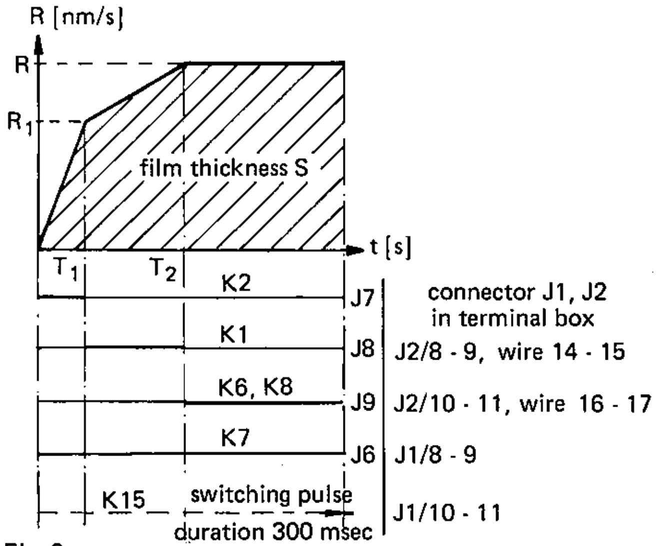


Fig. 2

Graph on the function of the nominal value with ist four "corners".

The corresponding switching sequences of the pertinent power relays K1, K2, K6,8, K7, K15 with the pertinent connector outputs on the rear panel of the ADU 100 as well as for the rack and panel connectors J1, J2 in the terminal box.

Thus, two galvanically separated, floating change-over contacts each are available per "corner" of the function indicating the nominal value (either in separate receptacles on the rear panel of the unit (fig. 4, items 6 - 9) or in the rack and panel connectors J1 and J2 in the terminal box).

These change-over contacts may be used as back indications for a computer system on a higher level or for triggering additional peripheral units.

An example for the triggering of peripheral units is given below:

2.2.1. Relay K7 (to receptacle J6 or in the terminal box J1/8 - 9) e.g. will switch on the rotary drive of the substrate holder for the total duration of the coating operation.

2. Relay K1 (to receptacle J8 or in the terminal box J2/8 - 9 and wire 14 - 15) e.g. will switch on a wire feed. The duration of the operation will then be exactly T2. By a suitable preselection of the number of revolutions, the amount required as refill per coating cycle can thus be set so that the contents of the crucible will remain constant for all practical purposes.

3. By means of the relay K6 or K8 resp. (to receptacle J9 or in the terminal box J2/10/11 and wire 16 - 17) e.g. a second evaporation source with the appropriate evaporation control ADU 100 may be switched on whereby an overlap process can be realised when T1 and T2 of the second control unit is properly selected.

4. The completion of the coating operation will be indicated by the relay K15 (THICKNESS REACHED) by means of a pulse of 300 ms duration (in the terminal box J1/10 - 11).

3. DESCRIPTION

3.1. On the front panel are located:

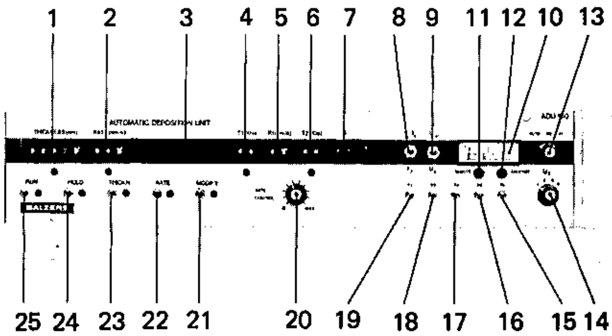


Fig. 3

1 Preselector switch (THICKNESS) for the film thickness. The light-emitting diode mounted underneath will light up when the film thickness set has been reached on the substrate (for manual and automatic operation).

2 Preselector switch (RATE) for the coating rate on the substrate in automatic operation. The light-emitting diode mounted underneath will light up as long as the substrate is coated in automatic operation.

3 Display for the coating rate, film thickness and the O-signal (flashing).

4 Preselector switch (T1) for the first rise time (set in steps of 10 s, i.e. setting 12 is 120 s rise time). The light-emitting diode mounted underneath will light up in automatic operation during the rise time set.

5 Preselector switch for the coating rate R1 after expiration of the rise time T1. R1 is the coating rate which would be obtained on the substrate after expiration of T1 with the shutter already opened. In the normal program flow, the shutter is closed at this period. Therefore, the source is operated with analog coating rate.

6 Preselector switch for the second rise time T2. After expiration of T2, the evaporation speed of the source has increased to the extent that the coating rate on the substrate (after expiration of T2 the shutter is open) has reached the value R which had been preset on the preselector switches RATE (under the condition that the ADU has been properly calibrated). The light-emitting diode mounted underneath will light up during this rise time in automatic operation.

7 Preselector switch for the division D of the pulse frequency of the VF-converter, These preselector switches are used when the unit is calibrated. Refer to description of item 21.

8 Selector regulating switch (S5). In position J_J the ion current is used as an acutal value signal (to be used for metal evaporation up to a beam power of approx. 8 kW).
In position $J_J \cdot J_E$ the product of the ion current signal and the emission current signal is used as an actual value signal (to be used in metal evaporation preferably for a beam power exceeding 5 kW).

9 Push-button switch (S6) for the analog instrument
position U_{VF}: analog actual value display of the regulating signal.
During the coating operation the display should between 2 and 8 V, whenever possible. Adaptation by means of potentiometer P3, item 17.
U_S: display of the detector voltage from 0 to 250 V. The detector voltage is indicated only when the push-button is actuated. During evaporation, this push-button must not be depressed as a faulty thickness of the film would then result. If the detector voltage is zero with the unit switched on, a short circuit will exist between detector and source.

10 Analog instrument for the regulating signal 0 - 10 V and for the detector voltage 0 - 250 V.

11 Light-emitting diode REMOTE. This lamp will light up when the toggle switch (fig. 4, item 14) on the rear panel of the ADU 100 is in position REMOTE. The digital section is then disabled. The nominal value is furnished to the ADU 100 externally. The actual value is fed back from the recorder output to the external control.

12 Light-emitting diode SHUTTER. This lamp will light up when the shutter above the source is open.

13 Mode selector switch (S7):
position AUTO: automatic program flow after the push-button RUN or EXT. START has been depressed,
HO: manual operation with shutter above the source closed,
H1: manual operation with shutter above the source opened

14 Detector voltage switch (S8). With this switch the detector voltage is set. The symbols used are as follows:
position 1 = −50 V
2 = −100 V
3 = −150 V
4 = −250 V

15 Potentiometer P5 (R69). Is used to set the operating point of the evaporation source. After the display has been calibrated (refer to section 5, start of operation), the nominal value on the P5 will be changed until the rate R, preset on the selector switches RATE will appear on the display (in the program flow with shutter opened).

16 Potentiometer P4 (R68). Is used for the correction of the shutter position. This potentiometer is set in such a way that at a constant electron beam power (manual control first mode, refer to section 5, start of operation) an equal rate display is obtained with the shutter opened and closed. In the program flow, the fluctuation in output (the electron beam power e.g. can be read on the EKS 110 A) is then neglible when the shutter is opened.

17 Potentiometer P3 (R67). Is used to set the operating point of the VF-converter (the regulating signal should be between 2 and 8 V), as well as for the fine adjustment (analog) when the unit is calibrated. The coarse adjustment is made by means of the preselector switches D, item 7 using the digital method.

18 Potentiometer P2 (R66). Is used to set the attenuation of the automatic control system.

19 Potentiometer P1 (R65). Is used to set the gain of the automatic control system. (The floating action which must not be changed normally can be set on the control circuit board E3, on the resistor R22 or on the capacitor C5).

20 Potentiometer RATE CONTROL (R70). With this potentiometer the rate control of the source is effected in manual control, second mode (refer to section 5, start of operation) (positions HO and H1 of the mode selector switch item 13 and the switch position CONST. RATE on the EKS 110 A).

21 Push-button switch MODIFY (S5). If during the program flow input data are changed on the preselector switches, item 1 - 7, these changed data will be effective only after they had been read in when the push-button switch MODIFIY has been depressed. The data input is automatically read during each program start. The adjacent light-emitting diode will light as long as the push button switch MODIFIY has been depressed.

22 Push-button switch RATE (S4). After depressing this push-button, the coating rate is indicated on the display. In a normal program sequence, the coating rate is indicated during the evaporation process (also with shutter closed). The film thickness will appear on the display automatically only after coating has been completed. If the push-button RATE is then depressed, the coating rate during the last second of the evaporation cycle is indicated.
The adjacent light-emitting diode will light up when the coating rate is indicated on the display.

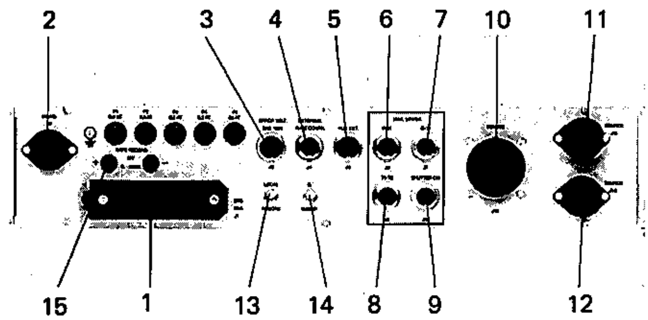
23 Push-button switch THICKNESS (S3). After depressing this push-button, the film thickness condensed on the substrate is indicated on the display. (The integration is effected only after the back indication of the opened shutter). The adjacent light-emitting diode will light up when the film thickness is indicated on the display.

24 Push-button switch HOLD (S2). After depressing this push-button, the momentary program point is fixed. Therefore, the source operates at the rate which has been reached at the time when HOLD was depressed, until the program sequence is started again by depressing the push-button HOLD once more. The switched on HOLD function is signalised by the light-emitting diode.

25 Push-button switch RUN (S1). The program flow is started with the push-button switch RUN if the mode selector switch (S7), item 13 is in position AUTO and the shutter above the source is closed. With the shutter opened (i.e. light-emitting diode SHUTTER, item 12 lights), the mode selector switch, item 13 has to be moved from position AUTO to position HO for a short period, since the program cannot be started with an open shutter. If prior to the program end the push-button switch RUN is depressed again, the coating process will then be completely interrupted (program stop).

3.2. On the rear panel are located:

(counting from serial 063)



1	J1	receptacle for control cable to EKS 110 A
2	J2	receptacle for power cable (connection from the EHV main power supply)
3	J3	J3 receptacle for signal line to EKS 110 A
4	J4	receptacle for signal line from an external control system in mode REMOTE
5	J5	receptacle for control cable ext. start
6	J6	receptacle for relay point during the entire process cycle (e.g. control of the rotary drive for the substrate holder)
7	J7	receptacle for relay point during the first rise time
8	J8	receptacle for relay point during the second rise time
9	J9	receptacle for relay point during substrate coating
10	J10	receptacle for cable to rack and panel connector in terminal box
11	J11	receptacle for cable to rack and panel connector in terminal box
12	J12	receptacle for cable to rack and panel connector in terminal box

13 Switch (S9) with the positions

LOCAL	ADU 100 is controlled by its own digital section
REMOTE	ADU 100 is controlled by a computer system on a higher level (the entire data input is external)

14 Switch (S10) with the positions

0	no sweep during coating in automatic operation
SWEEP	sweep during coating also in automatic operation (sweep amplitudes and sweep frequency are set on the EKS 110 A).

15 Recorder output 0 - 10 V

for serial number 053 - 062: recorder output 0 - 100 mV. The voltage at the recorder output may be increased to 10 V.

Change on the control circuit board E3: R17 = 5,6 kΩ, R18 = 47 kΩ. Precision resistor of recorder for measuring $R_i > 500$ kΩ.

3.2.1. In the interior of the unit are located:

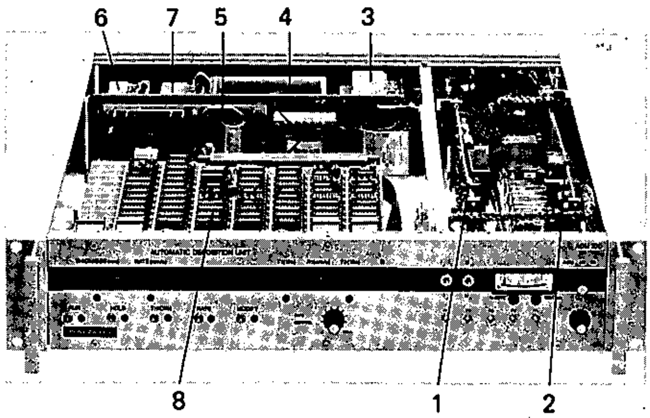


Fig. 5

1 Analog control circuit board E3
2 Relay circuit board E2
3 Transformer T3 for shutter bias
4 Power supply E1, ± 15 V, DC
5 Power supply for digital section
6 Transformer T1 for detector voltage
7 Transformer T2 for relay control
8 2 wire-wrap circuit boards, no. 1 above, no. 2 below

3.3. Control circuit board E3

Essentially, the control circuit board E3 fulfills the following functions (refer to diagram BG 241 403 -S on serial number 053 - 062: BG 241 154 -S).

3.3.1. Detector voltage

The detector voltage is laid at the detector of the source by the connector J18 across A15. The current used for rate measuring flows from the grounded position (crucible) across the potentiometers P4 (R68) as well as P1 (R65) on the front panel to the contact point B5 of J18 across the resistor R8 and the switch S8 to the positive output of the rectifier. With the shutter above the evaporation source closed, the voltage drop is then conducted as a rate signal to the inverter N1 and the multiplier N2 from the center tap of the potentiometer P1 (R65) and across the center tap of P4 (R68) referred to ground if the shutter is opened.

2. Signal preparation and rate control

Depending on the position of the selector regulating switch (S5), fig. 3, item 8, the signal transmitted by the inverter N1 or the output of the multiplier N2 is then conducted to the input of the (dual) Servo amplifier N3 (check point U3). The ion current signal is measured at the point U6, the emission current signal at the point U5 and the product of emission and ion current at the point U4. The actual value for the (dual) Servo amplifier N3 is the ion current signal J_J of the inverter or the product of the ion current signal and the emission current signal $J_J \cdot J_E$. The pertinent nominal value is conducted to this (dual) Servo amplifier N3 across the resistor R20 and the connector J19 at the contact A13. The floating action of the PID controller can be influenced by changing the resistor R22 or the capacitor C5 whilst the P and the D action can be changed by means of the potentiometers P1 and P2 on the front panel.

3. Relay K15

This relay is excited by the signal THICKNESS REACHED of the digital section I. The pulse duration for the contact point on the rack and panel connector J1 in the terminal box is approx. 200 - 300 msec. It is used as a back indication for the film coating e.g. in a sequential control or a control system on a higher level.

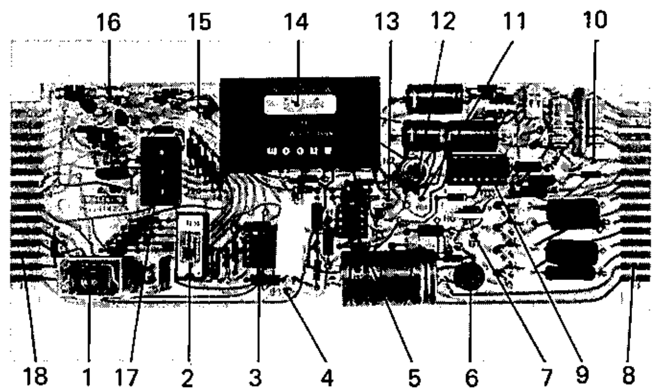


Fig. 6

1 Relay K15 (thickness reached)
2 D/A converter N5
3 Dual amplifier N4 to D/A converter N5
4 Check point U3, input voltage to Servo amplifier N3
5 Dual amplifier N3
6 Rectifier D1 for detector voltage
7 Check point U7, error voltage
8 Connector J18
9 Amplifier N1 for ion current signal
10 Check point U6, input voltage for N2 ion current signal
11 Check point U4, output voltage of N2
12 Multiplier N2
13 Check point U5, input voltage for N2 emission current signal
14 V/F transducer N6
15 Trimpotentiometer R40 for zeroing the D/A transducer N5
16 Trimpotentiometer R42 for offset zero N6
17 Connection for flat cable J20
18 Connector J19

3.4. Control unit

The nominal value required for rate regulation and control can be generated in different ways:

3.4.1. Manual rate control

The manual rate control is achieved by means of the potentiometer RATE CONTROL (fig. 3, item 20) in the two switch positions HO and H1 of the mode selector switch (fig. 3, item 13).

2. Automatic rate control

In the switch positions AUTO of the mode selector switch (fig. 3, item 13), the signal for the nominal value is transmitted to A13/J19 either by the dual amplifier N4 of the D/A converter (switch S9, fig. 4, item 13 in position LOCAL) or by an external control unit (switch S9 in position REMOTE). In case of an external rate control, the lamp REMOTE under the analog instrument will light up. The supply of the digital section will be switched off in external rate control (REMOTE).

The signal for the actual value (ion current signal or product signal of ion current and emission current) is conducted to the analog instrument MJ1 on the one hand and the VF-converter (voltage - frequency transducer) on the other hand via the balancing potentiometer ("geometric factor") P3 by means of the selector regulating switch S5 (fig. 3, item 8). The output of the VF-converter (rectangular pulse, pulse height approx. 4 V, pulse duration 15 µsec) is led to the opto-coupler located in the digital section I across the amplifier stage (H1 or H2) and the contact points 15, 16 of the flat cable connector J20.

The output pulses of the opto-coupler galvanically separated from the control circuit board E3 are divided in their number by the divisor D, adjustable on the front panel, and the time intervals in seconds are then counted. The number of pulses thus determined per second is transmitted to the display directly (e.g. 10 pulses = 1 nm/sec, 1 pulse = 1 Å/sec) and is also continuously counted for the film thickness.

3.5. Setting the operating point of the evaporation source

The gain of the dual amplifier N4 is adjustable by means of the potentiometer P5 (fig. 3, item 15) (in the feedback 6 - 7 of N4) in a range between 0 and 6.6.. The correct position of P5 will make it possible that the complete circuit amplification can be adjusted in such a way by means of the signal for the nominal value (RATE) of the digital section and the calibrated measuring device (calibration by potentiometer P3 and divisor D) that the same rate is indicated on the display, (and thus also furnished to the substrate by the source), as preset on the digital switches RATE. The output signal of the digital section (nominal value) does therefore not allow for the geometric factor or the material adaptation which both take place in the input signal (actual value). This adaptation is achieved by the potentiometer P3 (fig. 3, item 17) and the preselector switches D (fig. 3, item 7).

The analog signal for the actual value should be set on the potentiometer P3 (R67) in such a way that at the max. coating rate the voltage indicated by the analog instrument does **not** exceed 8 V (as long as the push-button switch S6 is **not** depressed since the instrument will then indicate the detector voltage). This will prevent an overshooting of the VF converter. For very small rates, the signal for the actual value in the feedback of the inverter N1 on the circuit board switch S1 of the control circuit board E3 can be increased. If necessary, R12 can still be increased to a maximum of 670 kΩ.

This signal amplification is effective in the regulation of the ion current only (selector regulating switch S5 on the front panel in position J_J). The full regulating accuracy of the ADU 100 is assured when the rate signal on the instrument MJ1 exceeds 2 V (therefore with shutter opened in the program flow).

3.6. Relay circuit board E2

(Serial number 053 - 062: diagram BG 241 154, counting from serial number 063: diagram BG 241 402 -S). The relays on this circuit board have mainly the function of switching amplifiers (galvanic separation) between the reed relays of the digital section and the output switching signals of the ADU 100. A maximum of 50 V, AC, 2 A Ohmic load can be applied to all contact points of the receptacles on the rear panel of the ADU 100.

220 V, AC, 2 A Ohmin load can be applied to the contacts on the rack and panel connector in the terminal box.

The switching functions of the various relays are:

- K1 will be excited during the second rise time T2
- K2 will be excited during the first rise time T1
- K3 will be excited by the back indication of the opened shutter (light-emitting diode SHUTTER will light) starting the film thickness integration. The automatic start can be initiated only when the relay K3 has dropped out (shutter closed).
- K4 will be excited by the mode selector switch (S7) HAND-AUTO in position AUTO controlling the automatic program.
- K5 will be excited over an external START contact point, via connector J5, contact points 1, 2. In this way, the program flow in the digital section is started in automatic operation (AUTO).
- K6 will be excited via the shutter contact in the digital section triggering the shutter above the evaporation source. The shutter bias (voltage of +15 ÷ 35V, DC, to ground applied to the shutter plate) is interrupted by this relay with the shutter opened.
- K7 will be excited via the RUN contact point of the digital section switching on the EKS 110 A (high voltage and cathode heater current as well as the rotation of the crucible).
- K8 for serial number 053 - 062
  will be excited via the contact point THICKNESS REACHED of the digital section (pulse duration approx. 200 - 300 ms). This signal exists in the receptacle J11 on the rear panel and is used e.g. in a sequential control or a control system of a higher level as a back indication for the completion of the film coating operation.
- K8 counting from serial no. 063
  will be controlled by the relay K6.

4. INSTALLATION

4.1. Installing an automatic electron beam source ESQ 110 (ESQ 200) for metal evaporation

The proper installation fo the standard evaporation equipment including electrical supply is a requirement (e.g. in accordance with operating instructions BB 800 066 BD), mains switch, however, in off position.

4.1.1. Installing the ion collector on the evaporation source ESQ 110 (200) (refer to spare parts list BB 800 095 E / 3)

a The Cu-sreening plate has to be shortened by 30 - 32 mm.

b If the two threads M3 and the recesses on the coil core for the detector holder do not yet exist, these have to be provided subsequently. (Refer to fig. 7).

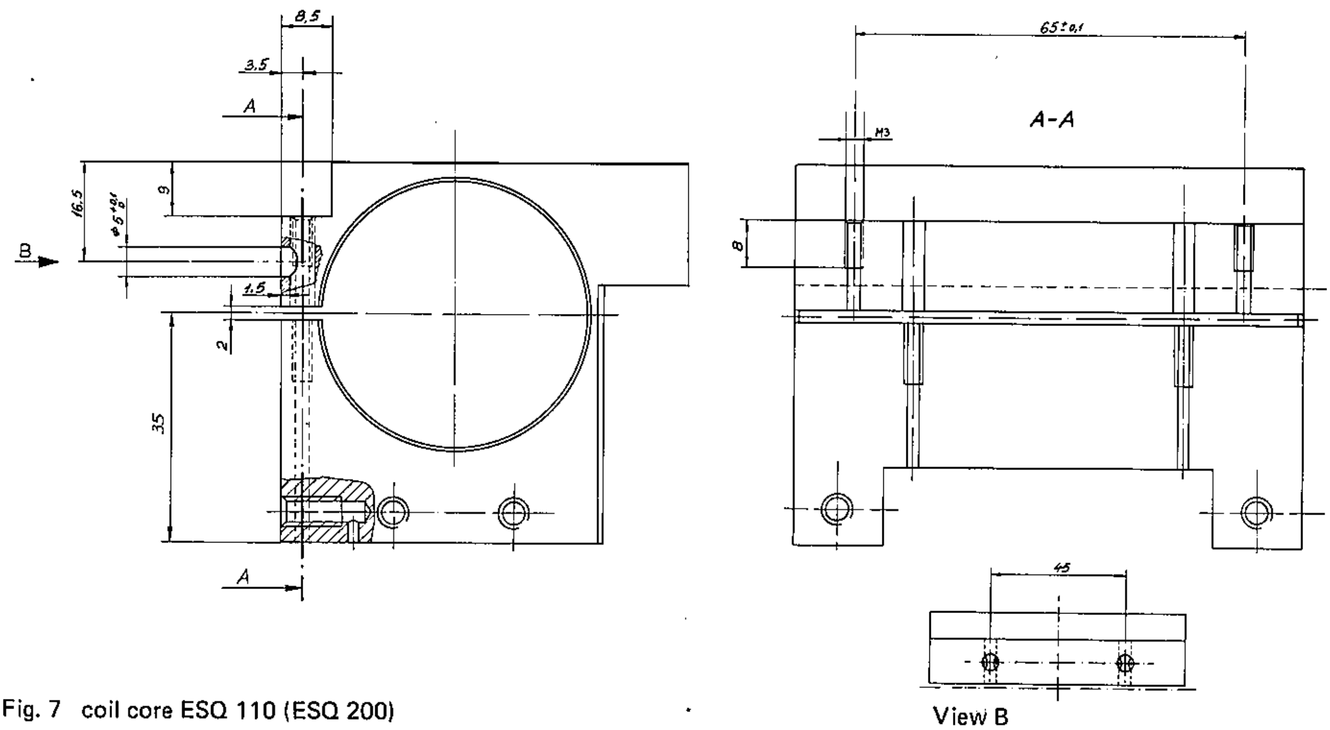


Fig. 7 coil core ESQ 110 (ESQ 200)

c Attach CrNi-beam by means of 4 insulaters (2 each between beam and coil core as well as 2 between beam and fastening screw) and the two screws M3.

d Establish electrical connection by means of terminal and glass fiber-insulated cable.

e Attach shutter plate by means of two M2 screws to beam.

f If materials are evaporated which cause a formation of flitters'in the plant (e.g. Cr, Ni, Au), the detector has to be raised by approx. 4 - 8 mm using 2 spacers. A flat section of equal thickness between detector and coil core will prevent a premature coating of the 4 insulators.

4.1.2. Installing the rotary shutter

a The rotary shutter has to be installed so as to keep the shutter plate in the position "open" as far away from the detector as possible. If this is not done, the measuring of the ion current may be falsified. The distance between crucible edge and shutter plate should be at least 80 mm.

b The rotary shutter (e.g. compressed air shutter) must be installed so as to provide for electrical insulation against the coating plant using the insulating disks or the insulating pupe which are part of the delivery. The installation has to be checked using an ohmmeter by all means.

c If a rotary shutter is used which cannot be installed insulated or where insulation is difficult, it will suffice if the shutter plate is insulated from the shutter drive (using ceramic insulators) and a potential is applied to the shutter plate only via the octuple lead-in of the respective contact in the terminal box.

d The potential of the shutter must never be undefined. Therefore, when opening, the shutter is made voltageless and grounding is accomplished across the terminal switch of the shutter. If no terminal switch is availbalbe for grounding, grounding must be replaced by a contact of the relay K6. In this case, the connections 3 and 10 as well as 11 and 12 on the terminal strip J2 in the terminal box have to be jumpered. By all means, the proper grounding of the open shutter has to be checked using an ohmmeter.

4.1.3. Other installation in the coating plant

Magnetic stray fields have to be kept away from the evaporation source. Special care should be taken that no magnetizable materials are used for movable parts. If a magnet or a soft iron component has to be installed in the plant, this constant magnetic field is automatically compensated when the unit is calibrated. If later on such a component will be displaced or removed, a recalibration of the ADU 100 is mandatory.

Care should be taken that the screening plates are properly grounded. Faulty connections of the plates will lose their grounding properties by oxidation after some time. For this reason, all cover plates have to be cleaned periodically after approx. 30 - 50 operating hours.

4.2. Electrical installation

4.2.1. Ther terminal box has to be mounted in the rack of the coating and the control cables have to be connected to the receptacles J10, J11 and J12 of the ADU 100 (use cable lead-in on the left hand side on the cabinet of the EHV 110).

4.2.2.a On the terminals of detector current, supply of detector voltage, shutter bias, shutter control as well as shutter back indication from the components to the terminal box refer to the respective wiring diagram, e.g. BG 241 405 -S.

b If a rotary shutter is used which has been installed insulated, the shutter bias has to be provided for on the atmospheric side. If a ground wire to the shutter control exists, this has to be removed. This operation is admissible only when the control voltage of the shutter cable lead-in is fully insulated (structureal component from plastic). Otherwise refer to section 4.1.2.c.

c If a rotary shutter is used without back indication (not recommended), the missing back indication must be furnished by the control unit ADU 100 itself, since the film thickness integration cannot be started otherwise. On the rack and panel connectors J1 two unused wires have to be squeezed off and insulated. The free wires 16 and 17 have to be connected to the free terminals. Following this, one terminal each has to be connected to the terminals 1 and 2 of the same rack and panel connector.
The shutter has to be grounded according to section 4.1.2.d.

d Also not the connecting facilities such as ext. start (RUN EXT), THICKNESS REACHED or the program points T1, T2 (refer to fig. 2).
These terminals are used when the ADU 100 is started automatically or when the ADU 100 itself controls other peripheral units. It is recommended e.g. to trigger the rotary drive of the substrate holder with the automatic start RUN (on rack and panel connector J1, contacts 8, 9 in the terminal box. On contact loads refer to section 3.6.).

e The triggering of a feeding device (e.g. wire feed) may be an additional control function of the ADU 100. In this operation, the feed is switched on during the second rise time in the program (switching contacts 8,9 on the rack and panel connector J2 in the terminal box).

Note:

connect power supply to the EHV and check detector voltage in the terminal box, rack and panel connector J2, terminal 7. When the coating plant is opened, no voltage has to be applied to the detector (monitored by a vacuum switch).

Switch off power supply.

The supply voltage for the transformer "detector voltage" is furnished by the rack and panel connector of the EKS. In this way, the detector voltage will be switched on only when the plant is evacuated. (When the plant is opened, the detector voltage cannot be checked).

4.2.3. Installations in the control cabinet

a The connection to the power supply is made by means of the cable being part of the delivery according to diagram BG 241 402.

b Control line from the ADU 100, receptacle J1 to the EKS 110 A, receptacle J4, COAT-O-MATIC. Signal line from the ADU 100, receptacle J3 to the EKS 110 A, receptacle J1, ERROR VOLT.

c If the start is external (RUN EXT), the respective control line must either be connected to the rack and panel connector J1, terminals 6, 7 in the terminal box or directly to the receptacle J5 of the ADU 100.

d As shown in the diagram BG 241 405 -S and the listing of the components of the rear panel in fig. 4, most switching functions of the ADU 100 can be established both from the rear panel of the ADU 100 and the rack and panel connectors J1, J2 in the rack of the coating plant.

4.2.4. Additional installation in the EKS 110 A

(for ADU 100 counting from serial no. 063)

a **Crucible rotation with constant rotation speed**

The rotary drive of the ESQ 110 is switched on and off automatically by the ADU 100. In this case, the crucible rotates **constantly** with its normal speed which is approx. 1.4 RPM. For this operation which is standard, the crucible control unit ETS 110 is **not required.**

In such a case, the relay K14 being part of the delivery of the ADU 100 has to be mounted according to the mounting instructions BG 241 414 and the COAT-O-MATIC circuit board has to be inserted in the interior of the EKS 110 A according to the operating instructions BB 800 064 BD.

b **Operation of the ADU 100 with crucible control unit ETS 110**

In this case, the relay K14 has not to be mounted in the EKS 110 A, since otherwise the following operational modes are not possible (ETS 110 disabled).

c ADU 100 in operational mode AUTOMATIC (Position AUTO of the mode selector switch (S7) (fig. 3, item 13).

The rotary drive of the crucible is automatically switched on and off (function ROTATION) by the ADU 100 across the ETS 110. Unlike an operation without ETS 110 (refer to item 4.2.4.a), **the rotation speed can be changed** now on the ETS 110 by means of the potentiometer SPEED. The other functions of the ETS 110, however, are not possible in automatic operation.

d ADU 100 in operational mode MANUAL, first or second mode

(Position "H0" or "H1" of the mode selector switch (S7), (fig. 3, item 13).

When this operational mode is selected, the rotary drive can be controlled from the ETS 110, as this applies to a standard manual operation of the ETS 110. This will also allow rate-adjusted coatings using the 4-way and oscillating crucible.

e For ADU 100, serial number 053 - 062.

The sections 4.2.4.a, b and d equally apply to these units.

In automatic operation of the ADU 100 all controls of the ETS 110 are enabled unlike section 4.2.4.c.

4.3. Installing an automatic electron beam source ESQ 110 (200) for the evaporation of dielectrics

Generally, the evaporation of dielectrics is possible only when the detector voltage exceeds –200 V significantly.

For this application, a DC voltage source is connected in series to the detector voltage.

The proper installation of the standard evaporation equipment including electrical supply is a requirement (e.g. in accordance with operating instructions BB 800 066 BD).

Power switch, however, in OFF position.

4.3.1. Installing the ion collector on the evaporation source ESQ 110 (200)

a Refer to section 4.1.1. a - g

b Connect detector voltage cable to the octuple lead-in. The adjacent contacts of the lead-in must not be used for other purposes, and the total detector voltage must not exceed –500 V, i.e. the boosting voltage must be under –300 V.

c If the booster voltage has to exceed –300 V, a high voltage lead-in has to be used (e.g. ordering number BB 192 359 -T) instead of the octuple lead-in.

4.3.2. Installing the rotary shutter

Refer to section 4.1.2.

4.3.3. Other installations in the coating plant

Refer to section 4.1.3.

4.4. Electrical installation

4.4.1. The terminal box has to be mounted in the rack of the coating plant and the control cables have to be connected to the receptacles J10, J11 and J12 of the ADU 100 (use cable lead-in on the left hand side on the cabinet of the EHV 110 A).

The power supply unit for the booster voltage of the detector has to be mounted next to the terminal box so as to allow easy accessibility of the potentiometer for the adjustment of the direct voltage (100 - 1000 V). Connect power supply unit according to the corresponding wiring diagram.

4.4.2.a On the terminals of detector current, supply of detector voltage, shutter bias, shutter control, shutter back indication from the components to the terminal box refer to the respective wiring diagram, e.g. BG 241 543 -S.

b In the terminal box, rack and panel connector J2, the wire 5 has to be detached from the terminal 5 and to be insulated. Ther terminal 5 is used as a base for the neutral conductor of the 115 V control voltage.

c Refer to section 4.2.2. c - d

d An additional control function of the ADU may consist in the triggering of a refilling device (e.g. coil supply BWF 103). In this step, the refilling operation is switched on during the second rise time in the program flow (switching contacts 8, 9 on the rack and panel connector J2 in the terminal box).

e Refer to section 4.2.2.e.

3. Installation in the control cabinet
Refer to section 4.2.3.

4. Additional installation in the EKS 110 A
Refer to section 4.2.4.

4.5. Installing 2 automatic electron beam sources for the evaporation of alloys or for the coating of successive films

The mutual interference of the sources (especially the Al source interfering with the Si source) depends quite essentially on their position to each other, and particularly on a careful installation of the various cover plates as well as the partition between these sources.

Also, as a primary requirement, an undefined electrical potential must exist in no case on any of the surfaces. It is therefore helpful to check the proper grounding of the various cover plates and to ensure, in the first place, that the shutter plate located above the source has been connected to the shutter lead-in excluding electrical hazards. Owing to the high terminal load to which the shutter is subjected, a good mechanical and electrical connection to the rotary axis of the shutter is not always assured. A jumper between the shutter plate and the shutter lead-in is a good engineering practice, in order that the required shutter potential of the ADU can reach the shutter plate with the shutter closed. All cover plates should be cleaned periodically after 30 - 50 operational hours each.

4.5.1. Installing the evaporation sources

The typical examples for proper installation as shown in fig. 8, 9 and 10 will produce good regulating results. The other installation procedures applying to the evaporation sources including electrical supply are a requirement (e.g. according to operating instructions BB 800 064 BD), power switch, however, in OFF-position.

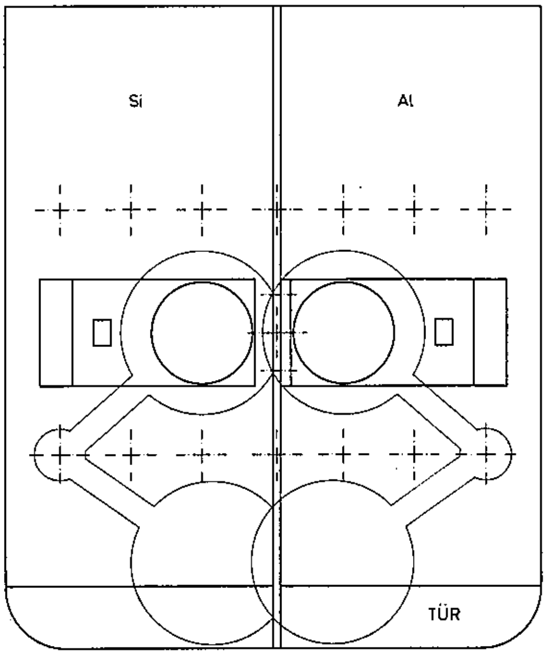


Fig. 8 Typical example for proper installation of 2 ESQ 110 with shutter in coating plant BAK 550.

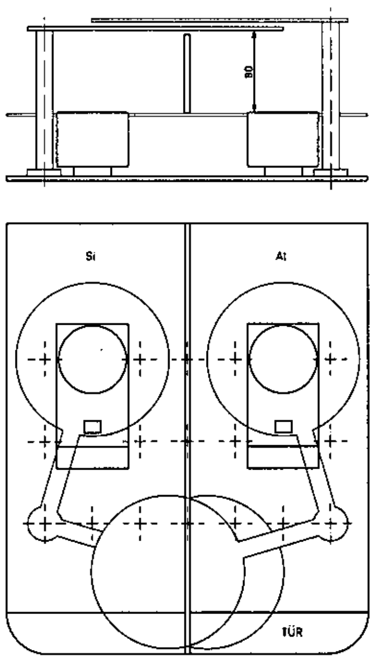


Fig. 9 Typical example for proper installation of 2 ESQ 110 with shutter in coating plant BAK 550.

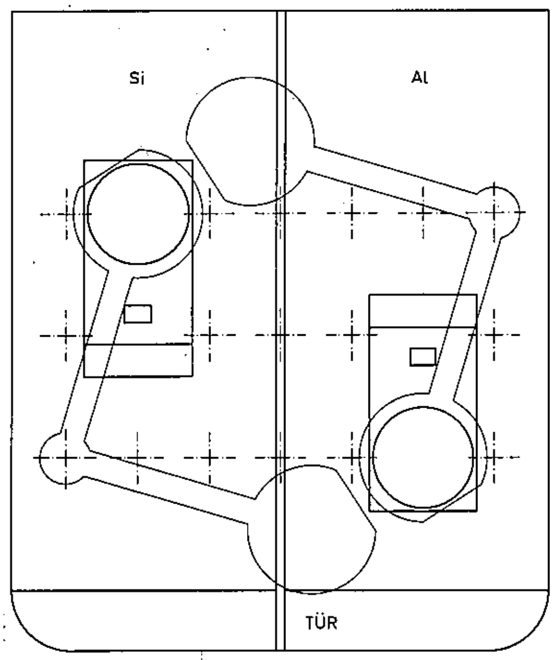


Fig. 10 Typical example for proper installation of 2 ESQ 110 with shutter in coating plant BAK 550.

4.5.2. Installing the ion collector on the evaporation sources ESQ 110 (200).

On both sources, the installation is made in an analogous fashion as described in section 4.1.1.

4.5.3. Installing the rotary shutters

On both shutters, the installation is made in an analogous fashion as described in section 4.1.2. Also refer to typical examples for installation as shown in section 4.5.1.

4.5.4. Installing the cover plates

When the cover plates are installed, the following requirements have to be met by all means:

a On the crucible level of the two sources a 1 mm thick Cr-Ni-plate is firmly attached. This plate may consist of two single sheets screwed together and should be fitted to each source as tightly as possible. To exclude high voltage arcing, the covering should be attached with care and especially fill the space between the sources completely also extending approx. 10 - 20 cm beyond each source (e.g. on the detector side). The shafts of the two rotary shutters are passed through appropriate holes in the cover plate. This cover plate should be as large as possible.

b The partition between the sources (50 - 70 mm high) should be as long as possible (if feasible, from "wall to wall").

c The ion collector of the Si-source has to be protected with a cap (110 mm wide, 25 mm high, 40 mm deep) at ground potential from undesired Al-ions. This cap should be screwed to the large horizontal cover plate. The distance to the shutter plate has to be approx. 5 mm on all sides. This cap should be cleaned after approx. 30 - 50 operational hours.

d The two ion collectors may be mounted with the short leg upward (rotation by 180 °C).

e The shutter above the Si-source should be at ground potential (the terminal 3 of the rack and panel connector J2 in the terminal box has to be changed to terminal 6) if the output of the Si-source decreases under 1,5 kW with the shutter closed (refer to start of operation, section 7.4.).

4.6. Electrical installation

4.6.1. Both terminal boxes have to be mounted in an analogous fashion as described in section 4.2.1.

Note:

Do not confuse the control cables! It is recommended to mark each terminal box and the pertinent ADU 100 conspicuously with 1 or 2.

2. Connect all terminals in ther terminal box in an analogous fashion as described in section 4.2.2.a. Refer to the respective wiring diagram.

3. Shutter control

a Each shutter will be opened by the pertinent ADU 100 after expiration of the preset time T1 + T2 and closed after the selected film thickness has been reached. The high voltage will switch off when both film thicknesses have been reached.

For this process flow each shutter has to be connected in the appropriate terminal box.

b Both shutters open and close in a synchronous operation. For this process flow shutter controls have to be connected in parallel in the appropriate terminal box of the guiding ADU 100. The back indication (terminal switch) has to be connected, however, in each of the appropriate terminal boxes.

c Refer to section 4.2.2. b - e.

4. Cross connection between the two terminal boxes to be established as follows:

terminal box no. 1		terminal box no. 2
rack and panel connector J1		rack and panel connector J1
terminal 6	→	terminal 8
terminal 7	→	terminal 9
terminal 8	→	terminal 6
terminal 9	→	terminal 7

5. Installation in the control cabinet

a Provide for power supply on each ADU 100 by means of the receptacle J2. The power supply has to be established with the cable being part of the delivery and in accordance with the wiring diagram.

b Control line ADU 100, no. 1, receptacle J1 to EKS 110 A, no. 1, receptacle J4.

Signal line ADU 100, no. 1, receptacle J3 to EKS 110 A, no. 1, receptacle J1.

Control line ADU 100, no. 2, receptacle J1 to EKS 110 A, no. 2, receptacle J4.

Signal line ADU 100, no. 2, receptacle J3 to EKS 110 A, no. 2, receptacle J1.

c If the start is external (RUN EXT), the respective control line must either be connected to the rack and panel connector J1, termianls 6, 7 in the terminal box or directly to the receptacle J5 on the rear panel of the ADU 100.

d For alloy coating **both** ADU 100 units are started by depressing the push-button RUN of the **guide unit** (e.g. ADU 100 no. 1). The **guided unit** (ADU no. 2) will be started externally by the guide unit.
If it is intended to start both units simultaneously, the following connection has to be made:

ADU 100 (no. 1)	ADU 100 (no. 2)
guide unit	guided unit
receptacle J7 (0 - T1) →	receptacle J5 (RUN EXT)

e If it is intended, however, to start the guided unit only after expiration of T1 of the guiding unit, the following connection has to be made:

ADU 100 (no. 1)	ADU 100 (no. 2)
guide unit	guided unit
receptacle J8 (T1 - T2) →	receptacle J5 (RUN EXT)

f Further, if it is intended to start the guided unit only after expiration of T1 and T2 of the guiding ADU 100 (may be necessary in an overlapping process), the following connection has to be made:

ADU 100 (no. 1)	ADU 100 (no. 2)
guide unit	guided unit
receptacle J9 ——→	receptacle J5
(SHUTTER ON)	(RUN EXT)

Important:
If the **guide unit** is started, the alloying process runs.
If the **guided unit** is started, the program of this unit runs only. Hence, this component is evaporated only.
In the conventional Al-Si process this means that the Si-ADU is installed as the guide unit.
Optionally, the Al-Si process (starting the Si-ADU) or a straight Al process (starting the Al-ADU) can run under these conditions.
In case it is intended to start the alloying process only (i.e. the guided unit cannot be started as a single unit), the following cross connections must be **removed** between the terminal boxes of both ADU 100:

terminal box no. 1	terminal box. no. 2
rack and panel connector J1	rack and panel connector J1
terminal 6 —✕→	terminal 8
terminal 7 —✕→	terminal 9

4.6.6. Additional installation in each EKS 110 A

a The relay K14 shipped with each ADU 100 has to be mounted according to the mounting instructions BG 241 414.

b The COAT-O-MATIC circuit board has to be inserted in the interior of both EKS 110 A units (refer to separate operating instructions BB 800 064 BD).

c Refer also to section 4.2.4.

5. START OF OPERATION

Initially, the electron beam evaporation equipment must be started according to the separate operating instructions (e.g. BB 800 066 BD).

For this step, the mode selector switch (S7) (fig. 3, item 13) on the ADU 100 has to be set at H0 or H1.

Position H0 = shutter above the source is closed.

Position H1 = shutter above the source is open, light-emitting diode SHUTTER lights.

5.1. Initial values for the coarse adjustment of the ADU 100

Set potentiometers P1, P2, P3, P4 approximately at center position.

Selector switch:	
film thickness (TCHICKNESS)	1000.0 nm
rate R	4.0 nm/s
first rise time T1	04 (40 s)
second rise time T2	05 (50 s)
divisor D	15
selector regulating switch (fig. 3 item 8)	$J_J \cdot J_E$
Source ESQ:	
crucible	pot crucible
material	Al, Cu, Ti

5.2. Manual control, first mode

The mode selector switch (S7) (fig. 3, item 13) on the ADU 100 allows the manual operation of the EKS 110 A if the switch S6 on the EKS 110 A is at CONST. EMIS. (refer to fig. 1, item 6 of the operating instructions BB 800 064 BD). In this case, the ADU 100 is used only for the triggering of the shutter.

This operating condition:
switch S6 on the EKS 110 A at CONST. EMIS. and
mode selector switch S7 on the ADU 100 at H0 or H1
is called **"manual control, first mode"** (control of the emission current).

5.2.1. At a working pressure in the coating chamber of less than $1 \cdot 10^{-4}$ mbar, the emission current on the EKS 110 A is increased slowly until a beam output of approx. 6 kW (10 or 11 kV accelerating voltage) has been obtained.

2. The detector voltage on the ADU 100 is set at —100 V (position 2 of the detector voltage switch (S8)(fig. 3, item 14). The respective voltage can be read on the analog instrument of the ADU 100 until the push-button switch has been depressed.

3. On the display of the ADU 100 the indication must exceed 0.
If at a beam output of 6 kW a rate is indicated on the display which is between 10 and 100 after the push-button MODIFY has been depressed, if necessary, the rate measuring of the power-adjusted evaporation source by the ADU functions properly.
If this is not the case, refer to troubleshooting procedure.

5.2.4. If th shutter is closed on the ADU 100 by means of the mode selector switch (S7) (fig. 3, item 13) and then opened again, the rate display for the two shutter positions (partial ion collection due to the shutter) will be different generally. On the potentiometer P4 the setting can be found allowing an identical display of the ion current irrespective of the shutter position. (Without a shutter installed above the source, P4 is set at a maximum). With the shutter closed, the display should be rather higher (approx. 5 - 10%) than with an open shutter!

5.3. Manual control, second mode

5.3.1. The potentiometer RATE CONTROL on the ADU 100 ist set at a minimum and the toggle switch on the EKS 110 A at CONSTR. RATE. In this case, the ADU 100 is used for both the shutter control and the rate control by hand. This operating condition:

switch S6 on the EKS 110 A at CONST. RATE and mode selector switch S7 on the ADU 100 at H0 or H1

is called **"manual control, second mode"** (rate control by hand). Now the beam output is increased slowly with the potentiometer RATE CONTROL on the ADU 100. In this step, the beam output of the evaporation source increases first and following this, the rate is indicated on the display. The nominal value is now increased slowly until the beam power is approx. 8 kW.

2. If the rate control is not constant, the circuit amplification can be set on the potentiometer P1 and the attenuation by means of the potentiometer P2. (The floating action must not be adjusted normally. If this is required, however, the resistor R22 or the capacitor C5 on the control circuit board E3 can then be changed).

3. If the spot position is correct (approx. 15 - 20 mm from the edge of the pot crucible, with the crucible rotation switched on), the coating rate can now be increased on the ADU 100 by means of the potentiometer RATE CONTROL until the electron beam power is approx. 9 kW. If in a cubical coating plant (BAK 550) the coating process is performed on a planetary substrate holder, a rate value of 100 must now appear on the display. If this is not the case, the setting has to be changed on the potentiometer P3 until a value of 3 - 6 V appears on the analog instrument of the ADU 100 now indicating the rate and a value of 100 is shown on the display. If necessary, the divisor D on the digital switch must be changed. A change of the setting D will be effective only when the push-button switch MODIFY has been depressed afterwards. Whenever necessary, a fine adjustment of the rate display can always be made on the potentiometer P3.

In this operating condiction, the ADU 100 acts as a manually operated rate control unit which has been calibrated in the first approximation.

5.4. Automatic operation

5.4.1. Setting the program

a The potentiometer RATE CONTROL on the ADU 100 is set at the minimum.

b The mode selector switch (S7) (fig. 3, item 13) on the ADU 100 is set at automatic operation (AUTO),

c The potentiometer P5 is carefully set at the minimum (max. 11 turns).

d The push-button switch HOLD allows the fixing of the momentary process condition. If this push-button switch is actuated again, the process will continue starting from the fixed position. This push-button switch is used e.g. during calibration in order to avoid a disruption of the process after the thickness has been reached (as long as no substrates have been inserted). After the calibration has been accomplished, the process end can be reached by depressing the push-button switch HOLD again.

e The push-button switch RUN is depressed. In order to start the program in the ADU 100 it is mandatory that the shutter above the evaporation source is closed and the respective back indication (terminal switch to shutter) takes place. If no shutter or no back indication exists, refer to section 4.1.2. d and 4.2.2.

f After the two rise times T1 and T2 have expired, the push button switch HOLD is depressed and then the potentiometer P5 is adjusted until the display coincides with the setting on the digital RATE (in our example 4.0 nm/s). Now the rate being controlled by the program section of the ADU 100 has been calibrated in the first approximation.

5.5. The coating process is stopped by depressing the push-button switch RUN.

5.6. Increase of the RATE input to 8.0 nm/s and program run. Recur to hunting on the P1 (gain), P2 (attenuation) of the ADU 100. When the film thickness (1000.0 nm/s in our example) has been reached, the shutter above the source is closed and the source switched off (high voltage and cathode heater current).

5.7. Increase of the RATE to 10.0 nm/s and program run.

5.8. Final calibration of the ADU 100

5.8.1. Check crucible contents (crucible level should be at the crucible edge or approx. 2 - 4 mm above the crucible edge).

2. Insert substrate and switch on rotary drive for the substrate holder.

3. After pumping down to $p < 5 \cdot 10^{-5}$ mbar, the push-button switch RUN has to be actuated. Wait for program flow.

5.8.4. Measuring the film thickness on the substrate. If the actual film thickness has been determined, the following equation rule applies:

$$\text{actual rate} = \text{indicated rate} \cdot \frac{\text{actual film thickness}}{\text{indicated film thickness}}$$

.5. For the finale calibration of the ADU 100 the following ratings are now set:

film thickness (THICKNESS)	1000.0 nm
rate R	10.0 nm/s
T1	06 (60 s)
R1	8.0 nm/s
T2	03 (30 s)

6. Insert new substrate and pump down to $p < 5 \cdot 10^{-5}$ mbar
7. Depress push-button switch RUN.
8. When the first rise time T1 has expired, the push button switch HOLD must be depressed immediately. The actual rate can now be set on the display by means of the digital switch D as well as the potentiometer 3. After changing D during the coating process, the push-button switch MODIFY must always be depressed.

   Now the display has been calibrated for the coating rate and equally the proper film thickness will be obtained.
9. With the potentiometer P5 the nominal value of the program transmitter is now changed until the rate on the display (in our example 8.0 nm/s) coincides with the rate set at the digital switch R1.

   The coating system now operates with the desired coating speed.

The evaporation system has now been calibrated. If a different film thickness is selected, no calibration is required. If the setting of the rate is changed considerably, a recalibration may be necessary. (The ion current measurement is not exaclty a linear function of the evaporation speed).

For the evaporation of metals at a beam power exceeding 8 kW the so-called product control (toggle switch (S5), fig. 3, item 8 at $J_E \cdot J_J$) has to be generally preferred to the ion current control (switch position J_J). The linearity error of the function: indicated rate = ((actual rate) is greater for the product control, the output error of the rate control is smaller however.

In any event, the control position (toggle switch (S5) at J_E or $J_E \cdot J_J$) must be established prior to calibration. Any changes of the control position following calibration require a recalibration.

5.9. Fixing the calibration parameters

If an ADU 100 has been calibrated for a specific process, this calibrating condition can be applied later on without a time-consuming film thickness measuring procedure. For this purpose, the detector voltage switch (S8) is set at position 4 and the push-button switch (S6) at position U_s.

After several seconds have passed, a constant display appears, generated by a simulated ion current of 1.0 mA. If this readout is now recorded, the same process may be calibrated under equal process conditions (refer to section 5.10.). In this operation, the detector voltage switch (S8) has to be set at position 4 and the push button switch (S6) at position U_s. By means of the selector switch D and the potentiometer P3 the same display has to be set again. Following this, the proper detector voltage has to be set once more.

Subsequently, the rate has to be calibrated in an analogous fashion as described in section 5.8.9.

5.10. Recalibration

Generally, a recalibration of the ADU 100 is performed only at the potentiometers P3 and P5 and the digital switches D.

A recalibration is required in the following cases:

a change of material,

b change of the shape and position of the spot. Therefore, as a first step, the shape and position of the spot has always to be determined prior to calibration,

c if the high voltage has been changed,

d if the source has been installed differently,

e if any changes have been made in the installation of the coating chamber.

6. TROUBLESHOOTING

6.1. Manual control, first mode

Failures	Causes	Elimination
High irregular display without material evaporation	Memory location undefined after switching on main switch	depress push-button switch MODIFY
High regular rate display without material evaporation, high deflection of meter at switch position J_J	Detector short circuit	Eliminate short circuit between detector and evaporation source
In switch position $J_J \cdot J_E$ the detector voltage is 0	Detector short circuit	Eliminate short circuit
No rate display during material evaporation (EKS manual control)	Detector not connected Potentiometer P1, P3, P4 at minimum Preselection D excessice	Connect detector Set potentiometer at an intermediate position Decrease D

6.2. Manual control, second mode

Failures	Causes	Elimination
Fluctuations in the output excessive during the coating operation	Some components (mirror) next to the source are not grounded or potential is undefinded (shutter!)	All components in the plant have to be grounded and cleaned! The open shutter must be grounded across the terminal switch.
Ion current (rate display) decreases with shutter closed when the beam output increases	Shutter bias not connected to shutter plate. Shutter is at an undefined or ground potential.	Mount shutter insulated in lead-in and provide for proper shutter bias in installation. The open shutter is grounded across the shutter terminal switch!
High fluctuations in the output when shutter is actuated	Potentiometer P4, shutter correction not properly adjusted	Potentiometer P4 has to be adjusted properly
Fluctuations in the output 15% also when shutter is opened	Potentiometer P1, P2 inaccurately adjusted	Optimise potentiometer P1, P2, if necessary switch at position $J_J \cdot J_E$ (product control)

6.3. Automatic control of the ADU 100

Failures	Causes	Elimination
Rise time T1, T2 do not run properly	Intermediate rate R1 exceeds nominal rate R	Set a lower rate for R1 than for rate R
After expiration of the rise times T1 and T2, film thickness integration does not start	Shutter back indication not actuated	Correct shutter back indication
Automatic start RUN disabled	Shutter above the source is not closed	Close shutter (mode selector switch at H0 and back to AUTO)
Rate display not coincident with	Unit has not been calibrated properly	Calibrate according to section 5
Reproducibility of the film thickness is inadequate	Shutter does not open fully One component (e.g. radiator) between source and substrate is not always in the same location (e.g. after cleaning) Crucible contents (metals) have oxydised	Open shutter fully (to final stop) All components have always to be mounted in the same location. Clean components periodically Crucible material (metals) should not be oxydised all over their free surface. Increase cooling-down period before venting.

Failures	Causes	Elimination
No rate display if selector regulating switch is in position $J_J \cdot J_E$. Rate display, however, if switch is in position J_J	No emission current signal of the EKS 110 A	Check signal path from control circuit board in the EKS 110 A to the multiplier N2 on the circuit board E3 in the ADU 100
	Multiplier N2 on circuit board E3 defective	Replace multiplier
Rate control in automatic operation irregular:		
a) only when shutter is closed	No shutter bias	Provide for proper installation
	Rise time too short	Increase rise times
b) also when shutter is opened and rate is constant	Rated voltage at test point U1 on control circuit board E2 not constant	Replace dual amplifier N4 or D/A transducer N5. Check ± 15 V on D/A transducer
	Ion current partially saturated	Set selector regulating switch at position $J_J \cdot J_E$ and recalibrate unit
Output increases out of proportion and rate decreases	Crucible contents alloys with crucible wall	It is absolutely necessary to replace crucible, displace spot towards center of crucible
Film thickness/rate has not been stored after process end	Voltage peak over power input of digital section	Wire all electrical loads (coil to compr. air shutter, rotary drive etc.) which are triggered by the relays K6 or K7 using RC-network (0,25 µF, 600 Ω).

7. SOME TYPICAL OPERATING CONDITIONS FOR THE ELECTRON BEAM EVAPORATION SOURCE ESQ 110 (200) AND THE ADU 100

7.1. Applying a metal film to cold substrates without glow discharge

As described in section 5, start of operation, the ADU 100 is calibrated and at least one test glass each is coated always in the same place of the substrate holder and with the substrate holder rotating. Initially, the rise times T1 or T2 respectively are set at 06 (60 s) and may be reduced later on to the extent (e.g. T1 = 05, T2 = 02, R1 = 9.0, R = 12.0) that the film thickness reproducibility is not additionally affected thereby.

In order to assure a proper automatic coating operation, it is necessary that the ADU 100 is switched on externally depending on pressure (e.g. via a vacuum switch VWS 110) with $p \leqslant 8 \cdot 10^{-6}$ mbar. The substrate holder can also be switched on by the same vacuum switch. The pressure-depending START of the ADU 100 is not attributable to the ion current measurement, it is rather a requirement inherent in the coating process, since the ion current will be affected by the residual gas appreciably only above $1 \cdot 10^{-4}$ mbar. If a film thickness of more than 10 µ has to be produced, the divisor D (selector switch "D") can be doubled or quadrupled for instance following normal calibration of the unit. In this way, the display only is reduced by the same amount. The actual rate and film thickness, however, are the double or the quadruple of the values displayed. By applying this procedure, the measruing range of the unit can be increased by a factor 10 (100 µ).

Important!

If the coating process has been interrupted prematurely (e.g. in an external triggering of the ADU, by interruption of the cooling water or high voltage failure etc.), the ADU 100 has to be set back subsequently by depressing the push-button switch RUN. This operation cannot be effected externally, the reason being that the values (film Thickness) of a parital coating process can be read only on the display of the ADU 100. Therefore, these values **cannot** be canceled externally. A continuation of the coating process, frequently permitted (where the film thickness has to be reset to compensate for the film thickness still lacking) must thus be effected on the ADU 100 exclusively.

7.2. Applying a metal film to hot substrates with previous glow discharge

Normally, such a process is taken over by a sequential control connected before the ADU 100 (or on a higher level). If no glow discharge is permitted, the heater can be switched on across the terminal switch of the plate valve without using a sequential control, i.e. the time between the opening of the plate valve and the onset of the starting-up pressure for the ADU 100 must be sufficient to allow the substrates to reach the temperature required. The adjustment of the correct starting-up pressure must be made experimentally and will change at an increasing contamination of the coating chamber.

If wafer coating is used in a coating plant, the substrates will reach a temperature of approx. 400 °C in approx. 3 - 5 min. at a heater power of 4 kW. After the film thickness has been reached, the heater can be switched off via the outlet THICKNESS REACHED (relay K15, contact 10, 11 on rack and panel connector J1 in the terminal box) and the plant be vented by means of a time lag, if required.

7.3. REMOTE control of the ADU 100

The ADU may also be triggered by means of an external nominal value (0 - 10 V, receptacle J4, REMOTE). In this application, the switch (fig. 4, item 14) is set at the position REMOTE. The recorder output is used as the actual value. As the automatic program has been disabled, all matching parameters for the entire coating process must be fed to the external control. The functions of the potentiometers P1 - P5 are maintained however.

7.4. Alloy coating with two sources ESQ 110 (200) and two control units ADU 100

(Refer to section 4.5.)

The deposition of an Al-Si alloy (approx. 1 - 2% Si) in Si-wafers in a film thickness of 1 - 1.2 μ is a frequently used coating process. Fig. 11 shows the Auger analysis of such a film. The Si distribution plotted has been produced on the cold substrate (T = < 100 °C). Frequently, the Si distribution should not be constant, but higher in the beginning and drop entirely approx. 200 - 400 nm before the film ends. This will simplify the etchability of the Al-Si film to a considerable extent.

Such requirements calling for a variable Si concentration can be met with the adjusting parameters T1, T2, film thickness 1 or film thickness 2 respectively (rate 1 and rate 2).

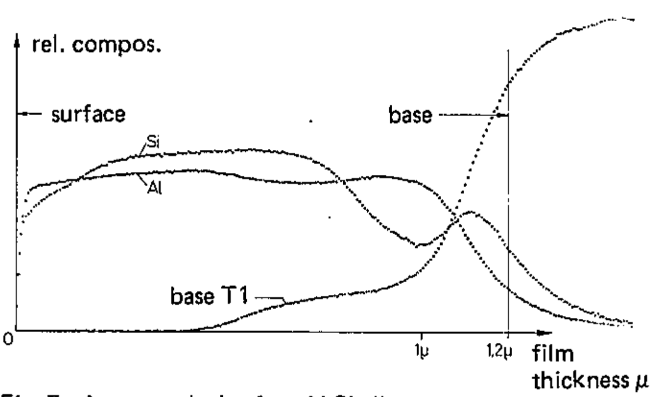


Fig. 7 Auger analysis of an Al-Si alloy

A typical example reflecting the adjustments for the two control units ADU 100, no. 2 on Al and ADU 100, no. 1 on Si may be as follows:

ADU 100, no. 2, T1=06, T2=03, R1=9.5 nm/s, R=10.0 nm/s
ADU 100, no. 1, T1=08, T2=10, R1=1.2 nm/s, R=1.5 nm/s

In this example, the ADU 100, no. 1 is started (externally or manually by depressing the push-button switch RUN) and then the ADU 100, no. 2 will be started after expiration of T1 (= 140 s). After another 100 s (expiration of T1 and T2 of the ADU 100 no. 2), the shutter above the Al source will open, and again another 10 s also the shutter located above the Si source. In this way, aluminium is evaporated only in the initial stage of the film growth. The installation shown in section 4.6.5.e between the two ADU 100 units will provide that the ADU 100 no. 1 which has expired prior to the ADU 100, no. 2 cannot transmit the switching-off pulse for the high voltage and the filament to the corresponding EKS 110 A. This switching -off pulse will be released only when the ADU 100, no. 2 has also reached its film thickness. Both gun control units EKS 110 A will then be switched off. The interval for subsequent coating of the Al source, ADU 100, no. 2 can now be set in the ADU 100, no. 1 by the proper selection of the film thickness. It is recommended to set the film thickness on the ADU 100, no. 1 in such a way that the Al source ADU 100, no. 2 will continue its coating operation for approx. 5 s at least. This will prevent an evaporation of Si alone also for a short period only.

The process flow as described above is feasible only when a separate rotary shutter has been installed above each evaporation source. Analogously, 2 complete ADU 100 units as well as two evaporation sources are installed.

If from beginning to end a uniform alloy composition is required, as much as this can be achieved for the coating operation involved, both shutters of the ADU 100, no. 1 must be opened (refer to section 4.6.3.b). This must now be the aggregate amount of T1 + T2 on the ADU 100 no. 2 equal to T2 on the ADU 100, no. 1. Otherwise, the film thickness integration has not been synchronised and one of the alloy components has not yet been included in the nominal rate value when the shutter opens. In the previous example, T2 must not be set a 09 on the ADU 100, no. 1.

Important!

When the two ADU 100 units are calibrated it should be borne in mind that a slight mutual interference of the measuring systems cannot be eliminated. Since the error of the other source remains constant in each case, however, (due to regulation), the mutual interference can be compensated when the two ADU 100 units are calibrated.

In our Al-Si example no interference of the Al Source can be discovered. It therefore follows that the ADU 100, no. 2 for aluminium has to be calibrated applying a standard procedure until the film thickness set is equal to the film thickness measured subsequently (refer to section 5, start of operation).

For the calibration of the ADU 100, no. 1 for Si it should be noted that this unit can be calibrated only when the Al source is also in operation and regulated by the ADU 100, no. 2. An initial adjustment can be made by means of the electron beam output. In a BAK 550 with Knudsen planetary and a coating rate of 10.0 nm/s of the Al source, the Si amounts to approx.

0.8% at 2.2 kW
1.5% at 2.5 kW
2.5% at 2.8 kW
} beam output and 10 - 11 kV accelerating voltage

In this case, the potentiometer AMPL. LAT. on the EKS 110 A is adjusted to 6 scale divisions, the potentiometer AMPL. LONG. to 2 scale divisions and the Wehnelt voltage to 0 V. Rotary switch on the EHS 110 in position 0. If the EHS 111 is used, the Wehnelt electrode is always at the cathode potential. The required connection on the Wehnelt section of the ESQ 110 (200) is made by replacing an insulator underneath the screw head of one check screw on the Wehnelt support with a Cr-Ni washer. The second check screw of the Wehnelt section must remain insulated, however, since otherwise the cathods will be shortcircuited (refer to operating instructions BB 800 059 BE, fig. 8).

The spot position should be adjusted for the Si source on the EKS so as to avoid a melting of the Si at the crucible edge for approx. 6 - 10 mm during Si evaporation (to prevent splashing!). (AMPL. LONG: 2 scale divisions, FREQU. LONG: 5 scale divisions, AMPL. LAT.: 6 scale divisions). In order to utilise the sweep action of the electron beam also in the automatic control operation of the ADU, the switch (fig. 4, item 15) of the ADU 100, no. 1 must be placed in position SWEEP.

Both crucibles should always rotate during evaporation.

In manual control, second mode, (refer to section 5.3.), the output of the Si source is slowly increased with the Al source operating simultaneously until after approx. 2 min the output is approx. 2 kW (the output will fluctuate around this value). Following this, the selector switches D (push MODIFY after each new input) and the position of the potentiometer P3 (almost full deflection) are set so that 1.5 nm/s are indicated on the display. In this way, the sensitivity of the rate measurement is increased by the factor 10 approximately. Subsequently, the values of

T1 ='08, T2 = 10, R1 = 0.8 nm/s, R = 1.5 nm/s as well as a film thickness of 250.0 nm (in order to cite an example)

are set on the ADU 100, no. 1 in automatic operation, and after opening the shutter, the nominal value input is changed on the potentiometer P5 until 1.5 appears again on the display.

Now both sources are re-adjusted and have the following power input:

Al source approx. 9 kW
Si source approx. 2 kW

If necessary, the position of the potentiometer P4 has to be readjusted to avoid a heavy fluctuation of the beam power on the Si source when the Si shutter has been opened. A fluctuation of the output amounting to approx. 50% during a period of less than 3 s is negligible. If two separate shutters are used, it may be a benefit to apply a ground potential to the shutter potential of the Si shutter (change shutter connection on rack and panel connector J2 in the terminal box from contact 3 to contact 6 - refer to section 4.5.4.e). Depending on the installation of both sources, the interference of the Si source becomes less only when the Al source is always kept at a ground potential. The potentiometer P4 must then be set in such a way that the beam output of the Al source with the shutter closed is approx. 10 - 20% lower than with the shutter opened.

7.5. Process flow for Al-Si coating operations

Have all coating parameters been set correctly, and particularly the installation in the coating chamber been made with care, the functions for rate, output, and ion current as indicated further below will result. In this regard, be sure to check that you have complied with the precautionary measures enumerated herewith: no undefined potentials, shutter above the Si source always at ground potential, if necessary. In the opened condition, the Si shutter should be located underneath the Al shutter so that the condensed Si film will always be covered with an aluminium film. Also be sure that the screening box above the Si detector has been firmly attached to the horizontal cover plate and that the Al block is periodically cleaned.

In fig. 12 the output of the Si source and the ionic current of the Si source are now plotted. Special care should be taken that the emission current does not exceed 300 mA (set POWER LIMIT on the EKS 110 A!).

If the emission current of the Si source decreases under 150 mA at an increase of the beam output on the Al source with the Si shutter still closed, the interference of the Al source is too high. If the Si shutter is also grounded when closed, the emission current will remain at above 200 mA. The plotted values (ion current approx. 50 μA, emission current 230 mA, high voltage 11 kV) amount to approx. 0.15 nm/s related to a Knudsen planetary in the coating plant BAK 550.

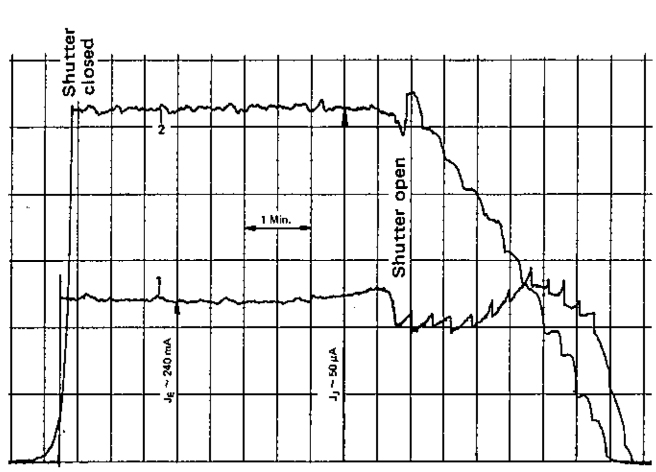


Fig. 12: electron beam output as a function of time (plotted as the beam current J_E at 11 kV accelerating voltage (curve 1) and the ion current J_J (curve 2) during the evaporation of Si. (Coating speed approx. 0.1 nm/s (1.0 Å/s) at a distance of 50 cm above the evaporation source).

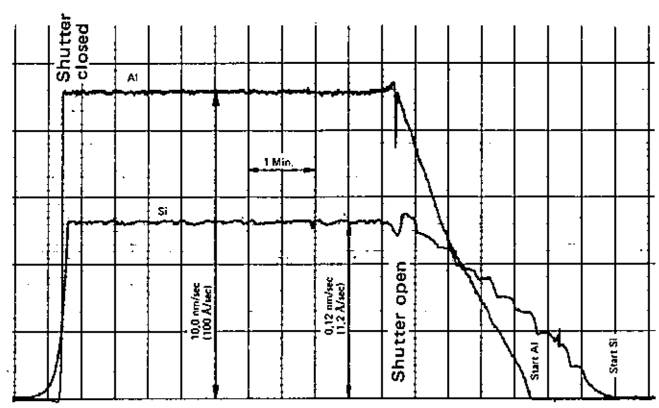


Fig. 13: rate of an aluminium-silicon alloy process (98.8% Al, 1.2% Si) plotted as a function of time.
The Si source is started approx. 80 s prior to the Al source.

In fig. 13 the rate signal of the two ADU 100 units is plotted. In this graph, the Si source is regulated by the ion current (selector regulating switch (S5) in position J_J), the Al source is regulated by the product signal (selector regulating switch (S5) in position $J_J \cdot J_E$).

The respective ion currents which can be measured in the detector circuit with a DC instrument for each detector, amount to approx. 50 μA for the Si source and approx. 4 mA for the Al source. The detector voltage of each source should be set at –200 V. Note the slight transient when the shutters are opened.

In fig. 14 the rate signal of the Si ADU 100 is compared with the rate signal of a quartz crystal measuring device (crystal head position: approx. 40 cm above the Si source, 20 cm laterally displaced).

Shortly after opening the shutters, the rate signal of the quartz crystal becomes negative (due to heat radiation). After 10 s the display increases to 7 Hz/s and then slowly to approx. 10 Hz/s during 1 min. If the shutter is closed again, the rate display of the quartz crystal decreases slowly to approx. 2 - 3 Hz/s reaching zero after approx. 2 min. The slow increase of the crystal frequency is due to an error in measurement of this measuring device. The periodical progress of the quartz crystal rate results from the crucible rotation. In contrast to the quartz crystal which covers the evaporation speed within a small solid angle only (point by point measurement), a mean-value signal across the entire evaporation rate (averaging in all directions) is obtained with the ion current on the collecting detector.

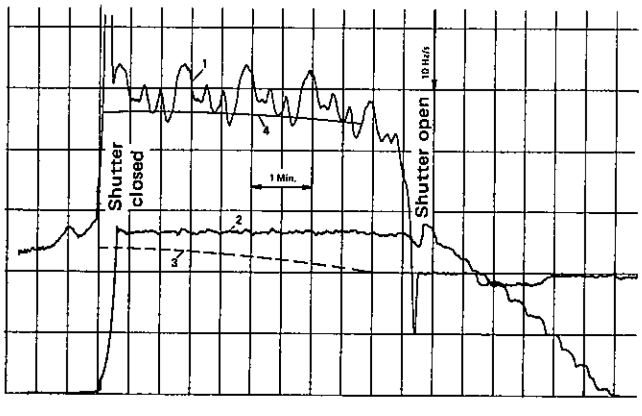


Fig. 14: comparision of the Si rate display measured with quartz crystal (curve 1) and measured with the ion current (curve 2).

When the shutter is opened, the quartz crystal is affected by the temperature radiation to a considerable extent. (Negative rate signaö of the quartz crystal for a few seconds). After 25 seconds only, the actual coating rate is indicated. The temperature drift takes place during the entire coating period. The zero line drifting under the influence of the temperature radiation is shown as a broken line (curve 3). Since the quartz crystal measuring system is a point by point measurement, the signals will periodically overlap due to the crucible rotation. The curve 4 indicates the mean-value line of the quartz crystal signal.

7.6. The alloy evaporation with variable composition of the alloy components

The film thickness integration starts as soon as the shutter above the respective source is opened (i.e. as soon as the shutter back indication has taken place). There are various possibilities to open the shutter already prior to the expiration of the second rise time T2.

If the voltage is supplied from the vacuum signal, contact 9/J1 in the terminal box of the EKS 110 A via the relay contact K1 (T1 - T2) in the terminal box of the ADU 100 at 8/9, J2 to the shutter control at contact 1/J2, the shutter will open already after the first rise time T1 has expired.

If during an alloying process both shutters are triggered in parallel by an ADU 100 and the rise times T1 + T2 for the two control units are set differently, an alloying progress as plotted in fig. 16 can be obtained.

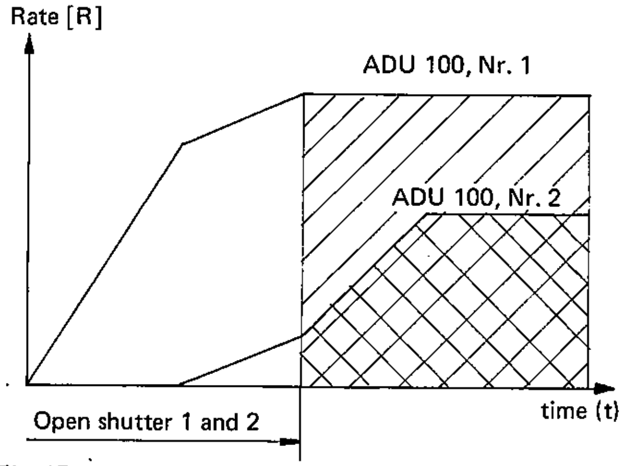


Fig. 15

Process flow of ADU 100, no. 1 and ADU 100, no. 2

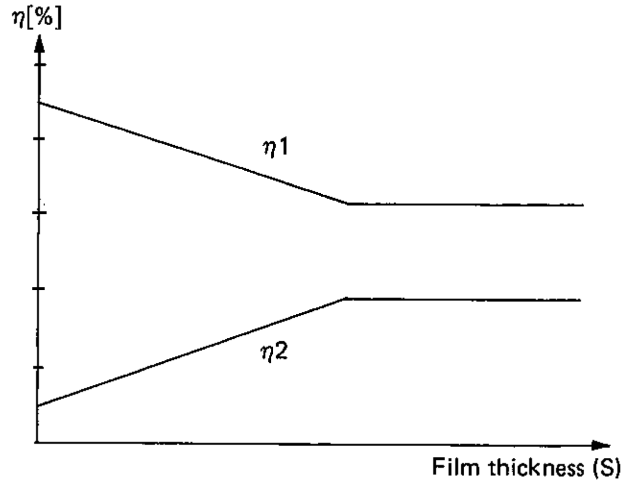


Fig. 16

Composition as a function of the film thickness

$$\eta 1 = \frac{\text{relative amount (1)}}{\text{relative amount (1 + 2)}}$$

$$\eta 2 = \frac{\text{relative amount (2)}}{\text{relative amount (1 + 2)}}$$

8. SPARE PARTS

Spare parts have to be ordered in accordance with the spare parts list attached.

When ordering spare parts, please indicate unit model and serial number as specified on the name plate.

Ordering example
1 set of insulating material according to spare parts list BB 800 095 E/1, item 54, ordering number BG 241 461 -T.

Mounting instructions for relay set BG 241 253 -T

The relay K14 is required in the model EKS 110 A for switching on and off the crucible rotation automatically in the operation of the gun by the automatic evaporation control unit ADU 100 being an integral component of the gun.

EKS 110 A models with serial numbers up to 244

In this units which in most cases have been furnished to the customers already, the relay K14 has to be mounted subsequently. The material required is included in the relay set BG 241 253 -T. The wiring is shown in the diagram BG 005 262 BS. The relay has to be mounted in the section on the right hand side behind the current relay K12.

EKS A modles with serial numbers counting from 245

In these units the wiring has already been made on a plug-in module for the relay K14 in standard production. The relay K14, included in the relay set, has to be inserted only.

BG 241 414

	Description Teil	Item Pos.	Code-No Bestell-Nr.	S	Remarks Bemerkungen
1	Regulating circuit board / Regelprint	1	BG 241 419 BU		
1	Relay circuit board / Relaisprint	2	BG 241 175 BU		
1	Power supply board / Netzteilprint	3	BG 241 183 -U		
1	Display board / Displayprint	4	BG 241 278 -U		
1	Switching board / Schaltprint	5	BG 241 282 -U		
1	Connection board / Verbindungsprint	6	BG 241 292 -U		
1	Power supply board / Netzprint	7	BG 241 295 -U		
1	Wire wrap board I / Wire wrap Print I	8	BG 241 286 AU		
1	Wire wrap board II / Wire wrap Print II	9	BG 241 287 AU		
1	Plate / Platte compl.	10	BG 241 430 -U		
1	Transformer / Transformator *BG 241 187*	11	B 5128 251 ME	T2	
1	Transformer / Transformator *BG 241 188*	12	B 5128 201 ME	T1	
1	Transformer / Transformator *BG 241 296*	13	B 5128 253 ME	T4	
1	Transformer / Transformator *BG 241 332*	14	B 5128 403 ME	T3	
		15			
1	Meter / Messgerät *BG 241 186*	16	B 5201 201 GH	MI1	
1	Switch / Schalter 01 - 2 x 3U	17	B 4743 071 PD	S7	
1	Switch / Schalter 01 - 4 x 6	18	B 4743 022 PD	S8	
2	Switch / Schalter 1-2/1U, S 2012	19	B 4752 012 SA	S5,S10	
1	Switch / Schalter 1-2/4U, S 2042	20	B 4752 042 SA	S9	
1	Switch / Schalter 1-M/1U, S 2015	21	B 4752 015 SA	S6	
		22			
5	Fuse holder / Sicherungshalter	23	B 4661 206 A0		
1	Fuse / Sicherung, 0,1 A slow / träge	24	B 4666 416		
2	Fuse / Sicherung, 0,2 A slow / träge	25	B 4666 422		
2	Fuse / Sicherung, 0,5 A slow / träge	26	B 4666 430		
		27			
1	Potentiometer 10 kΩ, 0,05 W pos.-log.	28	B 4873 410 DA	R70	
3	Potentiometer 10 kΩ, 1,5 W	29	B 4883 410 TC	R65,	R66, R68
1	Potentiometer 20 kΩ, 1,5 W	30	B 4883 420 TC	R67	
1	Potentiometer 100 kΩ, 1 W	31	B 4886 510 R3	R69	
3	Knob / Drehknopf 020 - 2320 SW	32	B 4797 101 FM		
3	Cover / Deckel 040 - 1010 GU	33	B 4797 115 DA		
		34			
1	Capacitor / Kondensator 220 V AC, 30561-7	35	B 4988 510 Y8	LC1	
1	Capacitor / Kondensator 63 V, 2200 µF	36	B 4902 522 R9	C15	
		37			
1	Socket / G-Stecker, 3 P + E, 3110 020	38	B 4722 121 CB	J2	
1	Socket / G-Dose, 6 P + E, 3107 020	39	B 4722 133 CB	J11	
1	Socket / G-Dose, 3BU, 326 3000	40	B 4722 463 CA	J3	
1	Socket / G-Dose, 4BU, 330 3000	41	B 4722 464 CA	J5	
5	Socket / G-Dose, 4St, 320 2000	42	B 4722 403 CA	J4, J6	– J9
1	Socket / G-Stecker, 6 P + E, 3106 020	43	B 4722 123 CB	J12	
1	Socket / GS-Dose, MS3102 E - 24 - 28 - S	44	B 4722 753 MC	J10	
1	Socket / M-Leiste, RTG 22 A 30 AE 130 - 5	45	B 4720 185 NA	J1	
4	Plug strip / Seckleiste PCC D15 S 04 - GE 0030	46	B 4717 181 QD	J16 –	J19
4	Polar key / Polarisationsschlüssel PCP4 - GE 3	47	B 4717 181 91		
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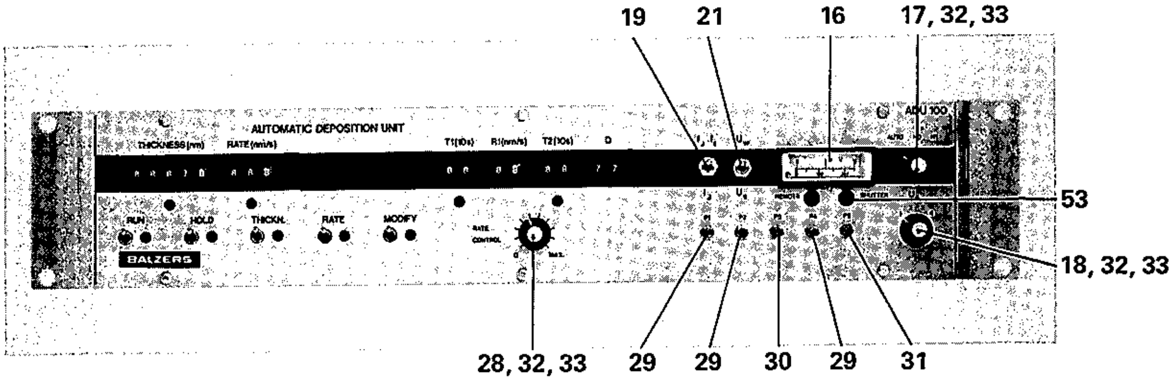
		49			
1	Socket / Buchse red / rot	50	B 4710 141 02		
1	Socket / Buchse blue / blau	51	B 4710 141 06		
		52			
2	Light diode / Leuchtdiode LEDXC 556 RTD, ϕ 5,1	53	B 5059 482 MR		
1	Set of insulators / Isoliersatz	54	BG 241 461 -T		*
		55			
1	Relay / Relais FR 11 P, 24 V, DC, 580 Ω	56	B 4782 123 KA		enclosed in item 2
1	Resistor / Widerstand 330 Ω, 4,2 W	57	B 4836 233 VC	R72	}
1	Resistor / Widerstand 5,6 kΩ, 5 W	58	B 4836 356 VB	R71	in Pos. 10 enthalten
1	Capacitor / Kondensator 4,7 nF, 500 V	59	B 4955 347 V7	C16	enclosed in item 10
1	Rectifier / Gleichrichter 10 DB 4A	60	B 5036 850 HS	D15	}

Spare Parts for / Ersatzteile zu BG M18 750

Autom. deposition unit / Autom. Aufdampfsteuergerät ADU 100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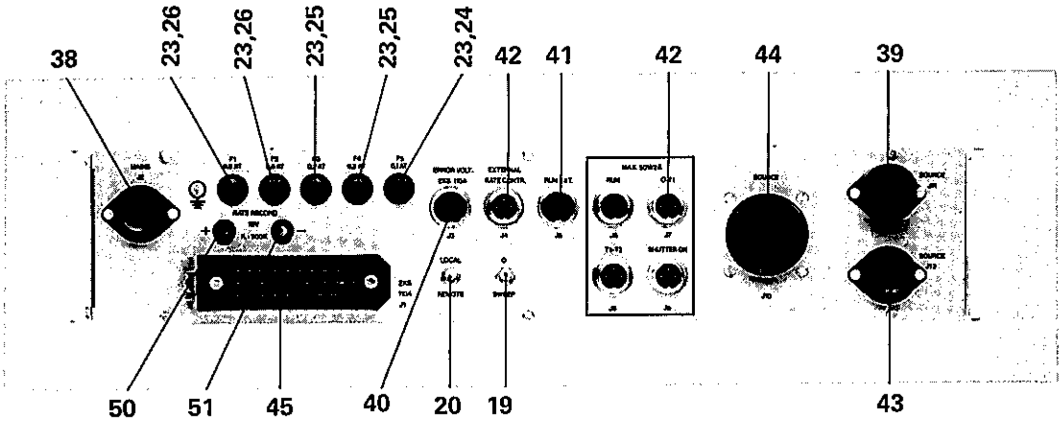
AUTOMATIC DEPOSITION UNIT
ADU 100
THICKNESS (nm)
RATE (nm/s)
T1(10s)
R1(nm/s)
T2(10s)
D
RUN
HOLD
THICKN.
RATE
MODIFY
RATE CONTROL
SHUTTER
BALZERS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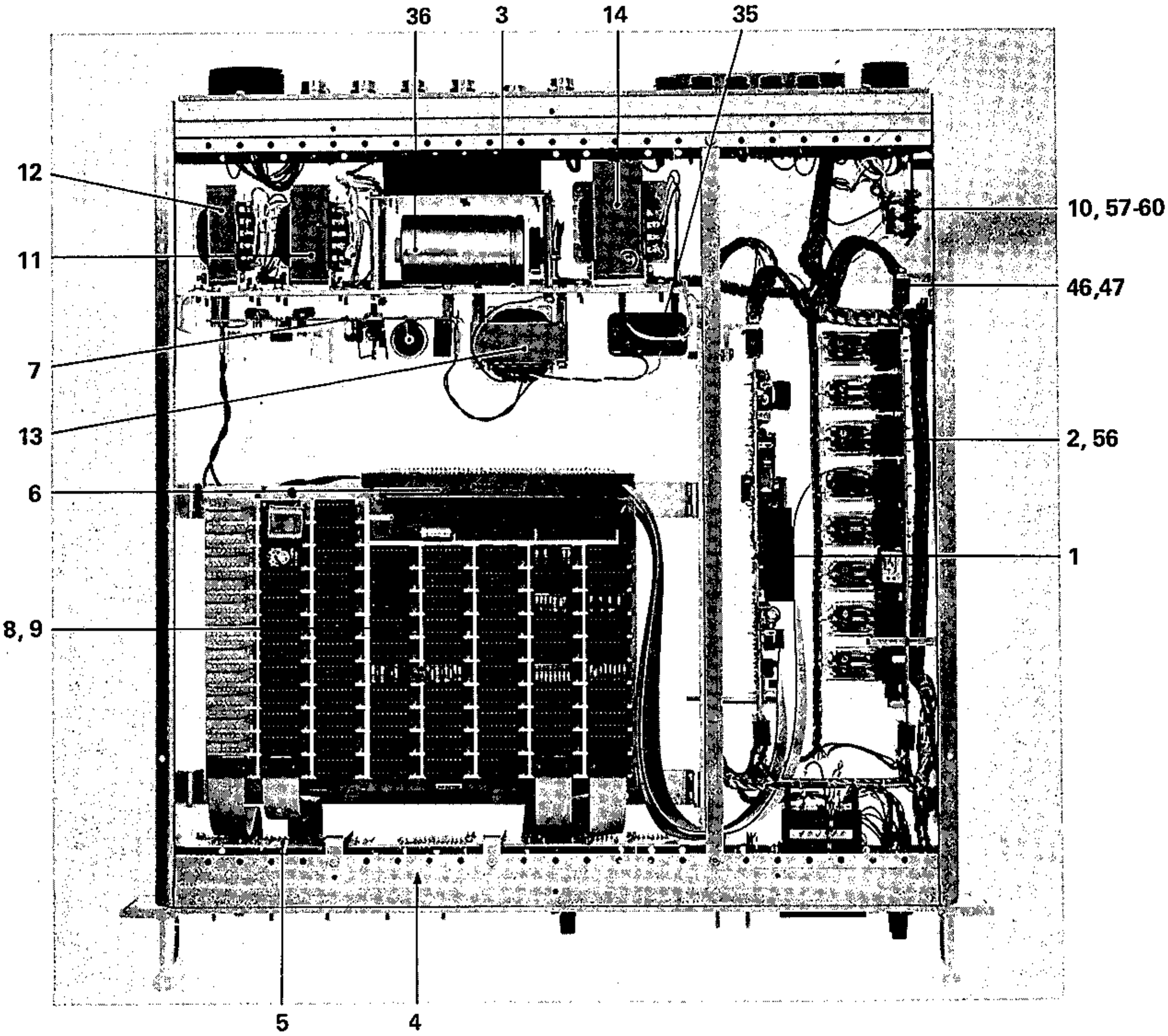
RATE RECORD.
ERROR VOLT.
EXTERNAL RATE CONTR.
LOCAL
REMOTE
SOURCE
SHUTTER ON


36
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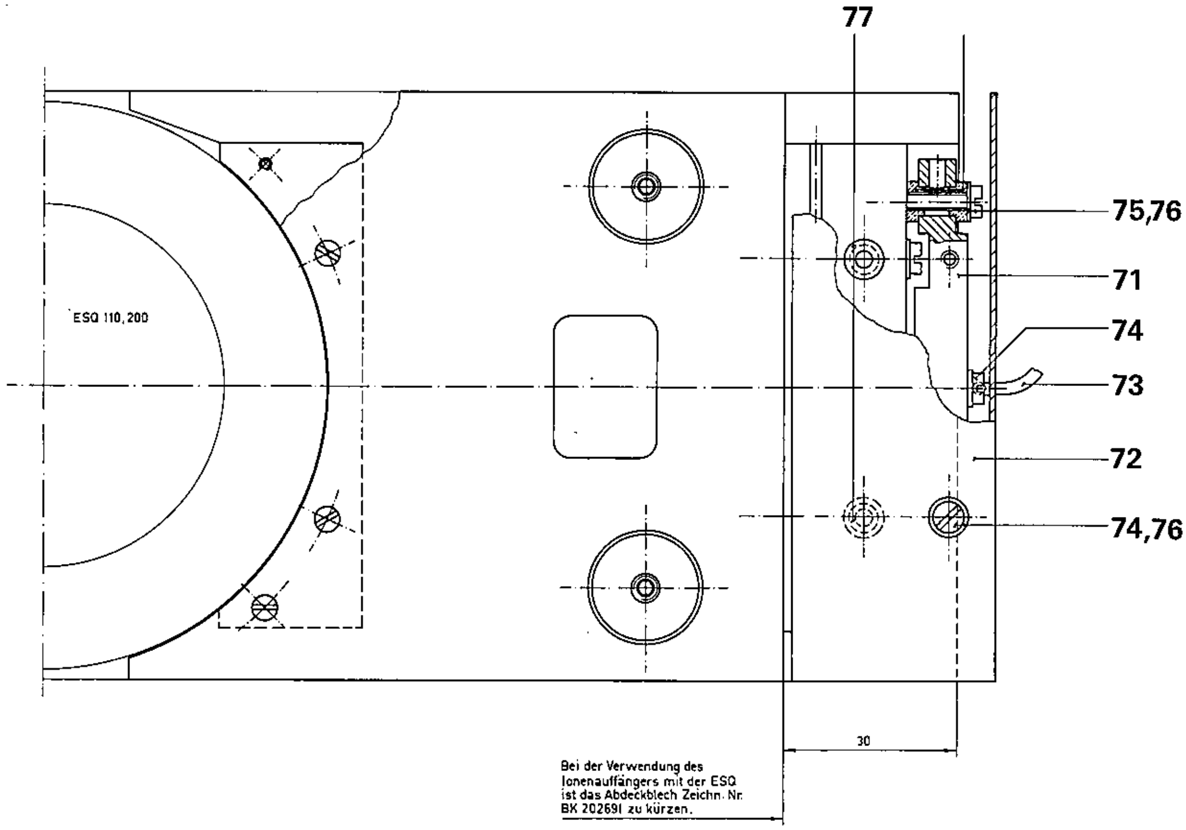
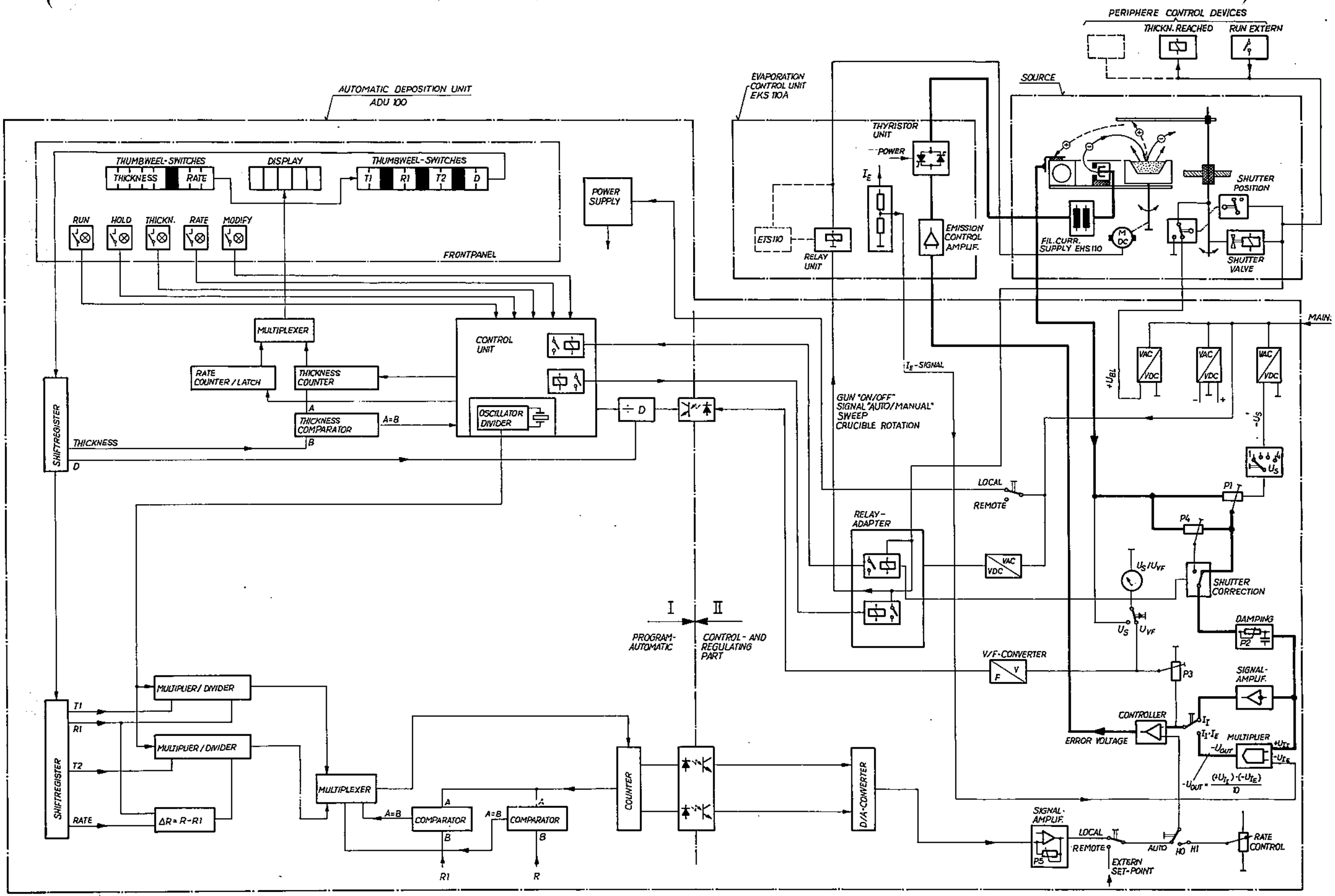
	Description Teil	Item Pos.	Code-No. Bestell-Nr.	S	Remarks Bemerkungen
1	Terminal bar / Anschlussbalken	71	BK 204 007		
2	Sensor / Auffänger	72	BK 204 008 A		
1	Cable / Kabel 1,5 m	73	BK 204 011 -T		
3	Screw / Schraube, M3 x 6	74	N 3052 189 -X		
2	Screw / Schraube, M3 x 16	75	N 3052 198 -X		
4	Washer / Unterlagsscheibe 3,2/7 x 0,5	76	N 3502 412 -X		
20	Nozzle / Einzeltülle 71-6115	77	B 4622 251 TN		



Spare Parts for / Ersatzteile zu

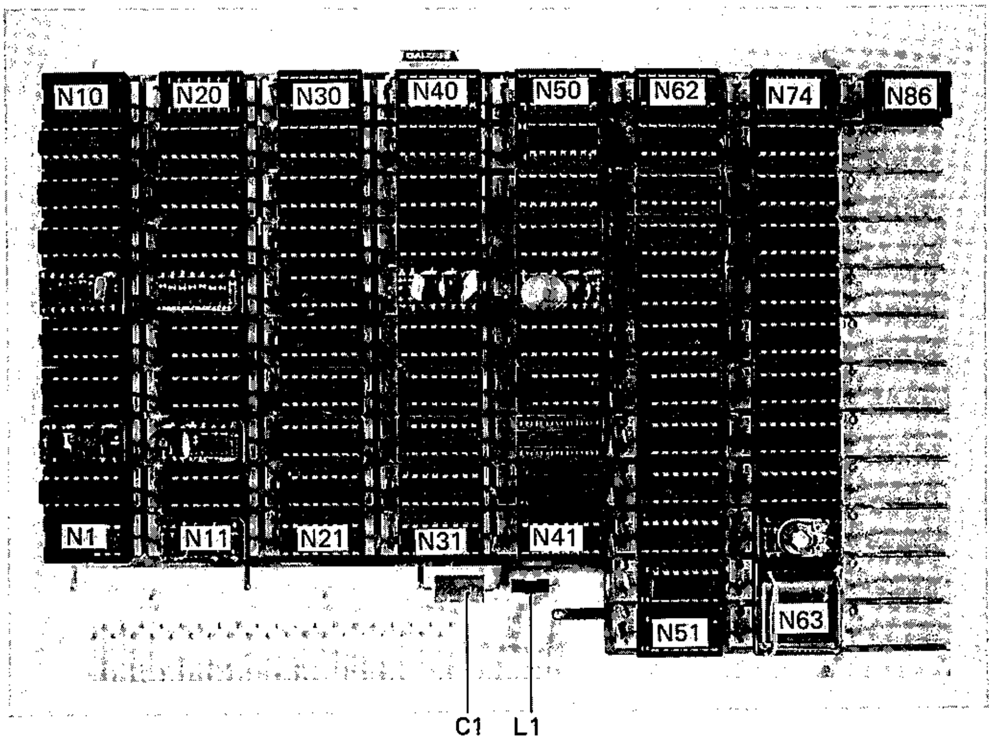
Ion collector / Ionenauffänger BK 204 013 BT

BB 800 095 E / 3

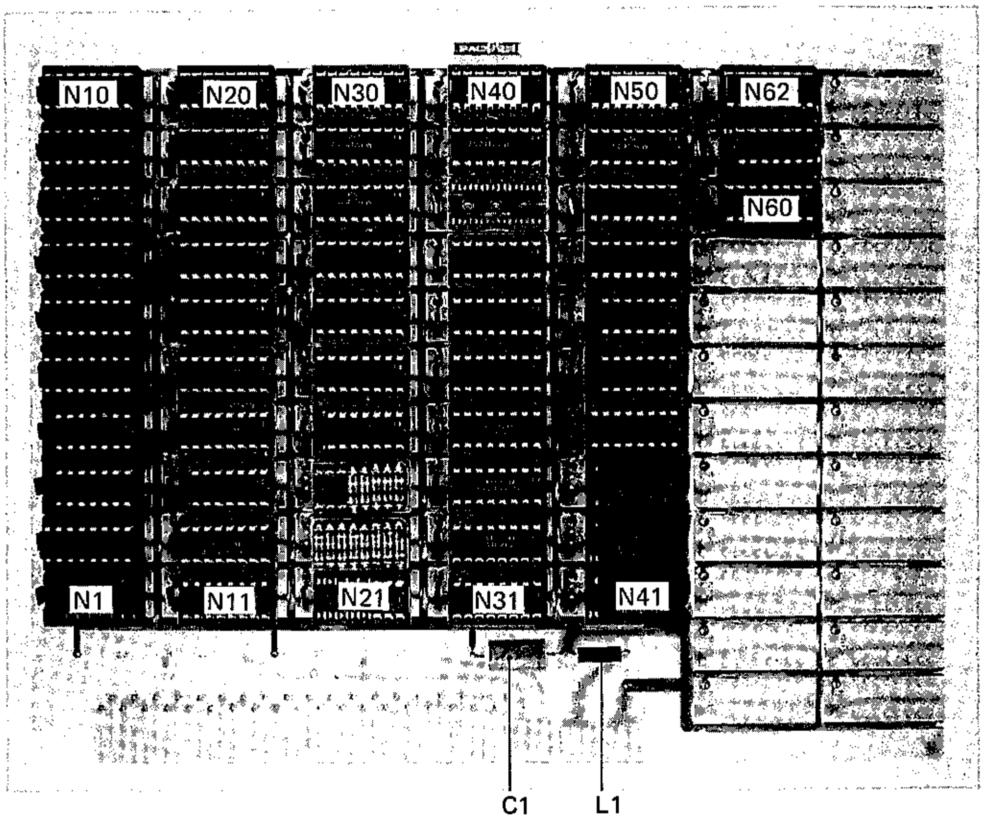


Blocdiagram / Blockschema

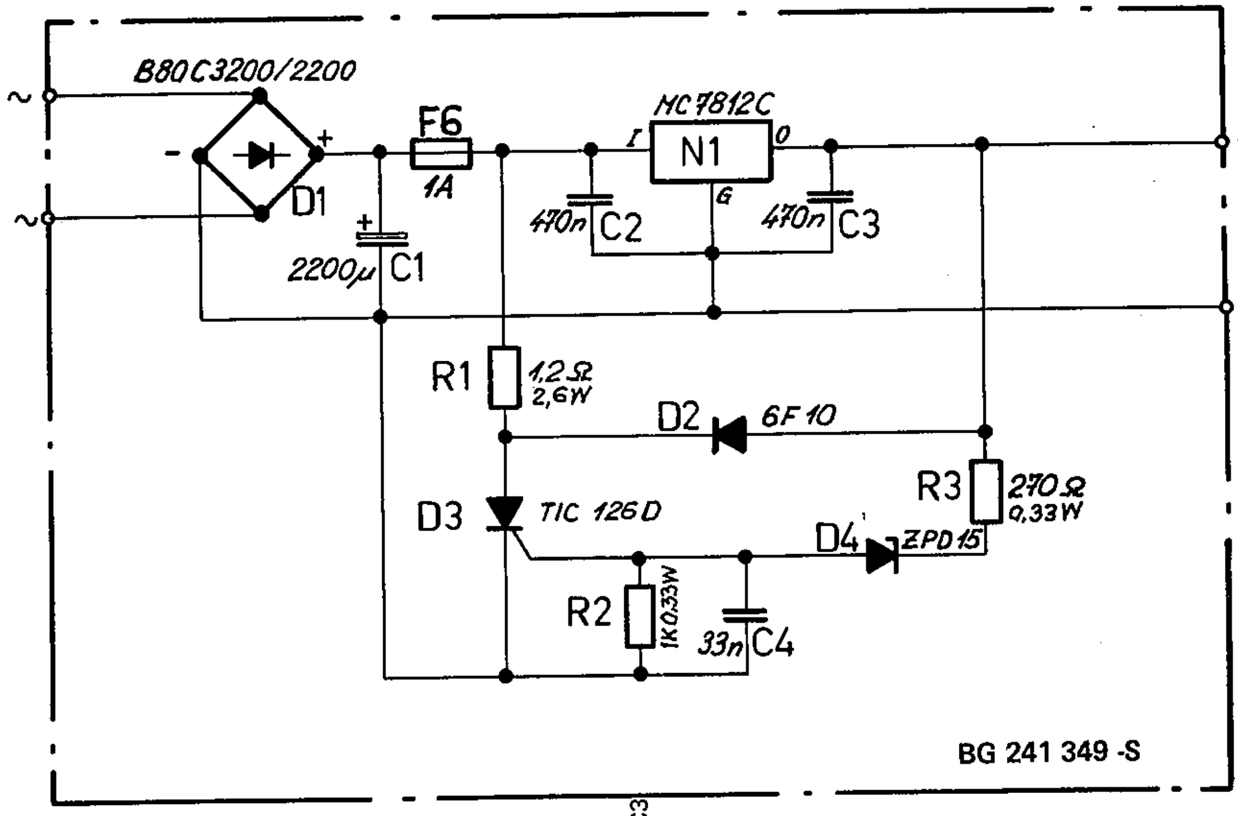
BG 241 500 -S

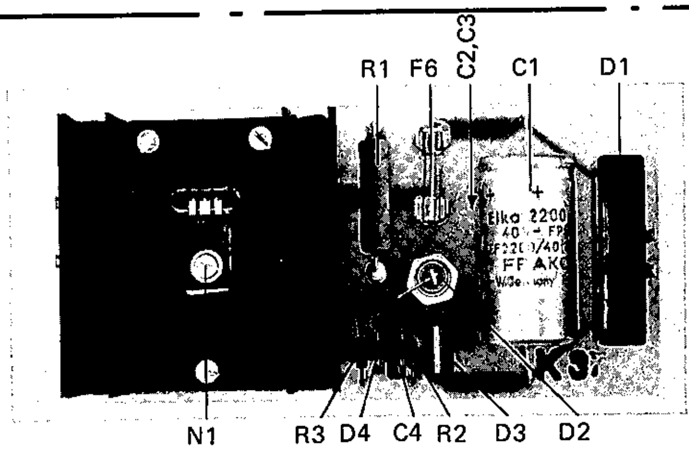


Wire wrape board / Wire wrape Print 1 **BG 241 286 AU**



Wire wrape board / Wire wrape Print 2 **BG 243 287 AU**





Power supply board / Netzprint

BG 241 295 AU

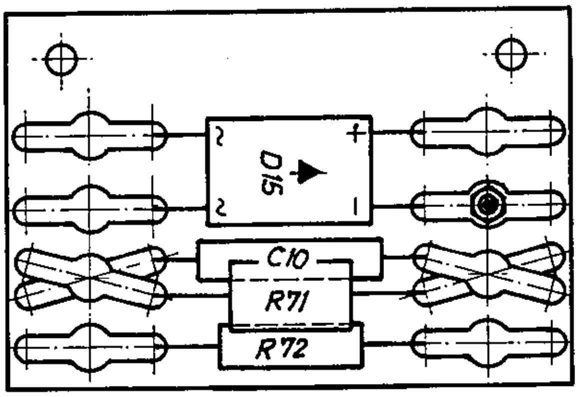
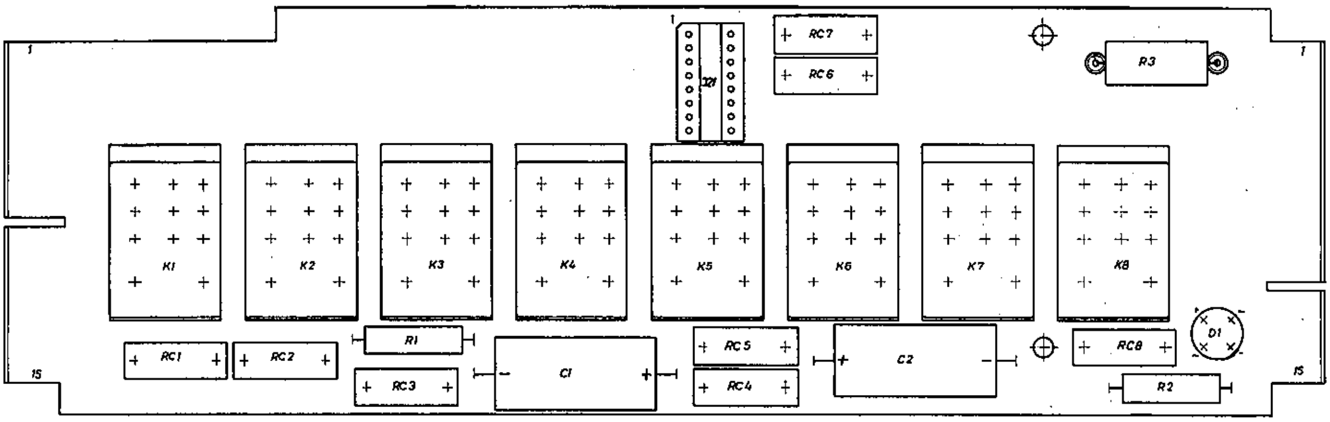
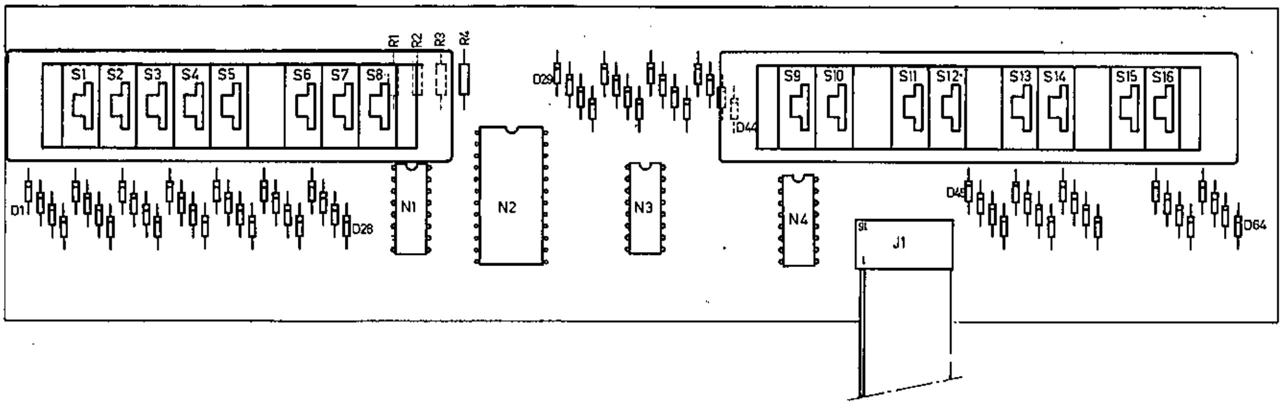


Plate / Platte

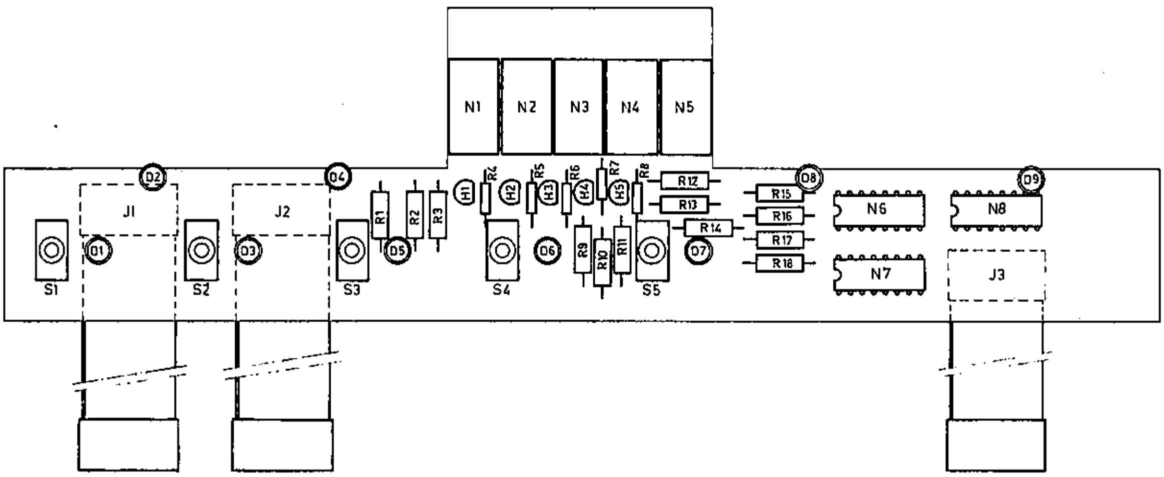
BG 241 430 -U



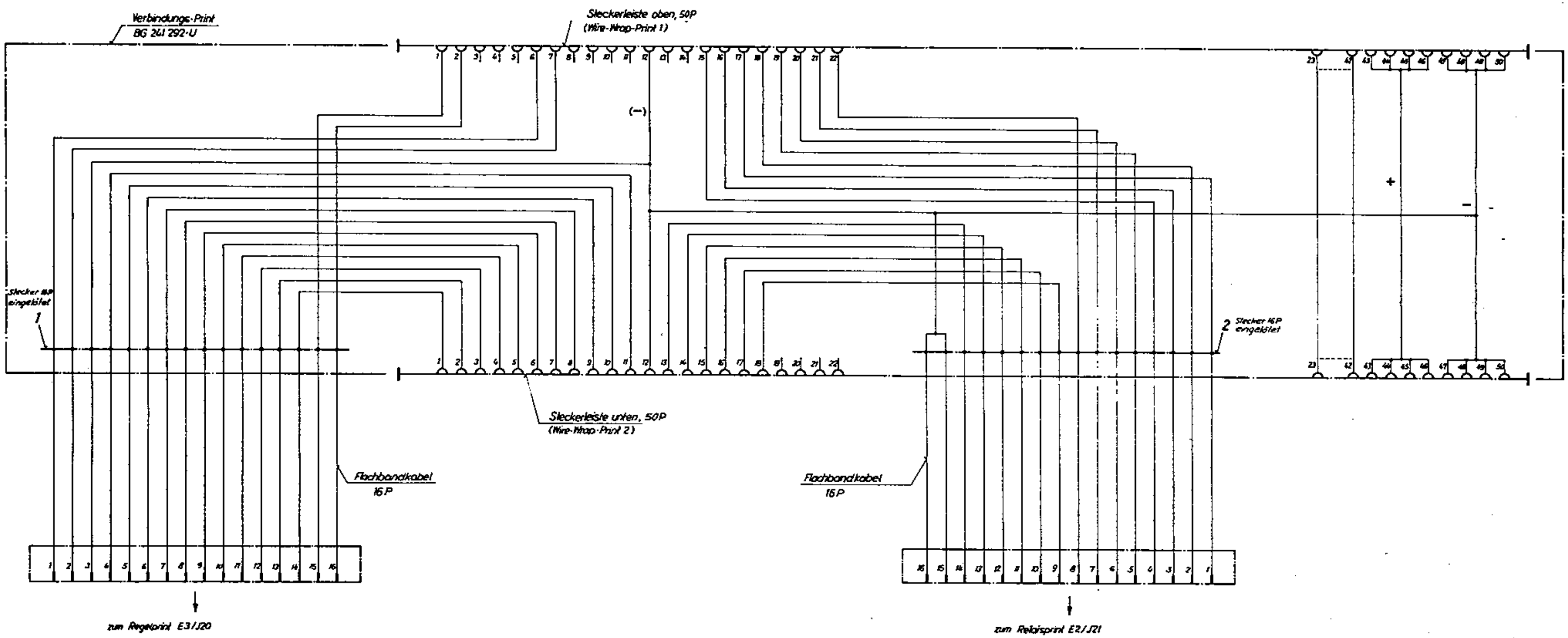
Relay ciruit board / Relaisprint BG 241 175 AU



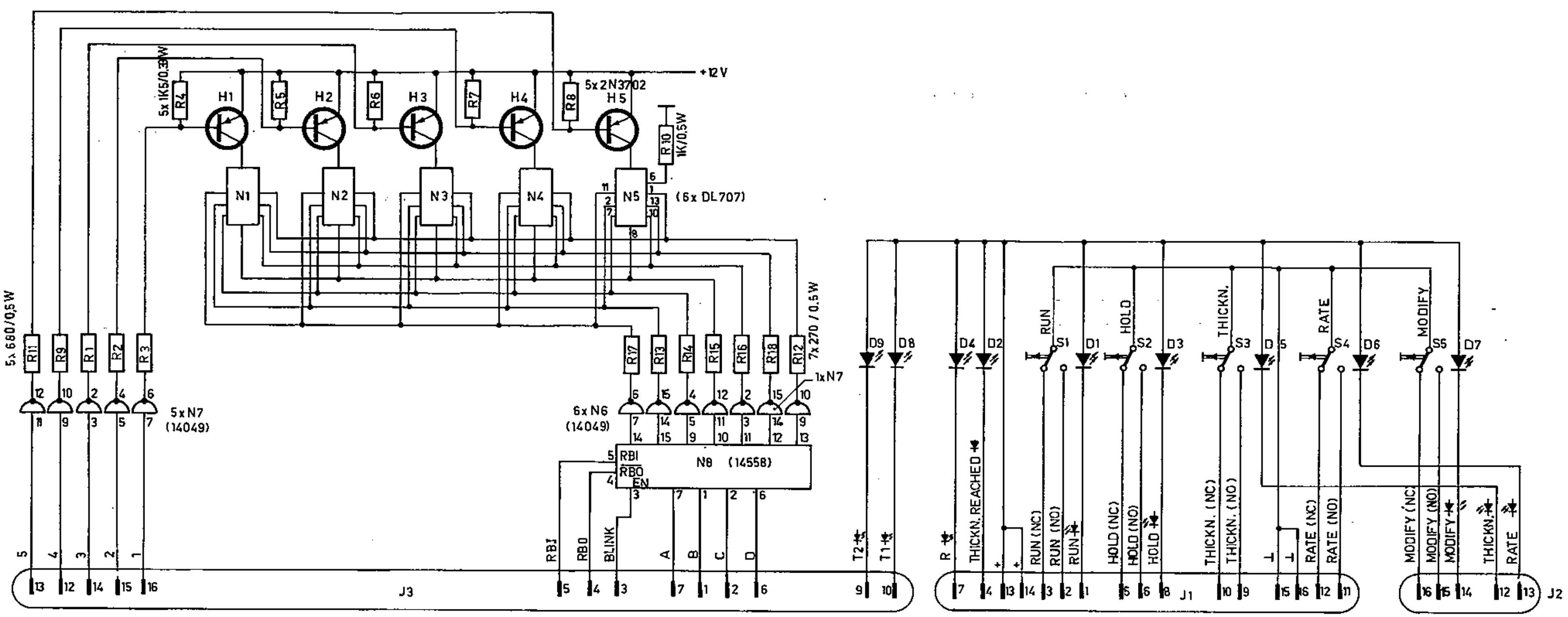
Switching board / Schaltprint BG 241 282 -U



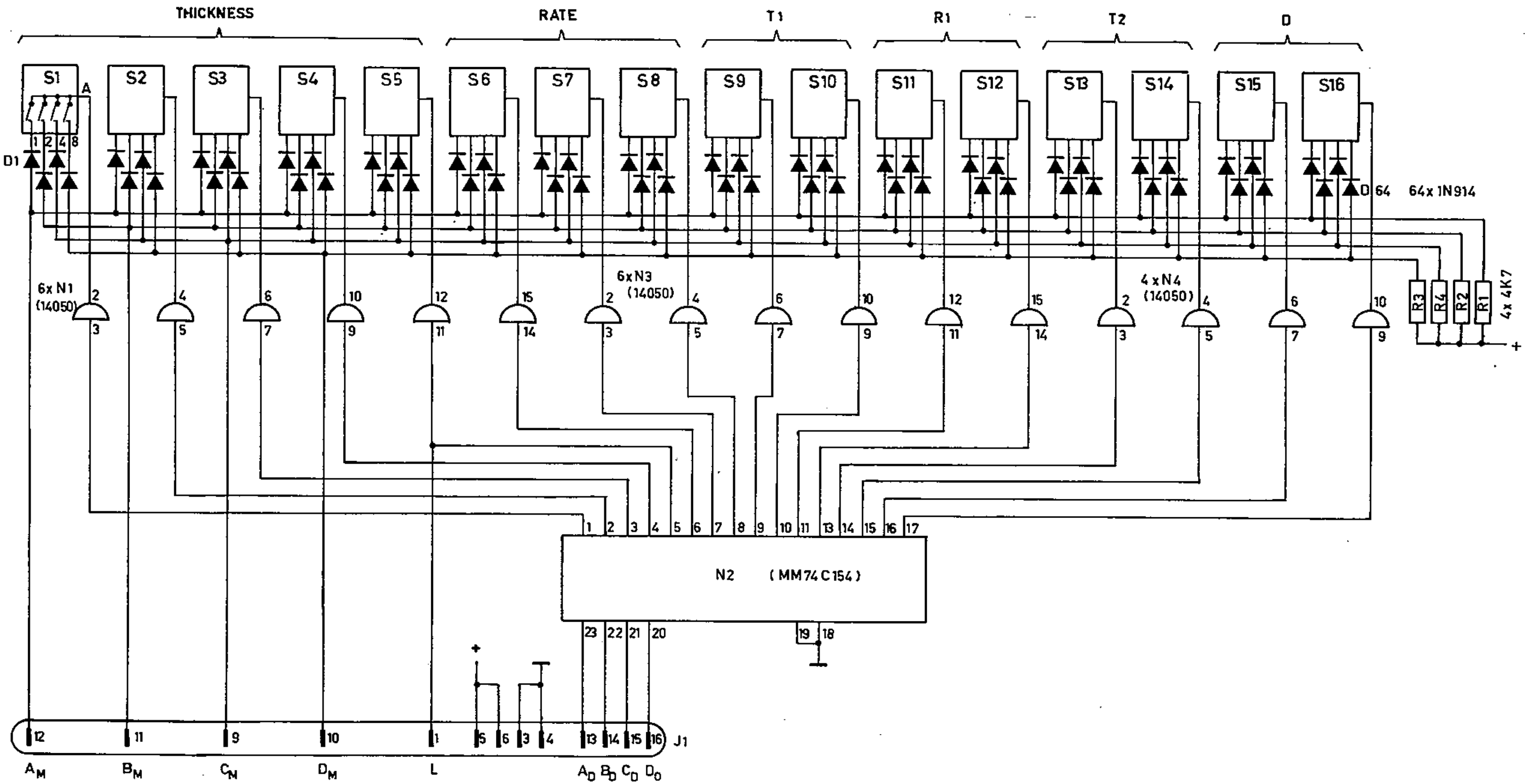
Display board / Displayprint BG 241 278 -U



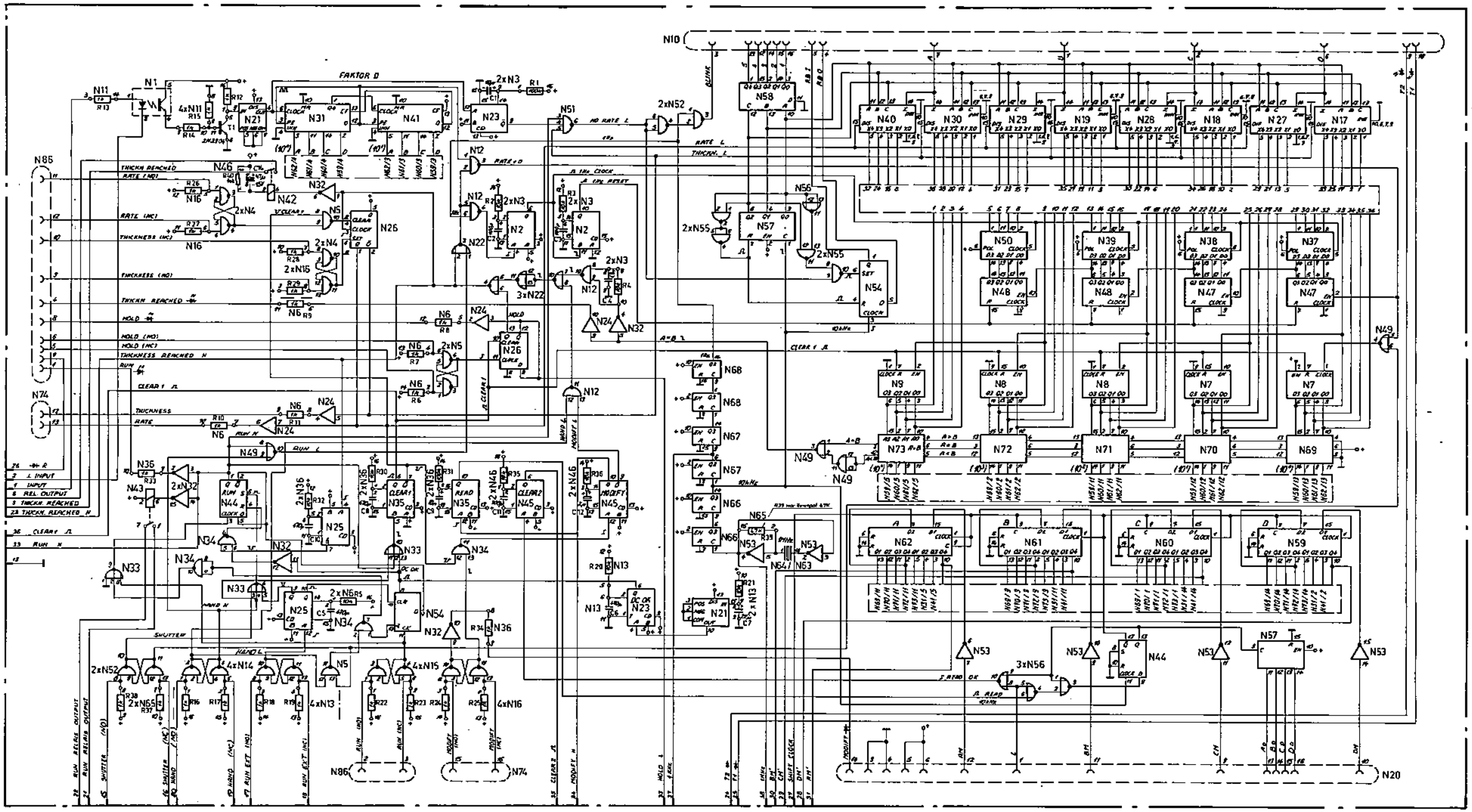
Connection board / Verbindungsprint BG 241 521 -S



Display board / Displayprint BG 241 347 -S



Switching board / Schaltprint BG 241 348 -S



N	Supply GND	Supply +V	Type	Repl Type
1		5	TIL 111	
2	8	16	4538	
3			Adapter	
4	7	14	4011	
5	7	14	4011	
6			Adapter	
7	8	16	4518	
8	8	16	4518	
9	8	16	4518	
10			Stecker	
11			Adapter	
12	7	14	4011	
13			Adapter	
14	7	14	4011	
15	7	14	4011	
16			Adapter	
17	8	16	4512	
18	8	16	4512	
19	8	16	4512	
20			Stecker	
21	8	16	4583	
22	7	14	4011	
23	8	16	4528	
24	8	1	4050	
25	8	16	4538	
26	7	14	4013	
27	8	16	4512	
28	8	16	4512	
29	8	16	4512	
30	8	16	4512	
31	8	16	4522	
32	8	1	MC 14049	
33	7	14	4025	
34	7	14	4011	
35	8	16	4538	
36			Adapter	
37	8	16	4042	
38	8	16	4042	
39	8	16	4042	
40	8	16	4512	
41	8	16	4522	
42		2	Reed Relais	
43		2	Reed Relais	
44	7	14	4013	
45	8	16	4528	
46			Adapter	
47	8	16	4518	
48	8	16	4518	
49	7	14	4001	
50	8	16	4042	
51	7	14	4023	
52	7	14	4011	
53	8	1	MC 14049	
54	7	14	4013	
55	7	14	4011	
56	7	14	4001	
57	8	16	4520	
58	8	16	4028	
59	8	16	4015	
60	8	16	4015	
61	8	16	4015	
62	8	16	4015	
63			Adapter	
64			Adapter	
65			Adapter	
66	8	16	4518	
67	8	16	4518	
68	8	16	4518	
69	8	16	4585	
70	8	16	4585	
71	8	16	4585	
72	8	16	4585	
73	8	16	4585	
74			Stecker	
75				
76				
77				
78				
79				
80				

Note:
all INPUTS nonused are grounded,
all resistors ¼ W 5%

BALZERS
AKTIENGESELLSCHAFT

OP | DV | ZV | MF

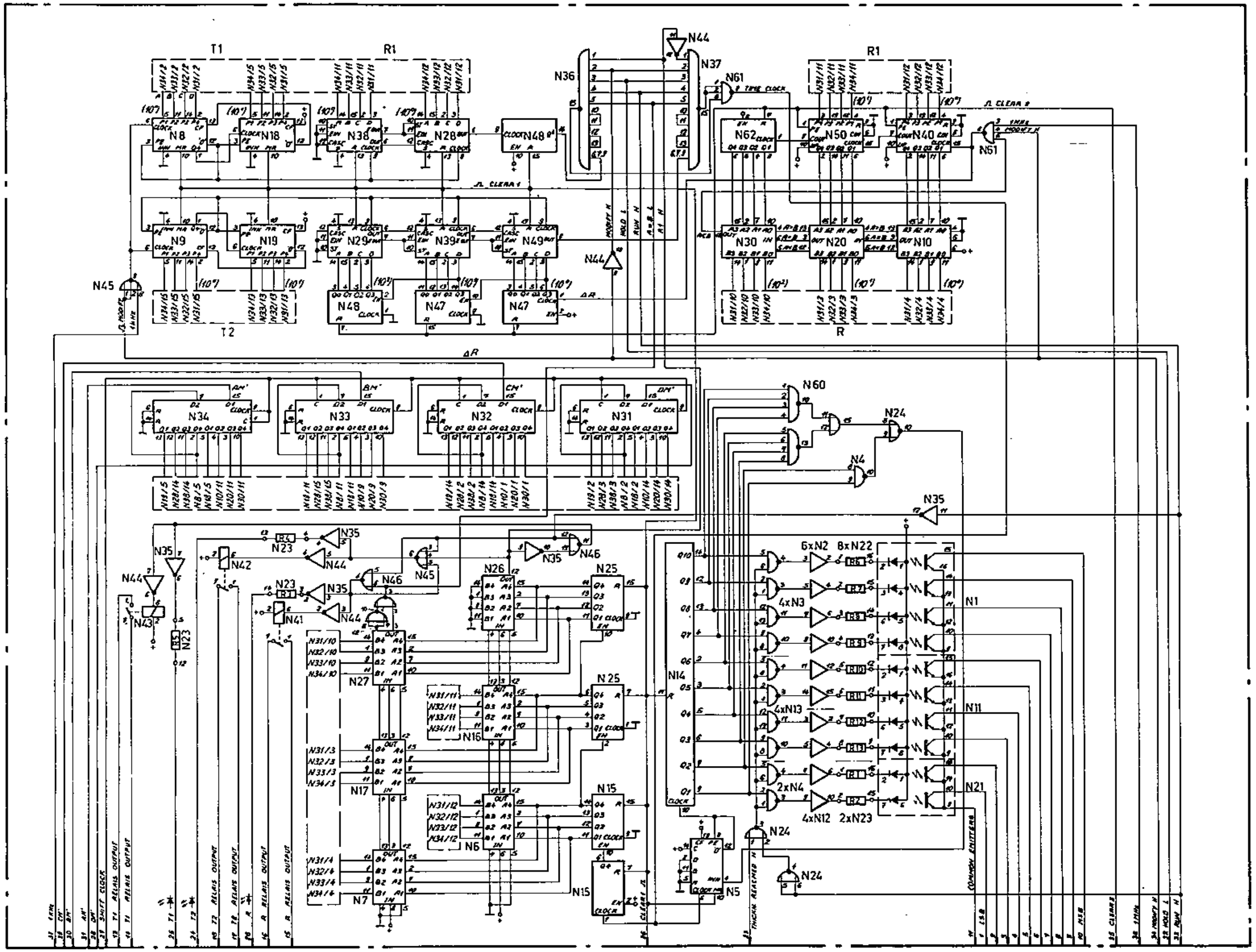
BG 241 273-Z

EEBR

02.7.75
7.11.75

WIRE-WRAP-PRINT 1 Schema

BG 241 345 S



N	Supply GND	Supply +12V	Type	Repl. Type	N	Supply GND	Supply +12V	Type	Repl. Type
1			ILQ 74		36	8	16	4501	
2	8	1	4050		37	8	16	4601	
3	7	14	4011		38	8	16	4527	
4	7	14	4011		39	8	16	4527	
5	8	16	4522		40	8	16	4510	
6	8	16	4585		41	/	2	Reed Relais	
7	8	16	4585		42	/	2	Reed Relais	
8	8	16	4522		43	/	2	Reed Relais	
9	8	16	4522		44	8	1	4049	
10	8	16	4585		45	7	14	4026	
11			ILQ 74		46	7	14	4001	
12	8	1	4050		47	8	16	4518	
13	7	14	4011		48	8	16	4518	
14	8	16	4040		49	8	16	4527	
15	8	16	4518		50	8	16	4510	
16	8	16	4585		51				
17	8	16	4585		52				
18	8	16	4522		53				
19	8	16	4522		54				
20	8	16	4585		55				
21			2×TIL 111		56				
22			Adapter		57				
23			Adapter		58				
24	7	14	4001		59				
25	8	16	4518		60	8	16	4501	
26	8	16	4585		61	7	14	4023	
27	8	16	4585		62	8	16	4518	
28	8	16	4527		63				
29	8	16	4527		64				
30	8	16	4585		65				
31	8	16	4015		66				
32	8	16	4015		67				
33	8	16	4015		68				
34	8	16	4015		69				
35	8	1	4049		70				

Note:
all resistors 1/3 W, 5%, 1kΩ
all INPUTS non used are grounded

BALZERS
BALZERS AKTIENGESELLSCHAFT

OP	DV	ZV	MF

Ersatz Version: BG 241275 -Z

Abteilung: EEBK

30.6.75

WIRE -WRAP- PRINT II Schema

BG 241346 -S