

Electron beam gun ESQ 300 U

A product of BALZERS AG, Balzers

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Warning — High voltage

Service or repair work on components of the power supply or the high voltage lead-in may only be carried out by suitably qualified personnel. Contact with high voltage carrying components is absolutely lethal.

Work on the high voltage lead-in for cleaning purposes, after removing the power supply plug, is the only exception to this rule.

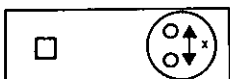
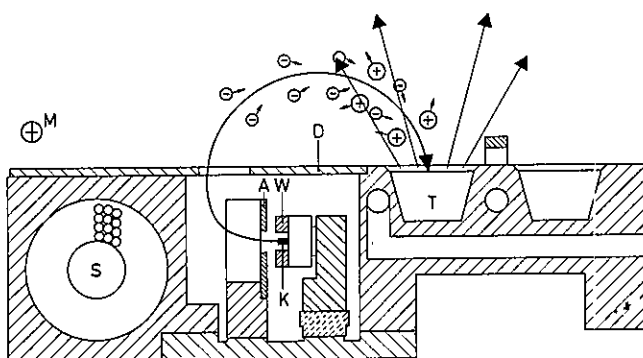
1. APPLICATION

Constructed as an all-purpose evaporator, this system provides the best possible solution to any evaporation problem which can be overcome by the use of an electron beam evaporation source. At the same time, it is this quality of adaptability to the process which creates the necessity for accurate adjustment, in order to ensure that the optimum material evaporation characteristics are fully utilised. The electron beam evaporation system is a complete unit, with a power supply, controls and monitors.

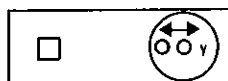
The electron beam evaporation source ESQ 300 U consists of two main components the electron beam gun, comprising the cathode K, the Wehnelt shutter W and the anode A, and the water cooled evaporation crucible (Fig. 1).

1.1. METHOD OF OPERATION

The electrons from the D.C. heated cathode (K), extracted through the electrical field, pass the anode (A), are deflected through approx. 270° by the magnetic field produced by the coil (S) and the pole shoes (M) and enter the crucible. The beam area is adjusted by the voltage connected to the Wehnelt shutter (W) (electrostatic focussing). There is another focussing effect in electrostatic focussing. The vapour atoms leaving the crucible are partially ionised by the electron beam. The electrons released by these vapour atoms travel at a much higher speed than the vapour ions, which have a speed distribution approximately corresponding to that of the neutral vapour atoms. Hence, high ion densities occur in the electron beam area, with a positive space charge capable of compensating for the negative space charge of the electrons. In fact, resulting from the vapour ions, a positive potential channel forms along the beam axis, which has a focussing effect on the beam electrons. Thus, with a 10 kV acceleration voltage, a density effect of the electron beam of approx. 40 kW/cm^2 is produced at the crucible surface.



X-sweep through an electro-magnetic additional field (50 Hz)



Y-sweep through periodic variation (2 – 40 Hz) of the deflection field

Fig. 1

Contrary to the evaporation of metal, a very much lower density effect of approx. $1 - 1.5 \text{ kW/cm}^2$ is desirable for the evaporation of dielectric materials. In this case the electron beam is de-focussed and "scanned" through an electro-magnetic A.C. field superimposed on the deflection field M.

2. TECHNICAL DATA

2.1. Dimensions

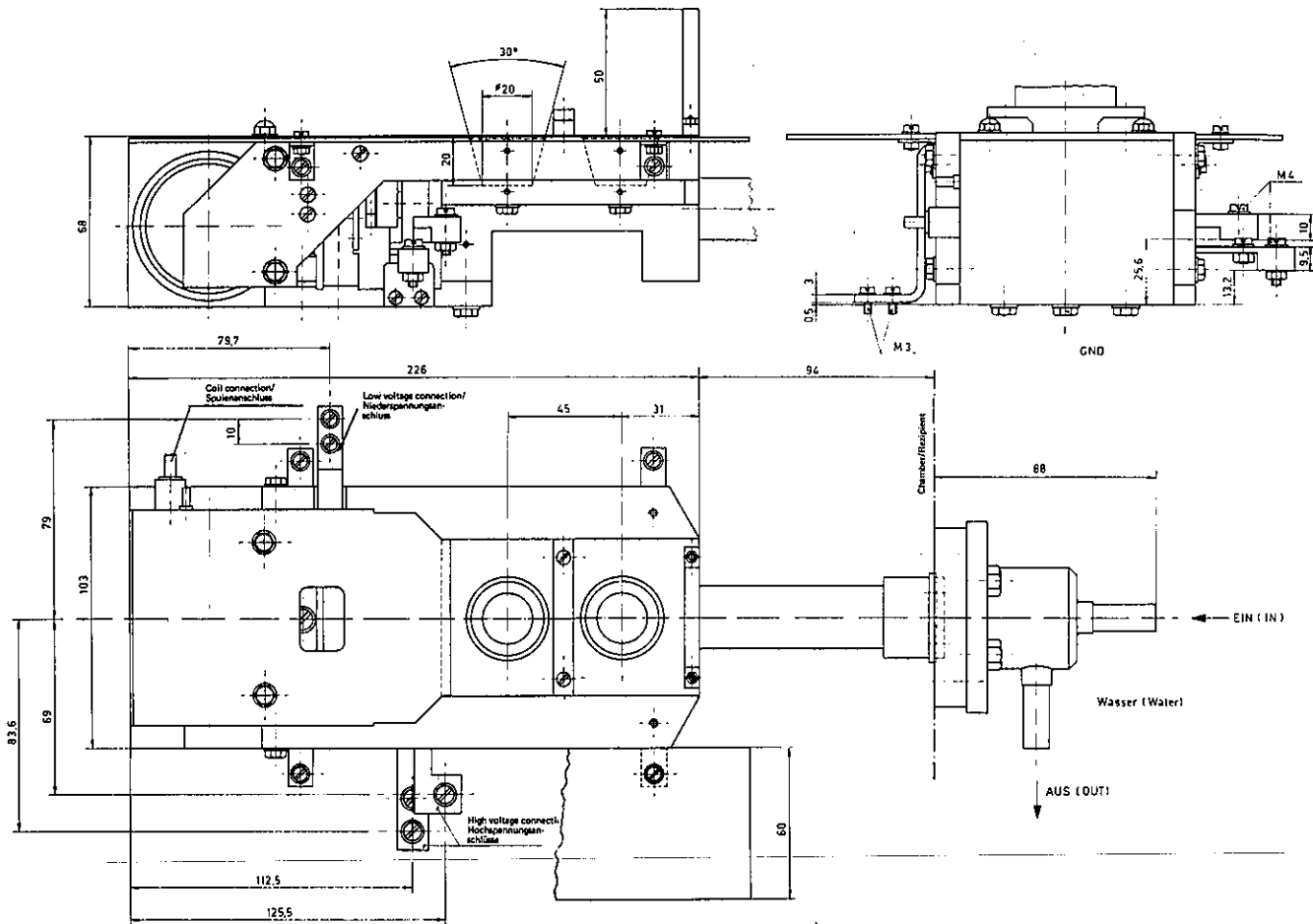


Fig. 2 Scale drawing

2.2. General data

Max. power input for aluminium	8 kW
other materials	10 kW
X-Y deflection	variable
Coil current	0 – 2 A
Cooling water connection for evaporation source	3/8" Serto screw coupling
Min. water pressure	4 bar
Max. water pressure	10 bar

Min. throughput for connection to EHV 108, power supply to EHV 110 A, power supply	8 l/min. 10 l/min.
Intake temperature of the cooling water	4 – 50° C
Beam spot, variable from	0.15 ÷ 2 cm ²
Working pressure	< 10 ⁻⁴ mbar
Bake-out, max.	400° C
Weight, approx.	10 kg

3. DESCRIPTION

3.1. Evaporation source ESQ 300 U

The evaporation source is designed to ensure that apart from the material being evaporated, no hot surfaces of the gun can interfere with the evaporation process. For this, the entire source has been made of copper.

3.2. Major components of the ESQ 110

It is advisable to clean crucible, crucible cap, deflecting plate and gun mask regularly by means of sand-blasting. In order to avoid frequent changing of the crucible (gold wire seal), the crucible block permits cleaning with an appropriate tool (steel brush, triangular scraper, glass pencil, etc.).

Do not sand-blast the pole shoes to prevent damages to the nickle-plated surfaces.

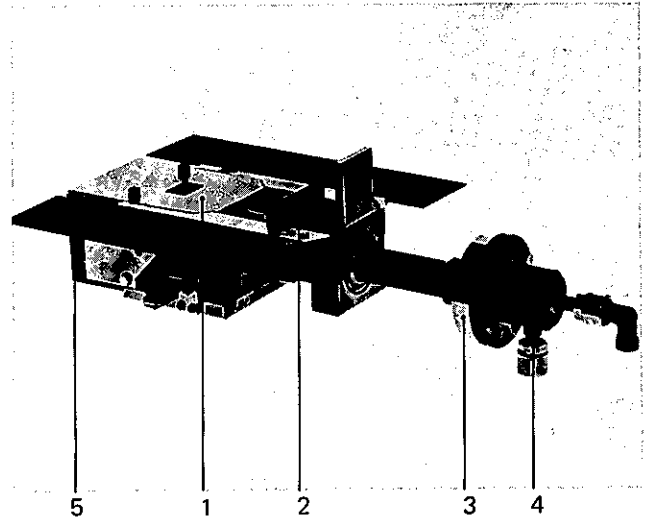


Fig. 3 UHV electron beam evaporation source ESQ 300 U

1. Electron beam source (covered)
2. Crucible block
3. Flange NW 35 CF
4. Cooling water inlet
5. Cr/Ni screen

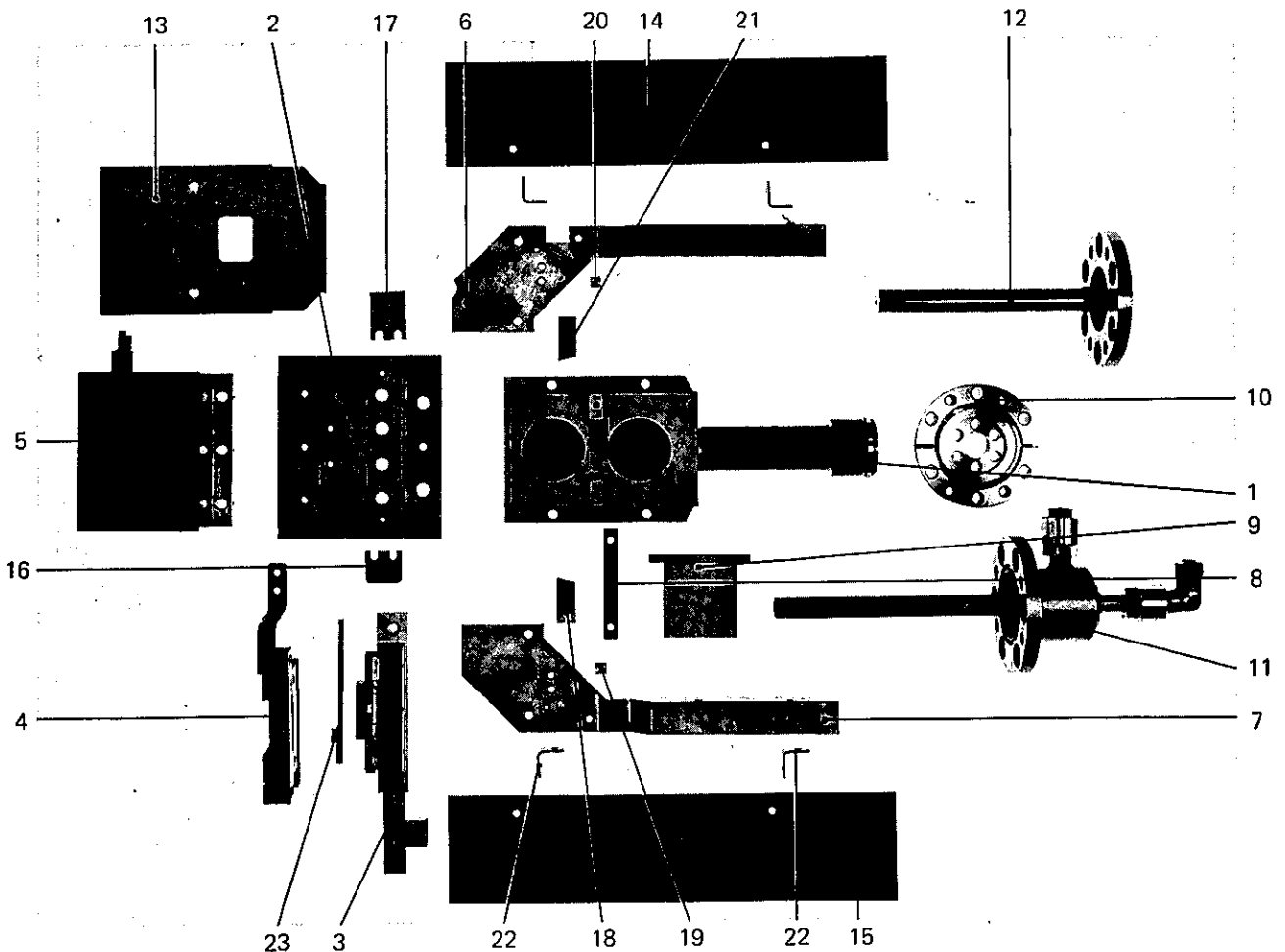


Fig. 4 Components of the ESQ 300 U

- | | | | | |
|-------------------|---------------------|------------------------------|--------------------------------------|---------------------|
| 1. Crucible block | 6. Pole shoe, left | 11. Cooling water inlet | 16. } Side screens for | 22. Fastening angle |
| 2. Base plate | 7. Pole shoe, right | 12. Dummy for bakeout | 17. } flat insulator (cathode block) | 23. Adjusting gauge |
| 3. Cathode block | 8. Separating web | 13. Copper mask | 18. } | |
| 4. Anode | 9. Deflecting plate | 14. } Lateral source screens | 19. } Auxiliary pole shoes | |
| 5. Coil | 10. Flange NW 35 CF | 15. } | 20. } | |
| | | | 21. } | |

4. INSTALLATION

Important: All screens that are used in UHV have to be coated with MoS₂ or Molykote!

4.1. Mounting the source ESQ 300 U

4.1.1. Mounting the cathode holder

Give all screws a good coating with MoS₂ or Molykote!

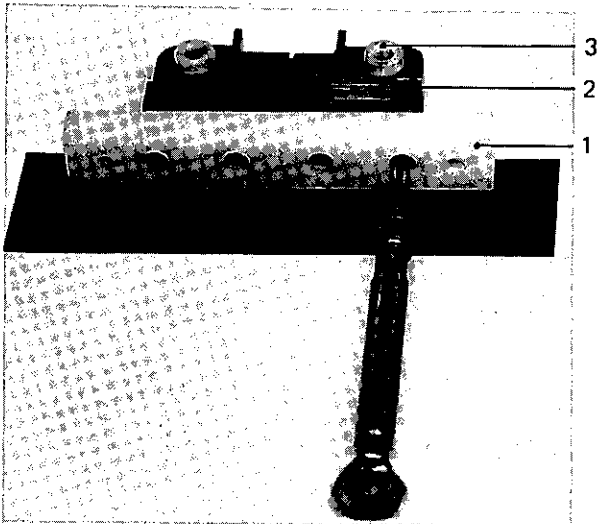


Fig. 5

1. Flat insulator
2. Cathode holder
3. Round insulator

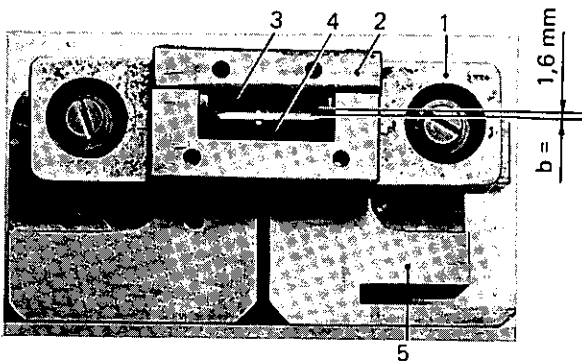


Fig. 6 Cathode block

1. Wehnelt section
2. Upper Wehnelt bar
3. Upper Wehnelt plate (Ta)
4. Lower Wehnelt plate (Ta)
5. Cathode holder

- a. Mount the two cathode holders (Fig. 5, item 2) on the flat insulator (Fig. 5, item 1) and screw in position with the two M3 cylindrical head screws.
- b. Fit the Wehnelt section (Fig. 6, item 1) with the two insulators (Fig. 5, item 3) to the cathode holder and tighten.
- c. Tighten the cathode holder on the flat insulator.
- d. Mount the cathode.

- e. Adjust the lower Wehnelt plate (Ta) (Fig. 6, item 1) approx. 0.3 mm from the cathode.
- f. Screw the upper Wehnelt (Fig. 6, item 2) slacky in position with the two M2 vertical head screws (coat with Molykote).
- g. Adjust the upper Ta plate approx. 0.3 mm from the cathode.
- h. Check the cathode, it should be located symmetrically in the gap $b = 1.6$ mm (Fig. 6).
- i. Mount the two Cu-lead-ins on the cathode holder.
- j. Tighten the Wehnelt wire firmly on the cathode holder (M2 socket head screw).

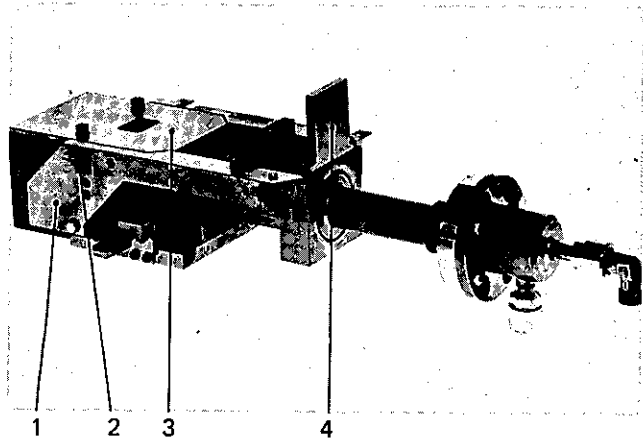


Fig. 7

1. Pole shoe
2. Fastening angle
3. Cu-screen
4. Deflecting plate

4.1.2. Mounting the crucible block and the gun

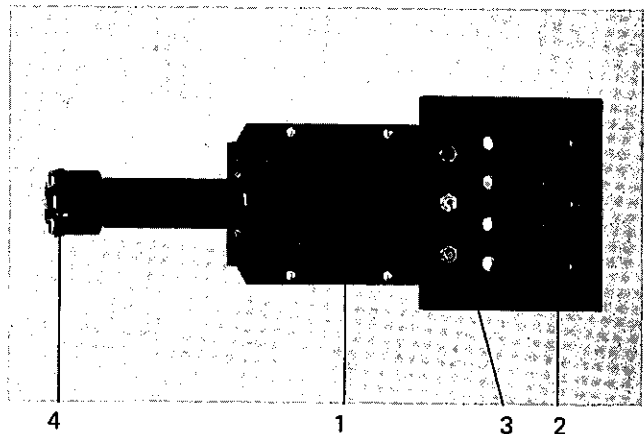


Fig. 8 Fastening the crucible block to the base plate

1. Crucible block
2. Base plate
3. Return connector for anode
4. Sealing surface for gold wire seal

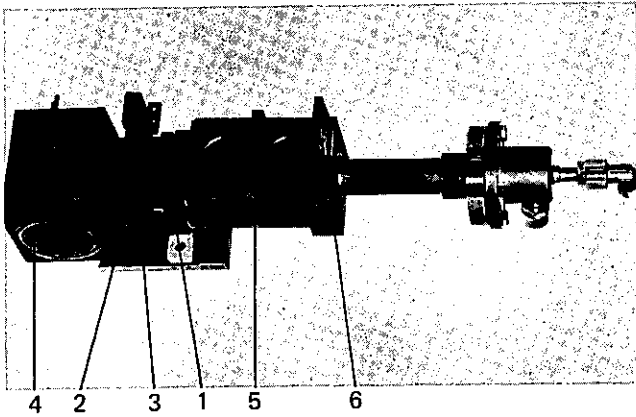


Fig. 9 Mounting the cathode block, anode and coil

1. Cathode block
2. Anode
3. Adjusting gauge for cathode block and cathode (Push the cathode in direction of the gauge and secure with 2 M3 screws)
4. Coil
5. Separating web
6. Deflecting plate (secondary-electrons-collector)

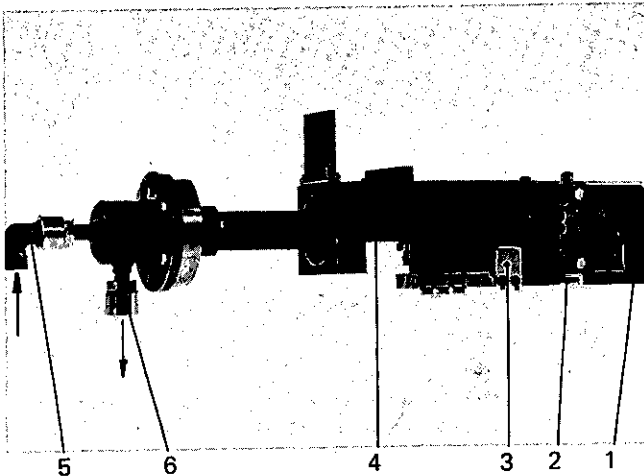


Fig. 10 Connections

1. Coil current connection
 2. Anode screen connection
 3. Cover screen of the flat insulator
 4. Fastening angles (2 on each side) for Cr/Ni-screen
 5. Water inlet
 6. Water outlet
- e. Fix the anode with 2 countersunk screws M4 · 20 mm
 - f. Fit the Cu-screen (Fig. 7, item 3) over the cathode block and anode
 - g. Screw the molybdenum web (Fig. 9, item 5) to the crucible block
 - h. Screw the deflecting plate (Fig. 7, item 4) for secondary ions to the crucible block.

- a. Attach the base plate (Fig. 8, item 2) to the crucible block (Fig. 8, item 1) with the two M5 · 20 screws. The threaded hole (Fig. 8, item 3) is used for attaching the return conductor of the anode circuit.
- b. Fix the coil (Fig. 7, item 1) with 3 socket head screws M5 · 20 mm.
- c. Attach the pole shoes (Fig. 7, item 1) with the auxiliary pole shoes (Fig. 4, items 18 – 21) at both sides.
- d. Push the cathode block with gauge (Fig. 9, item 3) towards the anode (Fig. 9, item 2) and attach it to the base plate with the two socket head screws. Screw the screens (Fig. 3, item 5) for the flat insulator to the base plate.

4.1.3. Mounting the source in the coating plant

(refer to "Mounting clearances in various UHV-plants", in the annex)

- a. Screw the source flange NW 35 CF (Fig. 4, item 10) to the lead-in of the UHV plant (ensure the right position of the threaded holes for the crucible block (Fig. 4, item 1)).
- b. Push the gold wire seal (ϕ 1 mm) over the crucible part (Fig. 8, item 4).
- c. Carefully mount the whole source from inside the vacuum chamber into the source flange and fasten symmetrically with the 6 hex screws M5 · 20 (coat the screws with Molykote!). Torque = 0.6 mkp.
- d. Screw the cooling water connection from outside to the source flange (4 screws M6 · 20 mm).
- e. Connect the hoses for water inlet and outlet (inlet via water valve, outlet via water flow control switch).

4.2. Mounting the high voltage lead-in

(refer to spare parts list BB 800 069 E/6, 7)

Important: The cylindrical cover hood with the connecting cables is controlled by two safety switches, i.e. the high voltage can only be switched on (or remains on) when the cover hood has been pushed completely over the flange and fastened with 3 nuts.

- a. Loosen the 3 nut (item 132) and push the cover hood, together with the metal hose about 5 cm over the current-input cable and support it to ensure that the insulator (item 111) is not damaged.
- b. Disconnect the 3 high-voltage connections at once and remove the insulator.
- c. Carefully mount the lead-in to the appropriate NW 35 CF flange (refer to the annex for mounting clearance)
Torque: 1 mkp (coat the screw with MoS₂ or Molykote)
- d. Push the insulator again over the ceramics up to the NW 35 CF flange.

- e. Connect the 3 high voltage cables (red cable to central connection).
- f. Fasten the cover hood with 3 nuts.
- g. Make the electrical connection in the UHV-chamber from the cathode block to the high voltage lead-in according to a separate drawing in the annex (see also Fig. 11).

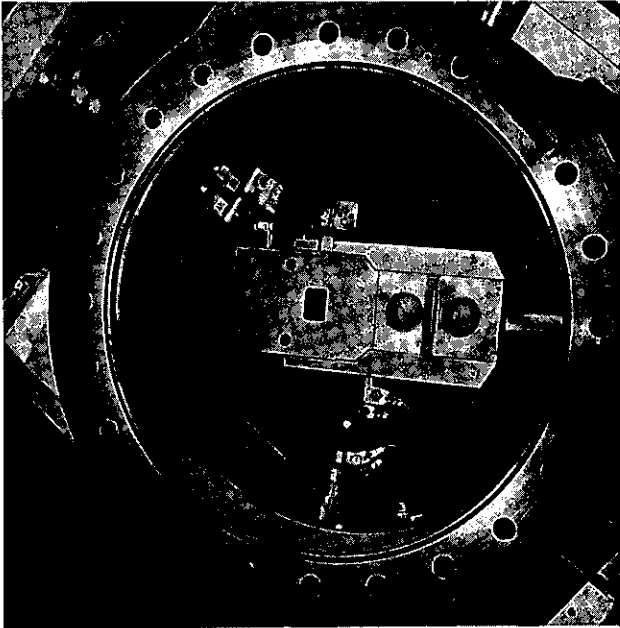


Fig. 11 ESQ 300 U, mounted in a UTS 350 UHV plant

4.3. Low-voltage lead-in

Attach the lead-in-flange to the appropriate flange of the UHV chamber with 6 M6 screws. Torque: 1 mkp (coat the screws with Molykote or MoS₂).

Refer to the annex for the mounting clearance.

With only one source mounted in the UHV-plant, the two high current lead-ins will be used as input and output for the anode current (lateral sweep) (an alternating current of up to 20 A will be necessary).

With 2 sources mounted in the UHV-plant, only one lead-in will be required.

Mount the lead-in flange with a circular segment to the appropriate flange of the UHV-chamber. The two silver bolts on the segment are used as return conductors for the anode current. The two high-voltage lead-ins serve as input conductors for each source. The return lead of the anode current in the UHV-chamber is made over earth potential to the threaded hole M8 below the lead-ins (see separate drawing).

There are two additional single-lead-ins for the coil current on the low voltage lead-in (one or two sources, resp.). Returning the coil current to earth potential is accomplished exclusively over the crucible block and the plant body.

After connecting the source with the high voltage lead-in, the coil and the anode current input, and after making the return lead according to the drawing, attach the two Cr/Ni screens (Fig. 3, item 5) with two fastening angles (Fig. 7, item 2) each to the source.

5. PREPARATIONS FOR BAKING THE PLANT

Maximum bakeout: 400° C

- a. Set main switch on EHV to Zero, pull the key out of the key-switch!
- b. Remove the cover screen and the cable connections of the high voltage lead-in.
- c. Remove the Teflon insulator from the high voltage lead-in.
- d. Disconnect the power connections for the low voltage lead-in.
- e. Shut-off the cooling water and blow out the cooling system with compressed air, for about 30 sec.
- f. Remove the cooling water input (Fig. 4, item 11) and insert the dummy (Fig. 4, item 12) into the source flange (corrosion protection during the bakeout).
- g. Bake the plant (see separate operating instructions for the UHV-plant).
- h. Dismount the dummy (Fig. 4, item 12) and re-mount the cooling water input (Fig. 4, item 11).
- i. Re-mount the items mentioned under b – d.

6. START-UP

Operation is started according to separate installation and operation examples, e.g. BB 800 075 BE.

In case none of the separate operating instructions corresponds with the delivered electron beam evaporation system, start the installation or initial operation according to the operating instructions for the single units.

7. MAINTENANCE

7.1. Maintenance of the source ESQ 300 U

The ESQ 300 U electron beam gun requires very little maintenance. None of its components is exposed to coating. The crucible, the web and the deflecting plate are the only parts to be cleaned, the frequency of cleaning depending on the quantity of material evaporated. It should be considered that it is not the source which requires periodic cleaning but

the cleanness of evaporation. Thick layers deposited on the deflecting plate can be re-evaporated because of the thermal radiation which is due to poor conductivity, although the cooling may be perfect. Therefore, to ensure perfect evaporation, we recommend regular cleaning of the crucible, the web and the deflecting plate.

Every 400 evaporation hours, dismantle the flat insulator and the two round insulators of the cathode holder and clean either mechanically (emery cloth) or chemically. The insulators are made of high purity Al_2O_3 .

Service life of the cathode:

30 hours of evaporation or 200 evaporation cycles.

7.2. Changing the cathode

- a. Remove the Cu-cap (two M5 milled nuts)
- b. Remove the Wehnelt bar (two M2 countersunk screws)
- c. Slacken the cathode holding screws (slotted screws M3)
- d. Remove the old cathode
- e. Insert the new cathode through the anode and into the hole in the holder
- f. Insert the feeler gauge between the anode and Wehnelt
- g. Press the cathode against the gauge and tighten the two cathode holder screws slightly.
- h. Mount the Wehnelt bar. Tighten the countersunk screws slightly. If new screws are being used it advisable to give them a thin coating of Molykote beforehand.
- i. Mount the Cu-mask.

8. TROUBLESHOOTING

Fault	Cause	Correction
The crucible is destroyed by the contents of the crucible (alloy the crucible)	<p>The spot is not in the center of the crucible</p> <p>Beam spot is not in crucible centre. Distance of beam spot to crucible edge is too short</p> <p>Beam power is too high</p> <p>Insufficient cooling</p>	<p>Correct the position of the spot</p> <p>Reduce the beam power</p>
Arcing at high evaporation rates	Poor screen of the high voltage installation	Screen carefully
Arcing at increased pressure, pressure peaks	The evaporant degasses too strongly	Degas at reduced pressure
The evaporant splashes too much	<p>The electron beam power density is too high</p> <p>The crucible is contaminated (e.g. from material previously evaporated)</p>	<p>Sweep or reduce the power</p> <p>Clean the crucible (e.g. sand-blast)</p>
No spot in the crucible though the high voltage has been turned on and the coil current read-out is correct	Incorrect polarity of the coil	Interchange the coil connection on terminal strip underneath the coating unit with ground connection.

9. SPARE PARTS

Please order your spare parts according to the enclosed spare parts list.

Always state type and serial number as indicated on the name plate of the unit.

Ordering Example

1 O-ring, Viton, ϕ 37,77 x 2,62 mm, Code No. B 4070 609 PV, as to spare parts list BB 800 069 E/1, item 12.

	Description Teil	Item Pos.	Code-No.	Bestell-Nr.	S	Remarks Bemerkungen
1	Anode compl.	1	see / siehe	BB 800 069 E / 3		
1	Cathode / Kathode compl.	2	see / siehe	BB 800 069 E / 4, 5		
1	High voltage lead-in / Hochspannungsdurchführung	3	see / siehe	BB 800 069 E / 6, 7 *		
1	Housing / Gehäuse	4	see / siehe	BB 800 069 E / 8,9 *		
1	Flange / Flansch NW 35 CF, BP 414 2960	5	BK	204 137 -R		
1	Rear plate / Rückplatte	6	BK	204 147		
1	Low voltage lead-in / Niederspannungsdurchführung	7	BK	204 080 -X	*	
1	Crucible / Zweilochtiegel	8	BK	204 104 -X		
1	Coil / Spule	9	BK	204 069 -X		
1	Web / Trennsteg	10	BK	204 066		
		11				
1	O-Ring, Viton, ϕ 37,77 x 2,62	12	B	4070 609 PV		
1	Cu-seal / Cu-Dichtung NW 35 CF	13	BP	414 606 -T		
1	Seal ring / Dichtring	14	BK	204 123		
1	Guard / Schutzblech	15	BK	204 113		
1	Plate / Deckplatte	16	BK	204 119		
6	Screw / Schraube M3 x 12	17	N	3111 194 X		
2	Screw / Schraube M3 x 6	18	N	3015 189 X		
2	Screw / Schraube M3 x 8	19	BK	204 149 -R		
4	Screw / Schraube M3 x 6	20	N	3052 189 X		
8	Screw / Schraube M3 x 8	21	N	3052 191 X		
4	Screw / Schraube M4 x 16	22	N	3015 259 X		
4	Screw / Schraube M4 x 20	23	N	3015 261 X4		
2	Screw / Schraube M5 x 10	24	N	3015 291 X		
8	Screw / Schraube M5 x 20	25	N	3015 298 X		
3	Screw / Schraube M5 x 20	26	N	3052 298 X		
4	Screw / Schraube M6 x 20	27	N	3015 341 X		
		28				
2	Threaded pin / Gewindestift M3 x 16	29	N	3211 198 X		
2	Threaded pin / Gewindestift M4 x 12	30	N	3208 255 X		
6	Nut / Mutter M3	31	N	3415 037 X		
2	Nut / Mutter M4	32	N	3457 039 X		
12	Washer / Unterlagsscheibe 3,2 / 7 x 0,5	33	N	3502 412 X		
10	Washer / Unterlagsscheibe 4,3 / 9 x 0,8	34	N	3502 414 X		
7	Washer / Unterlagsscheibe 5,3 / 10 x 1	35	N	3502 416 X		
		36				
2	Nut / Anschlussmutter SO20 - 10 - G 3/8	37	B	4117 569 GN		*
2	Nipple / Einschraubstutzen SO 18.1000-10, M18 x 1,5	38	B	4118 426 MX		*
2	Nut / Verschraubungsmutter SO18.10-10-M18 x 1,5	39	B	4117 376 MX		*
8	Clamping ring / Klemmring SO18.1-10	40	B	4119 367 -X		*
1	Angle / Einstellwinkel SO2600-10	41	B	4133 405 GN		*
2	Nozzle / Stecktülle BN 809 552 C	42	BK	204 136 -R		*
2	Aux. pol shoe / Hilfspolschuh	43	BK	204 111 -R		
2	Aux. pol shoe / Hilfspolschuh BK 604 013	44	BK	204 112		

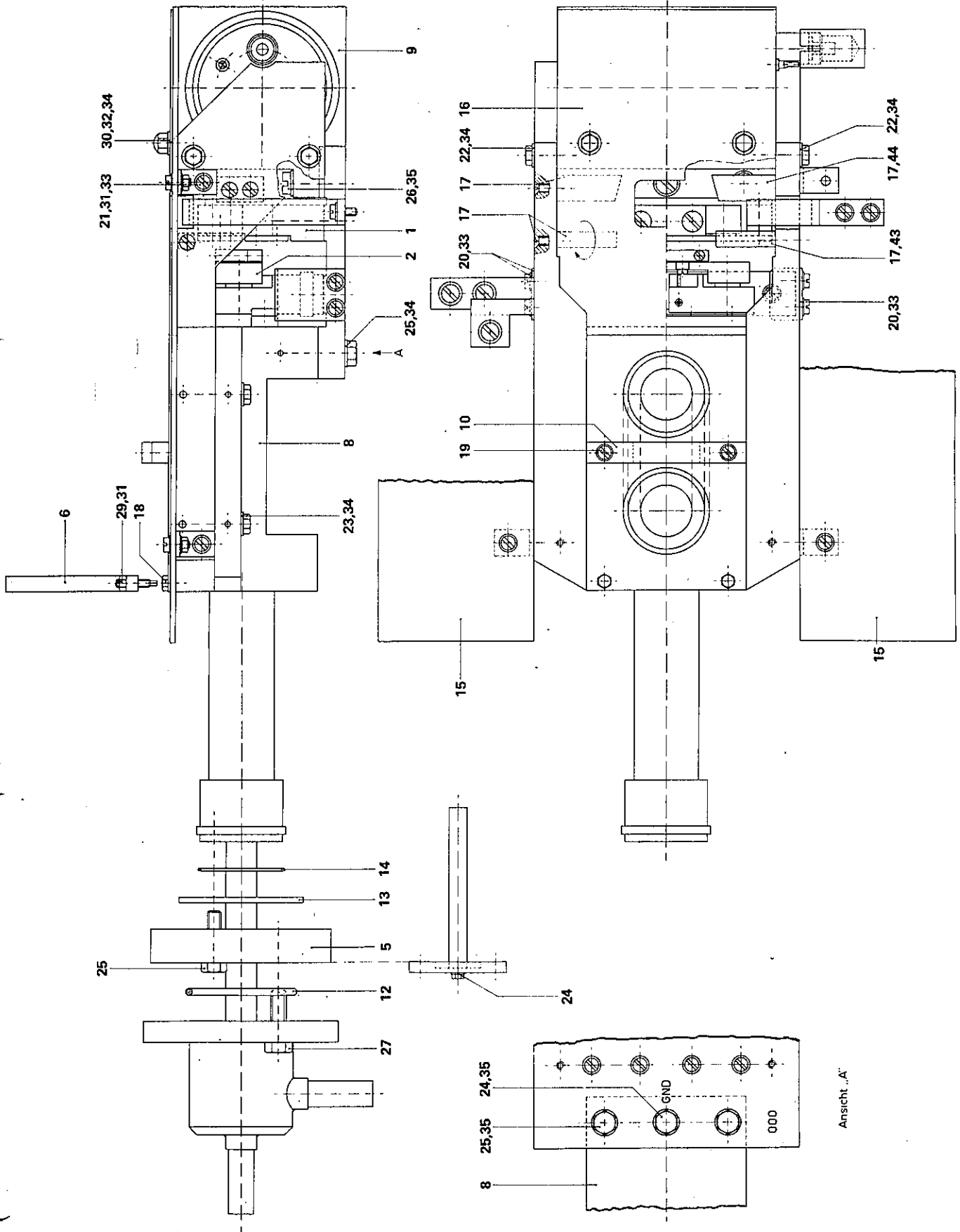
* not seen in the picture / nicht ersichtlich

Spare Parts for / Ersatzteile zu

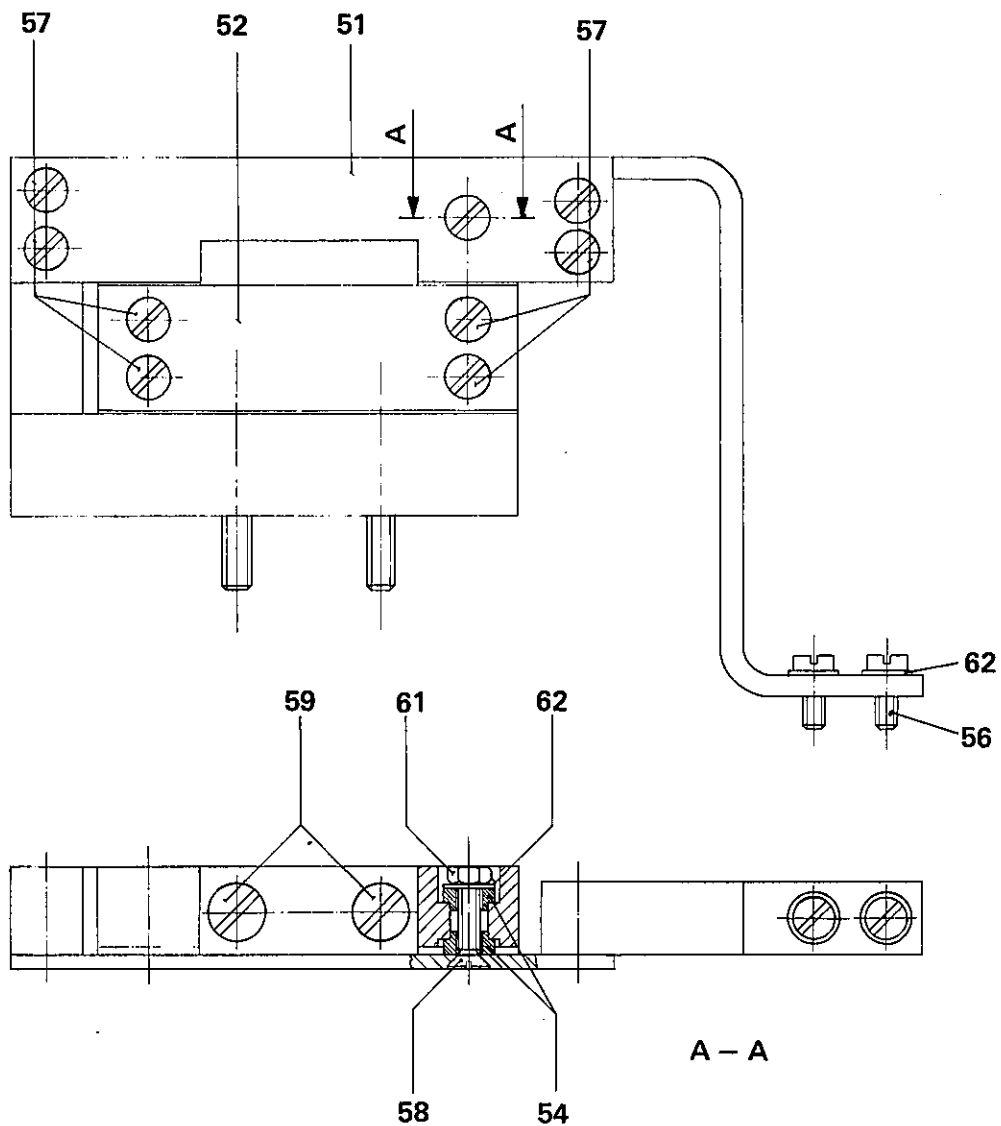
BK 204 150 -T

Electron beam evaporation source / Elektronenstrahlverdampfungsquelle
ESQ 300 U

BB 800 069 E / 1



	Description Teil	Item Pos.	Code-No.	Bestell-Nr.	S	Remarks Bemerkungen
1	Anode 1	51	BK 202 688 A			
1	Anode 2	52	BK 202 689			
		53				
2	Ceramic insulator / Einzeltülle 71 - 6115	54	B 4622 251 TN			
		55				
2	Screw / Schraube M3 x 8	56	N 3052 191 X			
8	Screw / Schraube M3 x 8	57	N 3111 191 X			
1	Screw / Schraube M3 x 12	58	N 3111 194 X			
2	Screw / Schraube M4 x 30	59	N 3111 267 X			
		60				
1	Nut / Mutter, M3	61	N 3415 037 X			
3	Washer / Unterlagsscheibe 3,2 / 7 x 0,5	62	N 3502 412 X			



Spare Parts for / Ersatzteile zu ESQ 300 U

ANODE

BK 204 125 AT

BB 800 069 E / 3

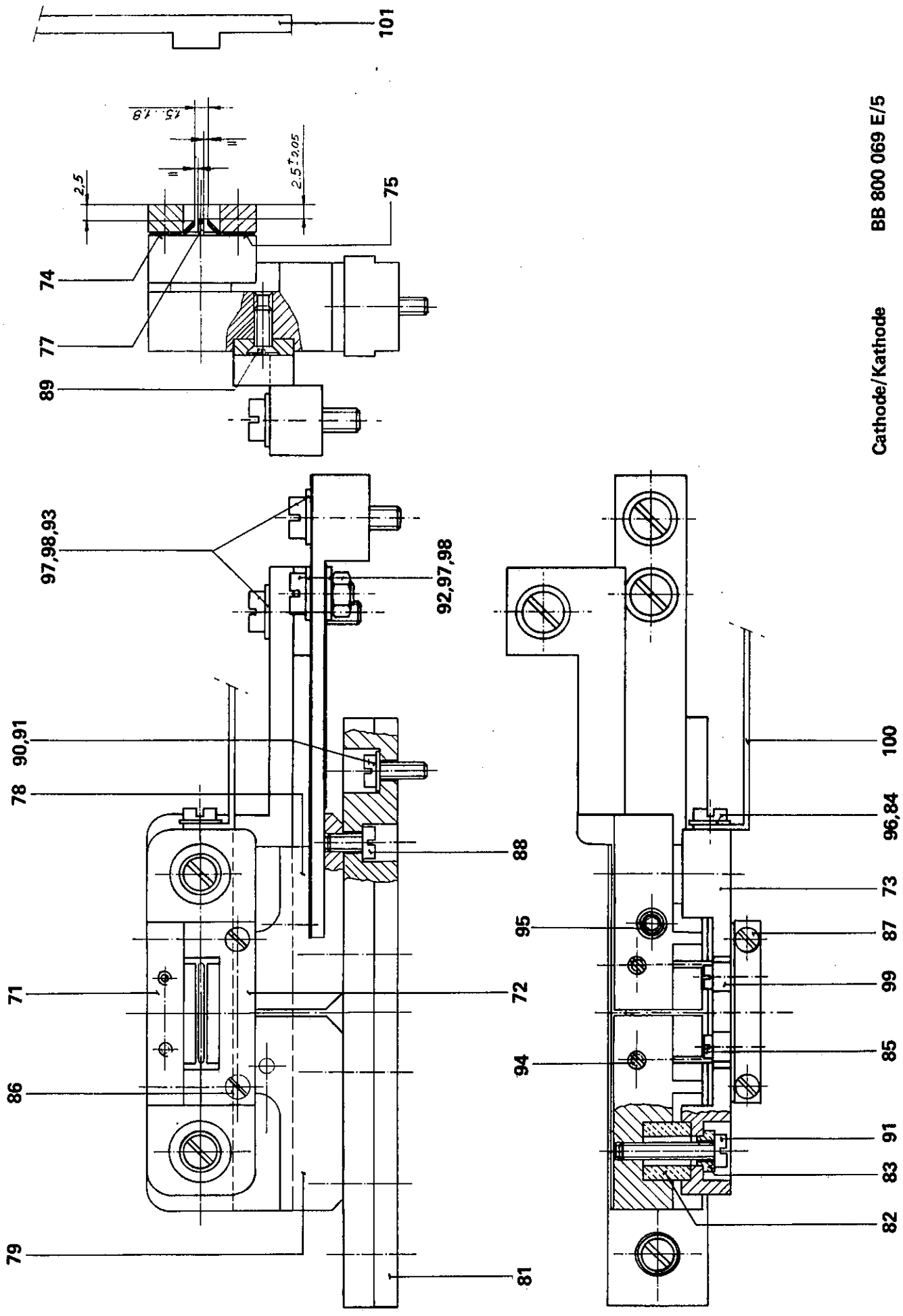
	Description Teil	Item Pos.	Code-No.	Bestell-Nr.	S	Remarks Bemerkungen
1	Beam / Balken	71	BK 202 697			
1	Pile bents / Joch	72	BK 202 698			
1	Wehnelt holder / Wehneltträger	73	BK 202 699 C			
1	Wehnelt plate / Wehneltblech	74	BK 202 702			
1	Wehnelt plate / Wehneltblech	75	BK 202 703			
		76				
1	Cathode / Kathode	77	BK 202 704 A			
1	Cathode holder / Kathodenhalter	78	BK 202 718			
1	Cathode holder / Kathodenhalter	79	BK 202 719			
		80				
1	Insulator / Isolator	81	BK 202 700			
2	Insulator / Isolator	82	BK 202 701			
2	Ceramic insulator / Einzeltülle 71-6115	83	B 4622 251 TN			
1	Screw / Schraube M3 x 4	84	N 3052 186 X			
2	Screw / Schraube M2 x 6	85	N 3052 114 X			
2	Screw / Schraube M2 x 6	86	N 3111 114 X			
2	Screw / Schraube M2 x 8	87	N 3111 116 X			
4	Screw / Schraube M3 x 6	88	N 3052 189 X			
2	Screw / Schraube M3 x 8	89	N 3111 191 X			
2	Screw / Schraube M3 x 10	90	N 3052 193 X			
2	Screw / Schraube M3 x 16	91	N 3052 259 X			
4	Screw / Schraube M4 x 8	92	N 3052 251 X			
2	Screw / Schraube M4 x 20	93	N 3052 261 X			
2	Threaded pin / Gewindestange M3 x 5	94	N 3204 188 X			
1	Threaded pin / Gewindestange M4 x 8	95	N 3208 251 X			
3	Washer / Unterlagsscheibe 3,2 / 7 x 0,5	96	N 3502 412 X			
4	Washer / Unterlagsscheibe 4,3 / 9 x 0,8	97	N 3502 414 X			
3	Nut / Mutter M4	98	N 3415 039 X4			
2	Jacket / Distanzhülse	99	BK 202 735			
1	Wire / Draht Ni 99,8, ϕ 1 mm, L = 0,5 m	100	B 2220 140-W			
1	Feeler gauge / Einstelllehre	101	BK 204 130			

Spare Parts for / Ersatzteile zu ESQ 300 U

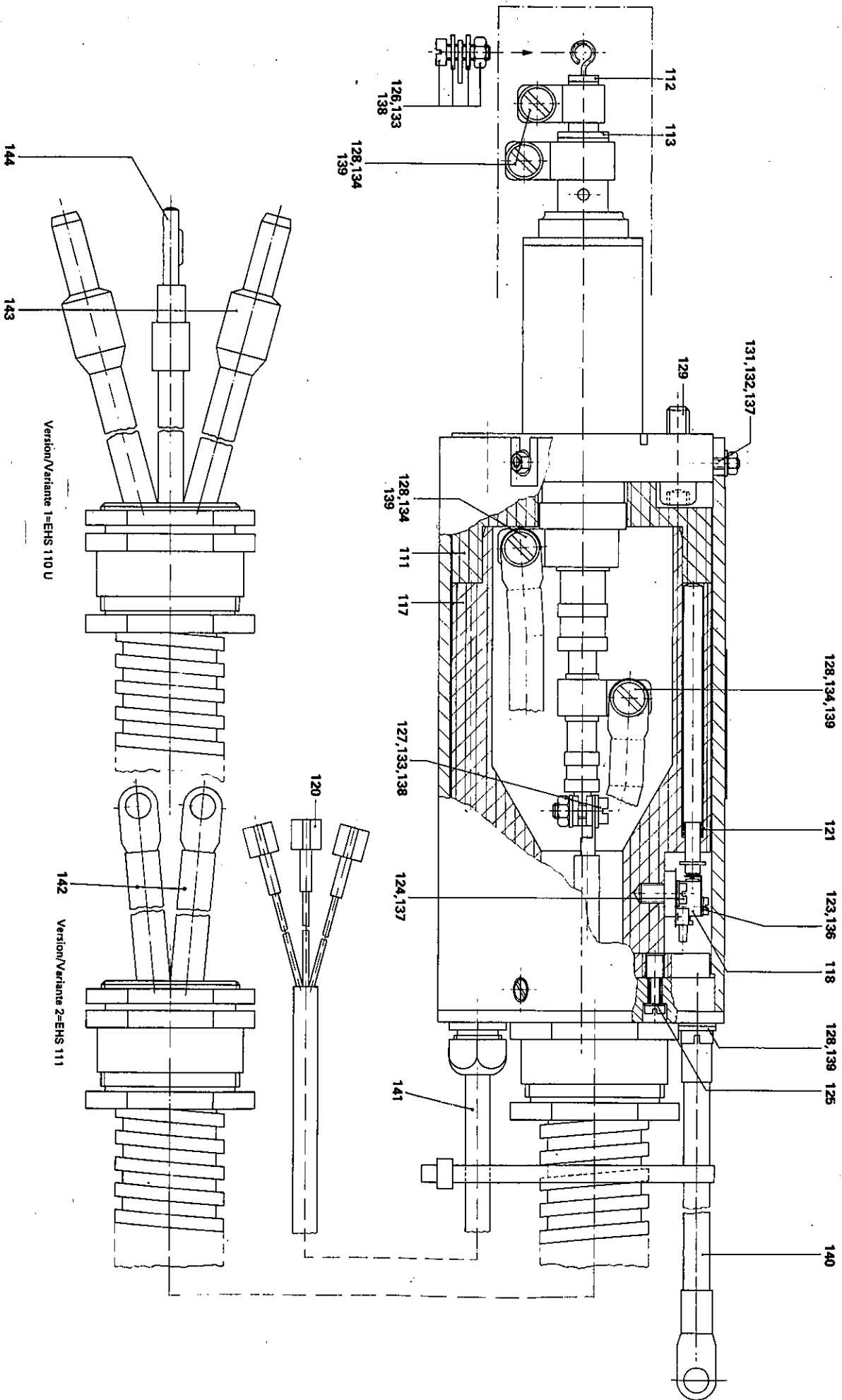
Cathode / Kathode

BK 204 162 - T

BB 800 069 E / 4

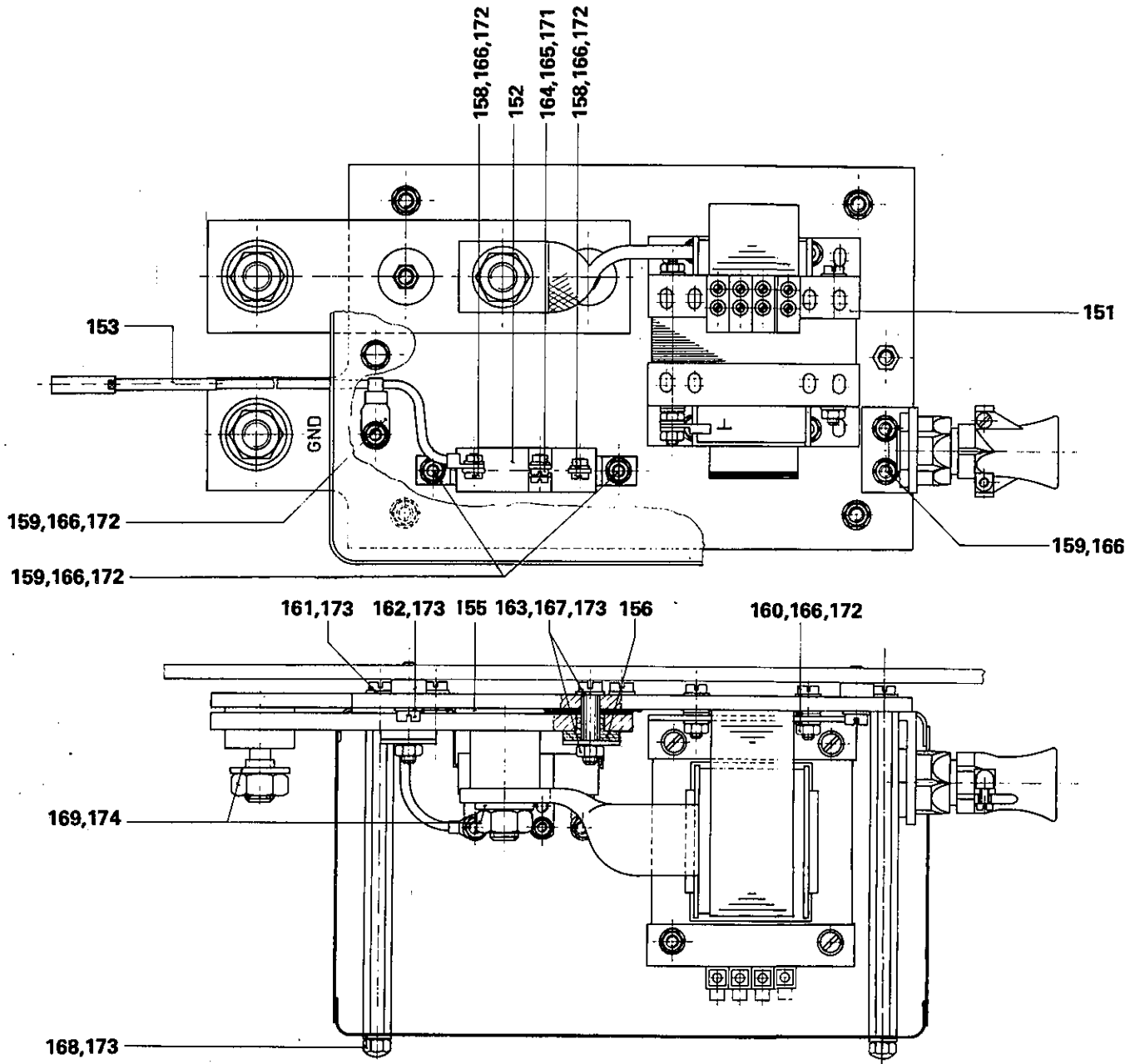


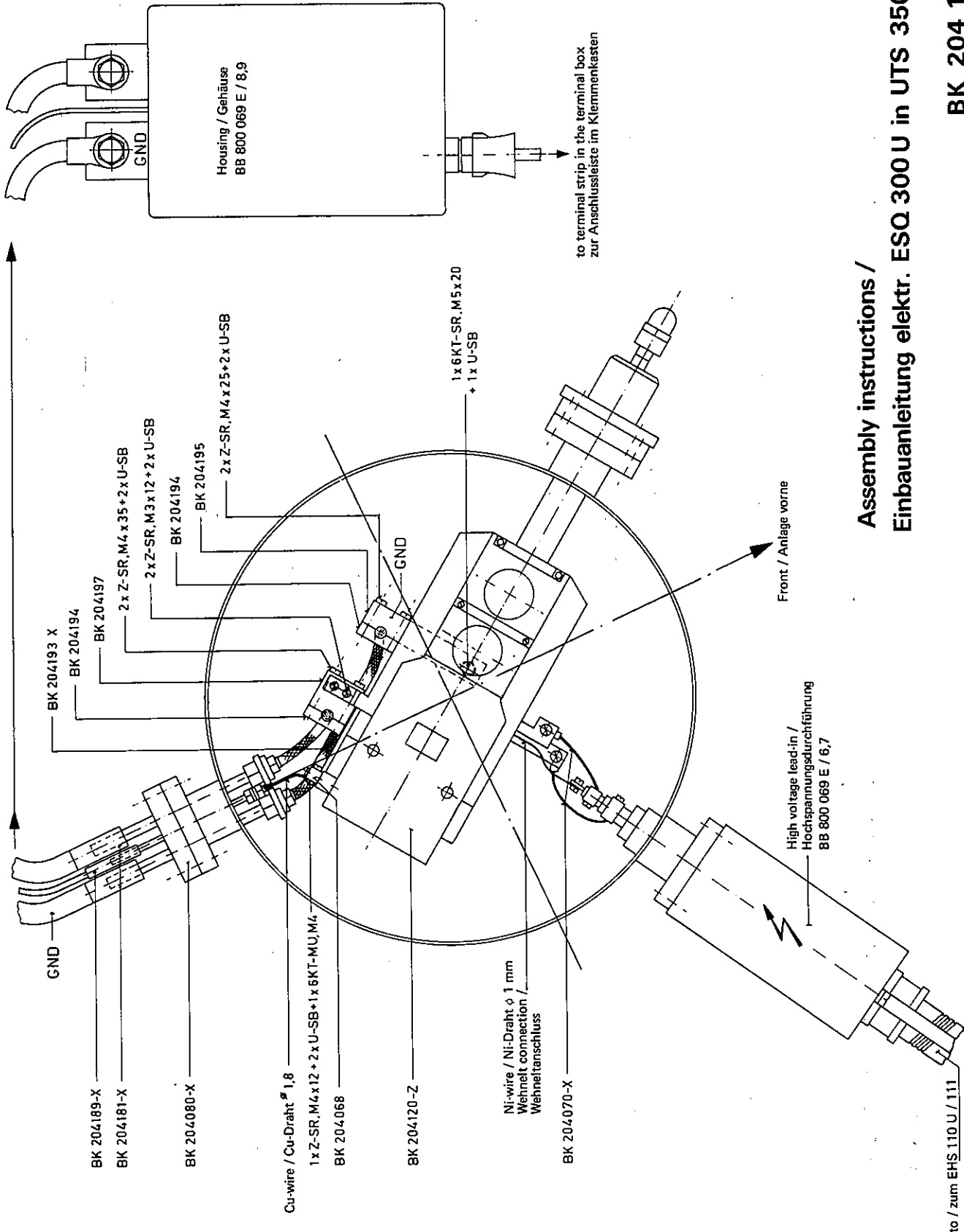
Cathode/Kathode BB 800 069 E/5



High voltage lead-in / Hochspannungsdurchführung BB 800 069 E/7

	Description Teil	Item Pos.	Code-No.	Bestell-Nr.	S	Remarks Bemerkungen
1	Transformer / Transformator EJ 84 B * BG 202 995*	151	B 5128 001 HA			
1	Resistor / Widerstand, 10 Ω, 25 W	152	B 4837 110 XA			
1	Connection cable / Anschlusskabel L = 1 m	153	BK 204 189 -X			
		154				
1	Insulating plate / Isolierplatte	155	BK 204 174			
2	Insulator / Isolator	156	BK 204 175			
		157				
2	Screw / Schraube M4 x 6	158	N 3052 249 X			
4	Screw / Schraube M4 x 12	159	N 3052 255 X			
4	Screw / Schraube M4 x 16	160	N 3052 259 X			
2	Screw / Schraube M5 x 12	161	N 3052 292 X			
4	Screw / Schraube M5 x 16	162	N 3052 296 X			
2	Screw / Schraube M5 x 25	163	N 3052 301 X			
1	Screw / Schraube M3 x 6	164	N 3052 189 X			
1	Nut / Mutter M3	165	N 3415 037 X			
8	Nut / Mutter M4	166	N 3415 039 X			
2	Nut / Mutter M5	167	N 3415 041 X			
2	Nut / Mutter M5	168	N 3457 041 X			
3	Nut / Mutter M10	169	N 3415 051 X			
		170				
1	Washer / Unterlagsscheibe 3,2 / 7,0 x 0,5	171	N 3502 412 X			
24	Washer / Unterlagsscheibe 4,3 / 9 x 0,8	172	N 3502 414 X			
10	Washer / Unterlagsscheibe 5,3 / 10 x 1	173	N 3502 416 X			
3	Washer / Unterlagsscheibe 10,5 / 21 x 2	174	N 3502 424 X			
Spare Parts for / Ersatzteile zu ESO 300 U						
Housing / Gehäuse			BK 204 184 AT			BB 800 069 E / 8

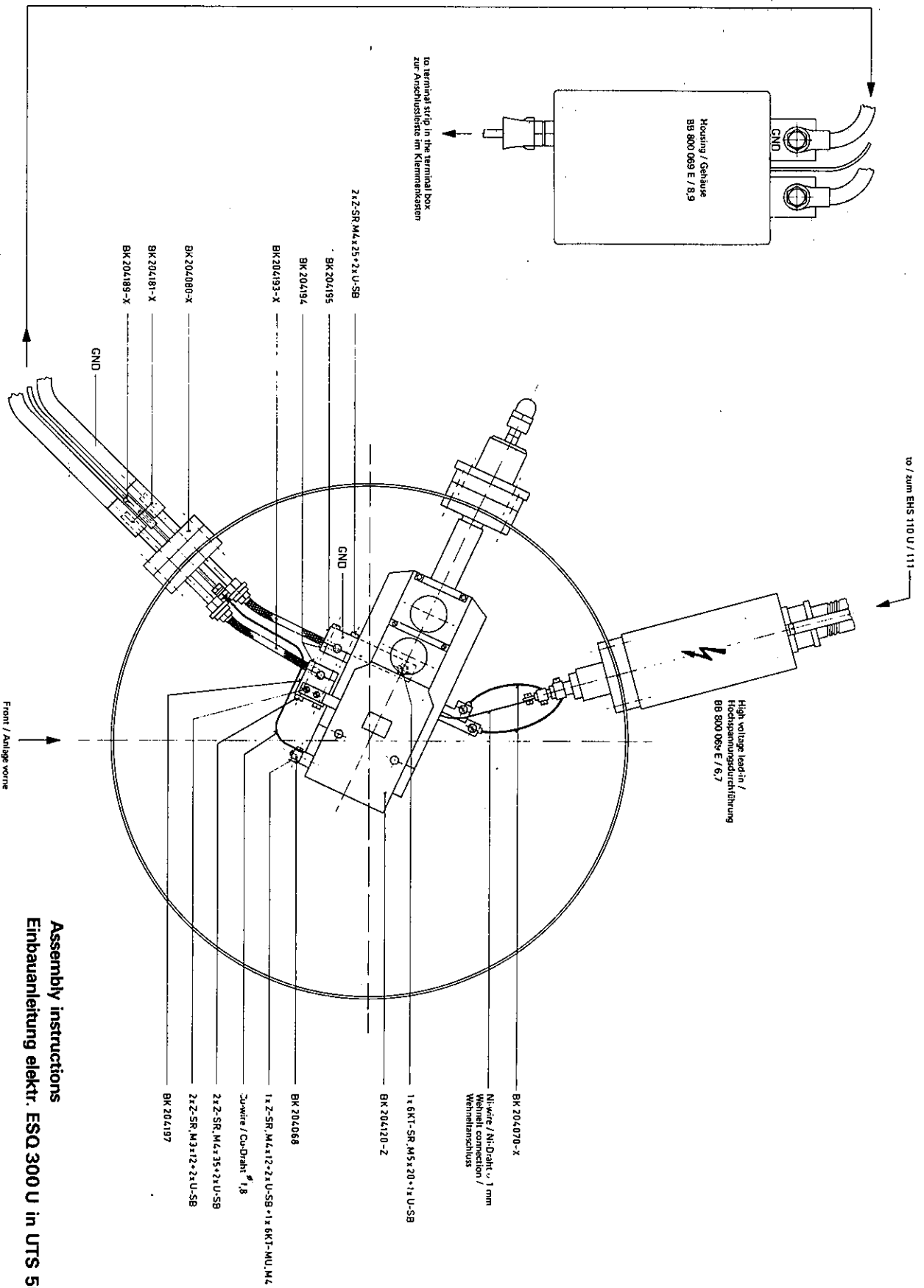




**Assembly instructions /
Einbauanleitung elektr. ESQ 300 U in UTS 350 A**

BK 204 186

to / zum EHS_110 U / 111



Assembly instructions
Einbauanleitung elektr. ESQ 300 U in UTS 500

BK 204 187