Lambda Physik

Excimer Laser

EMG 101 – 104 MSC

INSTRUCTION MANUAL

Operations Manual

EMG 101 - 104 MSC

Excimer Laser

Lambda Physik
Göttingen
W-Germany

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Dear Customer

Your new Lambda Physik Excimer Laser has been carefully tested at our facility. Before shipping it has performed at least two million shots at or above its specifications and has left Lambda Physik in good condition. We hope that it will give you many years of satisfactory service. Should any shipping damage or malfunction occur, please contact your closest Lambda Physik representative immediately. A test report and parameters and data for the optimum operation of this laser are contained in the test sheet at the rear of this manual.

INTRODUCTION

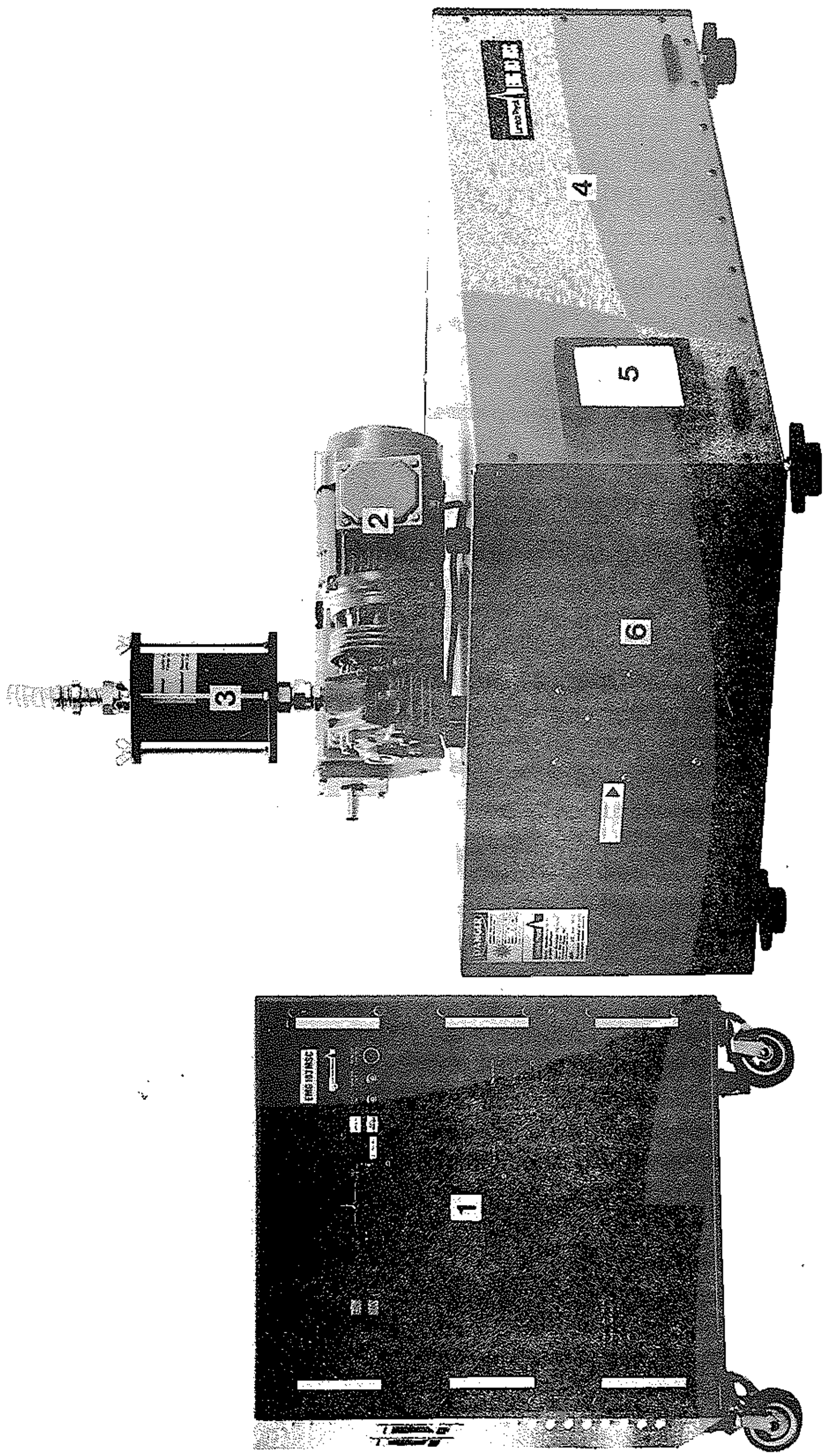
This LAMBDA PHYSIK excimer laser produces very intense laser pulses from the ultraviolet to the infrared spectral region. The high energy conversion efficiency and the broad, utilizable spectral range make this laser an ideal source of coherent light for all areas of technology, science and medicine.

The description of all control elements necessary for operating this instrument can be found in this manual and the attached test sheet. Further some advice on preparations to be made before and tests to be performed when installing the laser are laid down as well as instructions for maintenance.

At all times please observe the safety precautions given in the following section.

This laser is delivered, as a complete system, in three main parts: laser head, power supply and vacuum pump with gas filter (see Figure Introduction - 2 -).

The laser is ready for use after the necessary gases and the voltage supply have been connected. In addition an air outlet conduit and a water cooling system must be provided for permanent installation.



1. Power Supply
2. Vacuum Pump
3. Halogen Filter
4. Laser Head
5. Cooling Air Inlet
6. Beam Stop

ATTENTION! SAFETY PRECAUTIONS

Laser Radiation

This Laser emits high-intensity pulses ranging from the ultraviolet to the infrared part of the spectrum. These pulses can damage both the skin and the eyes. Therefore, never look directly into the laser beam or expose the bare skin to the beam.

Since even diffuse reflections can cause permanent injury, the user must take special precautions when operating the laser such that he as well as any other persons present can not be accidentally be exposed to the laser beam or its reflections.

It is urgently recommended that all persons present during the operation of the laser wear safety goggles appropriate for the wavelength in use at all times. The laser beam path should be shielded by proper means such as pipes, channels etc. to prevent uncontrolled reflections. The Accident and Safety Precautions as established by professional associations and unions (in Germany, VBG 93) must be observed at all times.

Beam stops must be made of non flammable materials.

Only qualified persons should operate the laser.

The enclosed laser warning sign should be clearly displayed.

Installation of an additional warning light is strongly recommended.

14.7
6
90.3 PSI
-14.7
75.6

High Voltage

High voltages of up to 45 kV are generated in the apparatus. Never open the laser before the high-voltage capacitors are completely discharged and the mains cable has been disconnected. Pay special attention to proper grounding of the apparatus.

Overpressure

Gas pressures up to 3.5 bar (abs) are used in the apparatus, and incorrect operation can result in pressures exceeding 3.5 bar (abs). Above this value, the pressure is released into the laser housing via the built-in safety valve.

The laser must always be operated with the hood closed. This protects the user in case of component failure or activation of the safety valve.

The pressure regulators situated between the external gas cylinders and the laser must be checked regularly to prevent the input pressure from exceeding the maximum allowable value (6 bar). = 90.3 PSIA

= 75.6 PSIG

Corrosive and Toxic Gases

Besides the various inert gases, fluorine and hydrogen chloride are also used in small concentrations in the apparatus. These gases are corrosive and can, even in small amounts, be toxic when used over a long period of time .

The following precautions must be observed (see also the regulations of the professional and labor associations):

1. Secure the gas cylinders in such a way that they cannot topple over.
2. Open the gas cylinder valves of the corrosive and toxic gases only while filling the laser.
3. Lead the exhaust of the vacuum pump and of the laser into a suitable exhaust.
4. Place a protective mask with proper gas filter in a clearly displayed and accessible part of the laboratory.

High power UV-radiation can generate ozone and nitrogenous gases. These should be removed with a proper air exhaust.

Saturated Halogen Filters

Please wear protective gloves when changing the halogen filters. The used filters are hygroscopic and contain oxydizing agents.

DESCRIPTION OF THE CONTROL ELEMENTS

1. Control Elements of the Power Supply (see Figure Description -2-)

The power supply contains three units, namely - from top to bottom - the control unit, the thyratron power supply, and the high voltage (HV) power supply.

1.1 Mains Power Switch

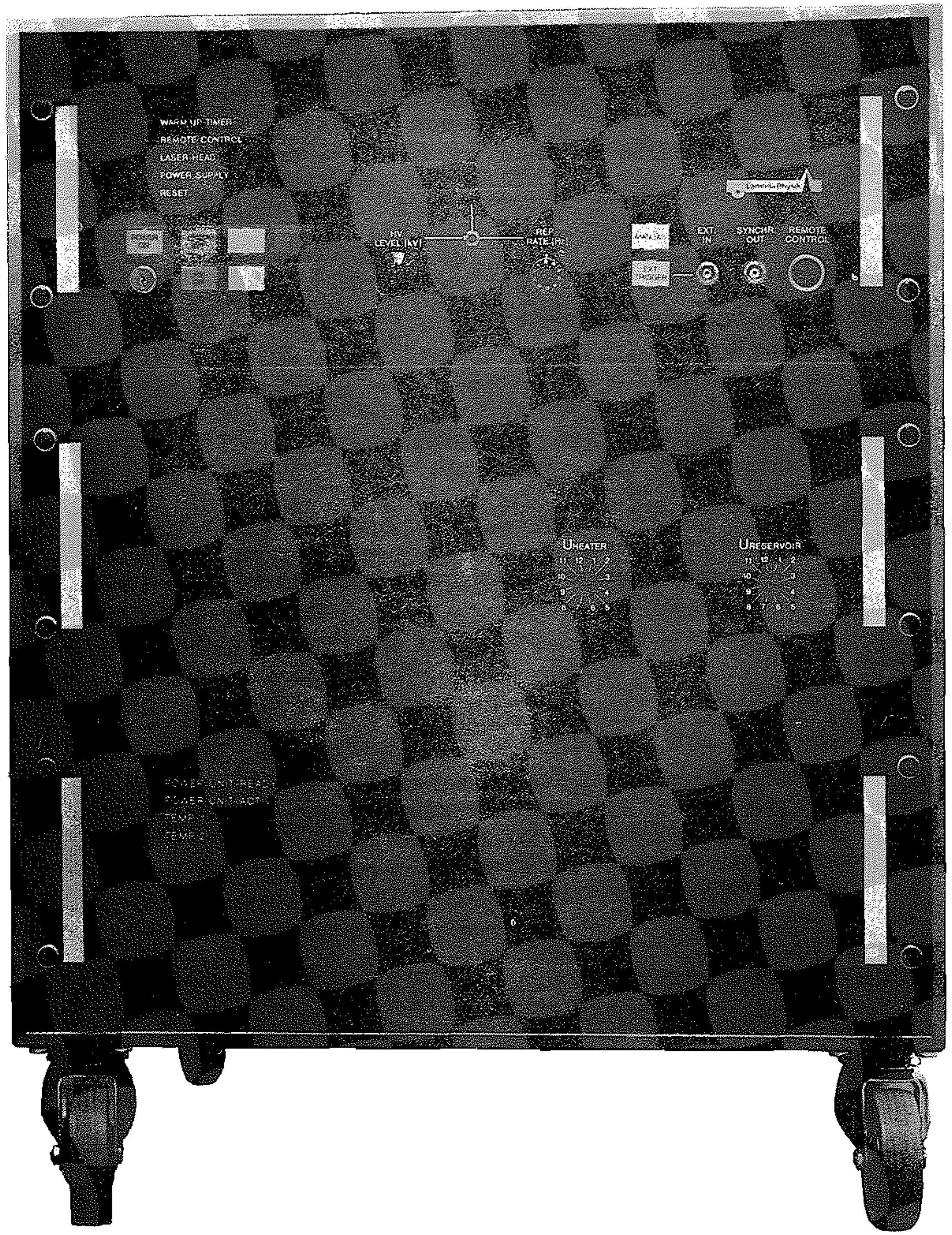
The mains power is activated by a key switch to prevent use by unauthorized personnel. After activating the switch the blue "Power On" indicator lamp comes on and the interlock LED's above the indicator lamp are activated.

1.2 Warm up Timer

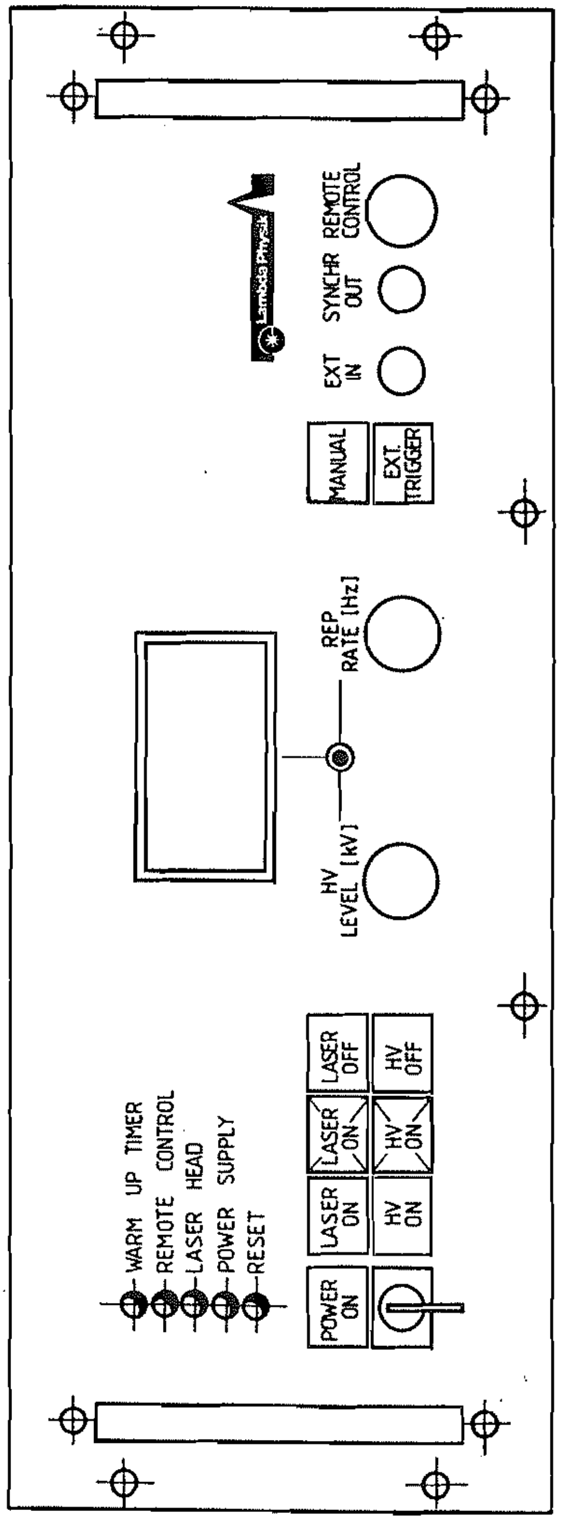
The warm up timer interlock is activated during the 10 minutes warm up time of the thyratron. After the thyratron has reached its operation temperature the warm up timer LED turns of and the laser can be operated.

1.3 Remote Control Interlock

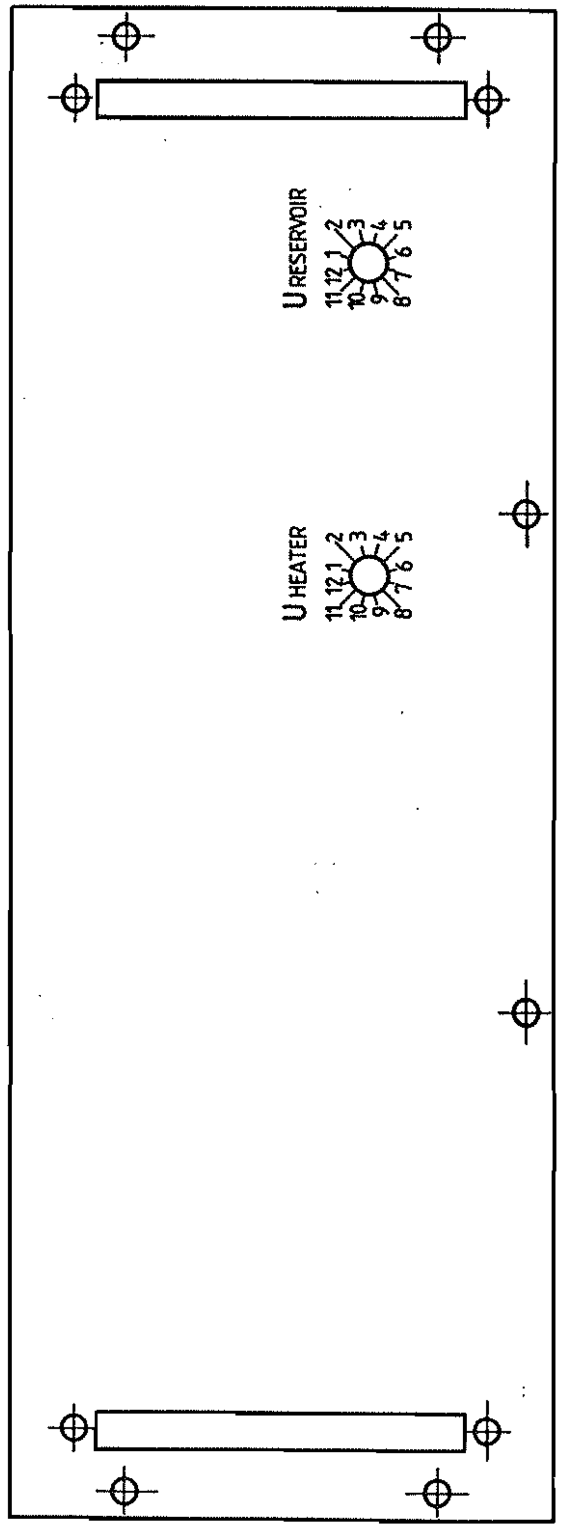
A control voltage of 24 V AC lies between contacts 2 and 3 of the remote control socket. If the connection between the two contacts (e.g. a user installed interlock controlling a door) is interrupted the high voltage is turned off and the remote control LED comes on. An interlock should be attached in accordance with the regulations of the professional and labor associations after removing the short circuit plug.



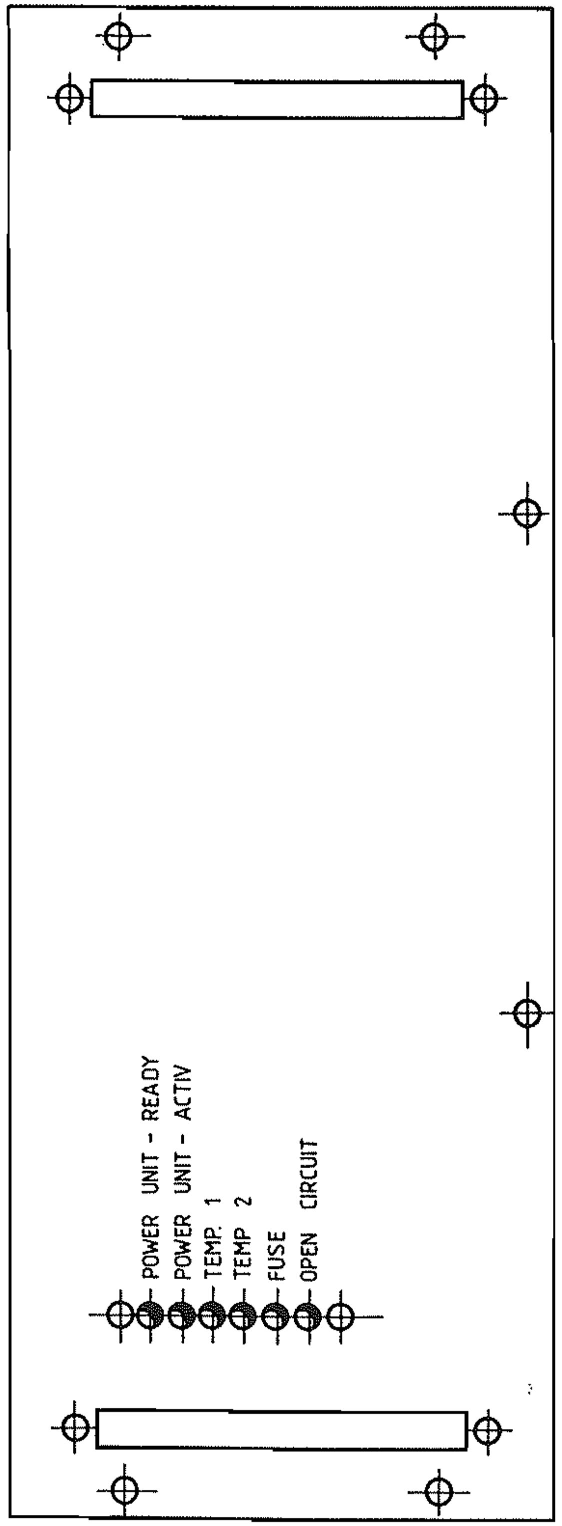
Front Panel Power Supply



CONTROL UNIT - FRONTPANEL-



THYRATRON POWER SUPPLY - FRONTPANEL -



HV - POWER SUPPLY - FRONTPANEL -

A voltage of 24V AC lies between the contacts 1 and 4 as soon as the high voltage of the laser is activated. This voltage may be used for switching an external 24V relay with a maximum current of 100 mA in order to run an external warning light.

1.4 Laser Head LED

This LED lights up if any of the interlocks in the laser head is activated (e.g. the cover is not closed).

1.5 Power Supply LED

This LED lights up if any of the interlocks in the power supply is activated. The power supply interlocks can be reset by pushing the "Reset" push-button below the power supply LED. Only if the cause for activating the interlock (e.g. overheating) has been removed the power supply LED can be reset.

1.6 Reset Push-button

(see 1.5)

1.7 External Trigger Push-button

The "Ext. Trigger" push-button is a two position push-button which allows the choice between an external and an internal trigger mode. Pushing the button switches between these two modes. If the button is illuminated this indicates that the laser is in the external trigger mode where a trigger signal has to be provided either via the "Ext. in" BNC socket or by manually pushing the "Manual" push-button.

If the "Ext. Trigger" button is now pushed the illumination turns off and the laser is then in the internal trigger mode where it is fired by its internal trigger generator.

1.8 Manual Push-button

Pushing the "Manual" button causes the laser to fire once provided the "Ext. Trigger" push-button has been set to the external mode as described in 1.7.

1.9 External Trigger Input

In the external trigger mode an external trigger pulse of + 15 V and a duration between 10 and 100 µs has to be supplied to the "Ext. in" BNC plug on the control unit. The laser triggers on a positive slope.

1.10 Repetition Rate

In the internal trigger mode the repetition rate can be adjusted by rotating the "Rep. Rate" knob. When the toggle switch below the digital display is flipped towards the "Rep. Rate" knob, the digital display shows the repetition rate in the internal as well as in the external trigger mode.

1.11 Synchronous Output

When the laser is triggered from its internal trigger generator, a signal of + 12 V and 15 µs duration which is synchronized to the laser trigger can be taken from the "Synchr. out" BNC plug.

1.12 High Voltage On

When the green "HV On" push-button is pressed the yellow "HV On" control lamp and the "Power Unit-Ready" lamp on the lower front panel come on with a time delay of three seconds. This indicates that the input circuit of the HV power supply, the gas circulation and the gas processor have been activated. However, no high voltage is provided yet.

1.13 Laser On

When the green "Laser On" push-button is pressed the yellow "Laser On" control lamp and the "Power Unit Active" lamps on the high voltage power supply front panels come on. This indicates that the laser will operate now, provided that the right high voltage level has been set, the trigger pulse is present and that the high voltage circuits of the high voltage power supplies are active.

1.14 High Voltage Level

With the "HV Level" knob, the high voltage can be adjusted to the levels indicated in the data sheet. The digital display shows the HV level in units of kilovolts after the toggle switch below it has been flipped towards the "HV Level" knob.

1.15 Laser Off

Pressing the red "Laser Off" push-button deactivates the laser and the high voltage side of the HV power supply.

1.16 High Voltage Off

Pressing the red "HV Off" push-button deactivates the input circuit of the HV power supply, the gas circulation, and the gas processor.

1.17 Thyratron Heater Voltage "U Heater"

The center panel contains the controls for the thyratron supplies. Behind the black removable plastic cap on the "U Heater" side is a twelve position switch which can be operated with a screw driver. This switch controls the thyratron heater voltage and should be set such that the thyratron heater voltage corresponds to the voltage specified in the data sheet. This switch is preset at the factory.

1.18 Thyratron Reservoir Voltage "U Reservoir"

The center panel contains the controls for the thyratron supplies. Behind the black removable plastic cap on the "U Reservoir" side is a twelve position switch which can be operated with a screw driver. This switch controls the thyratron reservoir voltage and should be set such that the thyratron reservoir voltage corresponds to the voltage specified in the data sheet. This switch is preset at the factory.

1.19 Power Unit-Ready Control Lamp

(see 1.12)

1.20 Power Unit-Active Control Lamp

(see 1.13)

1.21 Temperature 1 Interlock

This interlock is activated if the temperature of the thyristors in the HV power supply exceeds 65^{o}C (e.g due to excessive ambient temperature or a restricted flow of cooling air). After the reason for overheating has been removed the interlock can be deactivated by pressing the "Reset" button.

1.22 Temperature 2 Interlock

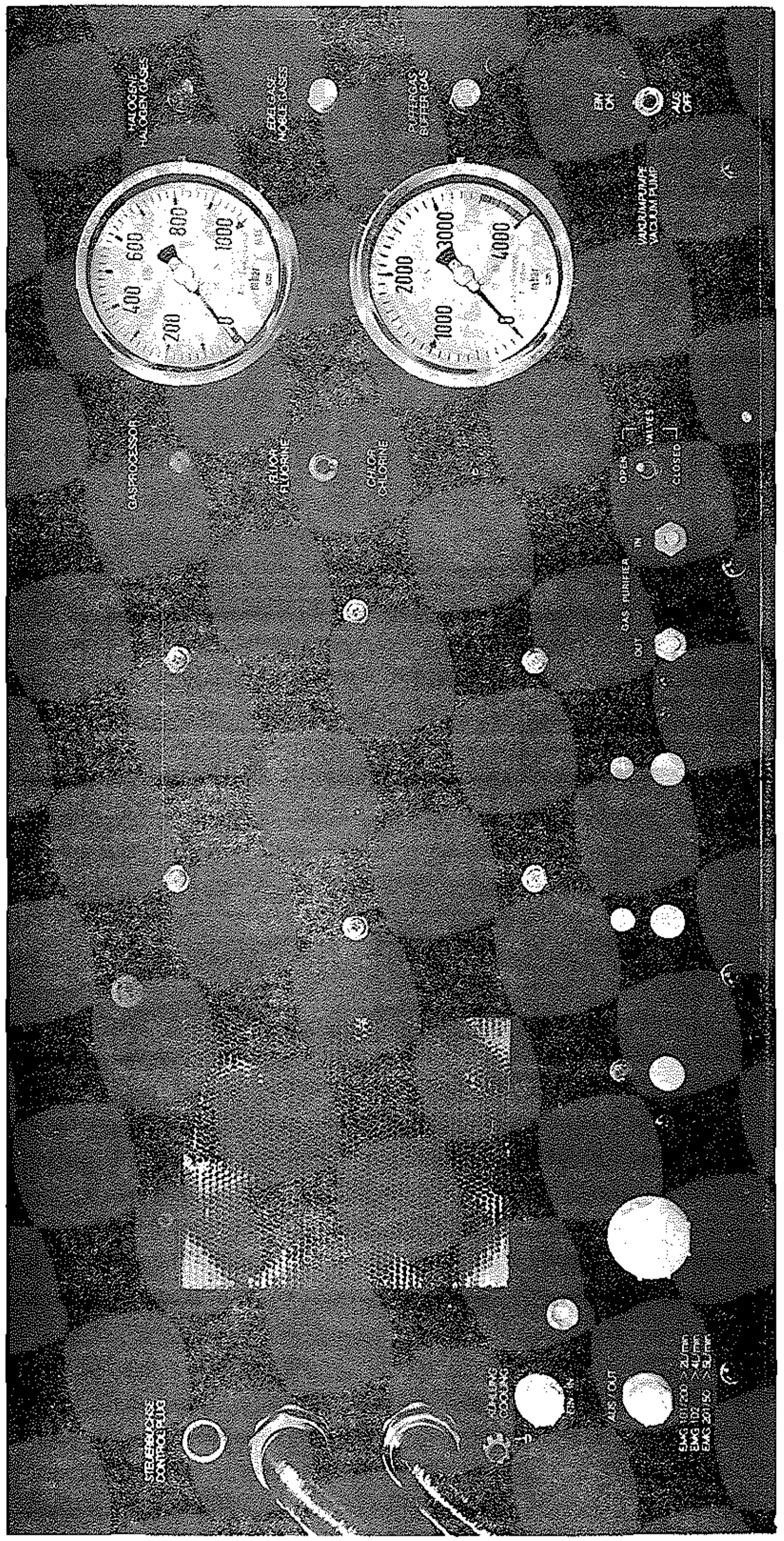
This interlock is activated if the temperature of the HV transformer in the HV power supply exceeds 65°C. (see 1.21)

1.23 Fuse

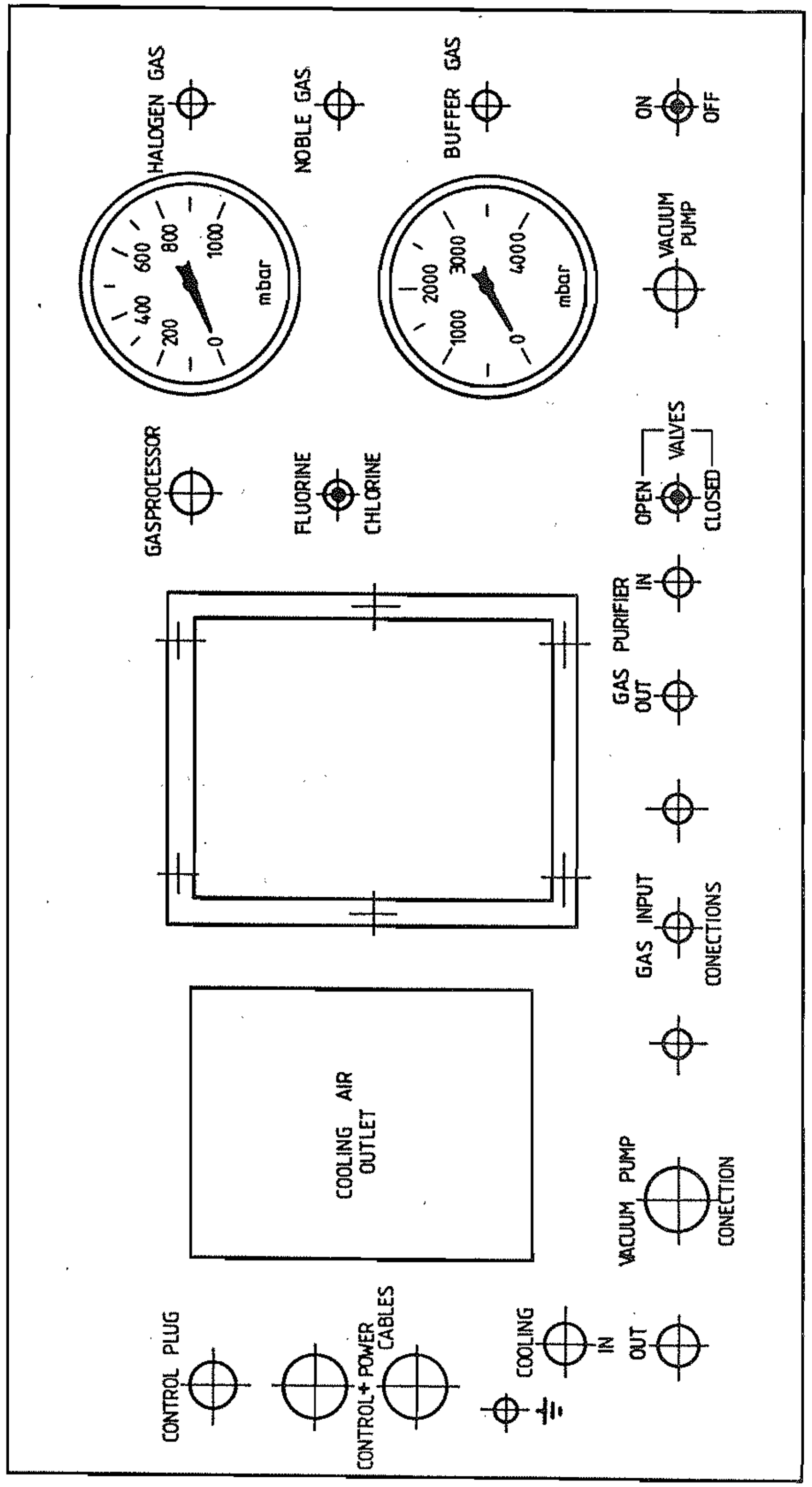
The "Fuse" LED indicates a faulty 40A fuse in the HV power supply. A spare fuse is provided with the laser tool kit.

1.24 Open Circuit

The "Open Circuit" LED indicates that the high voltage connection between the power supply and the laser head is either faulty or non existent. This interlock can only be reset by turning the mains power switch to the off position.



Rear Panel Laser Head



LASERHEAD - CONTROL PANEL -

2. Control Elements of the Laser Head (see Figure Description -8-)

The connections and control elements for the gas filling and purifying system are situated on the rear panel of the laser head.

2.1 Control Plug

If desired the solenoid valves in the gas filling lines and in the gas purifier lines can be controlled via the control plug from a remote position.

2.2 Control and Power Cables

The electrical connections between laser head and power supply are guided through two protective metal hoses which are screwed to the rear panel of the laser head. The high voltage cable is guided through one connector while all other cables enter the laser head through the other connector.

2.3 Cooling Water Connections

The supplied cooling water hoses should be connected to the two screw connections for water inlet and water outlet.

2.4 Vacuum Pump Connection

The vacuum pump with its halogen filter is connected to the conical screw joint by means of the supplied plastic tube.

2.5 Cooling Air Outlet

The supplied air exhaust connection has to be attached to the cooling air outlet and a suitable vent.

2.6 Gas Input Connections

The gas filling lines for the different gases are connected to the three screw connections (1/4", ∅ 6 mm Gyrolock). Above these inlets are color-coded markings for assignment to the color coded push buttons which operate the corresponding solenoid valves inside the laser housing.

2.7 Gas Processor Control Lamp

This lamp lights up as soon as the gas processor has been turned on via the "HV On" switch (see 1.12 above).

2.8 Gas Processor Switch

The built-in gas processor is turned on automatically by the "HV On" switch (see 1.12 above) on the power supply. The gas processor permits considerably longer gas-fill lifetimes. In order to guarantee proper functioning of the gas processor, the switch must be set to the position corresponding to the gas mixture used (i.e. containing fluorine or chlorine; see Installation -7-).

2.9 Vacuum Pump Control Lamp

The green control lamp lights up whenever the vacuum pump is turned on.

2.10 Vacuum Pump Switch

By setting the vacuum pump switch in the upper position, the vacuum pump is turned on. The high-voltage circuit of the laser is automatically interrupted to prevent firing of the laser at unappropriate pressures.

2.11 Pressure Gauges

The upper pressure gauge operates in the range from 0 to 1000 mbar (abs.) and serves as a pressure indicator for the gases which are used only at low partial pressures. These gases must be filled first. The lower pressure gauge operates in the range from 0 to 4000 mbar (abs.) and controls the operating pressure.The pressure should not be allowed to rise above 3500 mbar. Above 3500 mbar the built-in pressure relieve valve is activated.

2.12 Push-buttons for the Solenoid Valves

The laser is filled by pressing the push-buttons which open the solenoid valves in the input lines of the gas system. They remain opened only as long as these buttons are pressed. The push-buttons are color-coded to permit a clear identification of the corresponding filling lines.

2.14 Gas Purifier Connections

If the gas purifier GP 2000 which substantially extends the lifetime of a gas fill is used it's in and outlet tubes have to be connected to the "Gas Purifier in and out" screw connections (1/4", ∅ 6 mm Gyrolock).

2.15 Gas Purifier Switch

The gas purifier can be activated or deactivated by turning the "Valves, open-closed" toggle switch which is situated beside the gas purifier in and outlet. Turning the switch to the "open" position opens the two solenoid valves at the in and outlet. This situation is indicated by a lamp above the toggle switch. When no gas purifier is used the in and outlet ports have to remain blanked off vacuum tight.

Preparations for Installation of the Laser System

1. Electrical Connections

The laser has to be connected to a 208V (US), 380V (Europe) or 208/380V (Japan) three-phase power line. The correct data for your laser can be found in the data sheet at the rear of this manual and on the rear panel of the control unit which is accessible after the rear panel of the power supply has been removed.

2. Water Connection

Cooling water is required to cool the discharge system when operated at repetition rates above 3 Hz. Two plastic hoses are provided to supply and drain the cooling water. The water flow rate depends on the repetition rate used and the temperature of the cooling water. On maximum repetition rate 4 liters/min of cooling water (15°C) are necessary. At lower repetition rates the flow rate may be reduced correspondingly. In no case should the water temperature at the exit port exceed 30°C. LAMBDA PHYSIK recommends the use of a flow meter in the water cooling system.
In order to avoid leaks in the cooling system, the water pressure must be below 3 bar. To avoid sudden pressure jumps in the cooling system, we recommend the use of a suitable pressure regulator.

3. Air Exhaust Connection

The cooling air, which leaves the laser head should for safety reasons be conducted to a suitable exhaust. The cooling air unavoidably contains small quantities of ozone, which is always generated in high voltage systems. Also any toxic and corrosive gases which may be present because of a possible leak in the gas

system or whenever the overpressure valve in the laser head is activated have for safety reasons to be guided into an exhaust system. The laser should never be operated without a sufficient flow of cooling air.

The air must be conducted by tubes or flexible hoses with an inner diameter of at least 150 mm. Should tube lengths of more than 2,5 m be required and the laser is being operated at a repetition rate of more than 10 Hz an additional fan with an extraction rate of at least 100 liters/s must be fitted to the end of the exhaust tube; otherwise overheating of the system can occur.

4. Connection for the Vacuum Pump Exhaust

Corrosive and toxic gases can be contained in the vacuum pump exhaust because of faulty operation or saturated gas filters. For this reason the vacuum pump exhaust must be conducted into a suitable exhaust system using a 3/4" tube. The length of this tube must not exceed 5 m.

5. Gas Supply

Various different gases are needed for the laser operation depending on the wavelength required. The gases are mixed inside the gas system. Toxic and corrosive gases like fluorine and hydrogen chloride should be used in the form of 3 - 5% mixtures in Helium for safety reasons and to allow easier handling. These types of mixtures are obtainable from a number of suppliers.
The gases should have the following degrees of purity:

Helium : 99.995 % or better
Neon : 99.99 % or better
Argon : 99.995 % or better
Krypton : 99.99 % or better
Xenon : 99.99 % or better
Hydrogen Chloride/He: 99.995 % or better, mixed in Helium
Flourine/He : 99.9 % or better, mixed in Helium
Nitrogen : 99.99 % or better
Carbon Dioxide : 99.99 % or better
Neon 70[*] (first run) : 99.995 % or better

Krypton and Xenon can also be used with a purity of only 99.9 %, however, lower pulse energy and gas mixture life time might result.

The necessary gases have to be supplied by the customer in high pressure cylinders with appropriate pressure regulators. We recommend the use of LAMBDA PHYSIK's pressure regulators to guarantee proper operation. If other pressure regulators are used they have to be equipped with fittings for 6 mm outside diameter copper and plastic tubing.
For some emission lines the addition of Neon or Argon to the mixture leads to a considerable improvement in performance while at the same time improving the shot to shot reproducibility. Therefore a T-piece and additional plastic tubing has been supplied which enable an additional Neon or Argon cylinder to be connected. For this purpose a third pressure regulator for noble gas has to be used. The laser is supplied with color coded plastic tubing: blue tubing for buffer gas and yellow tubing for noble gas. For safety reasons the copper tubing must be used for halogen, plastic tubing can not be used.

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[*] The quality of Neon 70 seems to depend strongly on the supplier. Low quality Neon 70 can lead to somewhat reduced gas life times.

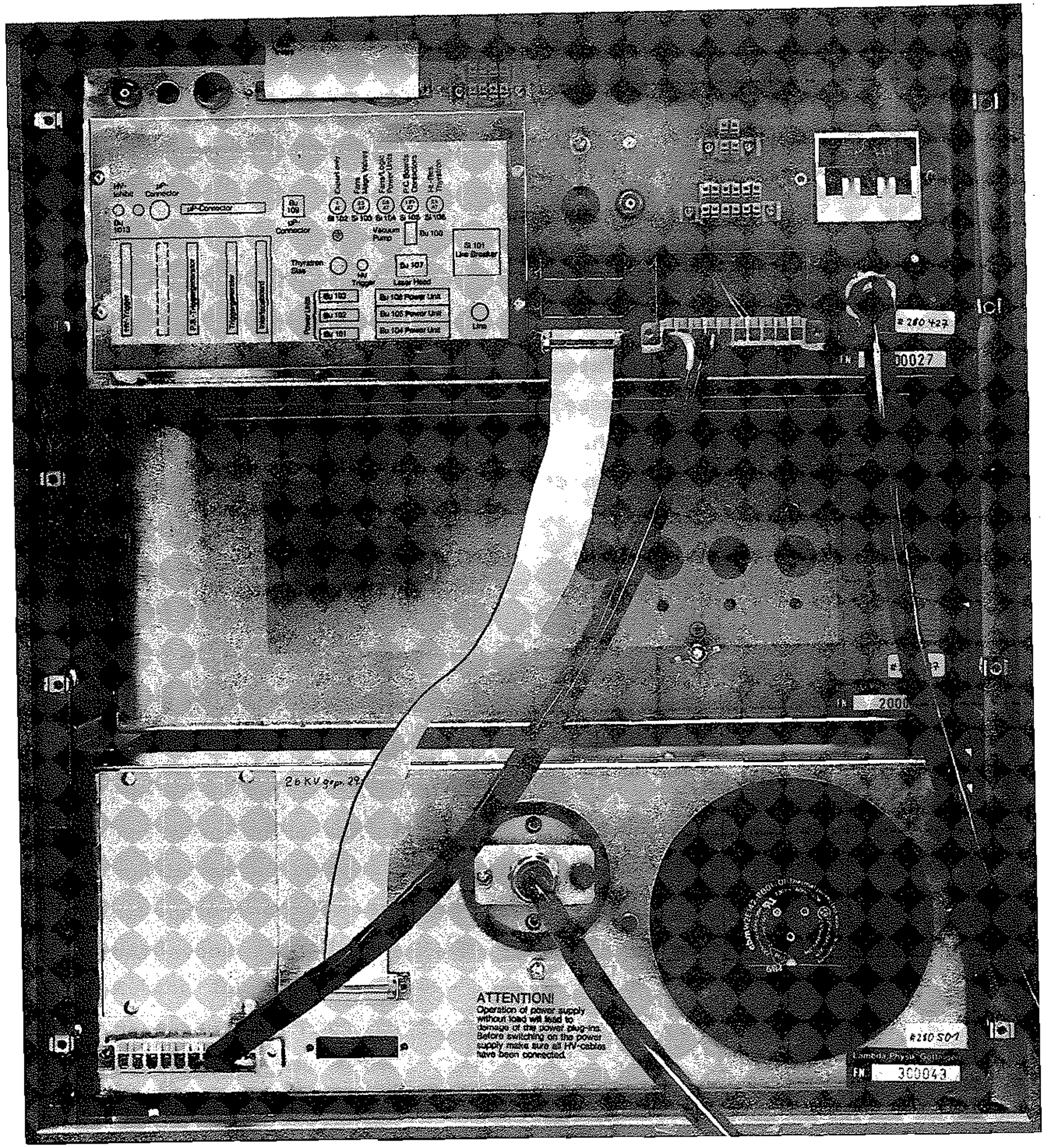
Installation of the Laser System

1. Connect the Supply Cables which come from the laser head to the Power Supply (see Fig. Installation - 2 -).
(Warning! Do not connect the power supply to the mains yet.)

This is done in the following way:

1.1 Remove the back panel of the power supply.
1.2 Feed the cables from the laser head through the port in the back panel and attach the cable support plate to the back panel using the four selflocking screws.
1.3 Insert the white plug of the high voltage cable into its socket in the rear of the high voltage power supply and secure by tightly screwing in the red kurled nob.
1.4 Connect the four thyratron cables to the color coded sockets in the thyratron power supply. Connect the red cable to the red socket, the blue cable to the blue socket the black cable with the blue ring to the black socket below the blue socket and the black cable with the red ring to the socket below the red socket.
1.5 Connect the four pin plug to the male four pin "Heater Module" socket on the back of the thyratron supply.
1.6 Connect the twelve pin plug to the twelve pin socket on the back of the control unit.
1.7 Connect the black color coded BNC plug to the black coded BNC socket on the back of the control unit.
1.8 Connect the remaining cable with its eye to the ground pin using the wing nut (on the back of the control unit above the thyratron bias indicator lamp).
1.9 Connect the vacuum pump cable which comes from the power plug in the back panel with its four pin plug to the female four pin socket on the back of the control unit.
1.10 Install the back panel of the power supply.

2. Connect the Vacuum Pump to the Control Unit.
Connect the plug of the pump cable to the socket on the back panel of the power supply. Take care to ensure that the safety guard for this plug connection is put into the correct position.



Rear Panels Power Supply

3. Connect the Laser to the Three-Phase Power Line.

Attention! Make sure that the ground conductor is properly connected.

4. Test the Direction of Rotation of the Vacuum Pump Motor.

A pump which runs with the wrong direction of rotation can introduce impurities into the laser system which strongly affect the laser performance and which are difficult to remove.

4.1 Turn the "Mains Power Switch" to the on position. Place a piece of cardboard or something similar onto the intake port of the pump.

4.2 Turn on the vacuum pump briefly. If the direction of rotation of the pump motor is correct the cardboard should be sucked towards the intake port.If the pump does not operate correctly two phases in the mains plug of the laser power supply have to be exchanged. Having done this ensures also proper direction of rotation of the gas circulation fan motor in the laser. It is important to test the direction of rotation of the motor each time the laser is operated from a different mains supply socket.

5. Install Vacuum and Exhaust Lines.

5.1 Connect the flexible plastic hose to the vacuum pump connection of the laser head and to the filter inlet at the pump. Make sure the connections are vacuum tight.

5.2 Connect the exhaust pipes for the laser head cooling air outlet and for the pump exhaust to suitable vents.

6. Connect the Cooling Water Lines.

This is necessary if the laser is to be run with a repetition rate of more than 3 Hz.

7. An additional customer supplied interlock can be connected to the "Remote Control" plug on the power supply (see Figure Description -2-).

If such a switch is not desired the supplied four pin plug with the red cap may be used to defeat the remote control interlock option.

8. Install the Gas Filling Lines and Test for Leak-Tightness.

In general the laser is shipped with a filling of buffer gas. Therefore the laser has to be filled with the appropriate gas mixture before operation.

8.1 Connect the supplied gas filling lines to the color-coded inlets at the laser head and the pressure regulators of the gas bottles. Use blue for buffer gas, yellow for rare gas and always copper tubing for halogen.

8.2 For your safety, and in order to prevent air from leaking into the laser system you have to check whether the gas filling lines are leak tight. For this purpose LAMBDA PHYSIK recommends to use a leak detection fluid (eg. SNOOP, Swagelock).

8.2.1 Turn on the vacuum pump and press the push-button for each of the gas inlet solenoids for approx. 30 s. This will remove most of the air from the filling lines.

8.2.2 Set the pressure regulators by turning the regulating knob counterclockwise to the minimum pressure position. Open the main valve of the gas bottle briefly.

8.2.3 Set the pressure of all adjustable pressure regulators to 3 bar (42 psi)

8.2.4 After closing the main valves open the outlet valves of the pressure regulators so that the gas filling lines can be filled with the appropriate gases.

8.2.5 Now check carefully the leak-tightness of all the connections you have made with the liquid leak detector mentioned above. The decrease of pressure with closed gas bottle main valves as indicated by the regulator gauge can also be used as a check.

9. Flush the Gas Lines.

At this stage, the gas filling lines are still filled with residual amounts of air. Since small amounts of air are detrimental to good laser performance, the gas filling lines have to be flushed. For this purpose proceed as follows:

9.1 Switch on the vacuum pump.

9.2 Flush all the filling lines up to the main valve of the gas bottles. Proceed as follows:

9.2.1 Close the outlet valves of the pressure regulators.

9.2.2 Press the push-button for each of the gas inlet solenoids for approx. 30 s while the vacuum pump is running. By this means the inlet valves are opened and the gas filling lines are evacuated.

9.2.3 Set the pressure regulators by turning the regulating knob counterclockwise to the minimum pressure position. Open the main valve of the gas bottle briefly.

9.2.4 Set the output pressure of all adjustable pressure regulators to 3 bar max.

9.2.5 After closing the main valves, open the outlet valves of the pressure regulators, so that the gas filling lines can be filled with the appropriate gases.

9.2.6 Evacuate the gas filling lines up to the main valve of the gas bottles as specified in 9.2.2.

9.2.7 Repeat the flushing procedure at least 5 times in order to remove all impurities.

9.2.8 The above procedure has to be performed whenever gas bottles are changed.

10. Flush the Complete Gas System and Test Vacuum Tightness.

10.1 Switch off vacuum pump.

10.2 Open the main valve of the buffer gas bottle and the outlet valve of the pressure regulator (pressure 3 bar, 42 psi).

10.3 Open the solenoid valve of the buffer gas line by pressing the corresponding push-button (color-code blue).

10.4 Fill the gas system up to 2500 mbar abs. and check if the pressure decreases. Any possible decrease must not exceed 5 mbar/h. (This test may be done over night.) Evacuate the gas system and fill with buffer gas to 1000 mbar abs.

11. Fill Gas Mixture for the Desired Wavelength.

11.1 The correct pressures of the individual gas components can be taken from the test sheet or from the table Installation -7-. For safety reasons please observe that the halogen constituents have to be used only diluted in helium.

11.2 After evacuating the gas system fill with the appropriate gases for the chosen wavelength by pressing the corresponding push-buttons on the laser head. This should be done in the following order: Halogen mixture, rare gas and buffer gas.

12. Final Test

12.1 Check the thyratron heater and reservoir voltage as well as the cathode bias of the thyratron. For control points see Fig. Installation -2-. Compare with the values specified in the test sheet. The presence of the bias voltage is indicated by the orange control lamp on the back panel of the control unit.

12.2 Check whether the gas processor switch is set to the correct position (see table Installation -7-).

After switching on the cooling water the laser is ready for start up. Before running the laser, please observe all safety precautions as laid down by law and prescribed in this manual.

900-666

oil 30 weight SAE

Gas mixtures for EMG 101 - 103 MSC

See also more recent listing in "site preparation" notes.

Active Medium	F_2	ArF	KrCl	KrF	XeCl	N_2	XeF	
Wavelength	157	193	222	248	308	337	351	nm
Helium (99.995 %)	2660	1700	1550	2230*	----	940	2265*	mbar
Neon (99.99 %)	250	----	----	----	2420+	----	----	mbar
Argon (99.995 %)	----	350	----	----	----	----	----	mbar
Krypton (99.99 %)	----	----	350	150	----	----	----	mbar
Xenon (99.99 %)	----	----	----	----	80	----	15	mbar
5 % Fluorine (99.9 %) diluted in He	90	150	----	120	----	----	220	mbar
5 % HCl (99.995 %) diluted in He	----	----	100	----	100	----	----	mbar
Nitrogen (99.99)	----	----	----	----	----	60	----	mbar
Total pressure	3000	2200	2000	2500	2600	1000	2500	mbar
Gas processor switch	Fluorine	Fluorine	Chlorine	Fluorine	Chlorine	Chlorine	Fluorine	
Number of fillings before replacement of halogen filters	60	35	125	45	125	----	25	

OIL SAE 30 weight w/ ½ quart.

Vac out — rosing on oil exhaust oil level or window oil consist of black look. Drain ½ c

— 1¾ full less ½

+ Instead of Ne, He may be used. This will reduce the output power by approx. 40 %

* The use of Ne instead of He will increase the laser output.

drain bag.

black cap was Hex a good

Maximum charging voltage 101 - 104 MSC at maximum repetition rate

		F_2	ArF	KrCl	KrF	XeCl	N_2	XeF
101 MSC	ν/Hz	10	50	50	50	50	50	50
	U_o/kV	26	24	22	24	22	22	24
102 MSC	ν/Hz	10	100	100	100	100	100	100
	U_o/kV	26	24	22	24	22	22	24
103 MSC	ν/Hz	10	200	200	200	200	200	200
	U_o/kV	26	24	22	24	22	22	24
104 MSC	ν/Hz	--	400	--	500	500	--	500
	U_o/kV	--	23	--	21	21	--	21

1. Start up of the Laser.

1.1 Turn on the mains power switch and wait for appr. 10 minutes. After this the thyratron has reached its operating temperature and the warm up timer interlock LED will turn off.

1.2 Set the "Ext. Trigger" push-button to the internal trigger mode (i.e. the button should not be illuminated). Turn the toggle switch below the digital display towards the "Rep. Rate" knob and rotate the "Rep. Rate" knob till the display shows a reading of 2 Hz.

1.3 Push the "HV On" button.

1.4 Turn the toggle switch below the digital display towards the "HV Level" knob and turn the knob all the way counter-clockwise. This sets the high voltage to zero.

1.5 Push the "Laser On" button.

1.6 Turn the "HV Level" knob clockwise till the display reads the high voltage value which is given in the test sheet for the gas mixture which you are using. If in doubt a high voltage of 23 kV will be suitable as a starting voltage for all gases. However for best performance the test sheet values should be chosen. Do not let the laser fire at too low voltages for extended periods of time.

1.7 The laser will now fire with a repetition rate of 2 Hz.

1.8 Should there be no or irregular firing of the laser, the high voltage must be switched off as irregular firing may prematurely wear out components. In this case please refer to the trouble shooting section of this manual.

1.9 Once the laser is running correctly at the low repetition rate, set the desired operating conditions. Do not forget cooling water (above 3Hz). The working voltage must be readjusted according to the used repetition rate.

2. Restarting the Laser after an Extended Period of Time.

A decrease in output power is to be expected should the laser be turned off for a prolonged period of time. This decrease is strongly dependent on the type of gas mixture employed. If the output power is too low or no emission does occur, the laser gas must be exchanged.

3. Changing the Emission Wavelength.

If the halogen component of the gas mixture remains the same as in the previously used gas mixture, the laser is ready for operation after the desired gases have been filled (see table Installation -7-). If a change of the halogen component is necessary, the laser has to be passivated according to General Advice -3-.

4. Charge on Demand Mode

In very low repetition rate applications where the laser is fired only occasionally it is advisable to operate the laser in the Charge on Demand mode. In this mode the high voltage is turned on only shortly before the laser is fired. This is a precaution against accidental firing or missfiring and in addition extends the lifetime of the high voltage components. The high voltage is inhibited when a DC voltage of + 15 to 30 V is applied to the green color-coded "HV-inhibit" BNC plug which is located on the back panel of the control unit. The current amounts to 7 - 15 mA. If this voltage is turned off the laser will charge the high voltage discharge circuit. Triggering with the standard external trigger pulse can now follow at any desired time, but not earlier than t_{HVon} where

$$t_{HVon} = 1/f_{max}$$

and f_{max} is the maximum repetition rate with which the laser can be operated.

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1. Decrease of Output Energy

1.1 Decrease of Pulse Energy with Time

Even in well passivated gas vessels and also in the absence of electrical discharges, a slow chemical reaction occures which leads to a decrease in the halogen concentration. Therefore it is normal that a slow decrease in the output pulse energy will be observed with time. The rate of this decrease varies for the different gases and is also dependent upon the degree of passivation of the gas circulation system.

1.2 Decrease of the Pulse Energy with Increasing Number of Pulses

Because of slow chemical reactions between the halogens and the discharge vessel, which are enhanced by the discharges, a slow consumption of gases occurs. This lowers the pulse energy with increasing number of pulses. Through the concept of the integrated gas reservoir and by the use of inert materials the useful life of the fillings has been increased to such an extent that one gas fill is sufficient for several hours of operation even at high repetition rates.

1.3 Compensation for Energy Decrease

The decrease of power output with number of pulses can be partly compensated for by adding small amounts of the appropriate halogen buffer gas mixture. When adding halogen buffer gas mixture, increase the total pressure gradually in steps of about 10 mbar and check the output power after each step. Our experience shows that the addition of more than 50 % of the originally specified amount of halogen buffer gas mixture leads to no further increase in output power. The simultaneous increase of the proportion of buffer gas which occurs through the addition of the gas mixture has no influence. When the laser is operated with XeCl for extended periods of time, it might become necessary to add small quantities of Xenon as well.

2. Dependence of the Pulse Output Energy on the Charging Voltage

In case where the maximum pulse energy is not required the charging voltage can be lowered. This has the advantage of extending the gas lifetime and the component lifetime in the high voltage circuitry. However care should be taken to avoid arcing which can occure at too low voltages. At the specified operating pressures the voltage can be varied between the threshold and the maximum value as given in the test sheet.

The threshold voltage can be lowered by decreasing the operating pressure, however, at decreased pulse energy.

It is recommended that the high voltage is turned off when the laser is not operating.

3. Operation as N_2-Laser

When operating the laser with N_2 it must be taken into account that besides the emission at 337 nm, other emission lines from the UV to the infrared can occur. The gas processor switch must be set to the position "Chlorine".

4. Operation with F_2

Due to the absorption of the 157 nm line in air the laser beam must be propagated in such a way that the beam paths can either be flushed with a non-absorbing gas or can be evacuated. The two window mounts are therefore constructed in such a way that a tubing system which allows flushing with a non-absorbing gas (Argon/ Helium) can be easily connected. A customer supplied connecting adapter must have an external screw thread of M 38 x 0.75 and be able to be sealed to the window adapter (e.g. with O-rings or gaskets). Such a connector with a Leybold KF 40 flange can also be obtained from LAMBDA PHYSIK (EMG 85).

4.1 Simultaneous Emission

With the normal concentration of fluorine which is used in the F_2 laser, red and infrared emission lines can be emitted simultaneously, when operating the laser at 157 nm. These are superradiant emissions which cannot be suppressed by using special dielectric VUV mirrors. Therefore, attention is drawn to the fact that one must never operate the laser at 157 nm without wearing the appropriate goggles for the red and infrared.

5. Passivation of the Gas System

The laser has been passivated in the factory for the halogen gas component which is requested by the customer. If no special request is made by the customer, the laser will be passivated for operation with gas mixtures containing fluorine. The gas system must be re-passivated: (i) when changing operation to the other halogen component and (ii) when accidental admission of air into the system has occured.

During certain servicing operations the system must be opened to the atmosphere. In addition air can also enter both through leaks in the gas system and by incorrect operation of the gas mixing system. In case of a leak, the leaking component has to be identified and repaired or exchanged.

After the system has been reassembled in a leak tight condition, the gas system must be evacuated and flushed at least twice by filling it up with 300 to 400 mbar of Helium or Argon and then evacuating it again. After this the passivation procedure is required.

5.1 Passivation Procedure

Attention ! During the passivation procedure the partial pressure of the halogen component should not exceed 10 mbar; (i.e. 200 mbar halogen/He mix).

In order to passivate the system for fluorine operation, the laser must be filled with the mixture for ArF (see table Installation -7-) and then must be run until the laser energy drops to onehalf of its initial value. This procedure must be repeated at least once more before the desired gas mixture can be used in the system.

When the gas bottles are changed the small amount of air which enters the filling lines can be eliminated by repeatedly flushing these lines.The laser should reach its specifications with respect to pulse energy and gas life time, after at most 3 fillings with the appropriate gas mixture.

The passivation for hydrogen chloride should proceed as follows:
Fill the gas system with 200 mbar HCL/Helium (5%) mixture and 800 mbar Argon or Helium and wait for 10 min. without high voltage discharges. Now the laser can be evacuated and the desired laser gas mixture added. After 3 fillings with the laser gas mixture the laser should meet its specifications.

After extended operation of the system, a larger number of passivation gas fills may be needed when changing from hydrogen chloride to fluorine-containing gas mixtures.

8. Alignment of the Resonator

It is important to ensure that the surfaces of the rear-mirror and the exit-window are orthogonal to the beam and parallel to each other. The adjustments can be carried out by one person (after the protection shields have been removed from the front and rear sides of the laser) with the aid of a HeNe-Laser and an Allen key (type 3 mm provided as an accessory). Each mirror gimbal mount has two Allen screws which rotate the mirror about the horizontal and vertical axis respectively.

8.1 Turn off the laser and remove the rear mirror as described in Sect. Maintenance 5.1 and 2.

8.2 Align the HeNe-laser such that its beam goes through both the center of the exit and rear window of the excimer laser. (Never look directly into the beam of the HeNe-laser. The alignment of the HeNe-laser can be facilitated by the use of irises which fit into the exit and rear window mounts).The HeNe-laser beam has to enter the excimer laser through the exit window.

8.3 Reinstall the rear mirror.

8.4 Fill the laser to the desired operating pressure.

8.5 Use the two alignment Allen screws at the exit window mount (3 mm Allen key, accessory kit) to tilt the exit window such that the reflected HeNe beam goes exactly back into the HeNe-laser (or a cardboard iris in front of the HeNe-laser). The exit window is now aligned perpendicular to the HeNe beam.

8.6 Use the same procedure to align the back reflex from the rear mirror.

8.7 The excimer laser is now aligned.

If no HeNe-laser is available the following alignment procedure can be used with Al rear mirrors. Small realignments can often be made by slightly tilting the exit and rear mirror mounts and adjusting for maximum laser power. For a visual alignment please proceed in the following way.

8.8 Turn the laser off.

8.9 Make sure the laser is filled to working pressure.

8.10 Look down the laser axis from the side of the exit window and try to align your eye with the elongation of the laser axis. (Turn up room lights or use a torch).

8.11 You will now see the two electrodes as well as the image of the electrodes which appears in the rear mirror. A second person now has to align the rear mirror such that the image of the electrodes in the rear mirror is a smooth elongation of the electrodes themselves.

8.12 The adjustment of the exit window can be carried out while the laser is running. For this purpose the output of the laser should be observed on a piece of paper and the exit window aligned till a uniformly illuminated rectangular beam emerges.

The following maintenance should be carried out regularly to guarantee best performance of the laser.

1. Change of the Vacuum Pump Oil

The oil in the vacuum pump should be changed once a year. (See vacuum pump manual).

2. Changing the Halogen Filter

After extended use the halogen filter at the input port of the pump saturates and has to be replaced. We recommend to replace the filter elements after the number of fillings given in table Installation -7- as saturation depends on the type of gas which is used.

To change the filter

2.1 Unscrew the four wing nuts which hold the filter housing together.

2.2 Remove the square connecting plate attached to the top of the filter housing.

2.3 Remove the housing with the 5 built-in filter elements.

2.4 Remove the old filter elements. Wear protective gloves while handling old filters.

2.5 When assembling new filter elements make sure that between each 2 elements and outside the element facing the gas inlet side an O-ring is mounted.

2.6 When assembling the filter housing, make sure that the O-ring used for sealing the connecting plate is in the correct position and the housing is leak tight.

3. Dust Filter

The dust filter which is placed at the air inlet of the laser head has to be cleaned occationally. Otherwise accumulation of dust on the inner components of the instrument and problems like arcing in the high voltage discharge system can occur. The intervals for cleaning depend on the environment in which the laser is used.

4. Laser Tube Windows

High voltage discharges evaporate small amounts of electrode material. Although in Lambda Physik lasers the space between laser discharge and window is carefully baffled, small amounts of this material will eventually reach the windows and reduce the laser output.
Therefore the windows must be cleaned from time to time. To avoid the loss of passivation it is recommended to flush the gas system with an inert gas during the exchange and cleaning procedure.

5. Instructions for Changing Resonator Optics

5.1 End Reflector

There are two different types of end reflectors. The first type is a MgF_2 flat with coated rear surface. This reflector simultaneously serves as a laser window and the instructions as given in 5.2 apply.

The other type of end reflector is a front coated dielectric or Al mirror which is pressed together with a plastic spacer ring against the rear window of the laser by a retaining screw (see fig. Mainenance -4-). This type of mirror can be handled with a plastic suction cap which can be attached to the rear-surface of the mirror. The mirror can be exchanged after the retaining screw has been removed.
When reassembling the mirror, the suction cap has to be placed in the centre of the back surface of the mirror and the mirror is then guided with the suction cap (which has a specially formed handle for this purpose) into the window mount.

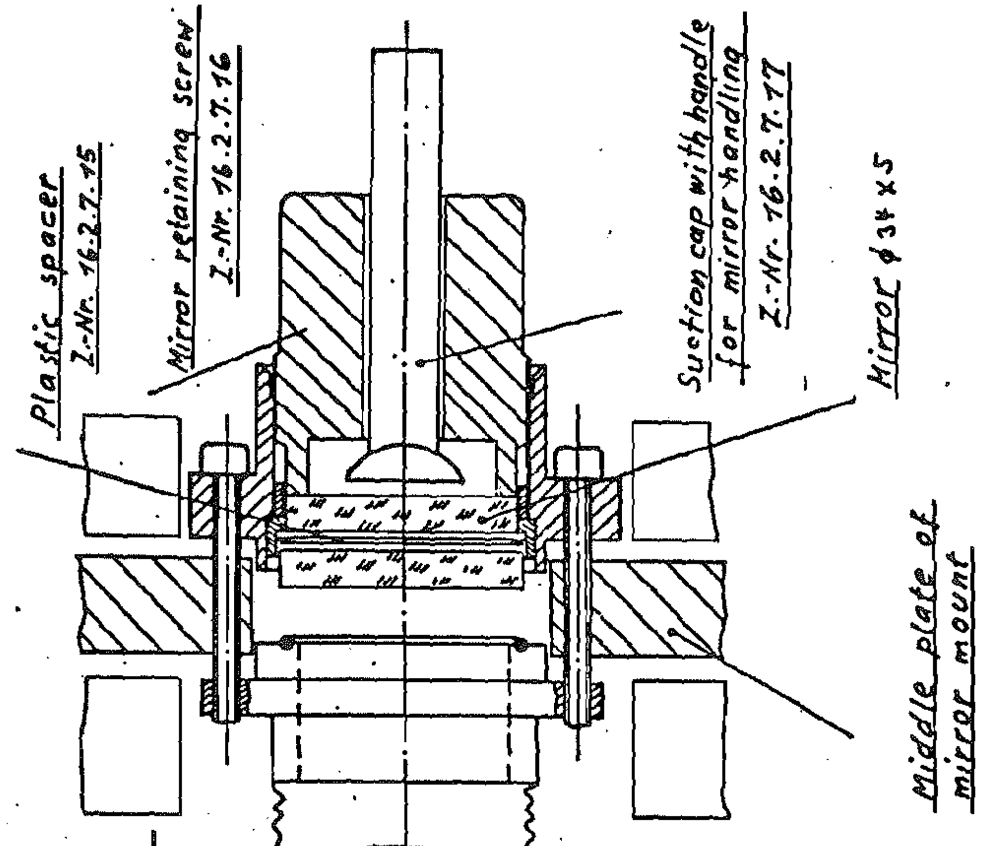
While doing this, care must be taken to ensure that the mirror is directed straight into the window retaining ring.

The mirror retaining screw has to be screwed on gently.

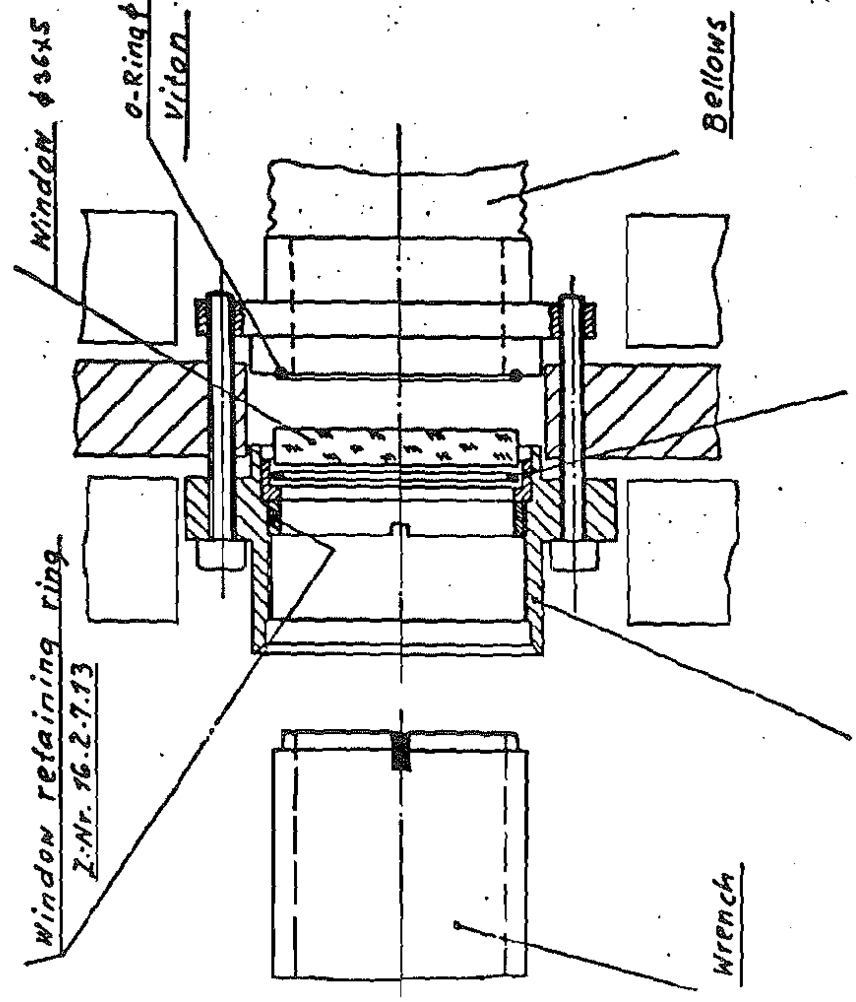
5.2 Laser Tube Windows

If a separate rear mirror as described in 5.1 is supplied, the rear window can be removed only after the end reflector has been removed. Before removing one of the windows the gas system must be flushed. In order to flush the system, it must be evacuated, then filled with an inert gas (if possible argon) to 500 mbar and then be evacuated again. This proceedure has to be repeated three times. The gas system is then filled with 1000 mbar inert gas. Next, the retaining ring of the window is turned 360° degrees counter-clockwise with the provided special key to slightly loosen the window (see fig. Maintenance -4-).

The 6 Allen screws, by means of which the window mount is screwed to the mirror mount, can now be loosened.



Mirror mount (in case a separate mirror is used)



Window mount

Refilling the Excimer Laser

(Notes for an old excimer system, not identical w.r. ours)

1) Turn vacuum pump on (power supply must be on). Slowly crack open valve to vacuum pump — halogen mixture must be pumped out slowly; it should take a minute or more to pump from 2600 to 1000 mbar. Pump down to within one small division of zero on more sensitive guage.

2) Shut off valve to vacuum pump. Refill cavity with few humdred mbar of helium and pump out again. Then fill to just over 1000 mbar (slight positive pressure w.r.t. atmospheric) with helium.

3) Take the first of the two windows off. Have within reach the T-wrench, the window loosening wrench (black cylinder), and stopper that fits in window opening (currently grey). Loosen window retainer ring half to one turn, remove screws, and carefully remove window and holder, making sure not to loose mylar ring which sits in mount under window. Immediately place stopper in opening and pressurize slightly with helium. If window seems to stick to o-ring, regrease o-ring slightly before putting window back on — use small amount of <u>fluorocarbon grease</u> (only!) – in tube in laser drawer. Clean window, replace (re-tighten screws, then tighten retainer ring) and immediately overpressurize slightly before moving to other mirror. If front window especially, gets dusty, dust may be removed from front window bellows by repeatedly over pressurizing and pulling stopper out (puff!).

4) Pump laser back down to near zero and while pumping, make sure xenon and HCl valves are closed and press solenoid buttons to evacuate the gas lines. Then open valves to fill ~~with~~ lines with gas. Refill laser with helium (500-1000 mbar) and pump back down. Repeat. Repeat again. If in doubt, repeat again.

CAUTION: Whenever laser is pumped down to near zero, close valve to vacuum pump. Never ~~[illegible]~~

pump on cavity for more than a few minutes after guage has stopped active travel, as at very low pressures, oil may backstream and severely contaminate cavity.

5) Refill gases, xenon first since it is most precious and tank pressure is lowest. If helium has been used, remember to shut off helium tank and open neon tank. If necessary, add small amount of buffer gas to bring guage to line, add 75 mbar xenon, 100 mbar HCl and then neon to 2600 mbar total pressure. At the top end, it's normal for the guage to drift down a bit, so several additional squirts of neon may be necessary to maintain 2600. Immediately close off all tanks at main and final valves. (ie., just leave diaphrugm set). If you run out of neon, a temporary alternative fill is:

60 xenon, 80 HCl, 350 Argon to 2500 with helium.

6) Turn laser on, measure energy at 1-2 Hz, meter terminated at 1MΩ on <u>D.C.</u>. Tweak tilting screws for horiz. and vert. tilt of mirrors (mounted in protruding black cylinders) on front and back mirrors alternately until maximum energy is reached. When a dye laser is set up, dramatic improvements in its output may be realized by very fine retweaking of these on the dye laser output.

WARNINGS: - NEVER fire the laser until power supply has been on for *atleast* ten minutes or thyratron may be destroyed.

- The laser gas reservoir is large. When pressurized to 2600 mbar, explosion at the windows, (as when looking at them) should be considered a real and serious danger - take precautions!

Tilt the part of the mount which faces the laser tube slightly upwards when removing the window mount so that the window cannot fall out of the mount. If the window should stick to the O-ring, the mount should be loosely attached again and the pressure in the laser tube should be carefully increased above 1000 mbar. The overpressure will than pop the window from the O-ring. This can be monitored by noticing a drop in pressure.

Before reassembling make sure that the O-ring is correctly fitted into its groove and that both the window and all parts which come in contact with the window, are free of dust. The crystalline materials of the windows are sensitive to mechanical stress and can crack when being pressed against dust particles or sharp edges.

First put the thin plastic spacer and then the window into the plastic collar. Then place the window into the mount and screw back the retaining ring far enough to ensure that the window disappears completely into the mount.

Now screw the mount back onto the mirror holder, paying attention to tighten the 6 screws evenly. Finally, tighten the retaining ring to achieve a vacuum tight seal.

6. Window Cleaning Procedure

Cleaning of the windows has to be performed in a clean and dust free area. Never touch the front or rear-surface of a window with your fingers. Handle windows only by touching their rims.

Inspect the window in transmission and grazing incidence for surface spots and dust. Remove all dust particles with a duster as these may scratch the window surface during the polishing procedure.

6.1 Uncoated windows

Position three layers of lens tissue on a smooth and clean surface. Mix two teaspoons of water with one teaspoon of polishing powder (tin oxide or vienna chalk) and place 1/2 teaspoon of the mix on the lens tissue. Rinse the window under a flow of lukewarm water. Place the window with its dirty side on the slurry and polish with a circular motion and gentle pressure for 2-3 minutes. Rinse the window under a flow of water and polish the other side if necessary. Rinse the window with water. Rinse the window with a flow of ethanol (reagent or p.a. grade) using a squirt bottle and making sure that as little ethanol as possible runs from your fingers over the window (this can transport dissolved impurities from the skin to the window surface). Dry the window by gently sliding it over 3 layers of dry lens tissue. Inspect the window and repeat the procedure if necessary. (When using a Freon duster, always use the duster in an upright position as liquid Freon may thermally crack the crystalline window material.)

6.2 Coated Windows

Apply the above procedure only to the uncoated side of the window. The coated side has to be treated according to the next section.

7. Mirror Cleaning Procedure

Mirrors should only be cleaned by putting a few drops of ethanol onto the surface close to one edge and pulling a sheet of lens tissue over the surface. However, only a few drops should be used and some time should elapse between repeated cleaning action, otherwise the mirror will be cooled below the dew point.

This section provides the user with a guideline for some fast and easy tests which should be performed in cases where the laser does not seem to function properly. The instrument is equipped with 9 fuses and 11 interlocks which are installed for the protection of the operating personnel and the protection of system components. If for instance the laser head begins to overheat because the cooling water flow has become interrupted the laser will turn off automatically. Similarly an attempt to open the laser housing while the laser is operating will turn the laser off. The positions and modes of operation of the fuses and interlocks are described in the next two chapters of this section.

In many cases where the laser does fire but fails to reach the specified output power, the reason can be found in a contaminated or otherwise improper gas fill. In such cases the laser should be carefully filled with a fresh gas mixture and the resonator optics should be inspected to make sure that it is clean and not damaged. Please bear in mind that even small leaks in the filling lines or filling lines whose inside is not clean will deteriorate the laser performance. The same holds for the use of gases with insufficient purity.

Before opening the laser hood or the power supply make sure that the laser is fully discharged and the mains line has been disconnected. Do not touch or come close to any parts of the high voltage circuitry before the grounding cable of the laser head has been properly connected to its plug. Besides the standard lines voltages, voltages of up to 45 kV are used in the discharge circuit and voltages of up to 4 kV regularly occur in the trigger circuit. In a faulty circuit voltages of 20 kV can occur. Trouble shooting in these circuits should only be performed by trained personnel which is familiar with safety precautions pertinent to high voltage circuitry. Please make sure that all test instruments which are used (e.g. high voltage probes or voltmeters) are specified for the voltage levels which are present in the laser.

If the gas system has to be opened it has first to be evacuated and then flushed with an inert gas three times to remove all traces of corrosive gases which are used in the laser.

Interlocks

The laser is equipped with eleven interlocks which help to prevent the use of the instrument outside its intended operational parameters and which protect the operating personnel. Five of the interlocks are located at the laser head while the remaining six protect the power supply. All interlocks turn off the high voltage when activated.

Laserhead interlocks

All interlocks at the laser head are wired in series. The fact that one or more of the laser head interlocks are activated is indicated by the "Laser Head" LED on the front of the control unit.
All laser head interlocks reset themselves automatically after the cause for their activation has been removed.

1) Laser head cover interlock

This is a mechanical switch which opens when the top of the laser head housing is removed or not properly closed. The interlock switch is positioned at the upper left hand corner of the laser head panel.

2) Vacuum pump interlock

While the vacuum pump is operating the electrical vacuum pump interlock switch is activated. This prevents firing of the laser during the pumping cycle where the laser is not at its proper operating pressure.

3) Oil flowmeter interlock

The flow of oil through the cooling circuit of the MSC unit and the thyratron is monitored by this flowmeter controlled interlock which is located at the side of the oil reservoir. If the oil flow is interrupted or falls below a preset value this interlock is activated. The reason for this can be the failure of or no voltage to the oilpump or an insufficient amount of oil in the cooling manifold.

4) Reservoir temperature interlock

This interlock is a thermal switch, which is located on the top of the laser reservoir (left when facing the MSC unit) and opens the interlock when the reservoir temperature reaches 46°C. The reason for overheating is no or insufficient flow of cooling water at high repetition rates, or insufficient flow of cooling air.

5) Fan motor interlock

The motor which drives the gas circulation fan in the reservoir is protected by an overcurrent interlock which is positioned in the control unit. Reason for activation of this interlock can be operation at the wrong gas mixture, a damaged fan bearing, or a damaged motor. On the bottom of the protective relay is a switch which has been set to the "auto" position at the factory. If this switch is set to the "hand" position the interlock will not reset itself automatically, but will have to be reset with the hexagonal push button on top of the relay. In addition the motor is equipped with a thermal switch which gets activated if the motor overheats.

Power supply interlocks

All power supply interlocks are wired in series. The fact that one or more of the power supply interlocks are activated is indicated by the "Power Supply" LED on the front of the control unit. The power supply interlocks have to be reset by pushing the "Reset" button below the LED's on the front of the control unit. This will deactivate the interlocks if the reason for their activation has been removed.

To facilitate trouble shooting in the power supply the following interlocks have additional and individual LED's on the high voltage power supply front panel: Temp 1, Temp 2 and Open circuit.

6) Temp 1 interlock

This interlock is a thermal switch which controls the temperature of the thyristors in the high voltage power supply. It is located on the thyristors board in the high voltage power supply and gets activated if the temperature exceeds 65°C. Reason for activation of this interlock can be a faulty cooling fan, blocked or restricted air flow through the high voltage power supply or excessive ambient temperature.

7) Temp 2 interlock

This interlock is a thermal switch which controls the temperature of the high voltage transformer in the high voltage power supply. It is located on the outside of the transformer housing and gets activated if the temperature exceeds 65°C. Reasons for activation are the same as for interlock "Temp 1".

8) Open circuit interlock

This interlock gets activated if the laser head is not properly connected to the power supply. The open circuit interlock can only be reset by turning the mains power switch of the "off" position.

9) Short circuit interlock

This interlock gets activated if the high voltage charging circuitry does not reach the set high voltage level.

Reasons for activation of this interlock can be a short circuit in the high voltage power supply, a damaged or faulty HV cable between the power supply and the laser head, a defective charging capacitor, a defective thyratron or the fact that the thyratron reservoir voltage is set too high so that the thyratron does not recover between laser shots. In addition operating the laser at maximum repetition rate and maximum HV level can activate this interlock.

10) Warm up timer interlock

The warm up timer interlock is a timer which prevents the high voltage from being turned on for ten minutes after the mains power switch has been turned on. The timer is located in the control unit of the power supply. This warm up time is needed for the thyratron in order to reach its operating temperature. This interlock has its own LED on the front panel of the power supply.

11) Remote control interlock

The remote control interlock is a 4 pin plug on the front panel of the power supply to which the user can connect an interlock of his choice (e.g. a switch controlling an access door). The interlock has to be connected between pin 2 and 3 of this switch and laser operation is possible as long as pin 2 and 3 are shorted. If no external interlock is desired, this interlock has to be defeated with the supplied screw in plug (red color cap).

Fuses

The electrical circuitry is protected by 9 fuses of which 8 are situated in the control unit and one is situated in the high voltage power supply. Spare fuses are supplied in the tool kit of the laser. Fuses 1 - 6 are located at the rear panel of the control unit and can be reset or exchanged after removing the rear panel of the power supply, fuses 7 and 8 are located inside the control unit and fuse 9 is located inside the high voltage power supply.

1) Main circuit breaker

This three-phase automatic circuit breaker serves as the entrance circuit breaker for the power supply. It is located at the rear panel of the control unit and can be manually reset.

2) Fuse Si 102, 5A slow

This fuse controls the second phase in 208V models.

3) Fuse Si 103, 2.5A slow

This fuse controls all low voltage (208, 220V) supplies to the laser head except for gas circulation fan and gas processor power supply.

4) Fuse Si 104, 0.8A slow

This fuse controls the input to the high voltage power supply as well as the fan and the logic board of the high voltage power supply.

5) Fuse Si 105, 1.25A slow

This fuse controls all control unit supplies.

6) Fuse Si 106, 2.5A slow

This fuse controls the thyratron heater and reservoir supplies.

7) Fuse for internal 24V, DC supply, 1.25A slow

This fuse controls the 24V DC power supply in the control unit. It is located beside the 6 pin connector on the vertical power supply board in the center of the control unit. To reach this fuse the top panel of the control unit has to be removed.

8) Fuse for internal 24V, AC supply, 1.4A slow

This fuse controls the 24V, AC power supply in the control unit. It is located beside fuse No.7.

9) High voltage power supply fuse 40A, fast fast.

This fuse protects the high voltage power supply against over current. To exchange this fuse the top panel of the high voltage power supply has to be removed. The exact location of the fuse can be found in fig. "Lay out HV plug in". In addition the fact that this fuse has blown is indicated by the "Fuse" LED on the front panel of the high voltage power supply.

Thyratron

The thyratron is a grounded cathode thyratron which requires a heater voltage of nominally 6.3 V, a reservoir voltage of nominally 6.3 V, a grid bias of - 140 V, and a trigger pulse of + 350 V. The thyratron is the main high voltage switch in the laser head.

1) Heater Power Supply

The heater power supply is located in the thyratron power supply. The heater voltage can be measured between the blue and the black/blue cables at the rear panel of the thyratron power supply. This measurement has to be performed while the thyratron is on and at its operating temperature. Do not remove the blue and the black/blue cable. The voltmeter can be pluged into the rear of the supply cable plugs. A typical heater current is 13A.

2) Reservoir Power Supply.

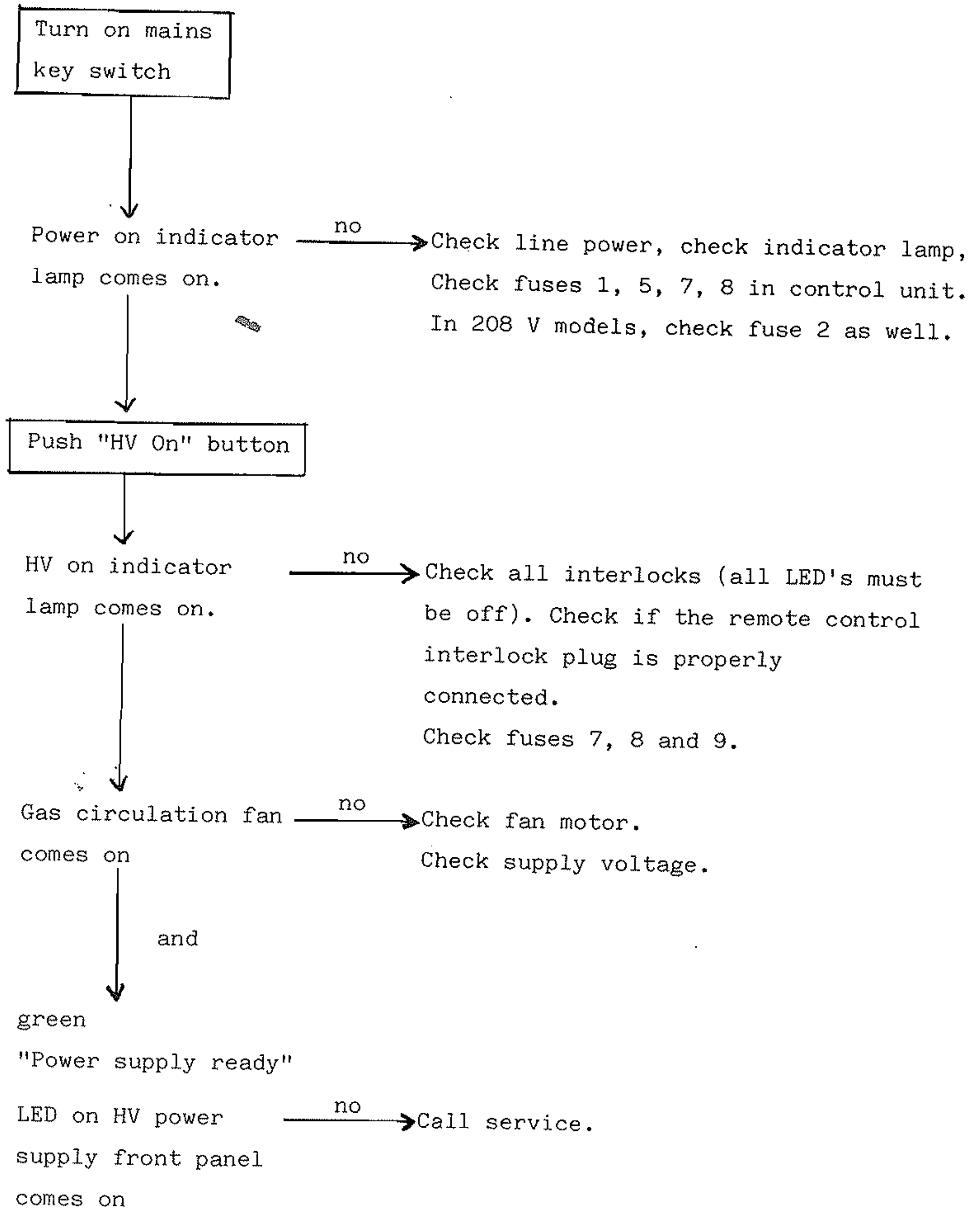
Using the same technique as for the heater supply, the reservoir voltage can be measured between the red and black/red cables. A typical reservoir current is 3.5 A.

3) Bias and Trigger Pulse

The bias and the trigger pulse can be measured with a high impedance probe. The signal should be taken from the black coded BNC trigger plug without disconnecting the thyratron. This can be done by using a BNC T connector. The trigger plug is located at the rear panel of the control unit.

A. Start up procedure is interrupted

The following guideline should be used if the start up procedure of the laser is interrupted at any point. Please bear in mind that the laser can only be operated if no interlock is activated.



Turn on mains key switch

Power on indicator lamp comes on. — no → Check line power, check indicator lamp, Check fuses 1, 5, 7, 8 in control unit. In 208 V models, check fuse 2 as well.

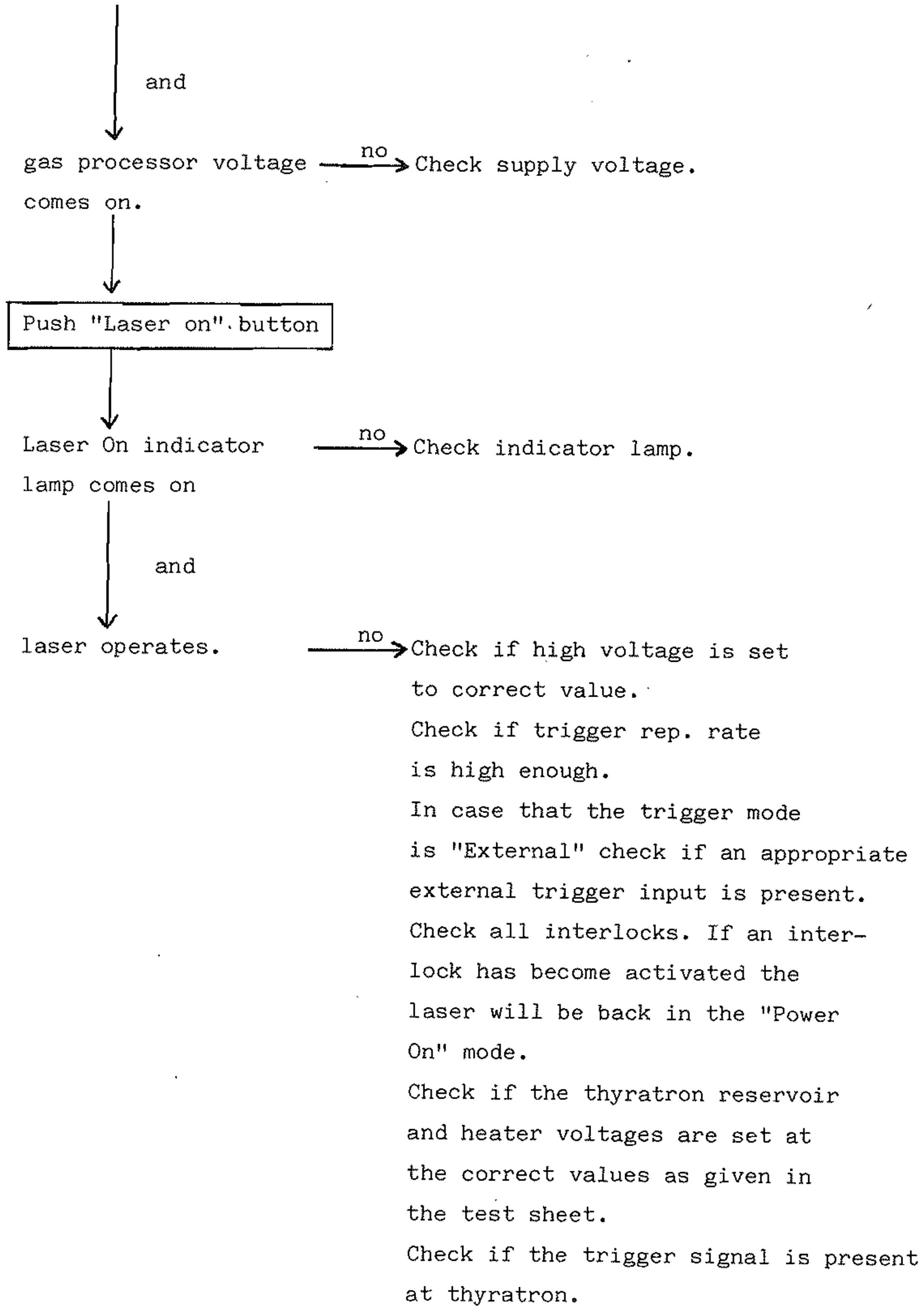
Push "HV On" button

HV on indicator lamp comes on. — no → Check all interlocks (all LED's must be off). Check if the remote control interlock plug is properly connected. Check fuses 7, 8 and 9.

Gas circulation fan comes on — no → Check fan motor. Check supply voltage.

and

green "Power supply ready" LED on HV power supply front panel comes on — no → Call service.



and

gas processor voltage comes on. —no→ Check supply voltage.

Push "Laser on" button

Laser On indicator lamp comes on —no→ Check indicator lamp.

and

laser operates. —no→ Check if high voltage is set to correct value.
Check if trigger rep. rate is high enough.
In case that the trigger mode is "External" check if an appropriate external trigger input is present.
Check all interlocks. If an interlock has become activated the laser will be back in the "Power On" mode.
Check if the thyratron reservoir and heater voltages are set at the correct values as given in the test sheet.
Check if the trigger signal is present at thyratron.

B. <u>The Laser discharge fires but no or too weak emission occurs</u>

1) Check if the high voltage level is set to the right value.

2) The gas mixture may be too old, wrong or contaminated. Exchange the gas mixture and make sure that the new fill agrees with the data sheet. Check if the right bottles are connected and that the gases have the specified purities. Make sure that the filling manifold is clean and leak tight.
If there is reason to believe that the laser is not vacuum tight any more a leak test as described in Installation - 5 - should be performed.

3) Check the resonator optics for alignment, damage, dust and color centers. Replace or clean the optics.

4) Check the thyratron reservoir voltage.

5) A peaking capacitor may be faulty. Visually check for any discolored or cracked peaking capacitor.

6) Check if the motor of the gas circulation fan on the reservoir is operating <u>and</u> has the proper sense of rotation.

7) In rare cases the gas circulation fan motor does operate but an internal bearing of the fan has become damaged. This condition is indicated by a rattling noise inside the reservoir which occurs when the fan motor is turned on or off.

C. <u>The laser fires erratically</u>

1) Check the thyratron reservoir voltage and set to specified value. Decreasing the reservoir voltage by one step can stop the misfiring.

D. The laser shuts itself off during operation

1) Check if an interlock has become activated (see section: interlocks)

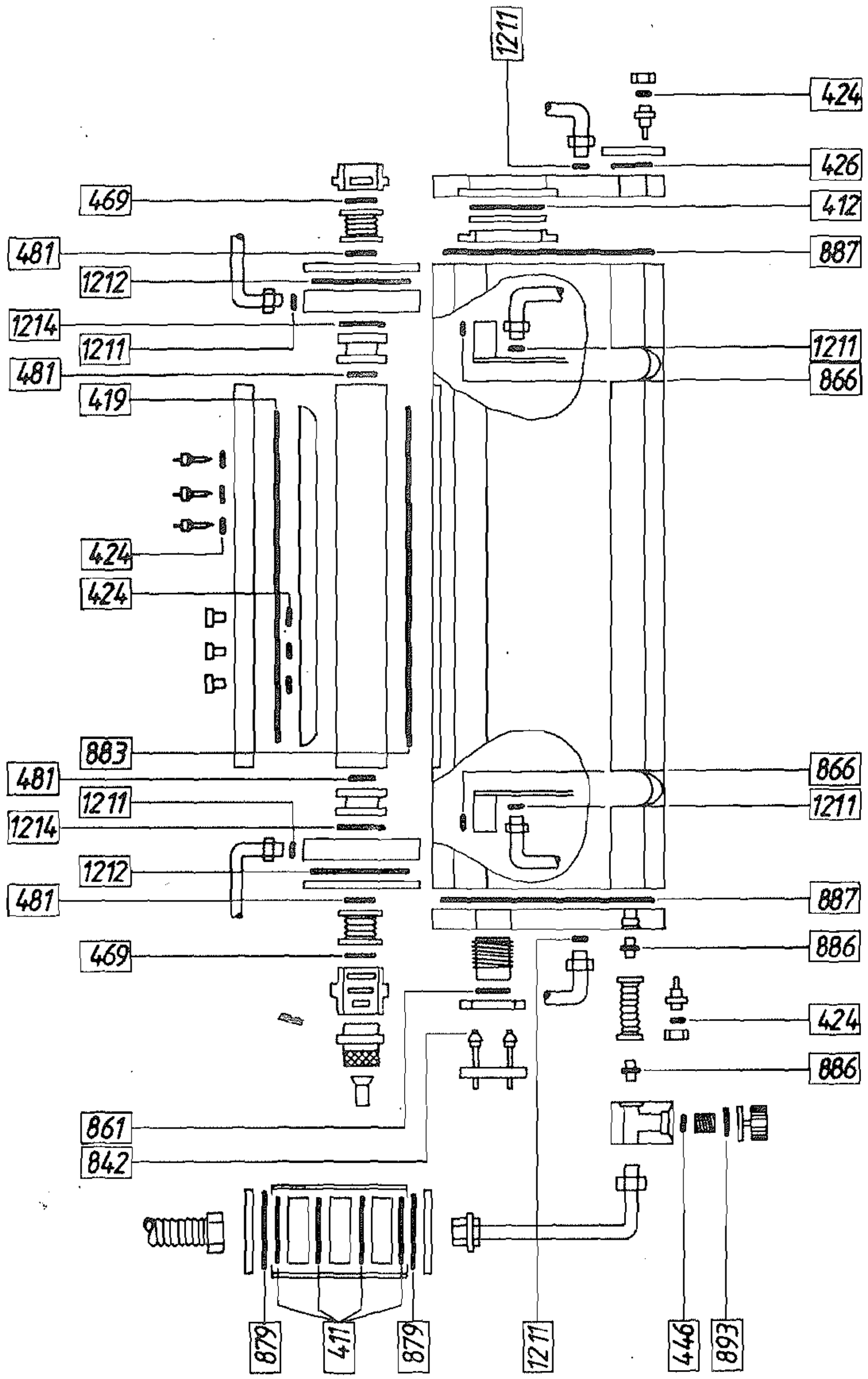
2) If the mains circuit breaker has tripped, reset the mains circuit breaker.

E. The laser does not fire with every trigger pulse.

1) This may happen if at maximum repetition rate the high voltage is set to the maximum value. Decrease the high voltage level.

F. The laser pressure rises with no valve being operated

If the pressure in the laser head still rises after filling procedures the solenoid valves in the filling lines should be checked for leak tightness.

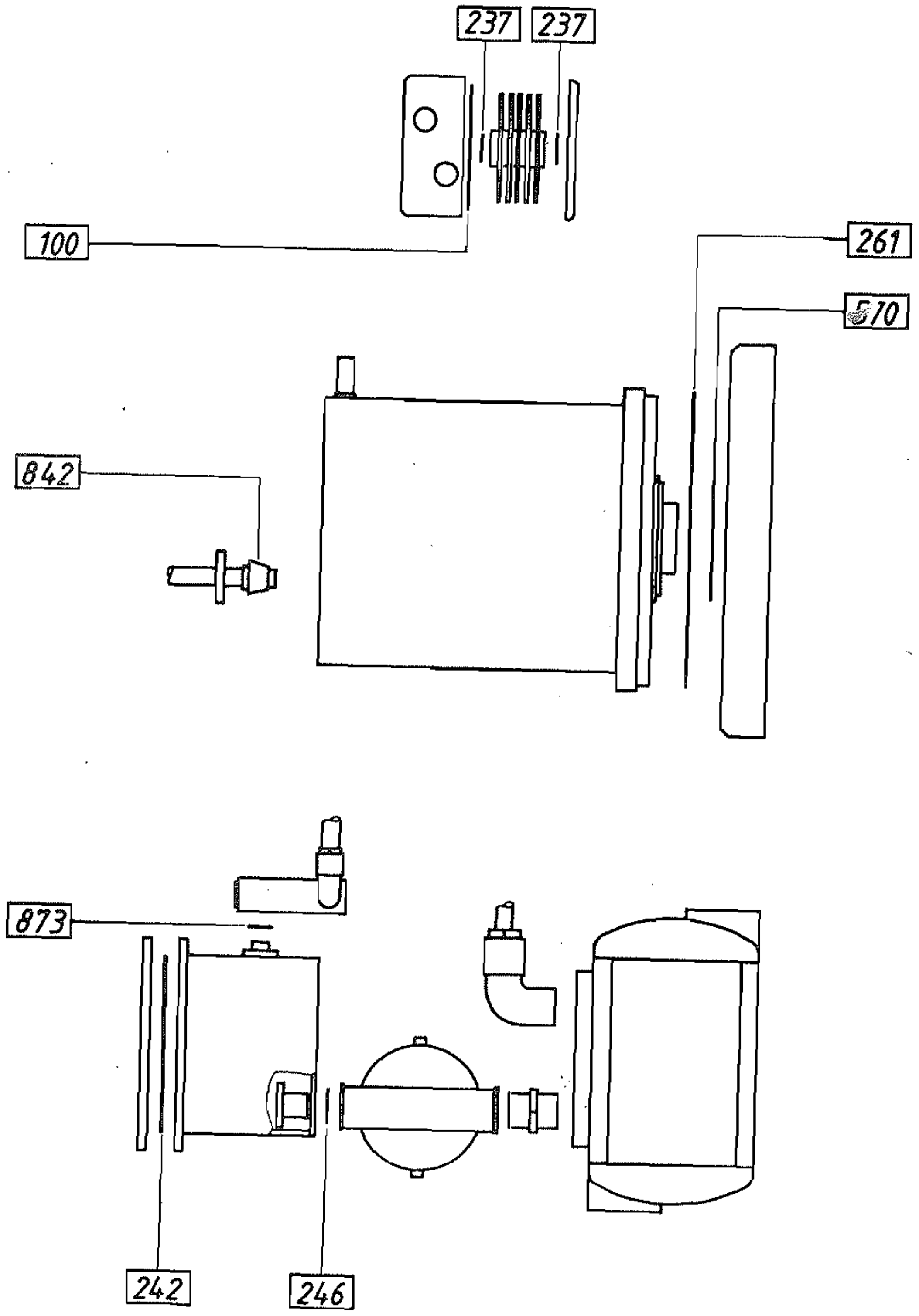


481	4		36 x 2	887	2		260 x 5	842	6		M260-P10
469	2		32 x 2	1212	2		120 x 2				
893	1		28,3 x 1,78	412	1		90 x 2	1218	–		8 x 2
886	2		17,5 x 4,2	879	2		88.57 x 2,62	949	–		655 x 4
1211	4		15 x 2	411	5		85 x 4	883	1		410 x 4
446	1		12,5 x 3,5	1214	2		55 x 2	419	1		400 x 4
866	4		6 x 2	426	1		48 x 2	1215	–		204 x 4
424	67		6 x 1,5	861	3		40 x 3	1213	–		200 x 4
Ord Nr	100-103		Dimensions [mm]	Ord Nr	100-103		Dimensions [mm]	Ord Nr	100-103		Dimensions [mm]

DICHTUNGEN
SEALS

EMG 100 - 104

Lambda Physik



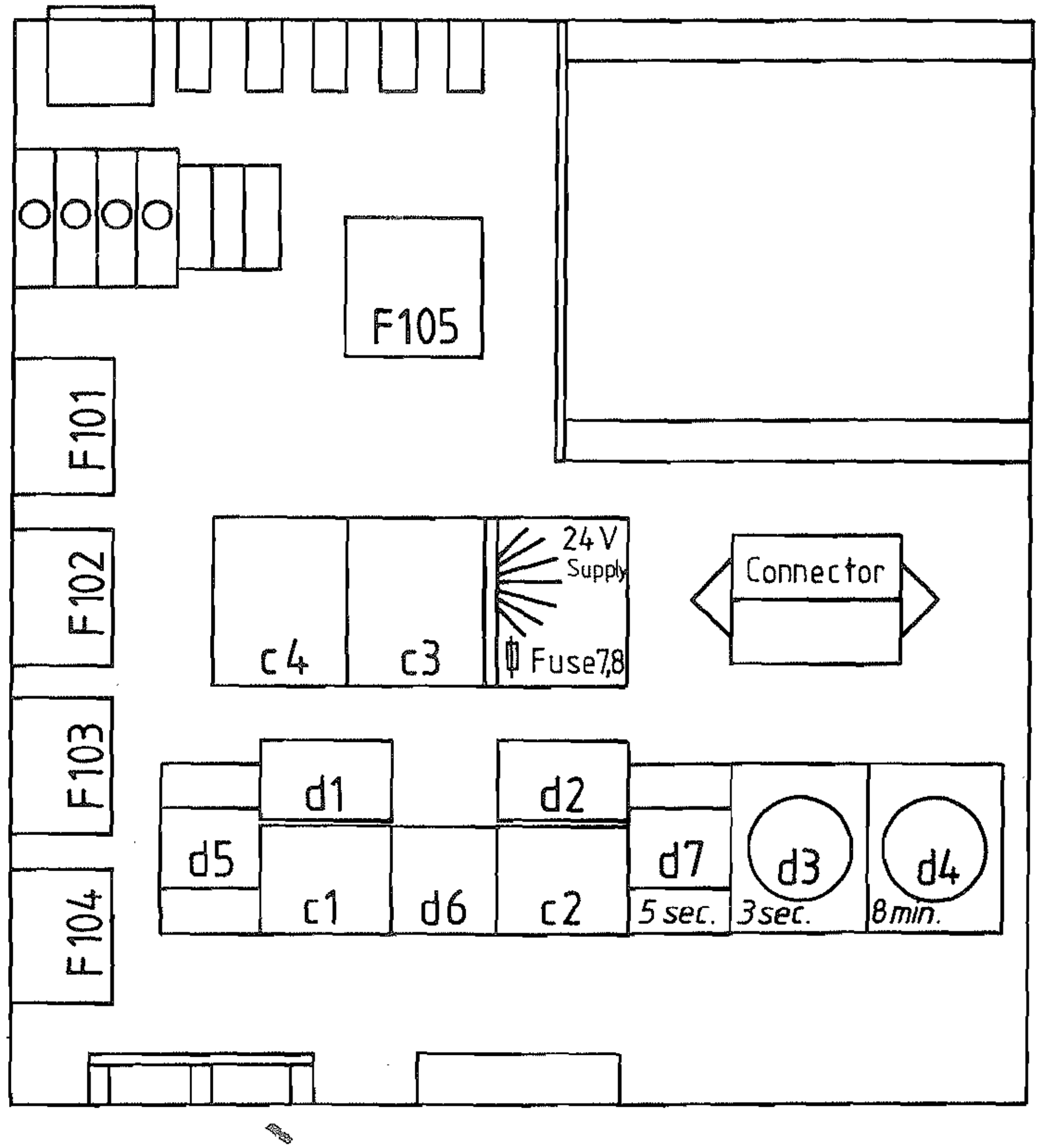
842	1		M260 - P10
570	1		64 × 3
242	1		98 × 2,5
261	1		146 × 2
100	1		68 × 2
237	2		14 × 2
873	1		10 × 2
246	1		23 × 1,5
Ord N.			Dimensions (mm)

Dichtungen
Seals
EMG 101-104 MSC

Lambda Physik

Änderung

1984	Datum	Name
Bearb.	25.10.	Sonu feld
Gepr.		
Gen.		



18.7.3.51

Änderung	FN-Nr.	Datum	Name
24V Supply, Fuse 7,8, Connector 2a.		14.3.80	Gr

LAY OUT - CONTROL - PLUG - IN

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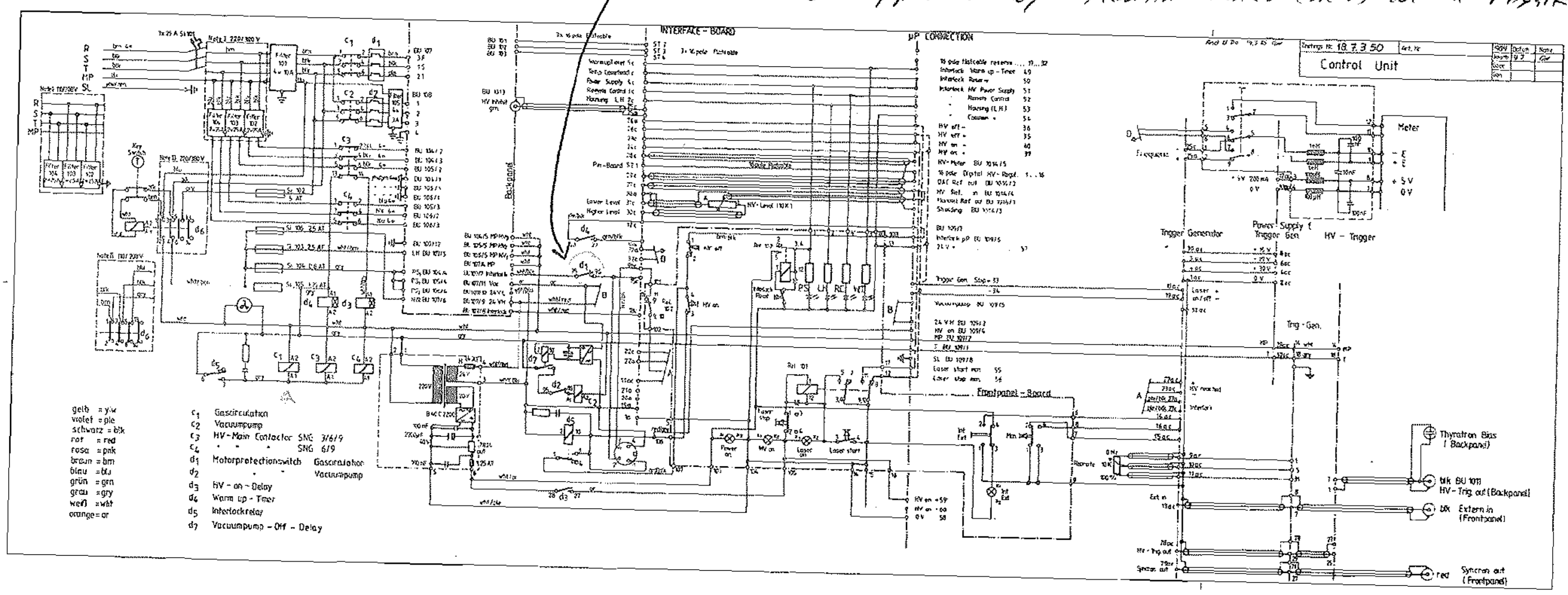
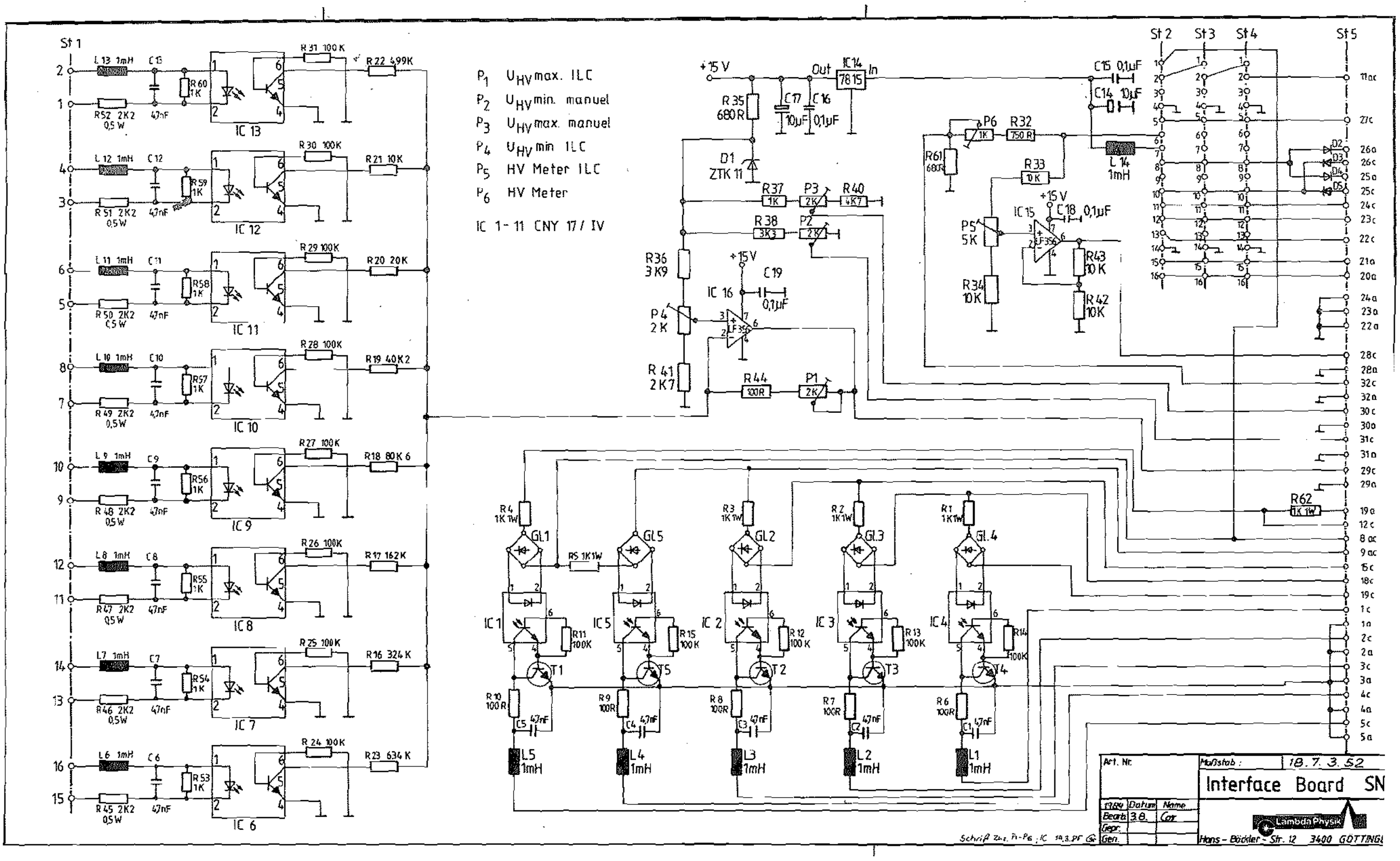
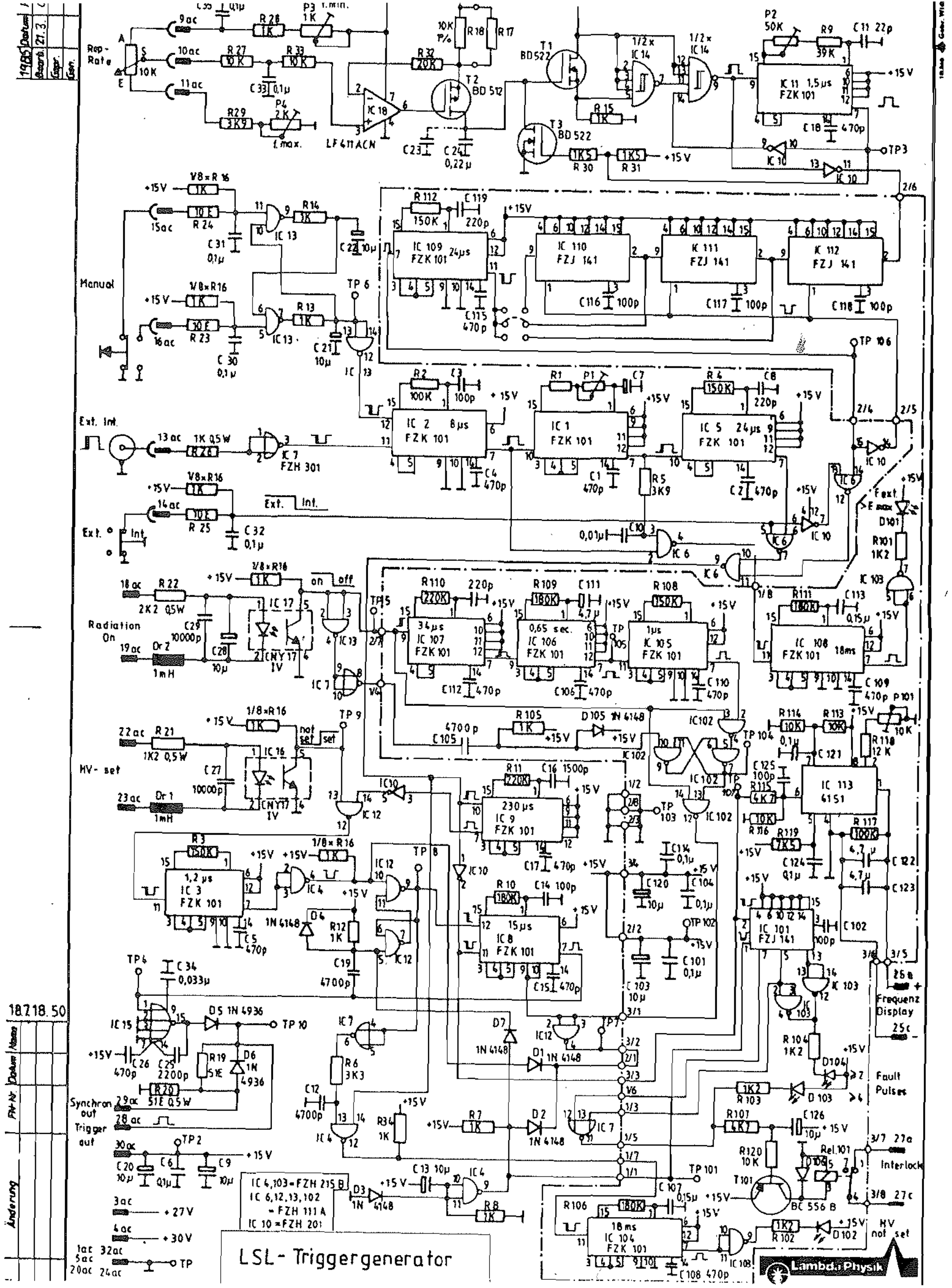
9/25/89 Set to just under 2.1A. Was tripping occasionally at 1.8 A Factory setting. Procedure approved by Martin Mikus (sic?) at λ-Physik

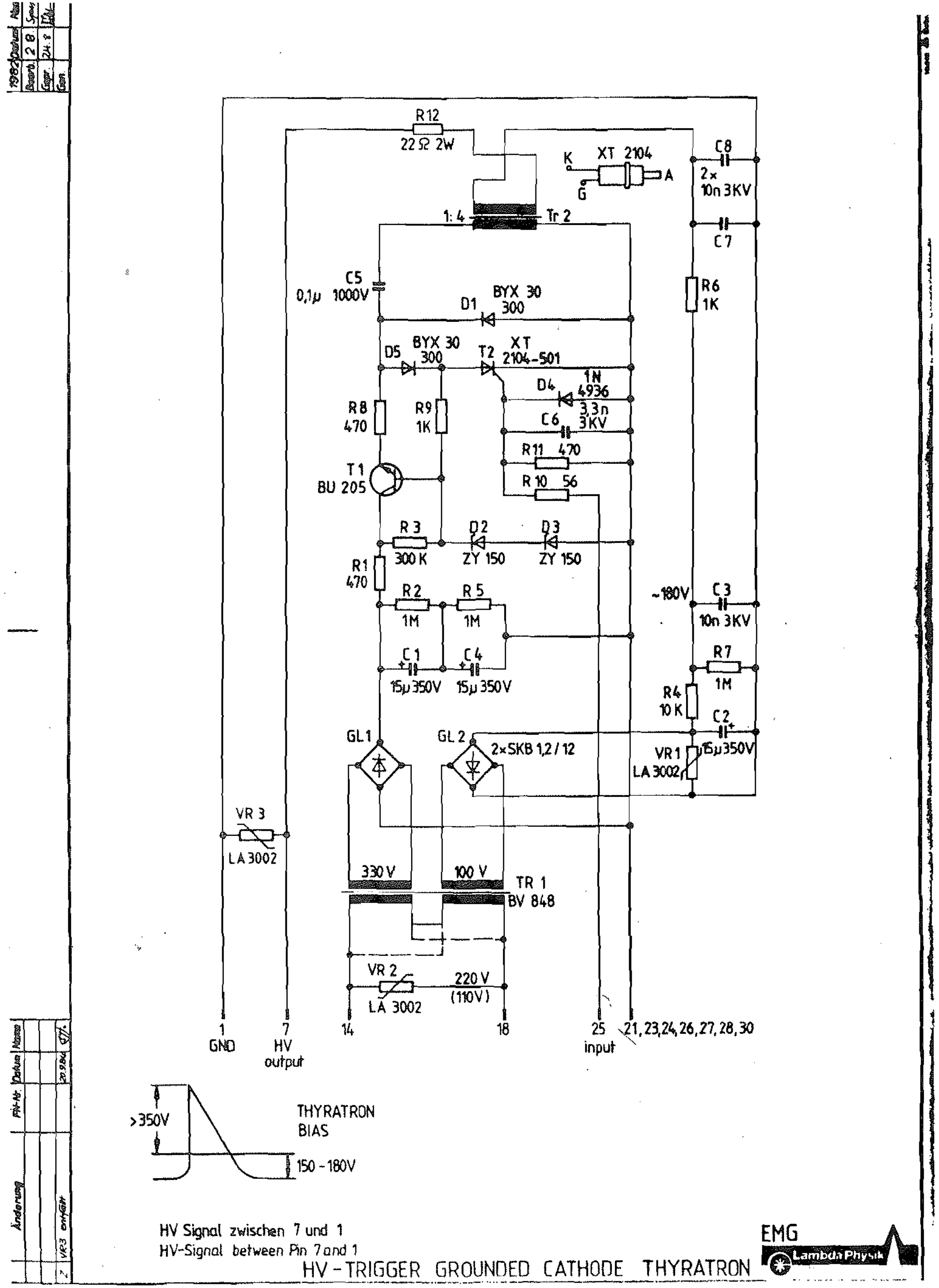






IC 4,103 = FZH 215 B
IC 6,12,13,102 = FZH 111 A
IC 10 = FZH 201

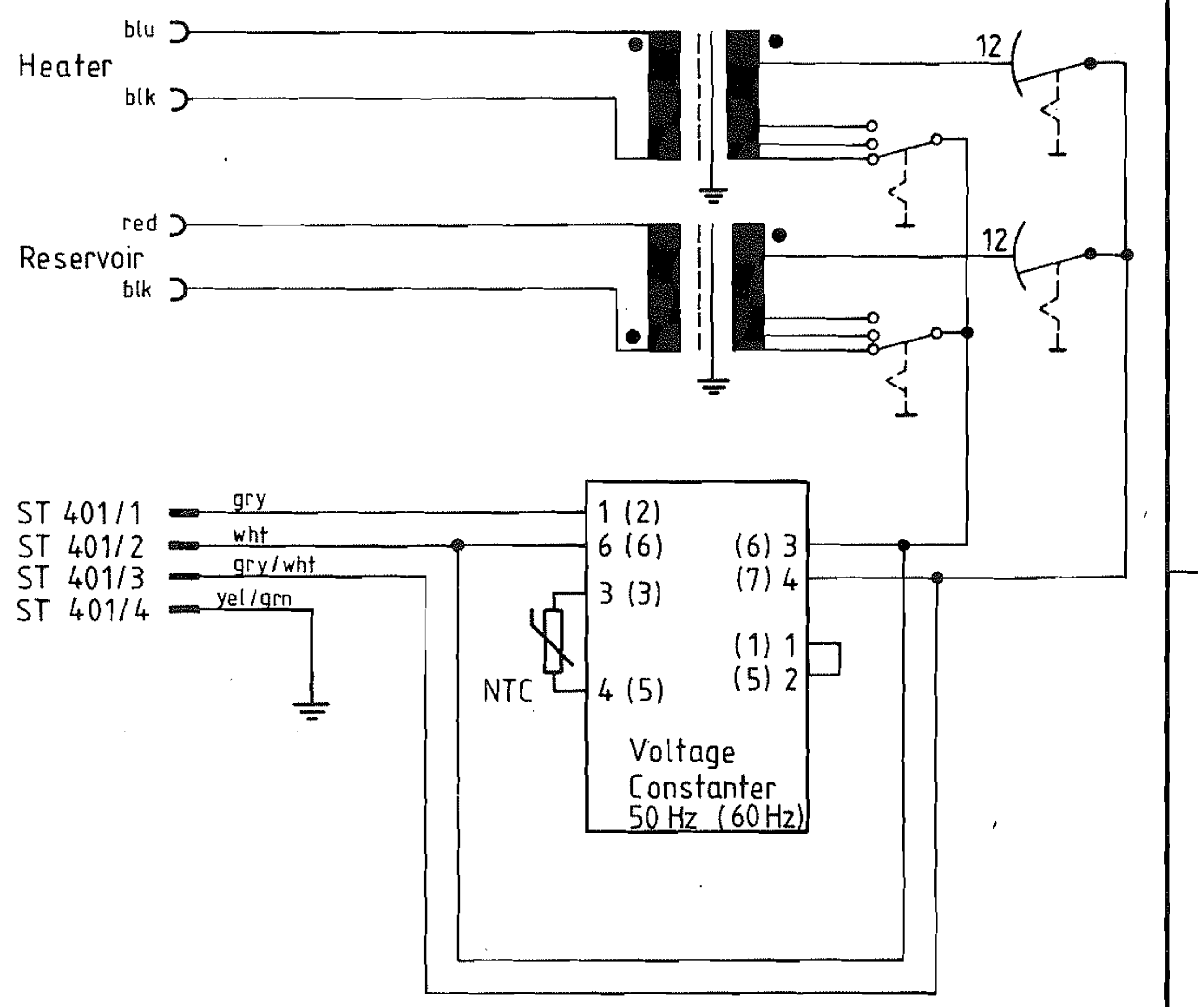
LSL- Triggergenerator



HV Signal zwischen 7 und 1
HV-Signal between Pin 7 and 1

HV-TRIGGER GROUNDED CATHODE THYRATRON

1985	Datum	Name
Bearb.	15.3.	
Gepr.		
Gen.		



18.7.17.52

Änderung	FN-Nr.	Datum	Name
Bezeichnug kor.		22.3.85	

SNG;3E 3M THYRATRON POWER SUPPLY UNIT

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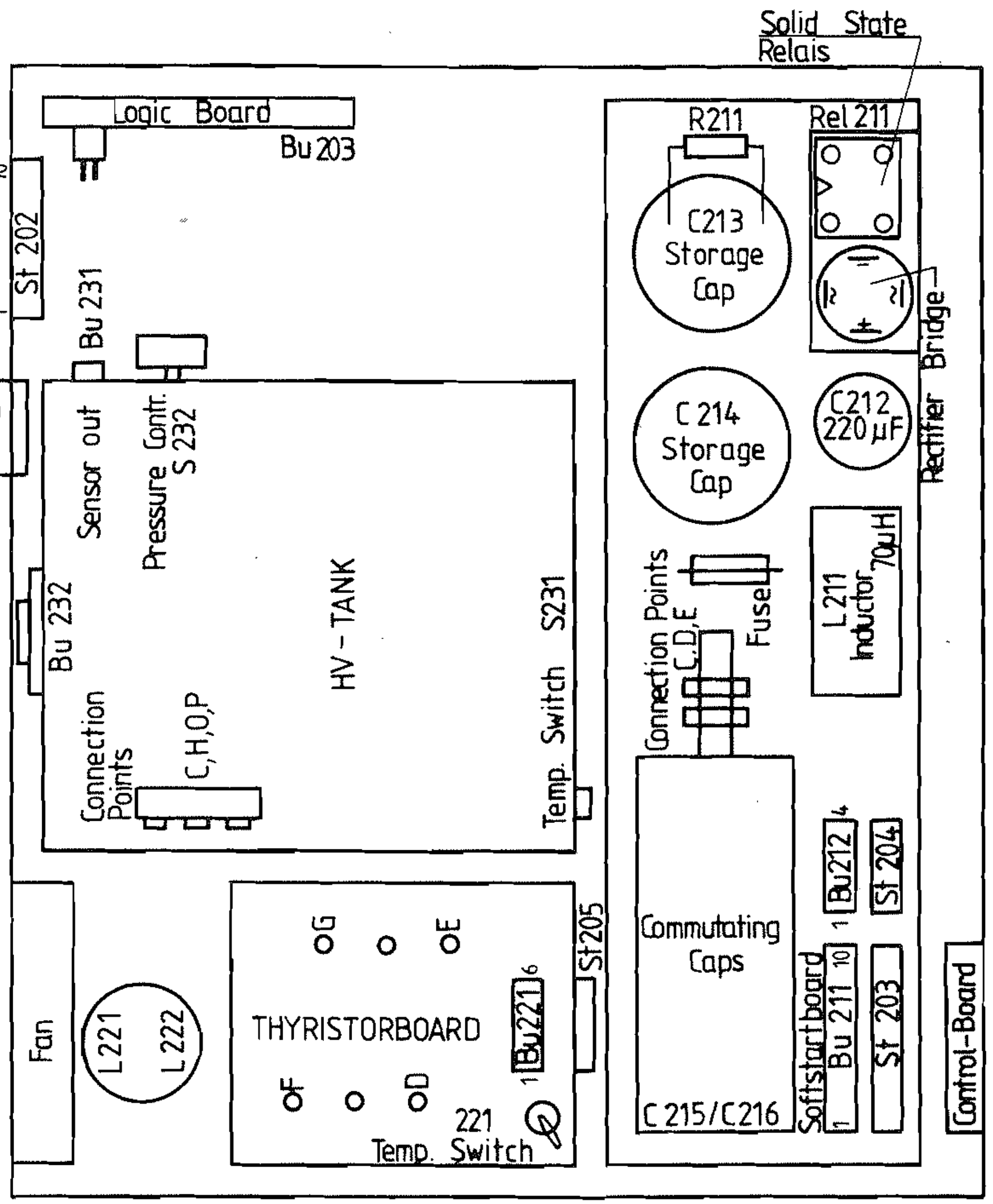
1984	Datum	Name
Bearb.	27.2.	
Gepr.		
Gen.		



18.7.8.52

Änderung	FN-Nr.	Datum	Name
		26.6.84	Sp
		25.4.84	

FIG. 301

LAY OUT - HV - PLUG - IN

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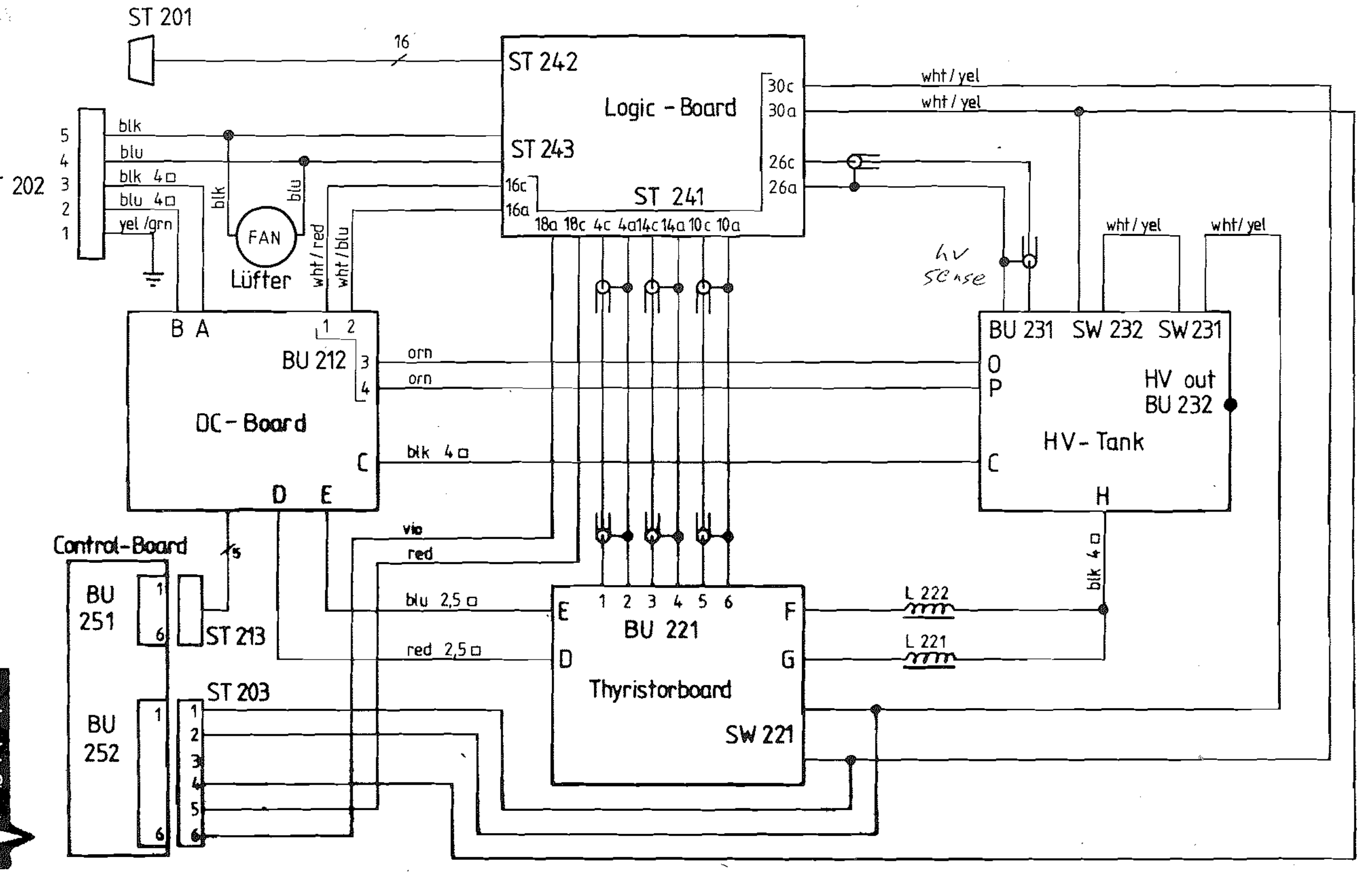
	Änderung	FN-Nr.	Datum	Name
Z	ST 241 (18a + 18c zus.)		9.11.84	
			27.6.84	Spr
			25.4.84	

18.78.50

Zu ST 213 4 Kabel in 5 geä. 14.3.85 Gu

1984	Datum	Name
Bearb.	6.2.	Spyra
Gepr.		
Gen.		

FIG. 300



HV - UNIT WIRING DIAGRAM

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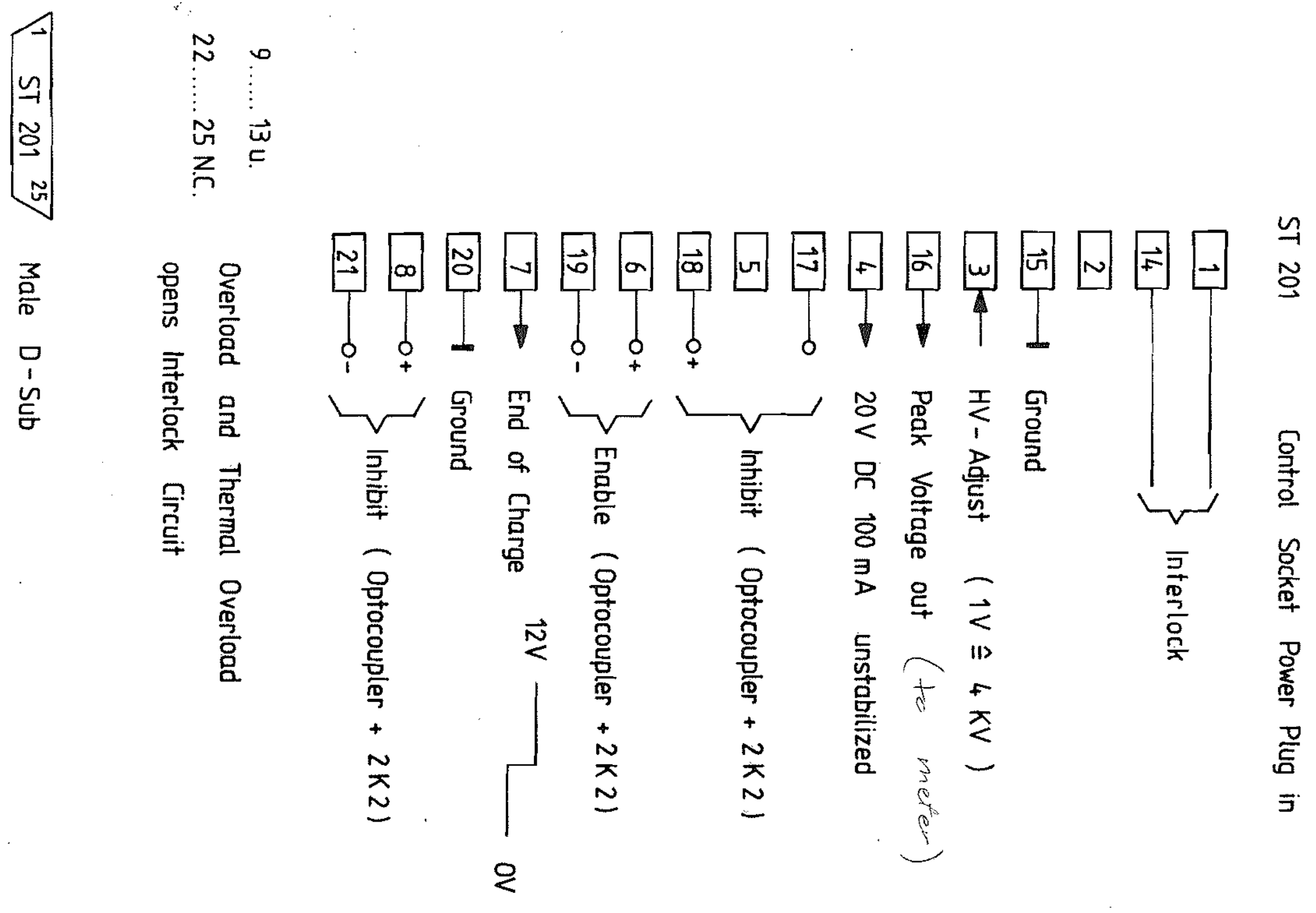
	Änderung	FN-Nr.	Datum	Name
	Optoco. in 2K2 geä.; Interl. nur 1,14		14.3.85	Gu
Z	Bu 201 entfällt		21.9.84	
			28.6.84	Spr

18.78.51

1984	Datum	Name
Bearb.	24.2.	Spyra
Gepr.		
Gen.		



INTERFACE DIAGRAM HV-PS

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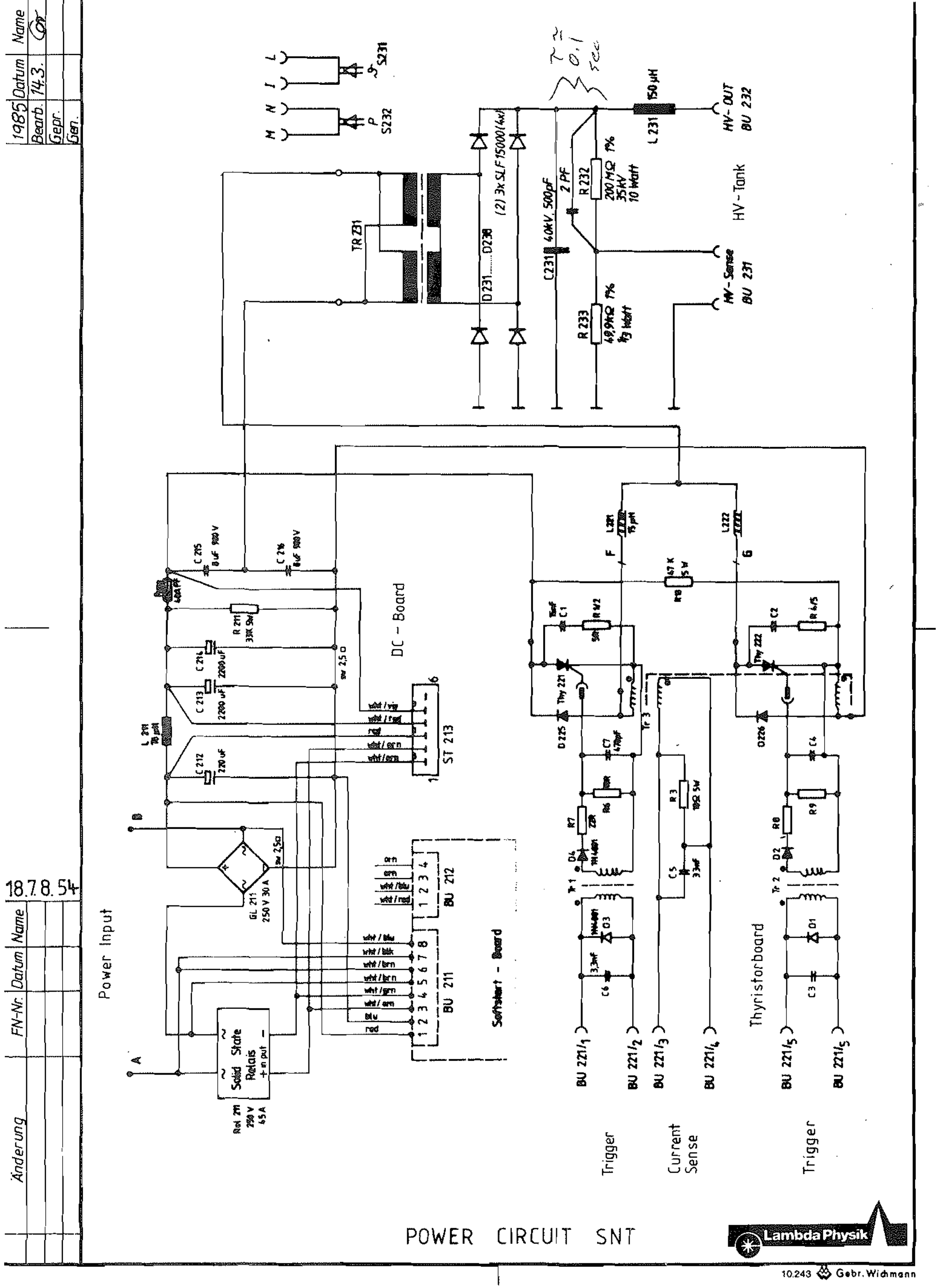
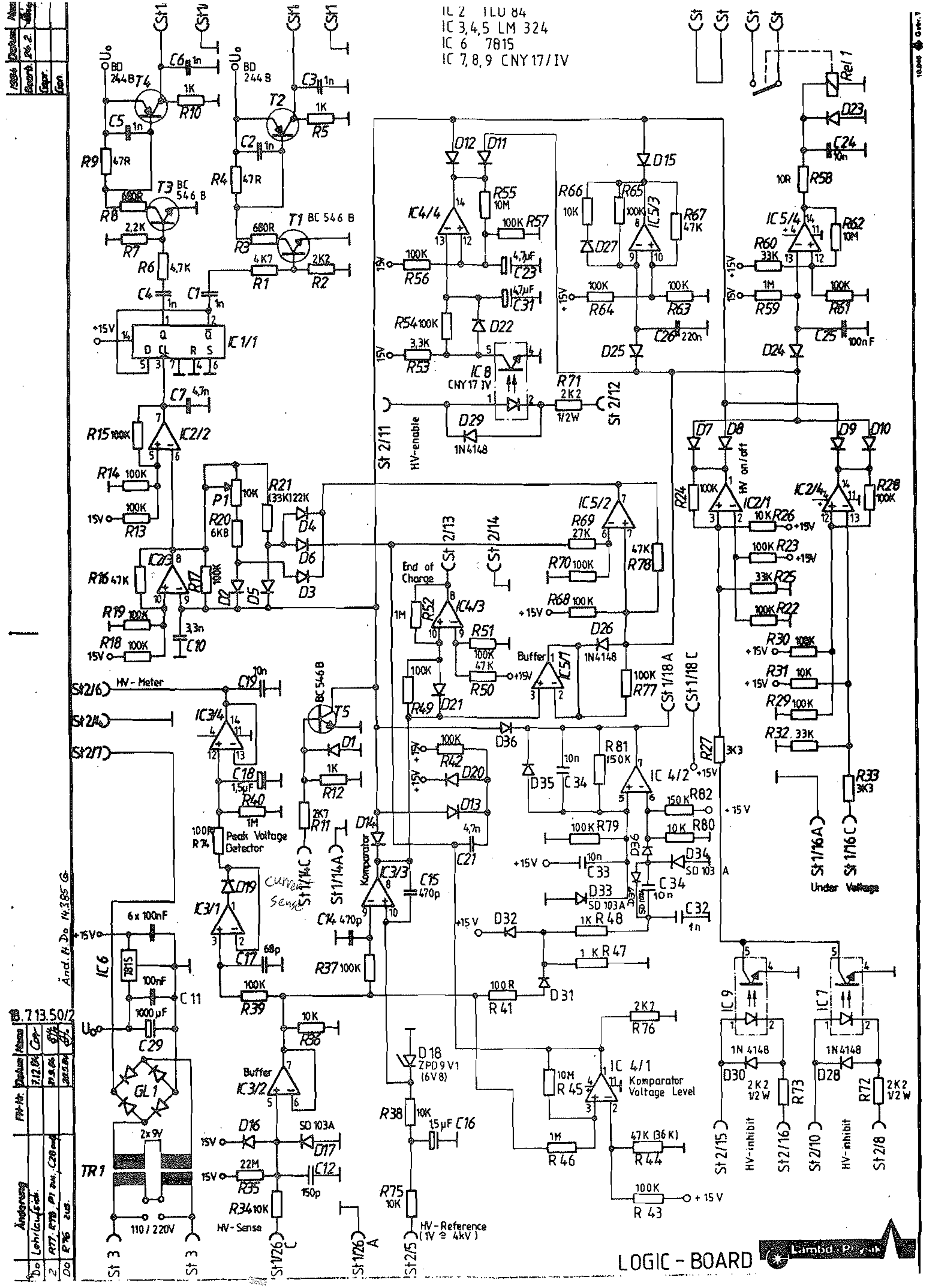


POWER CIRCUIT SNT



LOGIC - BOARD

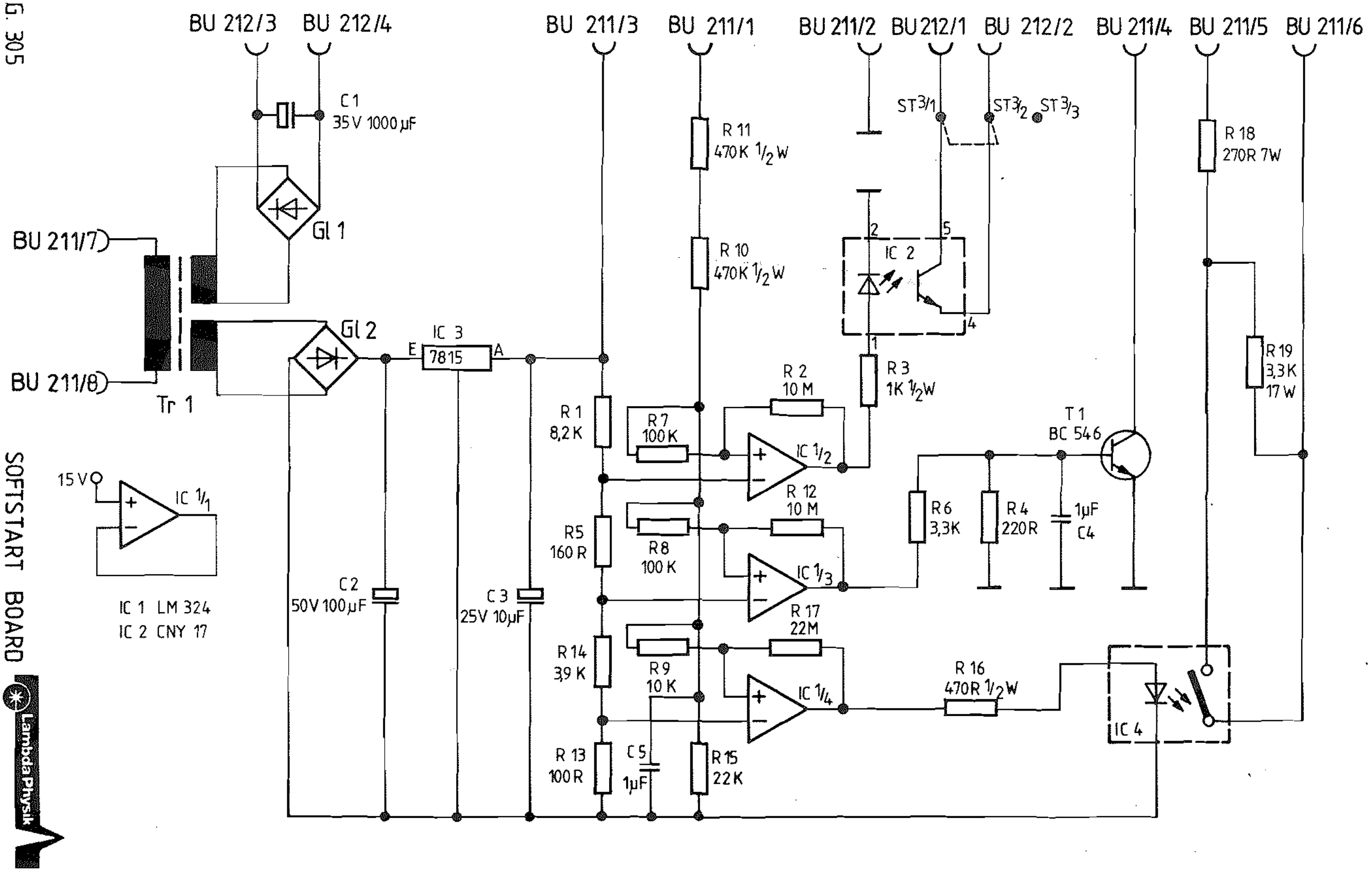
Änderung	FN-Nr.	Datum	Name
2 Beschriftung; ⊥ entfällt		24.9.84	
		4.7.84	
		25.4.84	

18.7.14.50

C5 u. C1 geä. 25.2.85 Gr

1984	Datum	Name
Bearb.	10.2.	
Gepr.		
Gen.		

FIG. 305



SOFTSTART BOARD

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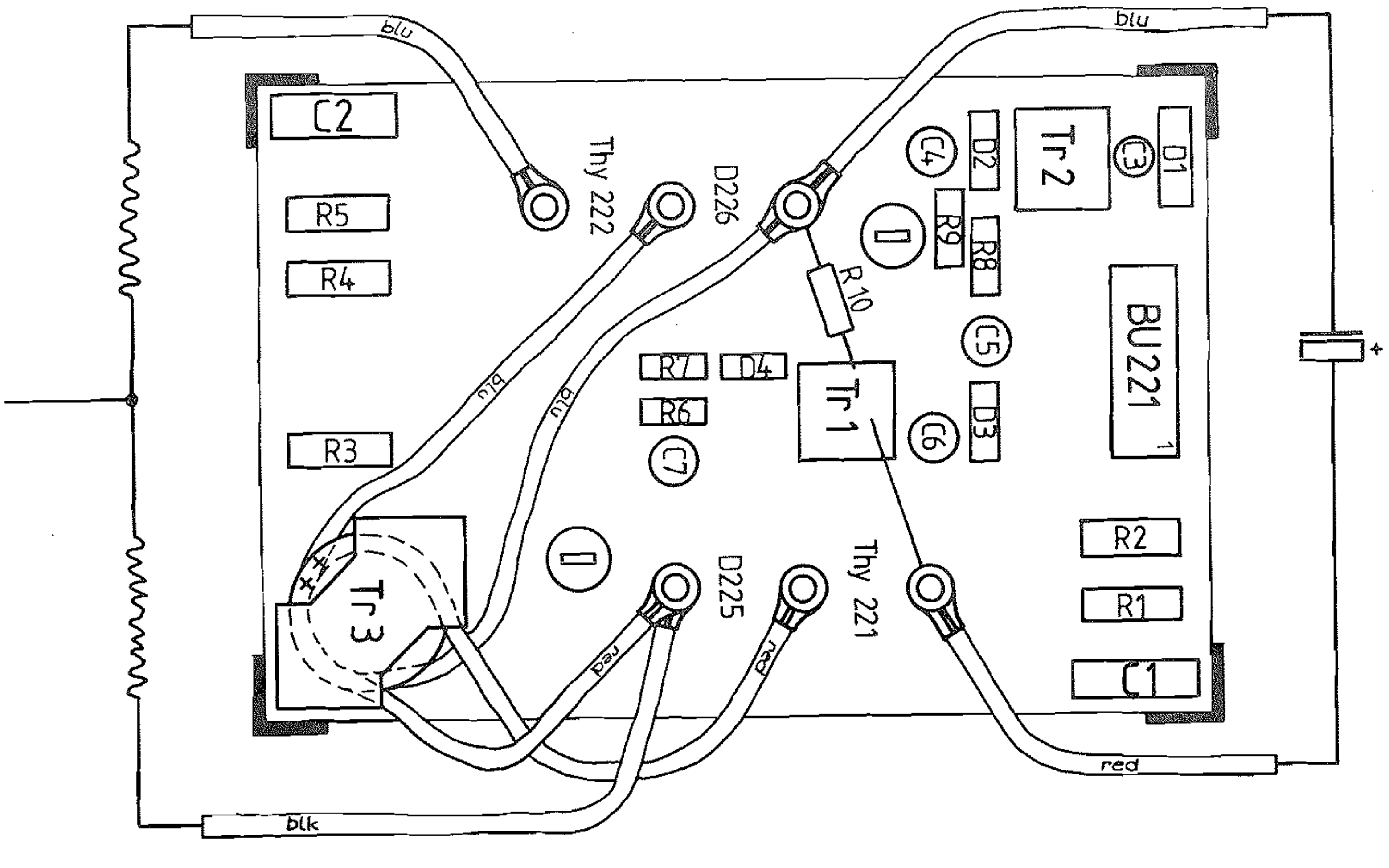
Änderung	FN-Nr.	Datum	Name
Korrektur		14.3.85	Gr
R10 zusätzlich		6.2.85	Gr

18.7.15.51

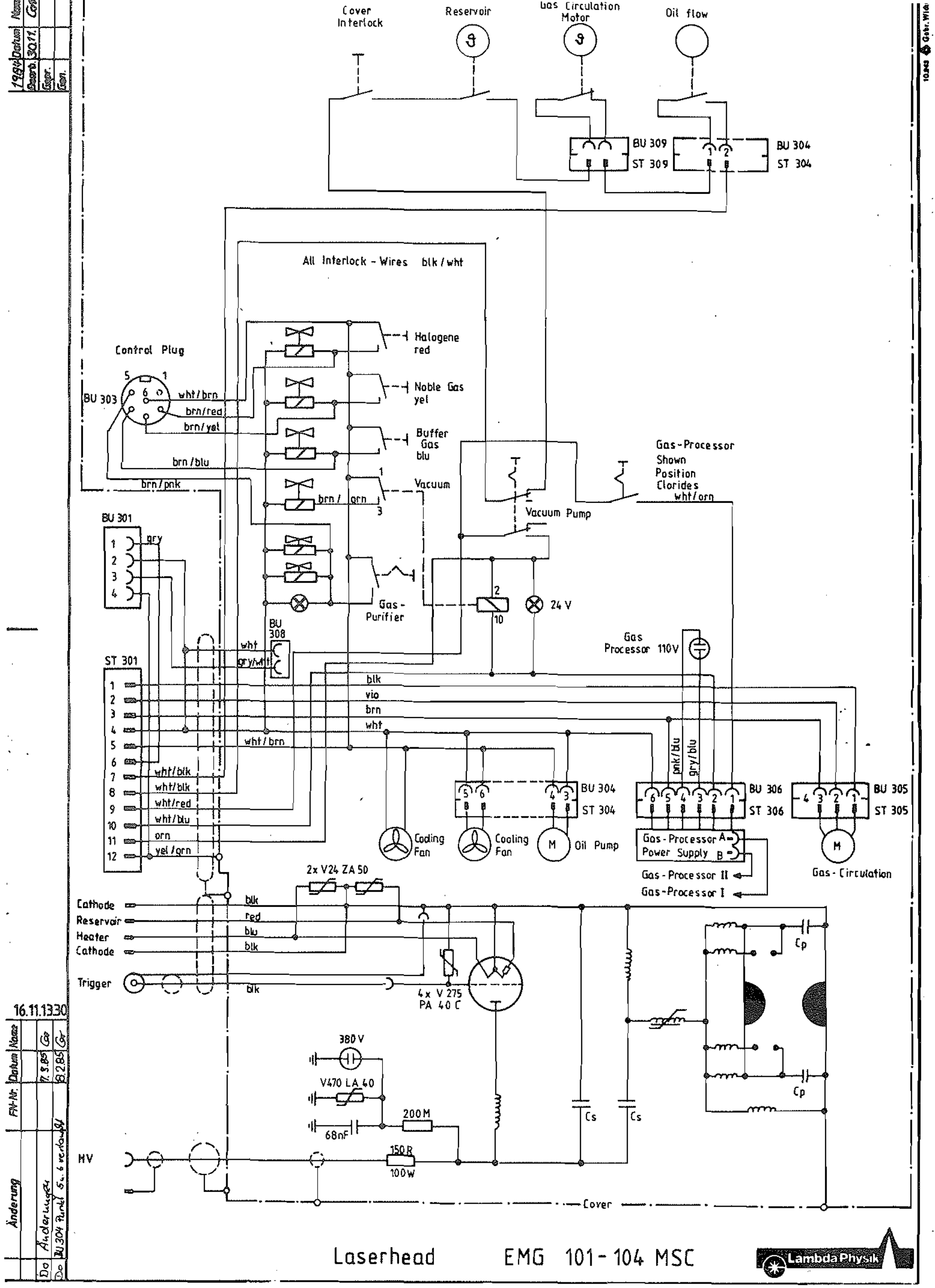
1984	Datum	Name
Bearb.	9.10.	
Gepr.		
Gen.		

THYRISTOR BOARD - LAY OUT -

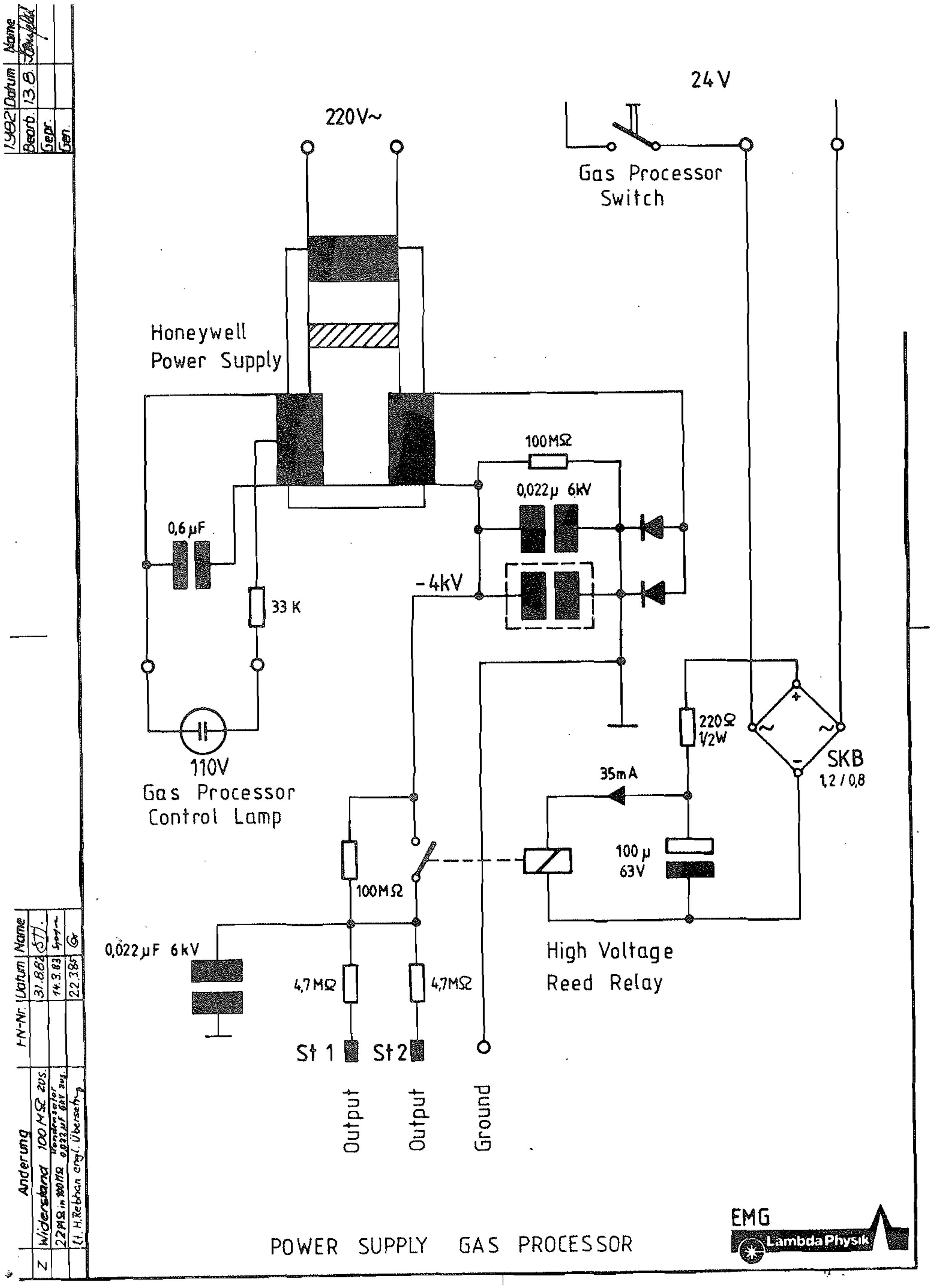


Lambda Physik

10.243 Gebr. Widmann



Laserhead EMG 101-104 MSC



POWER SUPPLY GAS PROCESSOR