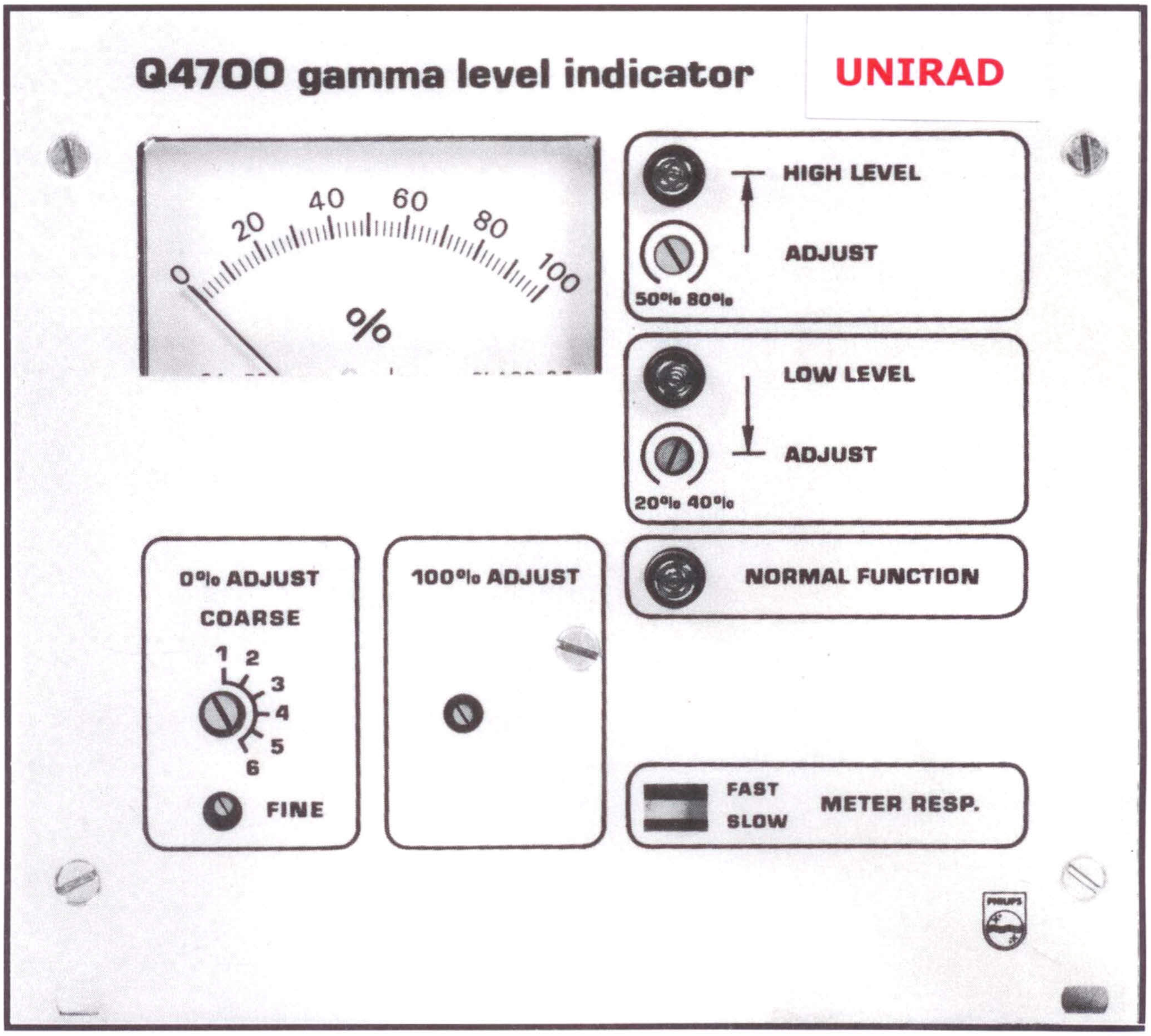
Q 4700

INSTALLATION

AND

OPERATIONS MANUAL



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Q 4700
GAMMA LEVEL
INDICATOR
INSTALLATION AND OPERATIONS MANUAL

Contents

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1. INTRODUCTION

1:1 General

The Q 4700 level indicator is based on the use of radioactive radiation, and it is used mainly for level measurements in closed vessels, vessels containing corrosive materials and applications that impose stringent reliability requirements. The radiation source unit is positioned on one side of the vessel, and the intensity of radiation is measured on the opposite side of the vessel.

The level indicator consists of one or more detectors provided with cables (Fig. 1), an electronic unit (Fig. 2) and one or more source units (Fig. 3). Each source unit contains a radioactive substance and a radiation shield.

Since the equipment is mounted on the outside of the vessel, it is ideal for level monitoring at high pressures, at high temperatures and under severe corrosive conditions. The vessels can thus be hermetically sealed, and they can contain liquids, slurries, paper pulp, wood chips, crushed materials, etc.

Fig. 1. Detector Q 4700/5 with casing removed

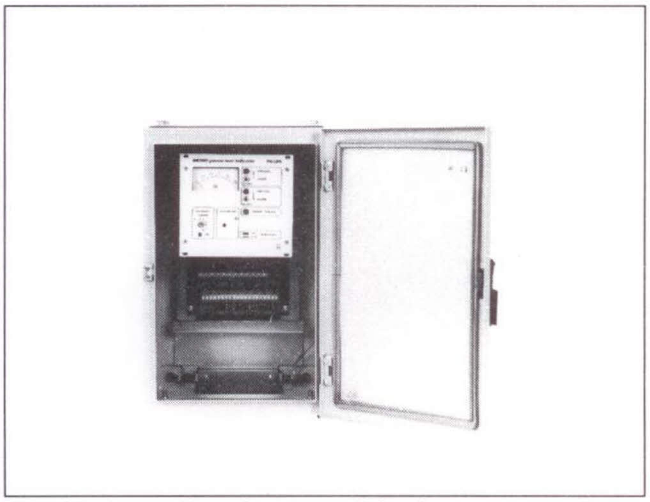


Fig. 2. Electronic unit mounted in sheet metal casing.

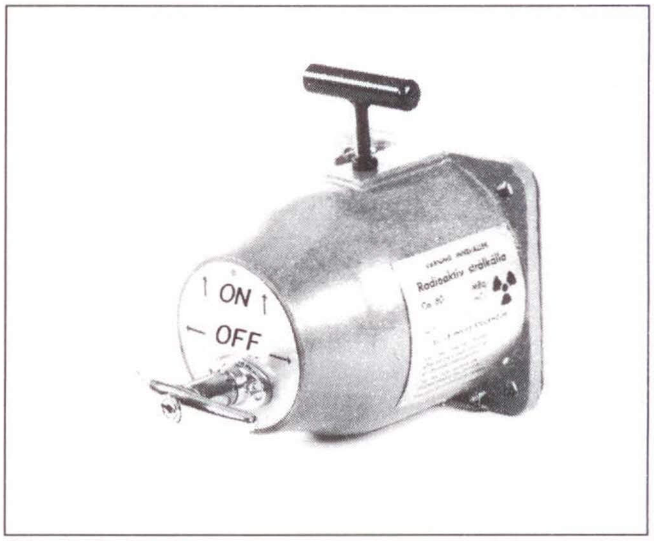


Fig. 3. Radiation source unit, type Q 4582B.

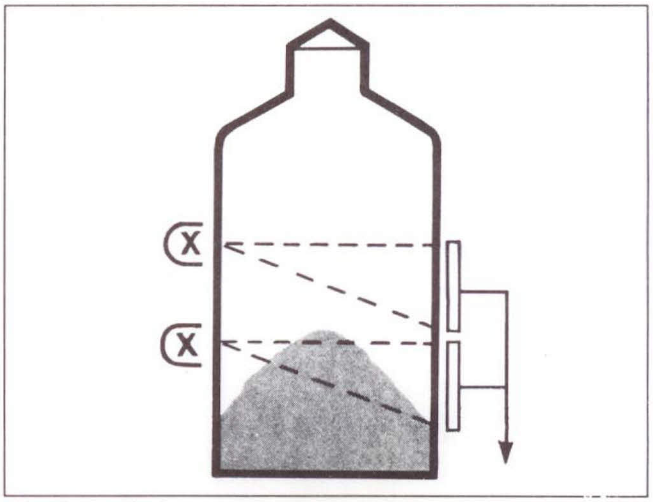


Fig 4. Radiation source units and detectors mounted on the outside of the vessel.

1:2 Radiation source unit

The radiation source unit consists of a radioactive substance enclosed in a lead shield. The lead wall thickness is based on the strength of the radioactive substance. Radiation is allowed to emerge through a port in the lead wall. Different radiation spread angles can be obtained by providing ports of different design. A lockable handle can be turned to one of two positions: radiation on or radiation off (shielded).

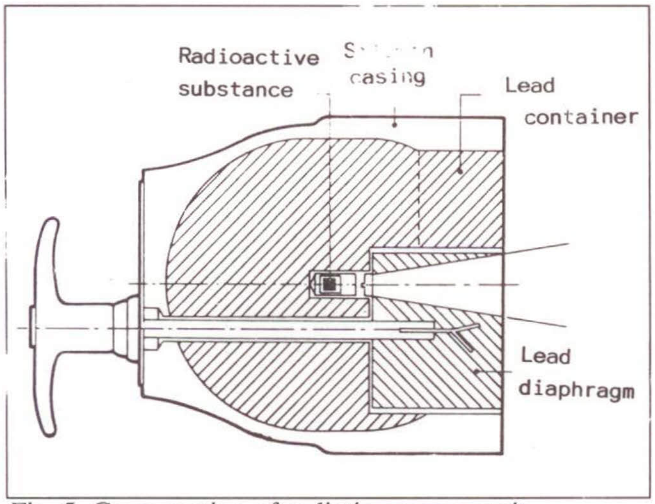


Fig. 5. Cross-section of radiation source unit

Radiation also "leaks" through the lead container, thus making it necessary to limit the time throughout which anyone is allowed to remain in the immediate vicinity of the source unit. However, at a distance of one metre from the lead container, the dose rate is always less than 0.75 µSv/h, except for the beam itself when the port is open. There is thus a radiation zone within one metre of the lead container, but outside this zone personnel can work full-time without encountering any radiation hazard.

The radiation sources used in the unit are prepared in accordance with international regulations. Those usually employed are Co-60 (Cobalt) and Cs-137 (Cesium).

The Co-60 source consists of a solid cylindrical piece of cobolt about 4 mm in diameter enclosed in a stainless steel capsule.

The Cs-137 source consists of ceramic-bonded cesium in a dual-wall stainless steel capsule.

The capsules for Co-60 and Cs-137 are tested and classified in accordance with the international ISO 2919 -1980 E standard.

The source units - source and shield - are supplied ready for use, and must be installed in accordance with the directions set forth in chapter 5 entitled "Installation".

Gamma radiation from the radioactive sources is harmless to all materials except living tissue, which is damaged by internal ionization. For this reason, the safety regulations set forth in chapter 2 must be rigorously observed. There is no risk of any radiation damage to the vessel or its contents.

2. SAFETY REGULATIONS

RADIATION SAFETY REGULATIONS

The following safety regulations comply with applicable regulations in Sweden. For installation in other countries, due regard must, of course, be given to the regulations that are in force in the country in question.

2:1 Maximum dose rate

Under current regulations, personnel who are exposed to radioactive radiation in the course of their work must not receive a greater weekly dose than 300 µSv. This is equivalent to a dose rate of 0.75 µSv/h throughout a 40-hour work-week.

For personnel engaged in radiological work who are provided with a personal dosimeter and who are examined medically at least every third year, the permissible radiation dose is three times higher than the figure stated above.

Since the dose rate does not exceed 0.75 µSv/h at a distance of one metre from the shield, personnel can remain constantly beyond this distance without receiving more than the permissible weekly dose.

Even personnel who never work with the radiological equipment are exposed to radiation. Radioactive substances are present in nature, and these natural sources together with cosmic rays subject us to a dose of about 10 µSv per day. A radiation dose of up to 20 µSv/h (gamma rays) has been recorded directly from wristwatches. Radiological examinations subject the body to quite heavy doses; a pulmonary X-ray, for example, provides about 10 000 µSv.

2:2 Responsibility

Anyone planning to install a facility employing radioactive sources must first abtain permission to possess and use the source unit. He must appoint a "responsible overseer" who will assume full responsibility for seeing to it that instructions are followed. Not until this is done will the radiation-protection authorities grant permission for the possession and use of the equipment.

2:3 Moving a source unit

If, for any reason, the source unit must be moved, the responsible overseer must be so informed. Prior to dismounting, the source unit must be turned off and locked. During the period throughout which the source unit is removed, it must be kept in a locked and fireproof area.

2:4 Surveillance after installation

The responsible overseer must check that all source units are in place, that they are in good condition and that they have been installed in accordance with the regulations. At the same time, a check must be made to see that the dose rate at the detector does not exceed 7.5 µSv/h and that the warning signs are posted correctly.

2:5 Changing a source unit

When the radioactivity of the source unit has decayed to a certain level, replacement becomes necessary. This applies primarily to cobolt-60 which has a half-life of 5.3 years, and for which replacement can become necessary after about 10 years. Cesium-137 has a half-life of 30 years and does not normally have to be replaced during the service life of the equipment. For replacement, an approved supplier must be notified. He will install a new source unit having the same activity level as the old one had when it was delivered. If it seems advisable, the supplier can use the old radiation shield and simply recharge the unit with a fresh radioactive substance. If the activity is altered, a new application must be submitted to the radiation-protection authorities.

2:6 Transportation of source units

Contact your supplier for further information.

ELECTRICAL SAFETY REGULATIONS

2:7 General

The Q 4700 level indicator has been designed, contructed and tested in accordance with the following safety regulations for electrical measuring instruments of class I: IEC 348, IEC 414 and VDE 0160.

Warning

Personnel doing fault tracing with the mains voltage turned on and using pointed objects such as probes can come inte contact with dangerous voltages.

– Personnel engaged in fault tracing during operation must use insulated tools.

– The mains voltage must not be turned on while personnel are replacing or repairing circuit boards.

– Always check to see that no dangerous external voltages are connected via relay contacts.

Signal ground

The device's signal ground - TP1 on the panel board and 0 V on the base board - must not be connected to chassis ground if the 4-20 mA or -15 V outputs are connected galvanically to ground.

2:8 Grounding

The ground line must be connected to the threaded ground terminal on the casing !

(Illustration taken from "Elföreskrifter", published in Stockholm 1980 by "Elfackets Centrala Yrkesnämnd" and "Liber Läromedel".)

2:9 Setting the mains voltage

Check to see that the mains voltage selector (SK201) on the base board is set to the local mains voltage. Remember that this must be done before the mains voltage is connected up. Use the 115 V setting for 110-127 V AC, and use the 230 V setting for 220-240 V AC.

2:10 Fuse

The Q 4700 level indicator is provided with a fuse designated VL201. This fuse must be replaced if the setting of the mains voltage selector is changed. Use a 5 x 20 mm, 160 mA slow-blow, glass-tube fuse for 230 V AC. For 115 V AC, use a 315 mA fuse of the same type.

3. TECHNICAL DATA, ELECTRONICS UNIT

3:1 Power requirements

Mains voltage
50-60 Hz
115 V ± 15%
230 V ± 15%

SK 201
115 V
230 V

Fuse (VL 201)
315 mA
160 mA

3:2 Electrical safety provisions

As set forth for IEC 348, class I, all input and output signals are galvanically isolated from ground. The maximum permissible voltages vis-à-vis ground are 250 V AC and 350 V DC.

3:3 Environment

Ambient temperature while in operation:	0 − + 50°C
Relative humidity:	0 − 90%
Vibration test:	As per IEC 68
Shock test	" " " "
Moisture and temperature test:	" " " "

3:4 Output signals

mA-output:
Galvanically isolated from ground. Provides 4-20 mA output depending upon level (0-100 %). Max load is 470 ohms.

High-level alarm:
Relay signal can be adjusted to issue an alarm between 70-100 % of full-scale deflection.

Low-level alarm:

Relay signal can be adjusted to issue an alarm between 20-40 % of full-scale deflection.

Relay signal used to monitor operation:
During normal operation, relay RE203 is pulled in.

The following are monitored:
1. That the supply voltages are normal.
2. That the flow of pulses to the electronic unit is not interrupted.
3. That no error signal has been received from any of the detectors.

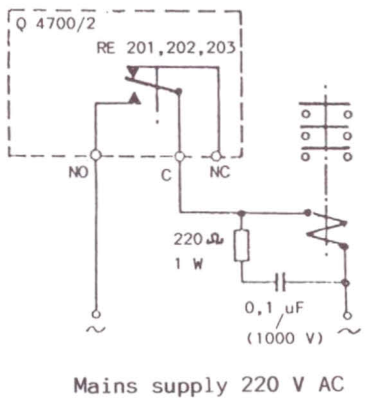
The 1-pole transfer contacts in relays RE201, RE202 and RE203 can be loaded to a maximum of 1 A, 220 V (resistive load). For an inductive load, a spark suppressor must be used as shown in Fig. 6.

3:5 Time constant

The rate of decay of the radioactive source varies widely. To provide sufficient output-signal stability and thus stabilize the pointer deflection, the output signal is sent through a low-pass filter. The meter response switch (SK101) can be used to select a time constant that provides a fast or slow response.

Example:(7.5 μSv/h at the detector)

Alarm-level measurement carried out using one detector of type Q 4700/5 with the meter response switch at the fast-response position provides an alarm response time of about 3.5 s. If additional detectors are used, the alarm response time will be shorter.



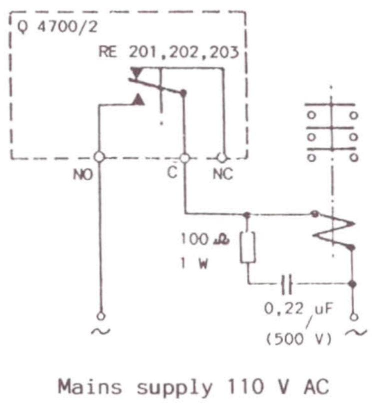


Fig. 6. Relays used for high-level and low-level alarms, and performance monitoring.

3:6 Sensitivity

The maximum sensitivity for a Q 4700/5 detector is about 0.2 µSv/h for alarm-level measurement. If additional detectors are connected, the sensitivity is even higher. The natural (background) radiation is about 0.1 µSv/h and this limits the possibilities of working at higher sensitivities.

3:7 Maximum cable length

To make certain that PFM transmission is not disturbed, the total cable capacitance must not exceed 68 000 pF. When the standard Philips cable (240 pF/m) is used, the total cable length can thus be 280 m. If a low-capacity coaxial cable (68 pF/m) is used for the signal sent out from the detector, the cable can be as long as 1 000 m.

3:8 Temperature drift

Measured at the 4-20 mA output with steady-state input pulse frequency.
Max ±0.05% / °C, typical ±0.02 %/C°.

3:9 Casing

Q 4700/3—Sheet metal casing with grey enamel finish, tightness as per IP65.
~~Q 4700/4—Sheet metal for rack mounting. Chromatized sheet steel.~~

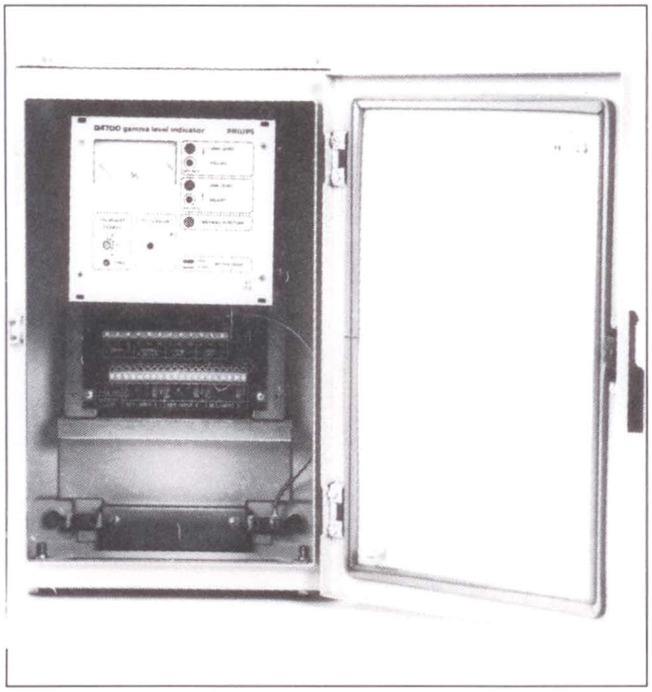


Fig. 7. Casing, type 4700/3

3:10 Connections

The mains voltage and relay signals are connected via terminal board BU202 (12 terminals). Max cable area is 2.5 mm².

The other inputs and outputs are connected via terminal board BU201 (20 terminals). Max cable area is 4 mm².

A maximum of four detectors can be connected to each detector-input section on BU201, since these sections are connected in parallel.

4. TECHNICAL DATA, DETECTORS Types Q 4700/5 and Q 4700/9

4:1 Supply voltage

+15 V DC, +10−20%, galvanically isolated from ground, max 15 mA.

4:2 Electrical safety provisions

As set forth for IEC 348, class I.

4:3 Environment

Ambient temperature while in operation:	−40°C − +70°C
Relative humidity:	0−95%
Vibration test:	As per IEC 68
Shock test:	" " " "
Moisture and temperature test:	" " " "

4:4 Output signals

PFM-output:
Galvanically isolated from ground. Pulse duration of 12 ± 2 µs, amplitude of 10 mA.

Error signal:
Performance monitoring, normally at +14 V. Error indication provides +6.5 V output signal.

4:5 Connectors

Circular, 6-pin chassis connector as per MILC-26482-1. Gold-plated pins of bayonet type.

4:6 Casing

Stainless steel casing with anodized, chromatized aluminium insert which withstands long-term exposure to severe environments.
Tightness as per IP67.

4:7 Temperature drift

Pulse frequency drift at steady-state dose rate:
Max ± 0.02% / °C
Typical value <0.01% / °C

4:8 Detector cable, type Q 4700/7

This 4-conductor, 0.22 mm^2 cable is provided with a 0.75 mm^2 shield and black plastic sheathing having an outside diameter of 7 mm. The standard lengths are 5 and 10 m. Maximum capacity between conductors is 240 pF/m. The circular 6-socket connector complies with MILC-26482-1. Gold-plated sockets are of the bayonet type.

5. INSTALLATION

READ THROUGH THE SAFETY REGULATIONS BEFORE INSTALLING THE EQUIPMENT

5:1 General

It is very important to have the source unit installed by personnel who have acquired the necessary knowledge about radioactive material. These personnel must be equipped with instruments that can measure the radiation dose rate. However, no restrictions are imposed for components other than the source unit.

Before the equipment is put into operation, the installation must be checked by the responsible overseer.

If any doubt should arise in connection with the relative positions of the radiation sources and the detectors, ask your supplier for information. The relative positions can vary, depending upon the diameter of the vessel and the type of radiation shield being used.

5:2 Radiation source unit

Make certain that the radiation beam is turned off and locked before commencing installation.

You must see to it that the source unit is not mounted in such a way that it can be obstructed by a concealed structural beam or anything else that can significantly block the radiation.

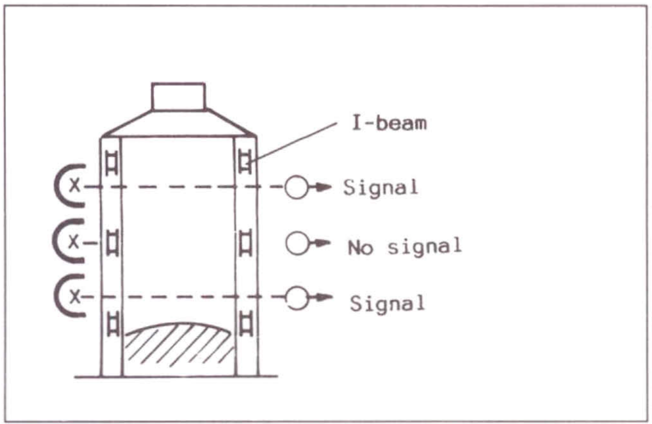


Fig. 9. Check to see that radiation is not blocked by beams or other parts of the vessel.

All types of source units are provided with holes for mounting bolts. All types have four holes in the front panel, while the large types also have a baseplate provided with retainer holes. See the dimension drawings. A retainer plate with mating holes and an opening for the radiation beam (see Fig. 10) must be welded or secured in some other way to the vessel wall.

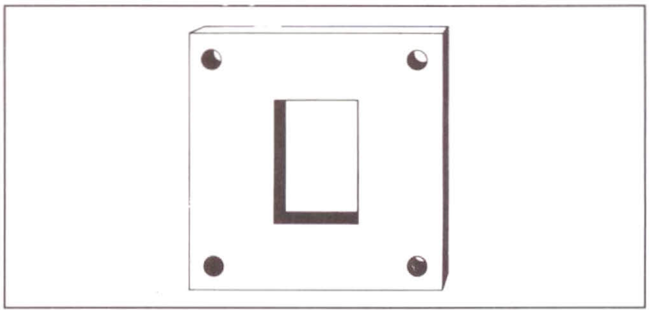


Fig. 10 Retainer plate.

If the vessel is insulated, it may be necessary to provide spacers between the retainer plate and the vessel wall. See Fig. 11.

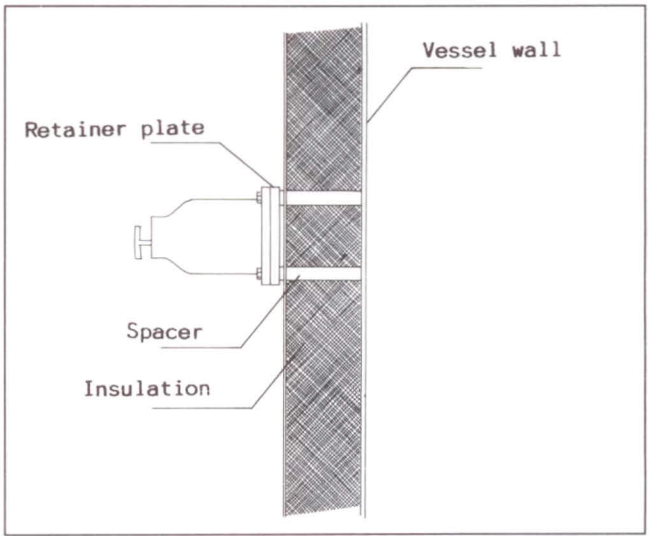


Fig. 11. Insulated vessel with spacers between the retainer plate and the vessel wall.

If it is possible to insert your hand (for example) between the front of the radiation source unit and the wall of the vessel, a safety guard that will prevent this must be mounted. It can be made of sheet steel, sheet aluminium or the like. See Fig. 12.

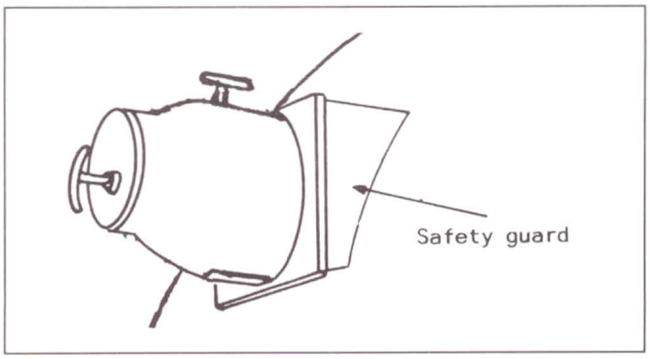


Fig. 12. Safety guard between the radiation source and the vessel wall.

Sometimes it is necessary to be able to adjust the equipment vertically in situations where production varies and where there is some uncertainty as to which working level is best. Here, the radiation source unit shall be mounted on slider bars. See Fig. 13. The detectors must also be vertically adjustable, and thus must be mounted on similar bars.

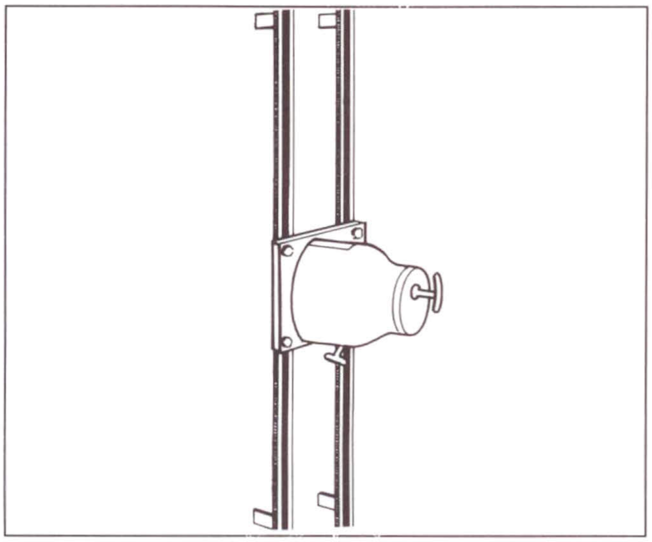


Fig. 13. Radiation source unit mounted on slider bars.

If, after installation, the radiation dose rate at the detector i higher than 7.5 μSv/h, a steel or lead plate can be mounted in front of the source unit. It is recommended that this absorber plate be designed in the same way as the retainer plate, but without any opening for the radiation beam. It can then be inserted between the retainer plate and the source unit. See Fig. 14.

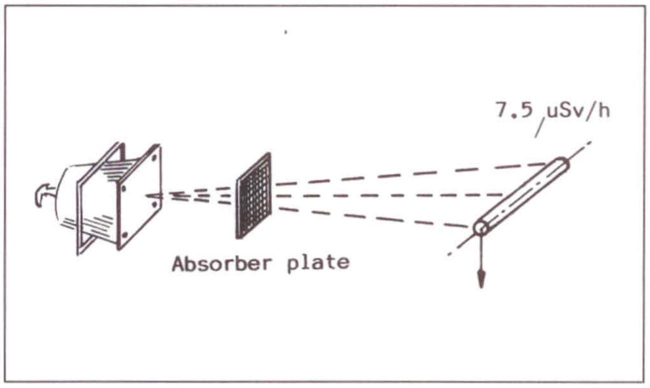


Fig. 14. An absorber plate can reduce the radiation dose rate to an acceptable value.

5:3 Detectors of type Q 4700/5, alarm level

The short detector is intended for alarm-level measurement. This detector is mounted horizontally on the opposite side of the vessel and at the same height as the source unit. If both a high level and low level alarm are to be issued, one horizontal detector must be mounted at each alarm level.

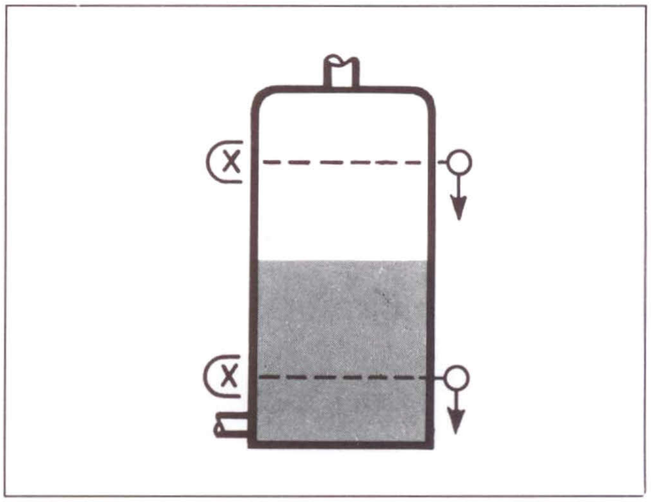


Fig. 15. High-level and low-level alarm.

Stainless steel holder Q 4700/8 for this detector is provided with two M8x25 mm bolts that are welded in place. See the dimension drawings. Two steel angles with holes for the aforesaid M8 bolts must be attached to the wall of the vessel. See Fig. 16. The holder can then be secured to the angles by means of nuts. The drainage hole in the holder must be at the bottom.

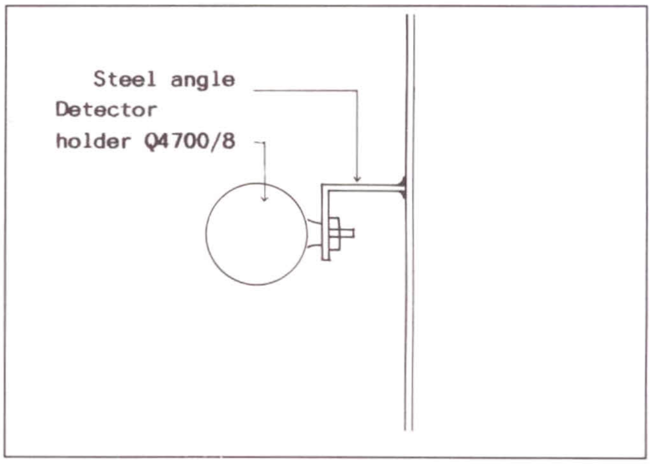


Fig. 16. Detector holder mounted on vessel wall by means of steel angle.

The detector itself is then inserted in the holder from the side and secured by means of a socket-head cap screw at the bottom of the holder.

5:4 Detectors of type Q 4700/9 for continuous measurement

The long detector is intended for continuous level measurement. Frequently, a number of detectors and a number of source units are used to provide full coverage of the measurement range in question. The detectors are mounted vertically.

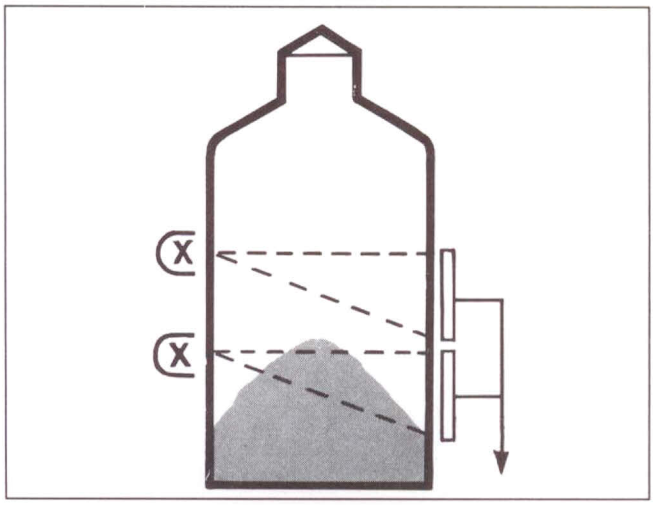


Fig. 17. Continuous level measurement

Stainless steel holder Q 4700/10 is provided with two M8x25 mm bolts that are welded in place. See the dimension drawings. One U-shaped steel fitting must be secured to the vessel wall for each M8 bolt. One of these U-shaped fittings can be used to secure two detector holders. Se Fig. 18.

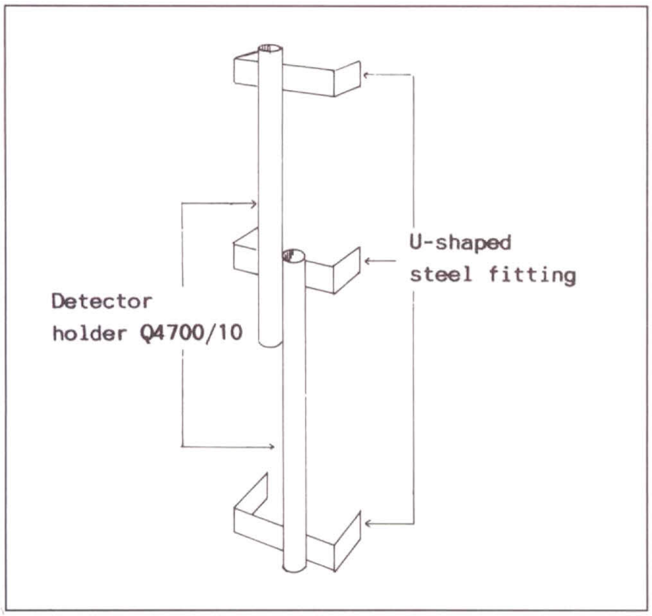


Fig. 18. Detector holders mounted with U-shaped steel fittings on the vessel wall.

If a number of detectors are to be installed, the Q 4700/10 holders must be mounted so that they overlap each other. The top of the lower holder must be at the same level as the lower retainer pin on the upper holder. See Fig. 18. The detector shall then be inserted into the holder from beneath and secured by means of a socket-head cap screw on the holder.

Frequently, the detectors can be spread out. Usually, they can be mounted one metre apart, although the resolution requirement is the determining factor.

5:5 Electronic unit

There are two versions of the electronic unit:

A. Q 4700/1,2,3: This unit is housed in a grey sheet metal casing that is designed for wall-mounting, etc.

B. Q 4700/1,2,4: This unit is designed for mounting in a 19" Eurorack.

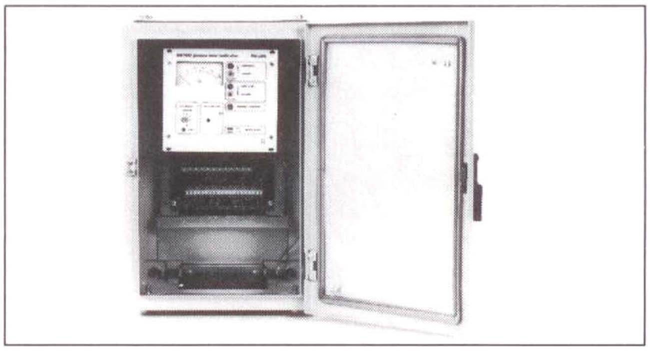


Fig. 19. Electronic unit mounted in sheet metal casing.

A. Wall-mounting version

The casing is delivered with four 22.5 mm cable glands. It is possible to mount an additional five cable glands in the bottom of the casing. The casing has four retainer screw holes provided with neoprene rubber seals. See also the dimension drawings.

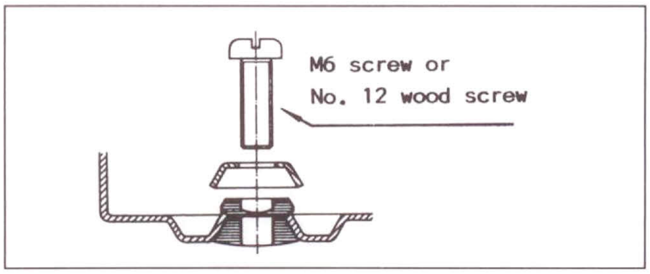


Fig. 20. Seal for retainer screw hole in casing.

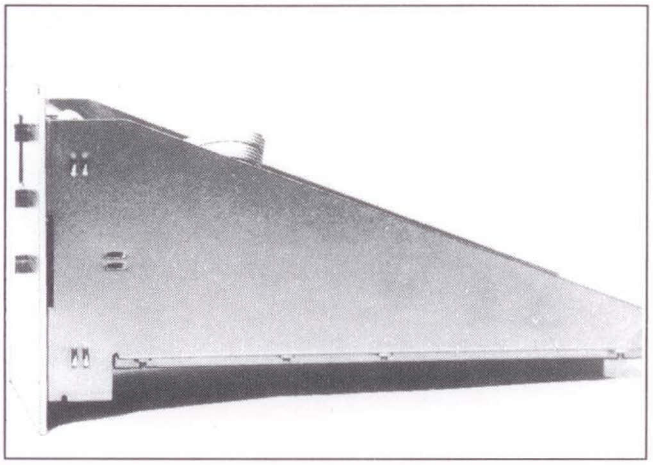


Fig. 21. Electronic unit designed for mounting in 19" Eurorack.

B. 19" Eurorack version

The front panel is 128.4 mm high and 141.9 mm wide, and the mounting depth is 230 mm. Holes for four M3 retainer screws are provided in the corners of the front panel. See also the dimension drawings.

5:6 Warning signs

A number of warning signs are delivered with the equipment. The radiation shield itself is delivered with all of the necessary signs already mounted.

The user must post two signs: one stating the regulations that apply and one at the manhole.

The sign stating the regulations that apply must be posted close (about 1 m) to the radiation source unit. The name of the responsible overseer must appear on this sign.

A manhole sign must be mounted at all manholes or openings where it is possible for personnel to enter the vessel in question.

Fig. 22. Sign, type IR 1015, stating the regulations.

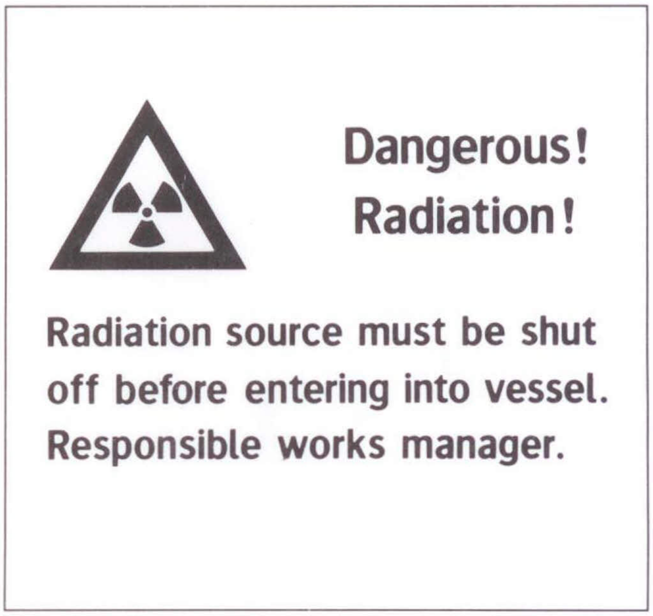


Fig. 23. Sign, type IR 1016, at the manhole.

6. CONNECTIONS

6:1 Connection to the mains

The phase line shall be connected to BU202:1, and the neutral line to BU202:2. The ground line must be connected to the threaded ground terminal on the casing. For the rack-mounted version, the ground line must be connected to the rack.

6:2 Relay outputs

The relay outputs are to be connected to threaded terminals 4-12 on terminal board Bu202. See Fig. 24. Information about the permissible load is set forth in the technical specifications. The relays used for high level and low level pull in when an alarm is issued. The performance monitoring relay drops out.

6:3 4-20 mA output

This output is galvanically isolated from ground. The positive lead shall be connected to BU201:1 and the negative lead to BU201:2. A ground connection must be provided to eliminate disturbance voltages, either at the electronic unit or some other connected unit. The maximum load is 470 ohms.

6:4 Connecting the detectors

Numerous detectors can be connected to the electronic unit. Terminal board BU201 has three parallel-connected sections, and the detectors can be distributed as desired among these. The openings in this terminal board are large enough to permit four detector cables to be connected to each section.

Cable colour coding	*Terminal board BU201*	
Shield	Shield	3, 9, 15,
–	–IN	4, 10,16
Blue	+IN	5, 11,17
Green	0 V	6, 12,18
Red	Error	7, 13,19
Yellow	+ 15V	8, 14,20

NOTE: – IN and 0 V are connected by a jumper on one of the aforesaid sections to permit pulse transmission. Do not remove this jumper.

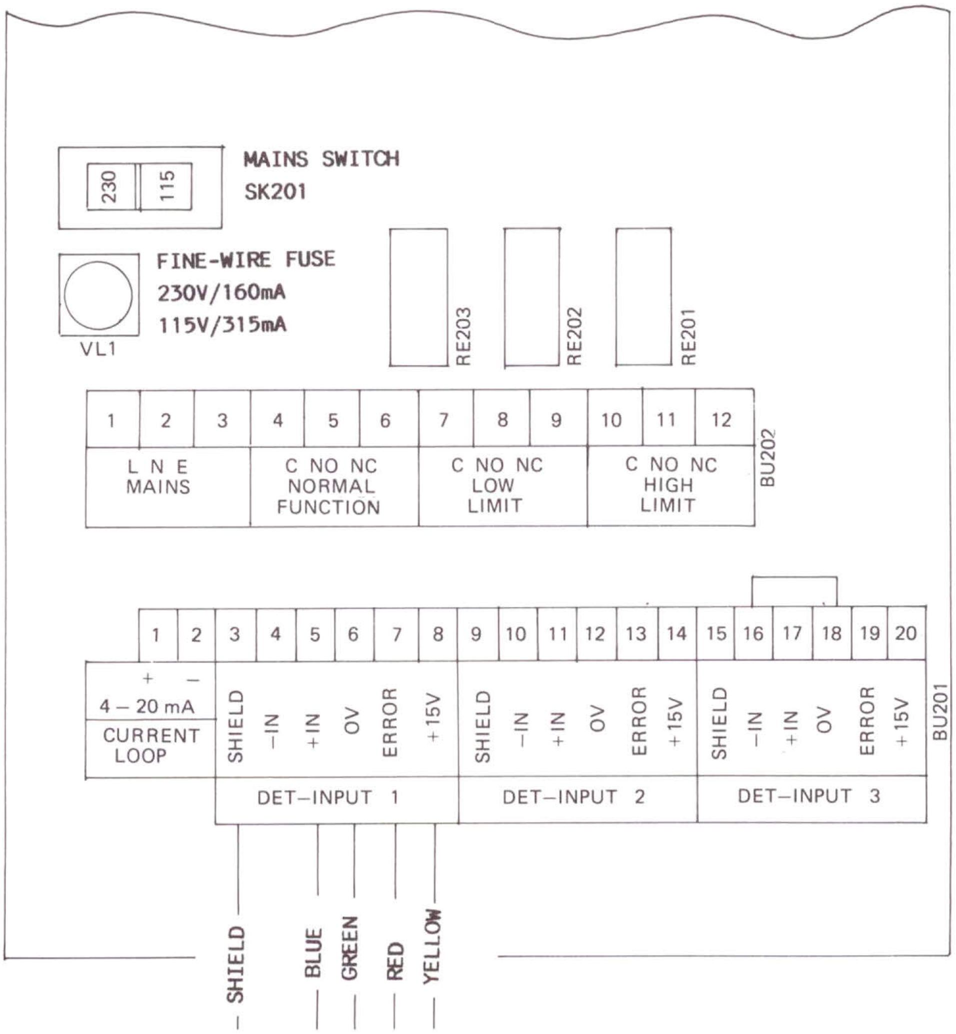


Fig. 24. Terminal boards in the electronic unit.

6:4 A Splicing detector cables

It is possible to splice a number of detector cables together. It is also possible to connect them to a junction box. In such case, a common cable then runs from the splice or junction box to the electronic unit. See Fig. 25.

6:4 B Extremely long detector cable

For distances longer than 280 m between the detector and the electronic unit, the PFM signal (+ IN) must be carried via a coaxial cable (68 pF/m) as shown in Fig. 26. This permits the distance to be increased to 1 000 m.

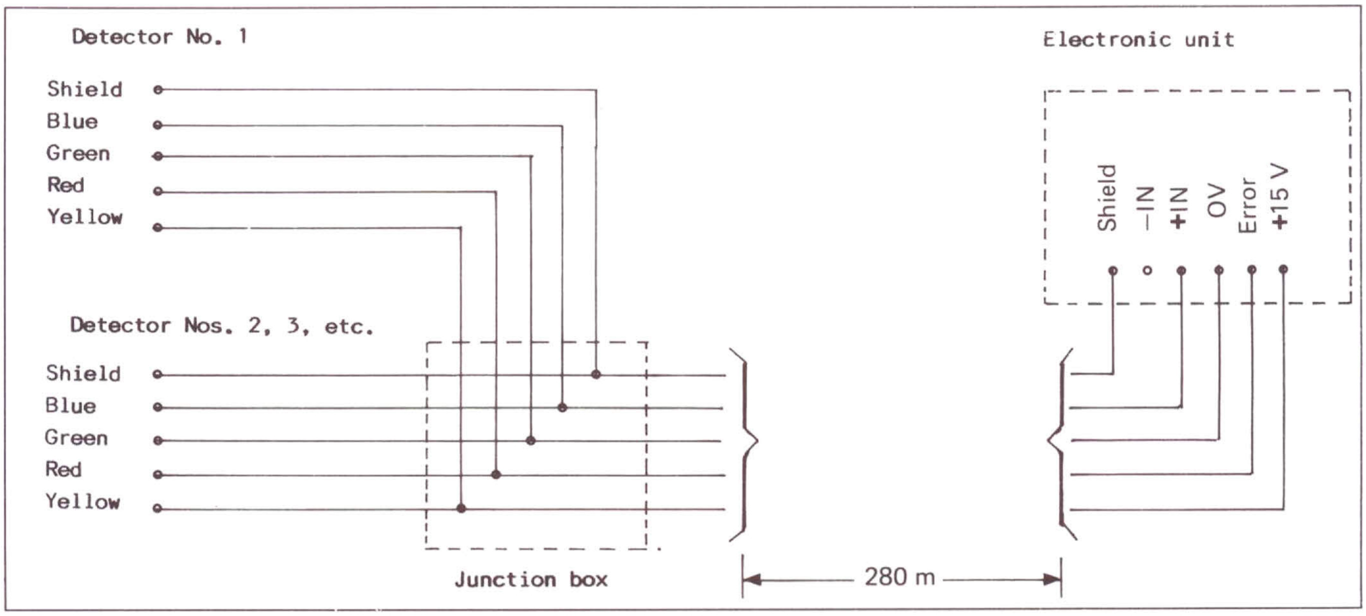


Fig. 25. Joining detector cables via a junction box.

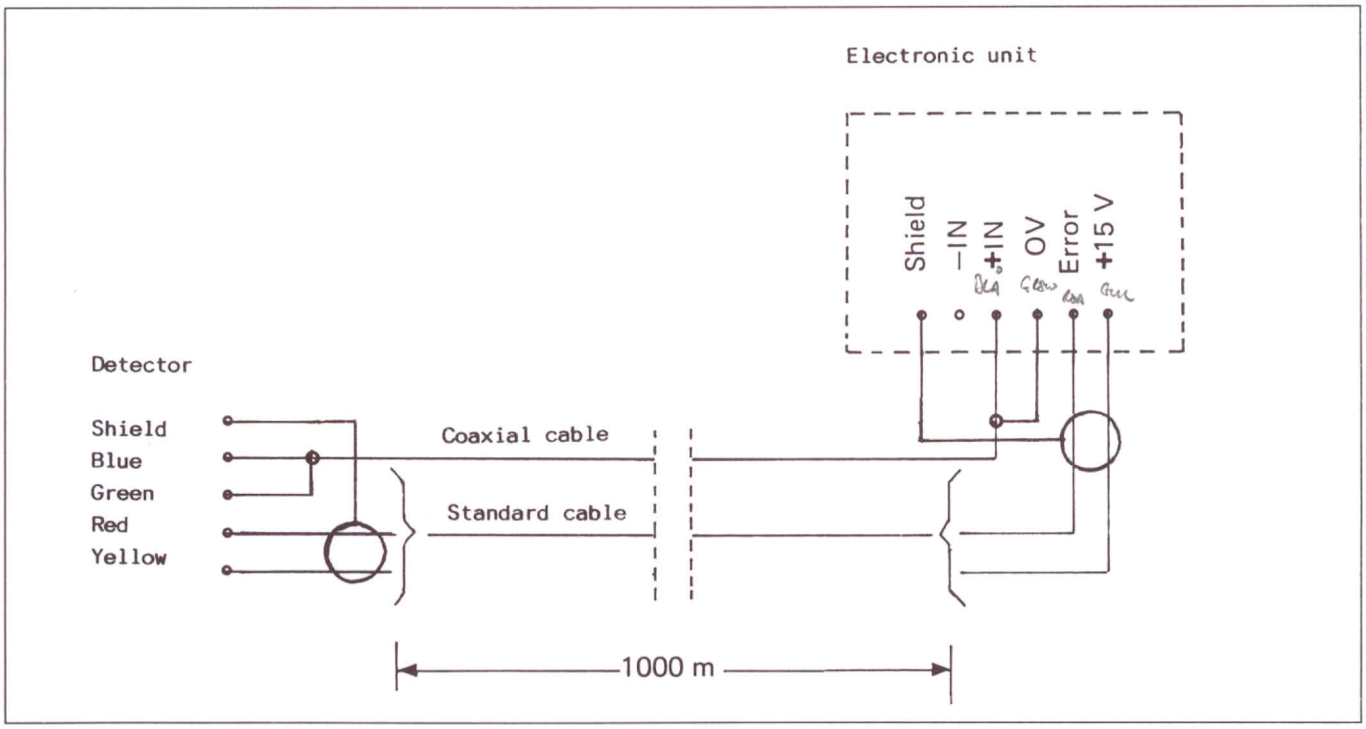


Fig. 26. Connecting the detectors via a coaxial cables.

7. INITIAL ADJUSTMENTS

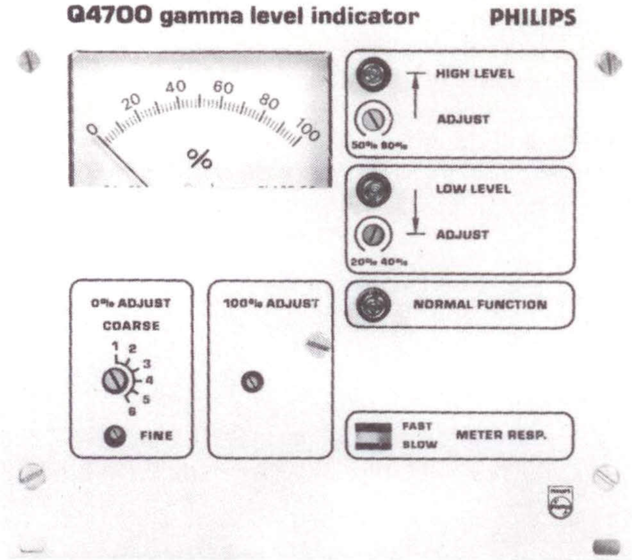


Fig. 27. Front panel of the electronic unit.

7:1 General

Check to see that the level of the material in the vessel is below the radiation beam. Measure the intensity of radiation at the detector. It must not exceed 7.5 μSv/h. Select a suitable time constant by means of the meter response switch. Normally, the fast position is used for alarm level measurement and the slow position for continuous measurement.
Set the sensitivity to "0% Adjust" by means of the coarse switch. The table that follows presents normal settings for different combinations of detectors.

7:2 Adjustment for alarm function

A Set the meter response switch to the fast position.

B Using the coarse switch, set the sensitivity to "0% Adjust". This switch is normally set to position 4 for one or two alarm levels.

C Using the fine potentiometer, adjust to obtain 0% scale deflection.

D Increase the level in the vessel so that it covers the radiation beam or turn off the beam.

E Adjust to 100% scale deflection by means of the "100% Adjust" potentiometer.

F Set the alarm points for the high and low levels by turning the radiation beam on and off. The appropriate lamp will light up when the alarm point is reached. Adjust the high level by means of the high level adjust potentiometer to provide a scale deflection of 70-100%. Adjust the low level by means of the low level adjust potentiometer to provide a scale deflection of 20-40%.

7:3 Adjustment for continuous measurement

A Set the meter response switch to the slow position.

B Select a sensitivity of "0% Adjust" by means of the coarse switch. Normally, this switch is set to position 4 for 1-3 detectors of type Q 4700/9 and to position 5 for 2-12 of these detectors.

C Using the fine potentiometer, adjust to 0% scale deflection.

D Increase the level in the vessel so that it covers the entire distance being measured or turn off the radiation beams.

E Adjust to 100% scale deflection by means of the "100% Adjust" potentiometer.

If alarm levels are desired within the continuously measured range, adjust as set forth in step F in section 7:2.

METER RESPONSE

FAST Coarse switch Pos.	SLOW
1. Not used in normal operation	Not used in normal operation
2. 1 detector Q4700/5 very low intensity	1 detector Q 4700/5 low intensity
3. 1 detector Q 4700/5 low intensity	1 - 3 detectors Q4700/5
4. 1-3 detectors Q 4700/5	1 - 3 detectors Q4700/9
5. 1 - 3 detectors 4700/9	2 - 12 detectors Q4700/9
6. 2 - 12 detectors Q4700/9	

8. CIRCUITRY DESCRIPTION

8:1 General

The level monitor includes one or more detectors which, via detector cables, are connected to the electronic unit. unit.

There are two versions of the electronic unit:
· Q 4700/1,2,3: Circuit boards mounted in a grey sheet metal casing designed for wall-mounting etc.

· Q 4700/1,2,4: Circuit boards (Q 4700/1 and 2) designed for mounting in a 19" Eurorack.

There are two versions of the detectors:

· Q 4700/5: Single detector with one GM-tube. Active length, approx 0.15 m.

· Q 4700/9: Dual detector with two GM-tubes. Active length, approx 0.6 m.

8:2 Detector block diagram

The detector contains one or two Geiger-Müller (GM) tubes (CT1/CT2) which, when exposed to ionizing radiation provide pulses having a duration of approximately 200 µs. The frequency of the pulses is proportional to the intensity of the radiation.

Each GM-tube is driven via a voltage divider from a 450 V supply that is regulated and temperature-compensated in order to minimize the detector's temperature drift.

High-impedance pulses having an amplitude of about 50 V and a duration of 200 µs are obtained from the centre tap on the voltage divider.

A pulse shaping circuit converts the pulse duration to 10 µs and the amplitude to about 10 mA. This is done to adapt the pulses to the electronic unit input.

For each GM-tube, there is a performance monitoring circuit. This circuit also monitors the pulse output and the supply voltage.

The output signals and error signals from the different GM-tubes are joined by means of WIRED OR circuits. This arrangement permits a number of detectors to be connected in parallel without losing any information.

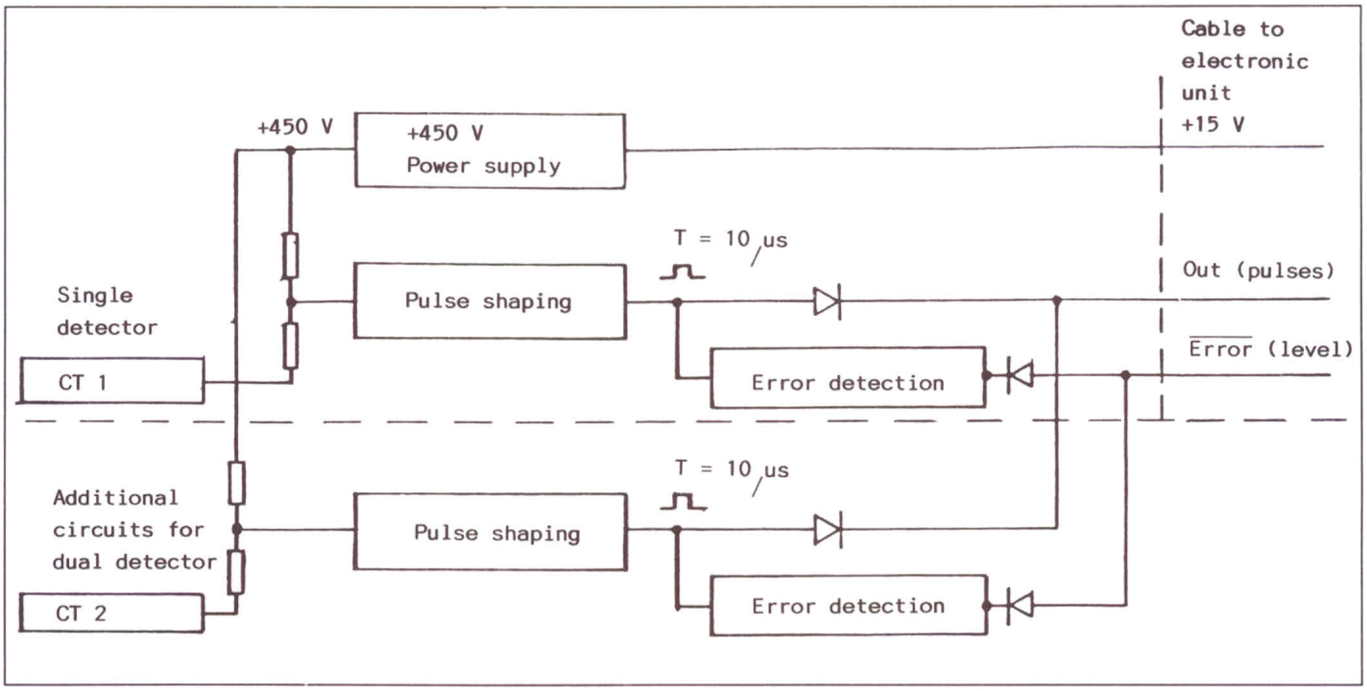


Fig. 28. Detector block diagram

8:3 Description. See diagram 4031 100 42180, single/dual detector

Power supply

0 V och +15 V are obtained from pins C and F in connector BU1. Diode GR13 is used only in explosion-proof equipment. GR9 provides protection against reversed polarity and negative voltage transients. GR9 lowers the drive voltage to about 14 V. C7 provides additional disturbance suppression.

The 450 V drive voltage is generated by a switched DC-DC converter of the flyback type. It is based on the free-running oscillator formed by three gates in IC3. When the high (drive) voltage is less than 450 V, this oscillator runs at about 25 kHz with a 50% duty cycle. The frequency is determined by C3 and R4. R3 protects pins 1 and 2 from damaging input currents. The oscillator output (pin 4) drives switch transistor TS2 (MOSFET).

Transformer TR1 receives +14 V via pin 2 and it is "charged" when pin 3 is short-circuited to ground via TS2 when its V_{GS} is high.

When V_{GS} goes low, TS2 is cut off and the transformer's energy is "discharged" from terminal 4 via GR6 and GR5 across smoothing capacitor C6.

Regulation When the output voltage is low, regulating transistor TS1 is cut off when its gate voltage is lowered to 0 V by R6. When the peak value of the voltage at TR1 (4) reaches 450 V, the output voltage across TR1 (3) becomes greater than 150 V, whereupon current flows through GR4 and GR3 and charges RC circuit R6-C4. TS1 commences to conduct (as a variable resistance) thus moving the oscillator's DC level and frequency upwards. As a result, the output voltage is limited about to 450 V, regardless of the input voltage.

Soft start Is provided by GR1 and R5. These prevent the oscillator from oscillating when the input voltage is lower than 5 V.

Pulse shaping

The signal is obtained from the centre tap on voltage divider R1/R2 or R10/R15. The level is 450 V. Capacitors C1 and C8 block the DC component. R16 and R17 pull up the DC level to +14 V. The negative 50 V pulses are clipped at -0.5 V via the protective diodes that are included in IC1 and IC2. C12 and C11 eliminate disturbances, thus preventing the flip-flops from being double-triggered. The monostable flip-flops are given a pulse duration of 10 us by R7/C2 and R12/C9. R8 and R13 limit the output current to 10 mA when pin D on BU1 (the output pin) is loaded by the electronic unit's optocoupler. Diodes GR7 and GR11 provide a WIRED OR circuit. When the output is high, the signal can pass through. When the output is low, the diode provides blocking so that the pulses on the parallel channels are not shunted to ground. Thanks to this arrangement numerous detectors can be connected in parallel.

Performance monitoring

The output pulses from pin 6 on IC2 trigger the next flip-flop in the same circuit via pin 11. It is retriggerable with a pulse duration of 10 s (C5 x R9). Since the pulses obtained from the GM-tube have a frequency of 1.5 Hz even in response to background radiation, the flip-flop (when CT1 is functioning normally) will always provide a high level at the output. This level is equal to the supply voltage.

If the supply voltage drops beneath about 12 V or if pulses are missing for a period longer than 10 s, a lower potential is applied to pin 10, thus pulling down (via diode GR8) the level on pin E in connector BU1 far enough to activate the electronic unit's performance alarm. If the Error signals for other connected detectors have a higher voltage, their serial diodes (corresponding to GR8) prevent the Error signal from providing any current. Regardless of how many detectors are connected in parallel, only one flip-flop has to go low to activate (via the WIRED OR circuit) the performance alarm.

IC1 functions in a similar manner.

8:4 Electronic unit block diagram

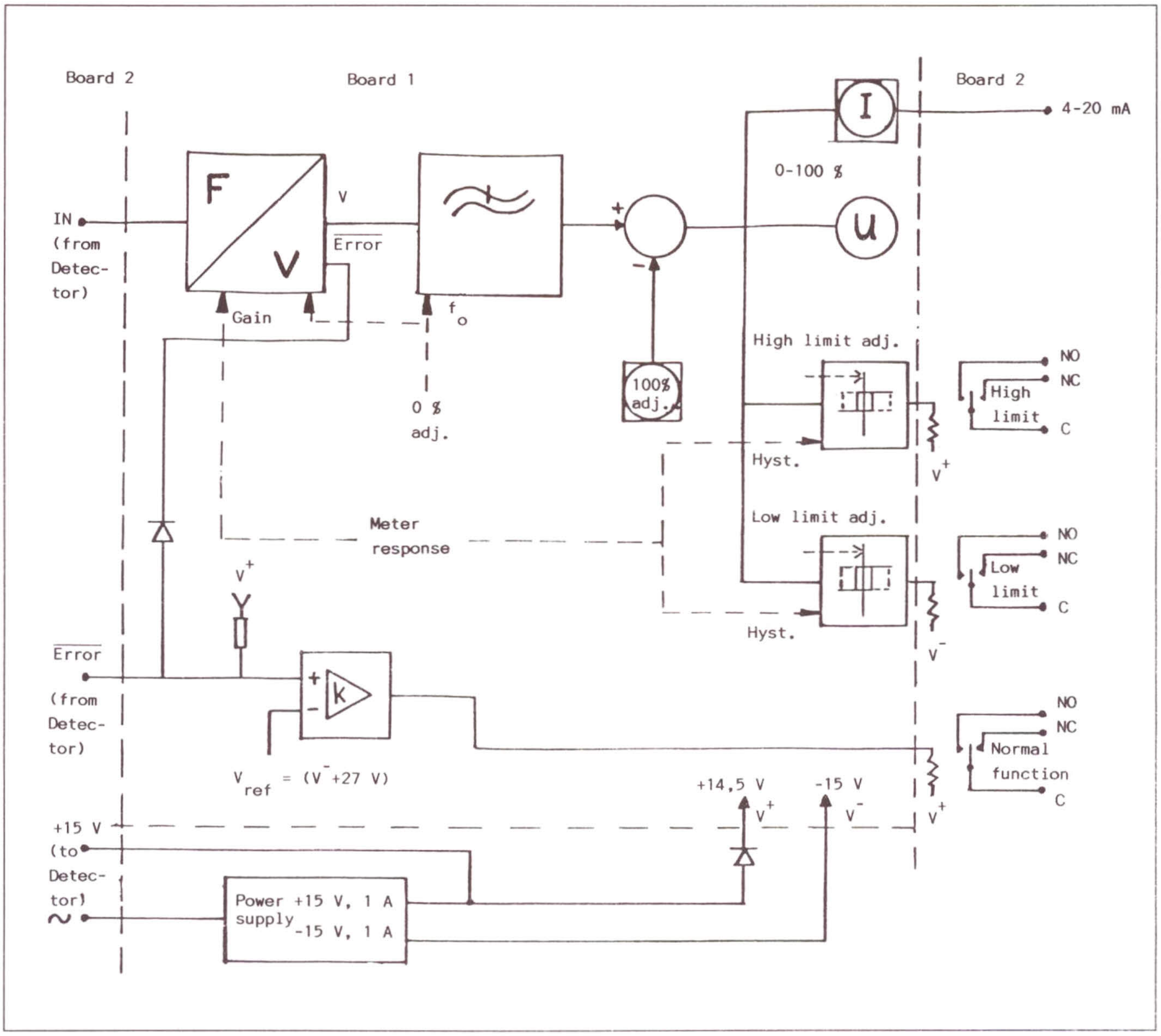


Fig. 29. Schematic circuit diagram.

Operation

Pulses from the connected detectors are sent to a frequency/voltage converter. Its sensitivity is controlled by "0% adjust" and "Meter response". The average frequency of the detector pulses is proportional to the intensity of the radiation, but the time-difference between the pulses is randomly divided (Poisson division). As a result, the F/V converter has high ripple, which is limited by the low-pass (LP) filter that follows. The frequency limit of this filter is adapted to the selected sensitivity (0% adjust). The output voltage from the LP filter is highest when the vessel is empty and lowest when the vessel is full (thus providing maximum attenuation of the radiation).

To obtain a "non-inverted" signal, an offset is thus subtracted from the LP filter's output signal. This offset corresponds to the maximum output voltage of the LP filter. The signal that is obtained then drives the pointer in the instrument, the current output and the Schmitt triggers used for the high-level and low-level alarms.

Performance monitoring is carried out by means of a comparator, and it issues an alarm if "Error" $\leq V^- + 27$ V. Since the Error signal never exceeds V^+, the monitoring system also checks to see that V^+ does not drop below +12 V.

Normally, "Error" is +14V. Consequently, V^- must be $\geqq 12$ V for the comparator to change state.

8:5 Physical description

All of the electronic circuitry is mounted on two circuit boards. All connections proceed via the base board (board 2). This board also contains the relay and linear power supply.

The other electronic circuitry, light-emitting diodes, pointer instrument, trimmer points and front panel are mounted on the panel board (board 2).

Board 1 and board 2 are connected via a 26-conductor flat cable (double wires are used for each signal).

8:6 Board 2 (see diagram 4031 100 42060)

Connections for the mains voltage and relay outputs are made on terminal boards BU202 (threaded terminals). The 4-20 mA current outputs and the detector inputs are on BU201. The line fuse, designated VL1, shall be 160 mA (slow-blow) for 230 V and 315 mA (slow-blow) for 115 V. You can change back and forth between a mains voltage of 115 V and 230 V by means of switch SK201.

The secondary voltage from TR201 is rectified in bridge GR201, and it charges smoothing capacitors C201 and C202 to about +23 V and -23 V respectively. ±15 V and ±0.6 V are obtained after regulators IC201 and IC202 respectively. GR202 is in series with +15 V (sent to board 1) in order to prevent negative transients from reaching board 1. (These negative transients are obtained when the detectors are connected.) The diode voltage drop lowers the voltage to 14.5 V.

Each of relays 201 and 203 has one end of its coil connected to +15 V. Consequently, an inverted signal (-15 V) is needed to pull in a relay (HINV, NFINV). Relay 202 is pulled in by -15 V and a positive signal (L).

8:7 Board 1 (see diagram 4031 100 42030).

Input

The input signal from the detector consists of 10 mA pulses having durations of 10 us. They are obtained via PFM+ and PFM-. Normally, PFM- is connected to 0 V. R383 reduces the effect of cable capacitance and disturbances. The input current drives a light-emitting diode in optocoupler IC101. To increase the optocoupler's speed, it is driven by +5 V via R103 and GR101, and it provides a low output signal of max 0.7 V across R102 and the base of TS101. The collector provides 15 V pulses having a duration of 10 µs (TP5). This triggers the F/V converter (frequency/voltage converter).

F/V converter

Each pulse that arrives at the input (pin 4 on IC102) gives rise to an output pulse having a definite amplitude (approx 14 V) and duration (R x C). The average value of the DC at TP6 is thus proportional to the input frequency x RC, where C is determined by the meter response switch:

When this switch is at the slow position, C = 680 pF. When this switch is at the fast position, C = 2.88 nF. R is controlled by the "0% adj. coarse" switch which cuts in R105 R106, ...R110.

LP filter

The circuit between TP6 and TP7 consists of an active low-pass filter (LP filter) which has a variable frequency limit f_0 and gain G. This filter converts the irregular pulses arriving at TP6 to a fluctuating DC at TP7. To make certain that the ripple is independent of the preset sensitivity, f_0 is affected by both the gain in the V/F converter (0% coarse) and the gain in the LP filter (0% fine).

IC103 functions as an inverter, where:

$$G = \frac{R(0\%\ \text{fine}) + 68.1k}{7.5k} \quad \text{where}$$

$$f_0 = \frac{1}{2\pi\,(R(0\%\ \text{fine}) + 68k)\ C\ (0\%\ \text{coarse})}$$

R113 does not affect the gain since the input (pin 2 on IC103) has high impedance and no current flows through the resistor. However, it protects the input against overcurrents that occur when the drive (supply) voltage is turned off.

Offset

The signal at TP7 is "reversed". When instrument B101 shows 0%, the voltage is about -10 V. At 100%, the voltage (U) is about 0 V. An inverter (pins 8, 9 and 10 on IC104) is used to "unreverse" the signal. It has two additive inputs (R115 and R116) and the gain is 1. A voltage obtained from VR102 (about 8.5-14.5 V) is added to input R115 (-10 V to 0 V for 0 - 100%). This voltage is added across R116. The result is an "unreversed" signal that is sent via TP8 (0 to -10 V for 0 - 100%). If VR102 is set to its minimum resistance, +14.5 V is obtained across R116.

0 to -10 V at TP8 corresponds to an input voltage range at TP7 of −14.5 V. Since trimming to 100% can take place at an input voltage of -4.5 V, a background radiation or residual radiation corresponding to 30% of full deflection (0% at -14.5 V) can be trimmed out.

4–20 mA output

Pins 5, 6 and 7 on IC104 comprise an inverter in which pins 5 and 6 are at 0 V.

$$\text{Gain} = \frac{U(TP9)}{U(TP8)} = \frac{R123}{R120//R121}$$

$$= \frac{2.61k}{10k/4.64k} = 0.317$$

The output (TP9) generates current via R110 and R123. 10 V in (TP8) provides an output current of

$$\frac{10\ V \times 0.317}{215\ ohms//2.61k} = 16.0\ mA$$

0V provides 0.0 mA.

To provide 4-20 mA, an offset current is added via R122 to -15 V, thus providing an output current of:

$$\frac{-15\ V \times 2.61k \times (-1)}{49.9k(215\ ohms//2.61k)} = 3.95\ mA$$

0–10 V at TP8 thus provides an output signal of 3.95-19.95 mA. Here, the deviation from the desired 4-20 mA is low compared with the galvanometer's deviation (class 2.5) and the resistance network's deviation (1%).

High limit indication

Pins 12, 13 and 14 on IC104 form a Schmitt trigger (ST) based on a feedback network. VR103 can be used to vary the working point of the Schmitt trigger between about 60% and 100%.

$$\text{Relative hysteresis} = \frac{R124\ \ (\text{Swing-out})}{R126 + R127\ (\text{Swing-in})}$$

Swing-in is 10 V

Swing-out is $V^+ - V^- - 2\ V = 27\ V$

R 127 can be short-circuited by means of SK101 when the system is in the fast mode.

When SK101 is open, the hysteresis is:

$$\frac{10k \times 27\ V}{430k \times 10\ V} \times 100\ \% = 6.3\ \%$$

When SK101 is closed, the hysteresis is: 12.6%.

The ST input signal (TP8) is 0 V at 0% and -10 V at 100% of full-scale deflection. The ST output (pin 14 on IC104) normally provides -13.5 V. After changeover to the high level, it provides -13.5 V, whereupon the emitter on TS103 goes to 12.8 V. Re102 is pulled in via light-emitting diode GR107.

Low limit indication

Pins 1, 2 and 3 on IC104 form a Schmitt trigger (ST) that is used for the low limit. VR104 can be used to vary the working point between about 20% and 40%.

$$\text{Relative hysteresis} = \frac{R129\ \ (\text{Swing-out})}{R131+R132\ (\text{Swing-in})}$$

With SK101 open (slow) the hysteresis is:

$$\frac{28.7k \times 27\ V}{766k \times 10\ V} \times 100\ \% = 10.1\ \%$$

With SK101 closed (fast) the hysteresis is: 20.2%.

The ST input signal is the same as that described in under "High limit“ , while the output signal is normally -13.5 V and, after changeover to the low level, +13.5 V. The emitter on TS 104 then goes to +12.8 V and Re202 is pulled in via light-emitting diode GR108.

Error indications

The Error signal (TP15) normally has a potential of $V\text{-}+V(GR103)+V_{BE}(TS105) = -15\ V + 24\ V + 0.7V = 9.7V$. Normally, a current of 0.6 mA is driven through R134, GR103 and the base of TS105. TS105 has ß = 100. When the transistor is operating under saturated conditions, the collector current is = 25 mA. Consequently 0.25 mA is sufficient to cause the transistor to enter the saturated state. During normal operation, Re203 is pulled in via light-emitting diode GR109 and TS105.

All Error outputs in the detector and electronic unit are normally at +14.5 V, but this does not increase the potential at TP15 since every output is provided with serial-diode blocking (see GR102). When any Error output drops beneath 9.0 V, it begins to draw current via the serial diode, whereupon GR103 is shunted out, TS105 is cut off, light-emitting diode GR109 goes out and Re203 drops out.

9. FAULT TRACING

9:1 General

Level monitor Q 4700 is designed and constructed to meet very stringent quality requirements. Both the detectors and the electronic unit are provided with performance monitoring circuits that ensure highly reliable operation and facilitate fault tracing.

9:2 Simple fault tracing

A. If the electronic unit is "dead", check fuse VL201.

B. If the green "normal function" indicator lamp has gone out and its relay has dropped out, replace the detector or detectors one at a time until the green indicator lamp is lighted again.

C. If the equipment does not respond to level changes, use a radiation monitor to check whether radiation from the source unit is striking the detector.

9:3 Complete fault tracing

If a fault cannot be found using the simple fault tracing measures set forth above, you can carry out more detailed fault tracing using two flowcharts. The diagram in Fig. 30 is for faults that cause the green "normal function" indicator lamp to go out and its relay to drop out. The diagram in Fig. 31 is used in situations where the green "normal function" indicator lamp remains lighted but the equipment still does not function properly.

In most cases, the panel indications suffice for fault tracing. However, it will sometimes be necessary to remove the panel in order to access the testpoints on the underlying circuit board.

See separate drawings showing the locations of the testpoints on panel board Q 4700/1 and base board Q 4700/2.

The detectors never have to be opened in order to trace faults in the system.

9:4 Remedying a fault

The fastest and easiest way to remedy a fault is to replace the faulty unit.

The user can easily repair base board Q 4700/2 by following the instructions set forth in section 8:6 (circuitry description).

There is also a circuit description for panel board Q 4700/1 and detectors Q 4700/5 and Q 4700/9, but repairing these units is more difficult, and we thus recommend that they be sent to the Philips service centre.

Fault tracing, Q4700
- active performance alarm

Green lamp "Normal Function" NOT lighted

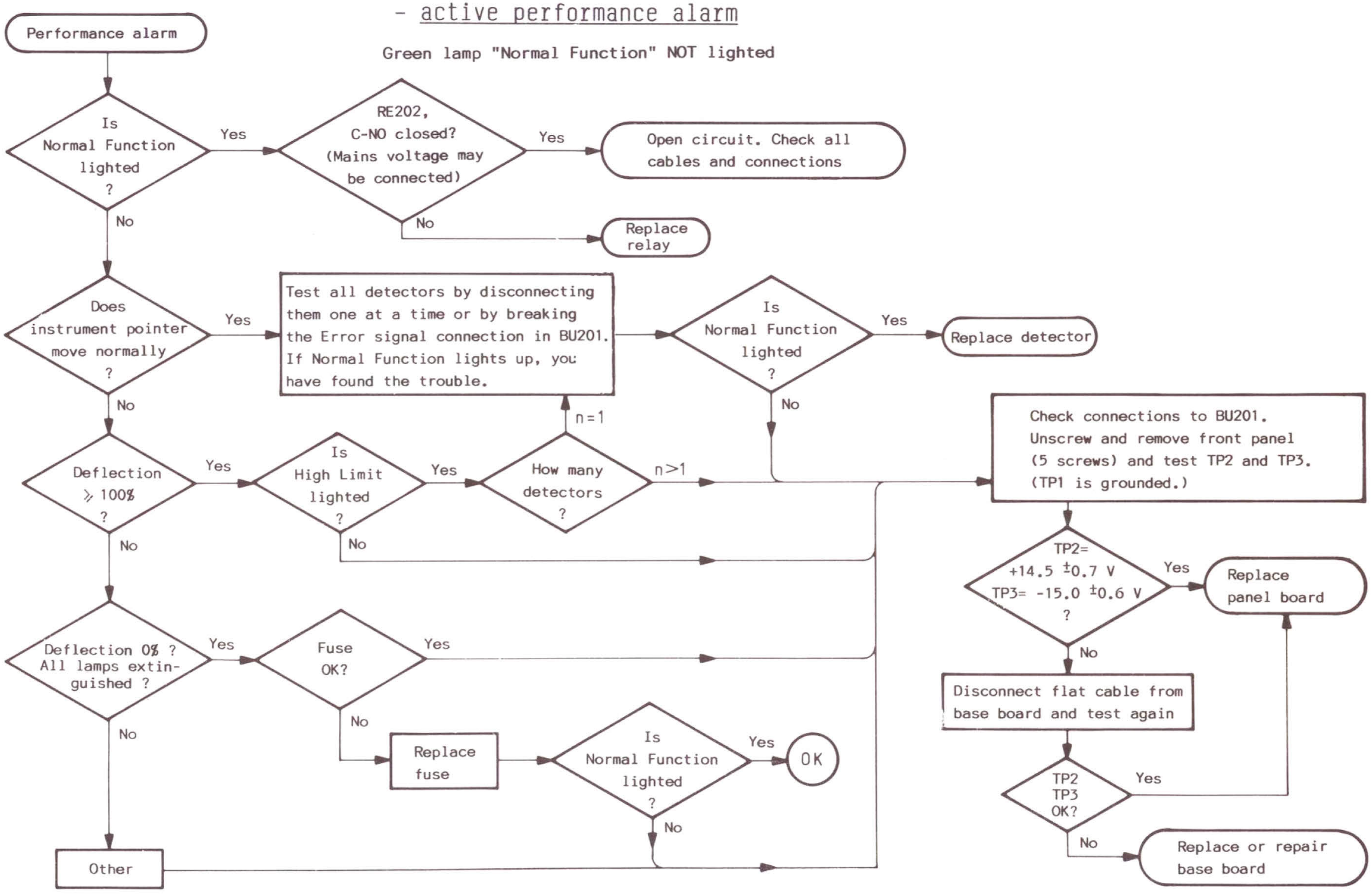


Fig. 30. Fault tracing diagram. Active performance alarm.

Fault tracing, Q4700 - inactive performance alarm

Green lamp "Normal Function" lighted

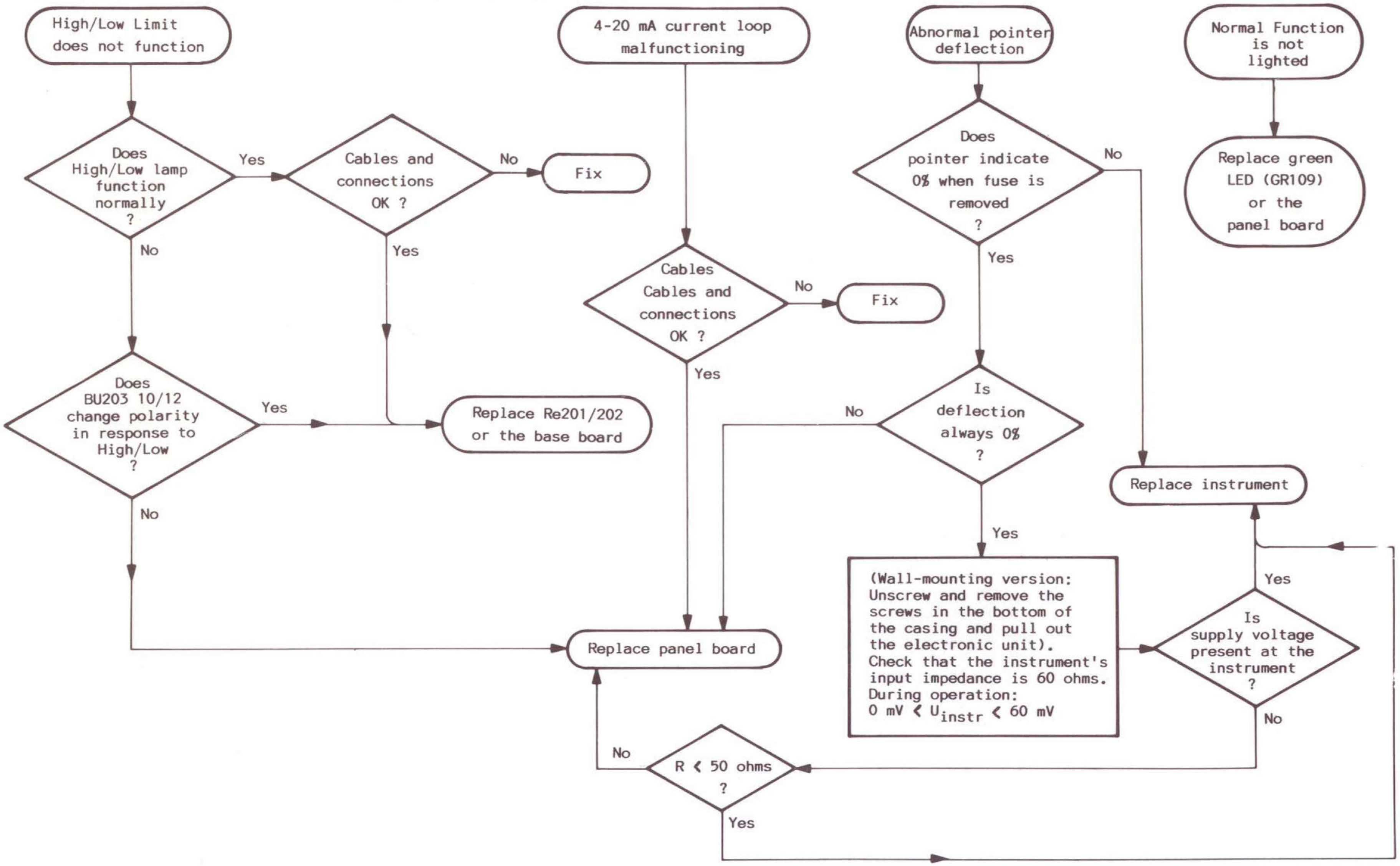


Fig. 31. Fault tracing diagram. Inactive performance alarm.

9:5 Replacing panel board 4700/1

Wall-mounting version:

- Unscrew and remove the five countersunk retainer screws that hold the panel and lift it off.
- Unscrew and remove the two upper screws in the bottom frame and pivot out the entire electronic unit somewhat.
- Disconnect the flat cable connector from the base board and pull the panel board out and up.
- When you replace a panel board, it is important to lower it into the slots in the side panels. Then continue by performing the above steps in reverse sequence.

Rack-mounting version:

- Loosen the electronic unit from the rack and pull the entire unit out somewhat.
- Unscrew and remove the five countersunk retainer screws that hold the panel and lift off the panel.
- Disconnect the flat cable connector from the base board and pull the panel board out and up.

When you replace a panel board, it is important to lower it into the slots in the side panels. Then continue by performing the above steps in reverse sequence.

9:6 Replacing base board Q 4700/2

Wall-mounting version:

- Check to see that no external voltages are applied to the unit.
- Disconnect all cables that are connected to terminal boards BU201 and BU202. Also disconnect the separate ground line that runs from the base board and is connected to the casing.
- Dismount the panel board as instructed in section 9:5.
- Unscrew and remove the two upper screws in the bottom frame if they are not already removed. Pivot out and unhook the base board together with the bottom frame.
- Unscrew and remove the seven Philips (cross-slotted) screws from the long sides of the base board and lift out the board.

To reassemble, perform the above steps in reverse sequence.

Rack-mounting version:

- Check to see that no external voltages are applied to the unit.
- Disconnect all cables that are connected to terminal boards BU201 and BU202. Also disconnect the separate ground line running from the base board that is connected to the chassis.
- Pull the entire unit out of the rack and disconnect the flat cable connector.
- Unscrew and remove the seven Philips (cross-slotted) screws from the long sides of the base board and lift out the board.

To reassemble, perform the above steps in reverse sequence.

10. ABCs OF RADIOACTIVITY

All material is composed of atoms which, in turn, consist of a nucleus containing a number of positively charged protons. The nucleus is surrounded by a cloud of negatively charged electrons, equal in number to the protons. The number of protons (or electrons) is referred to as the atomic number of the material. Each element has a different atomic number, and they range from 1 for hydrogen to 92 for uranium.

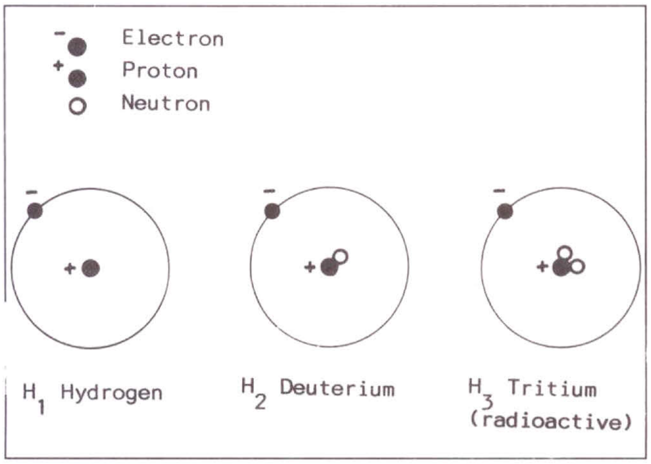


Fig. 32. Isotopes of hydrogen

The nucleus also contains a varying number of neutrons. Each neutron number corresponds to an isotope of the element in question. Some of these isotopes are unstable and undergo disintegration, accompanied by the emission of radioactive radiation.

Radioactive material is composed of atoms which disintegrate spontaneously and emit radiation regardless of their environment. The radiation may be of three kinds: alpha, beta and gamma. The first two kinds consist of particles. Alpha rays consist of positively charged helium nuclei, and beta rays consist of positive or negative electrons. Gamma rays, which often occur together with the other two kinds, are electromagnetic waves of short wavelength and of the same nature as X-rays. Gamma radiation possesses great penetrative power.

The number of radioactive disintegrations per unit of time in a given amount of radioactive matter is measured in Becquerel (Bq). One Bq corresponds to one disintegration per second. Previously, this was measured in Curies (C). Each atom in the radiation source disintegrates only once, so that the activity decays (diminishes) with time. The time required to reduce the radioactivity of a material to one-half is referred to as the half-life. Any given source of radioactivity thus has a specific half-life.

The half-life of radioisotopes varies from a fraction of a second up to millions of years.

Another property of isotopes is the energy with which the radioactive radiation is emitted.

The energy of nuclear radiation is expressed in electron-volts, this unit being defined as the energy which one electron gains or loses on passing across a potential difference of 1 V. It is equivalent to only 3.6×10^{-12} Watt-seconds.

Normally, a larger unit is used, namely the MeV (one million electron-volts).

The greater the energy of the radiation, the more penetrative power it has.

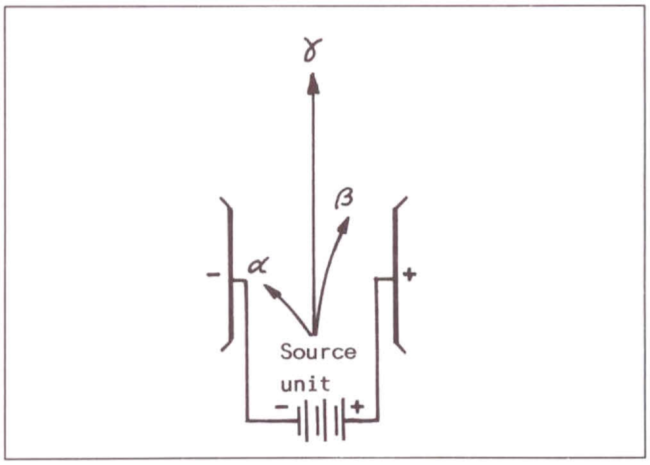


Fig. 33. Deflection of alpha, beta and gamma rays in an electric field.

The alpha and beta rays, both of which consist of particles, have a range in air of several centimetres and several metres respectively. However, such rays are completely absorbed by an aluminium sheet that is a few millimetres thick (for example). Gamma rays, on the other hand, have a considerably greater range and can penetrate even very thick steel walls.

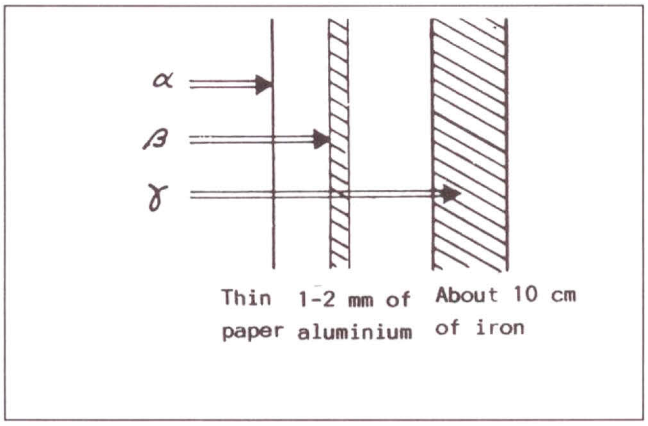


Fig. 34. Absorbtion of alpha, beta and gamma rays.

An element that is normally inactive, such as cobalt, can be made radioactive by neutron bombardment in a reactor. Certain materials undergo fission in a reactor, whereby one heavy element is transmuted into two light elements. Different kinds of isotopes, such as cesium 137, are obtained from these fission products. Cobalt (Co-60) and cesium (Cs-137) are the radioactive sources most commonly used in level indicating equipment. When radioactive rays pass through a material, it is ionized to some extent.

Here, electrons are separated from the atoms. It is possible to measure the dose rate, i.e. the amount of ionizing radiation absorbed in an irradiated substance. The unit used to measure an absorbed dose is the Grey (Gy).

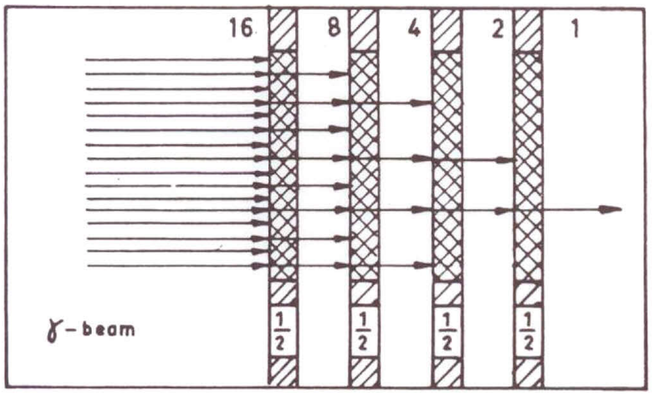


Fig. 35. The absorbtion of gamma rays is exponential

Gamma radiation is measured in Sieverts (Sv). A Sievert is a radiation dose measured in Gy multiplied by a special quality factor to obtain the equivalent dose in Sieverts.

The intensity of radiation, also called the dose rate, is measured in Sieverts per hour (Sv/h) or microsieverts hour (μSv/h). Previously, it was measured in Röntgens per hour (R/h).

1 mR/h = 10 μSv/h.
Radiation intensity varies with the distance from the radioactive substance and also depends upon the activity and energy of the emitted radiation.

Note that the dose rate varies inversely with the square of the distance from the source. Doubling the distance will thus reduce the dose rate to a quarter of its original value.

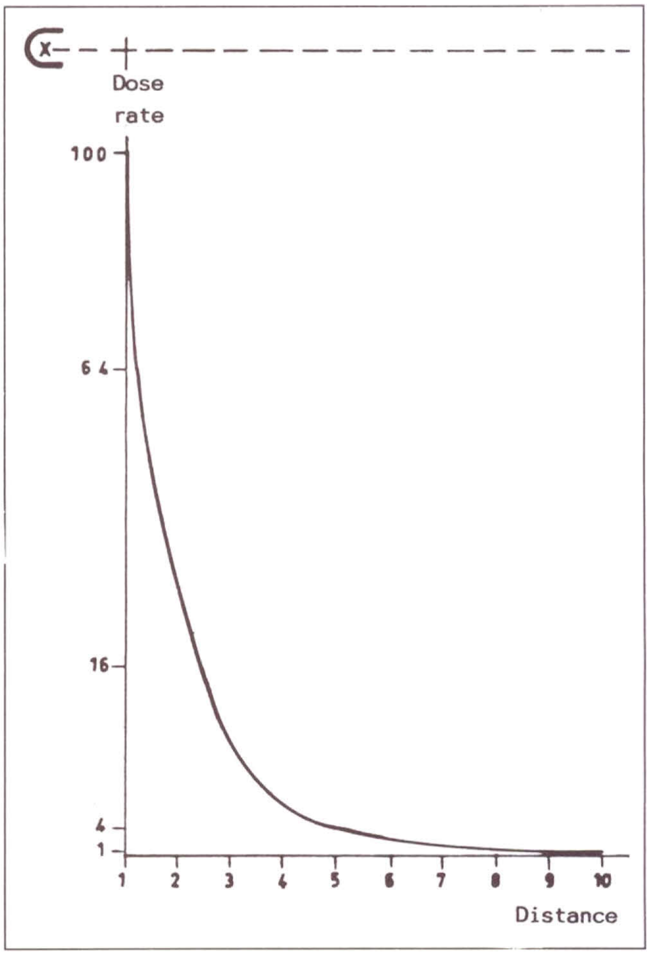


Fig. 36. The dose rate varies inversely as the square of the distance

The first table overleaf shows the dose rate at various distances from an unshielded radioactive source. The dose rate is expressed in both new and old units.

New units:					
Distance from source	10cm	1m	2m	5m	10m
μSv/h from 40 MBq Co^{60}	1350	13.5	3.4	0.54	0.14
μSv/h from 40 MBq Cs^{137}	350	3.5	0.9	0.14	0.04
Old units:					
Distance from source	10cm	1m	2m	5m	10m
mR/h from 1 mC Co^{60}	135	1.35	0.34	0.054	0.0135
mR/h from 1 mC Cs^{137}	35	0.35	0.09	0.014	0.0035

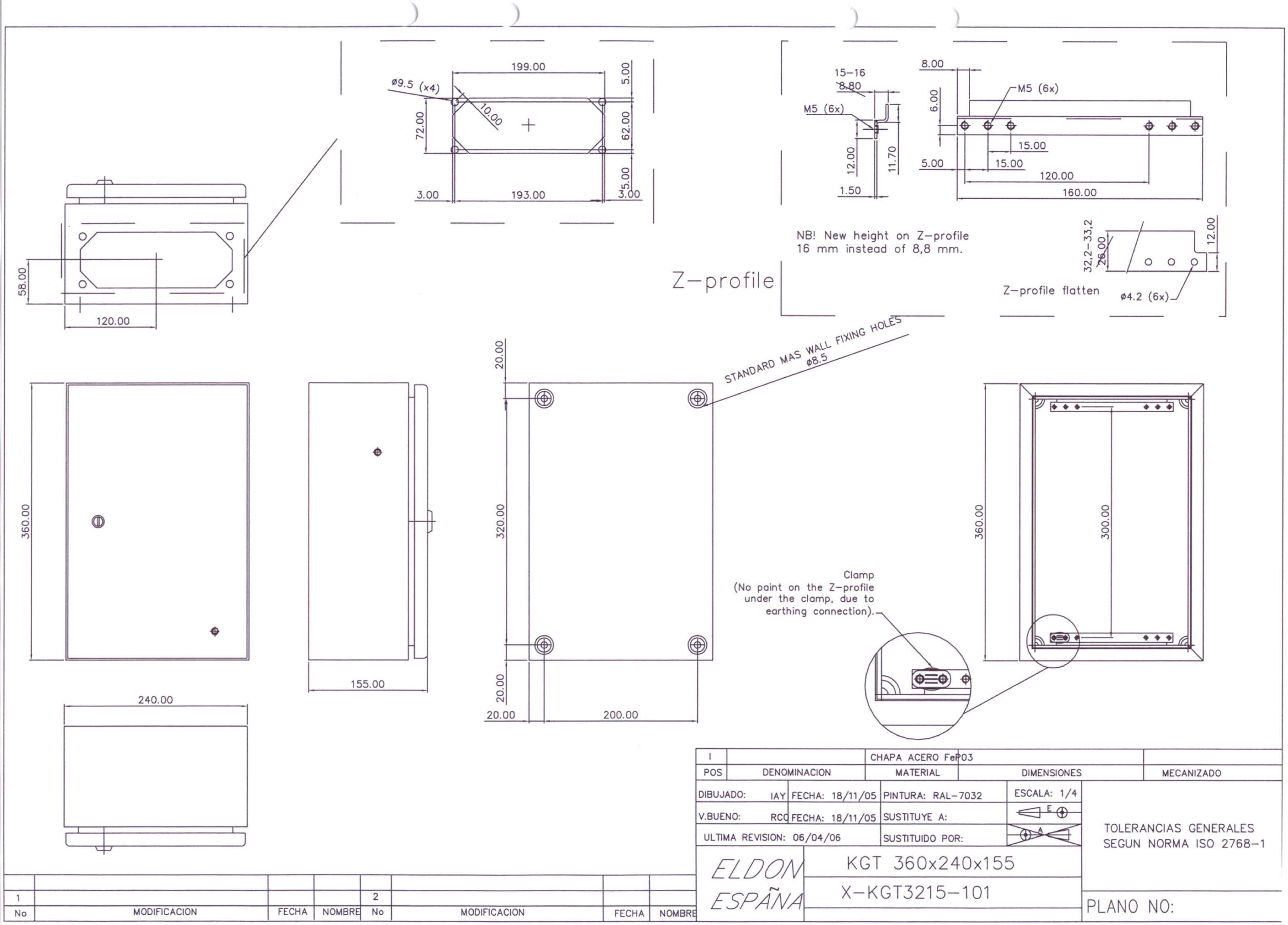
It is clear from the above tables that the intensity is very great at points near the surface of a source. As a general rule, it is necessary to shield the source with a material that is capable of absorbing most of the radiation. Among the available materials, lead is the most serviceable. Since it has a high specific gravity, it is easy to work with. Moreover it is inexpensive.

The tables shown below present the shielding capacity of three materials. The absorption is an exponential function, so that two half-value layers will reduce the dose rate to a quarter, etc. The tables show the thicknesses in mm of the half-value and tenth-value layers for some common shielding materials.

Source	Shielding thickness in mm					
	Lead S=11.6		Iron S=7.8		Concrete S=2.4	
	1/2	1/10	1/2	1/10	1/2	1/10
Co^{60}	12	41	22	74	60	230
Cs^{137}	6.5	21	17	57	53	180

S = density in kg/dm^3 or g/cm^3.

11. DIMENSION DRAWINGS



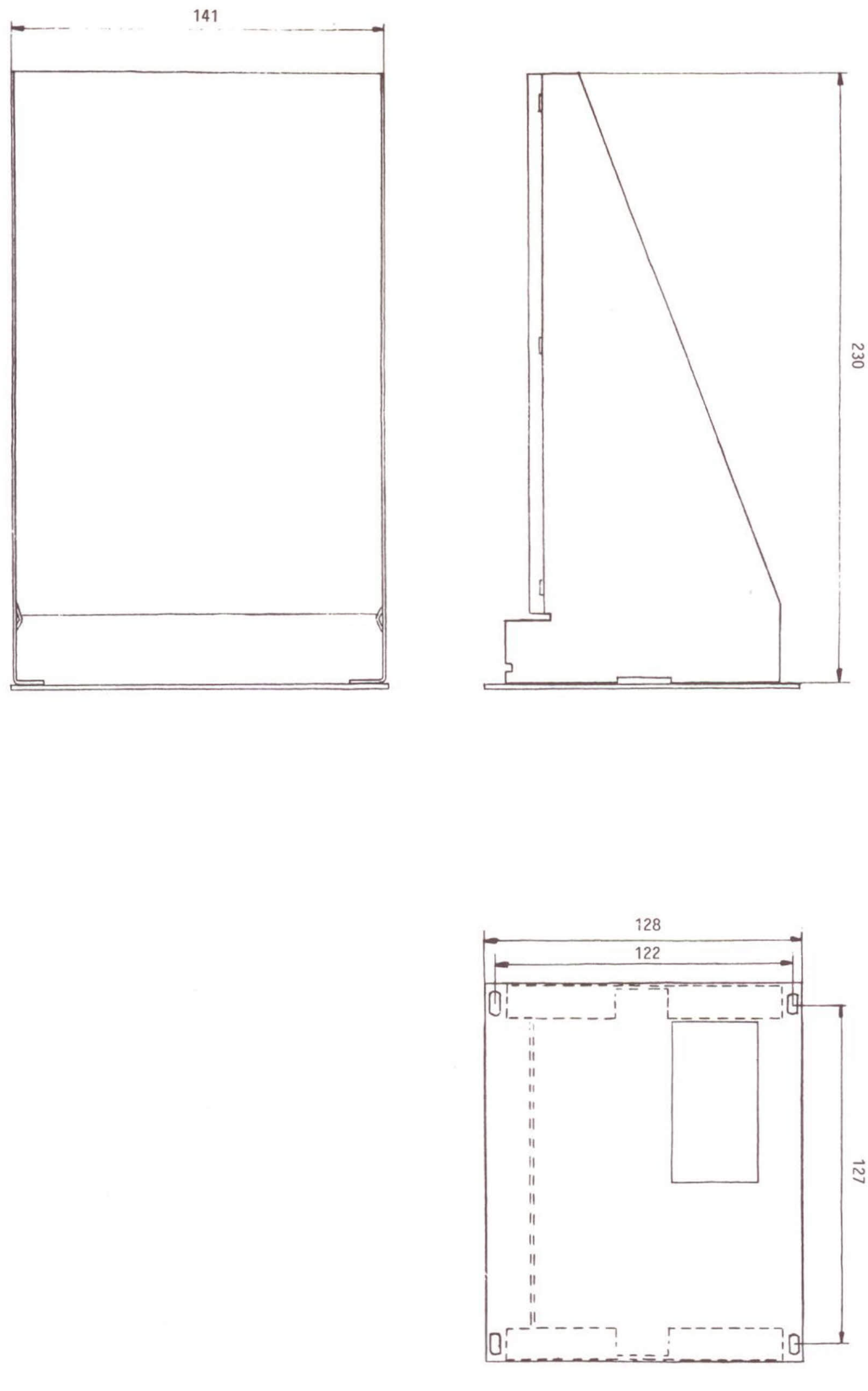


Fig. 38. Q 4700/4 sheet metal casing for rack-mounting electronic unit.

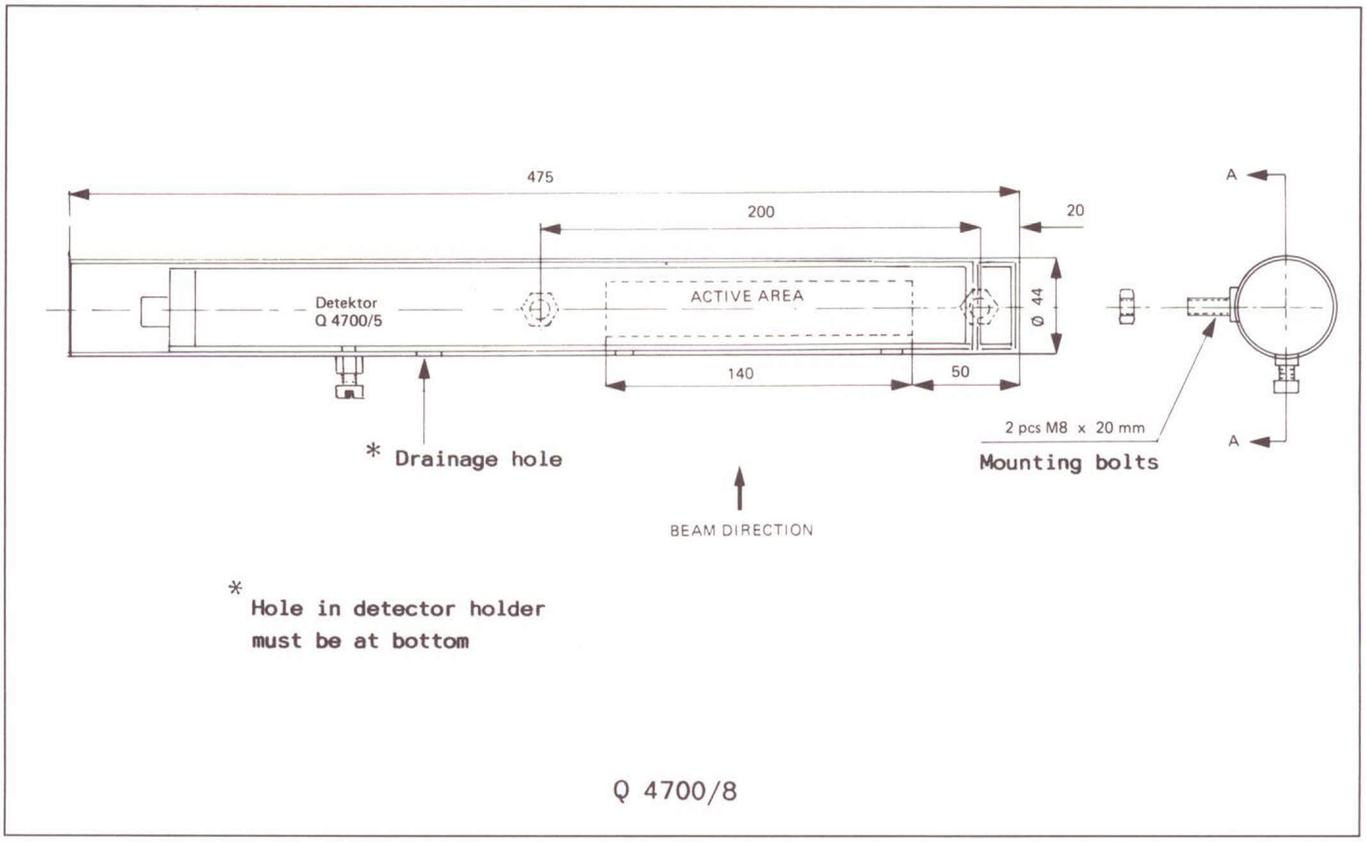


Fig. 39. Detector holder, short version.

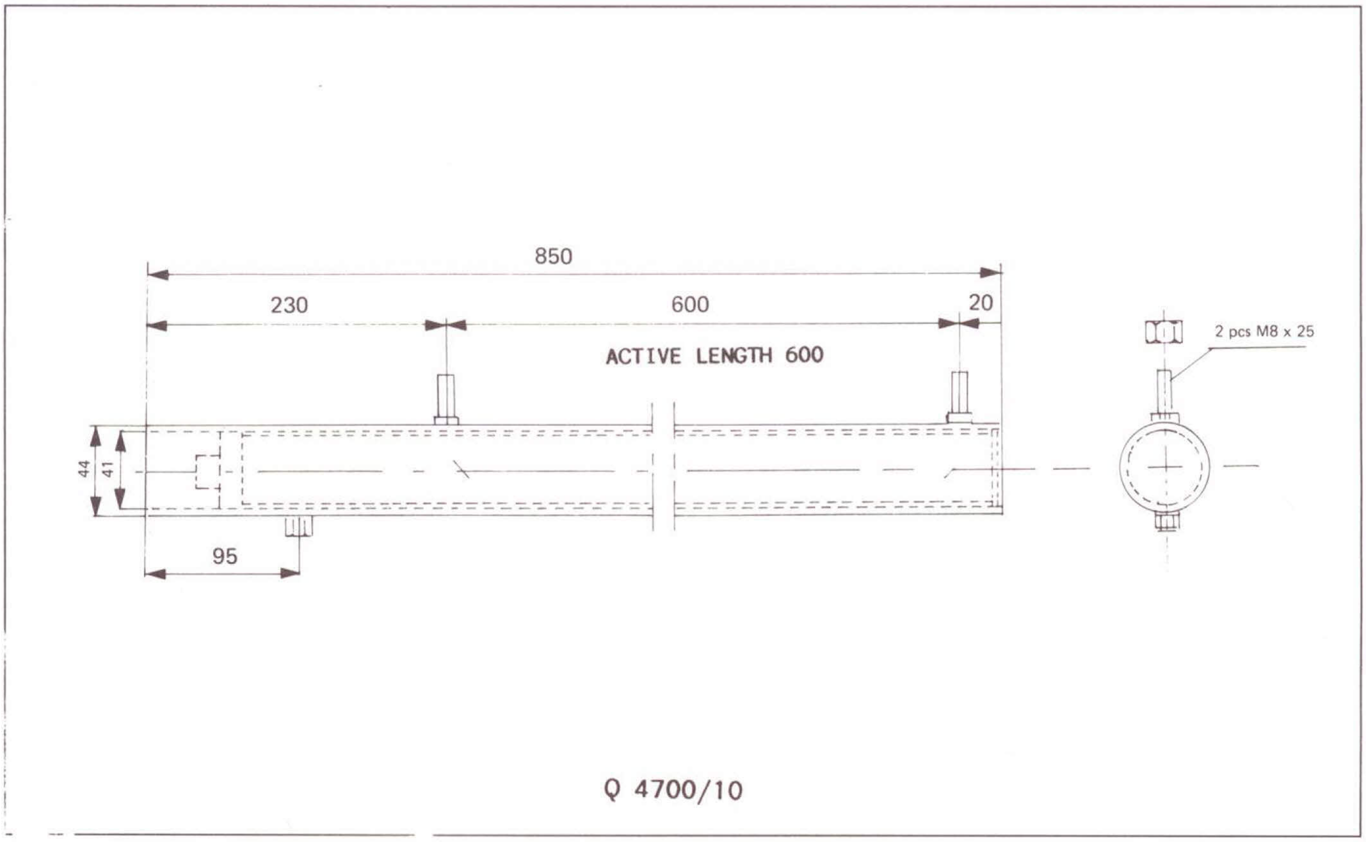


Fig. 40. Detector holder, long version.

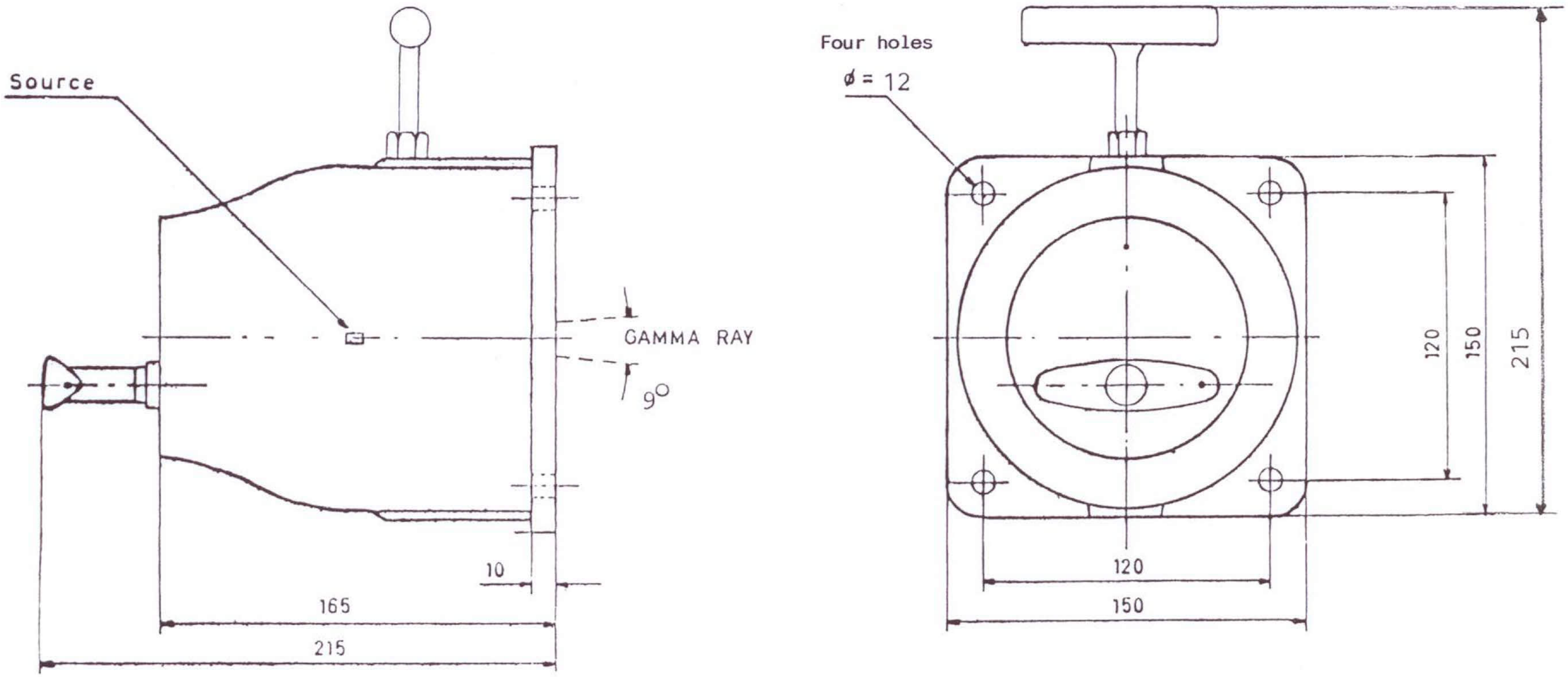
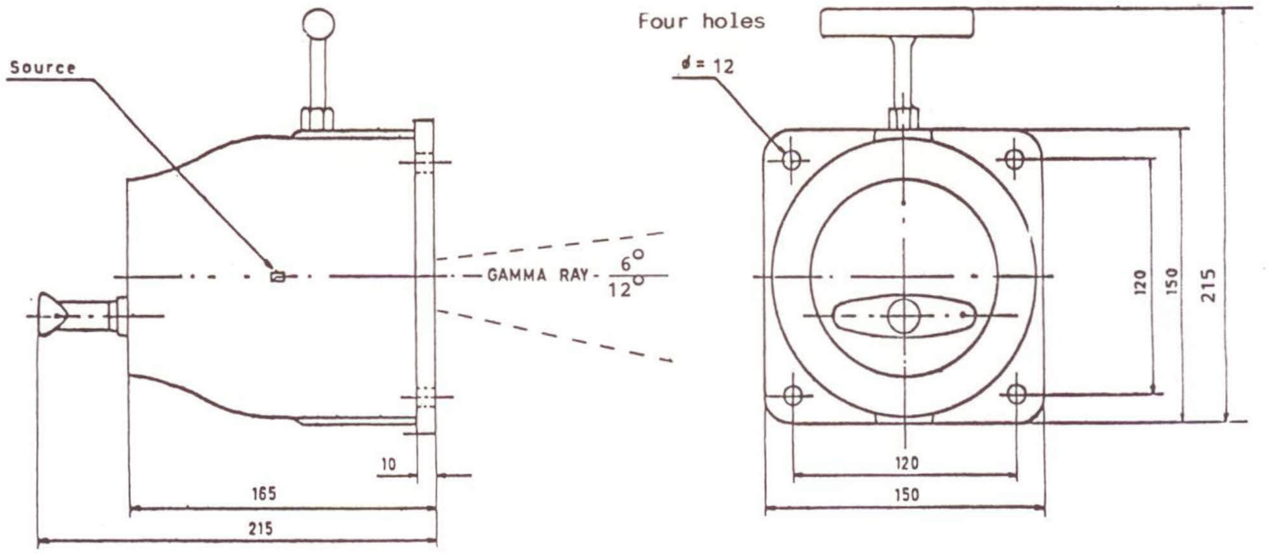
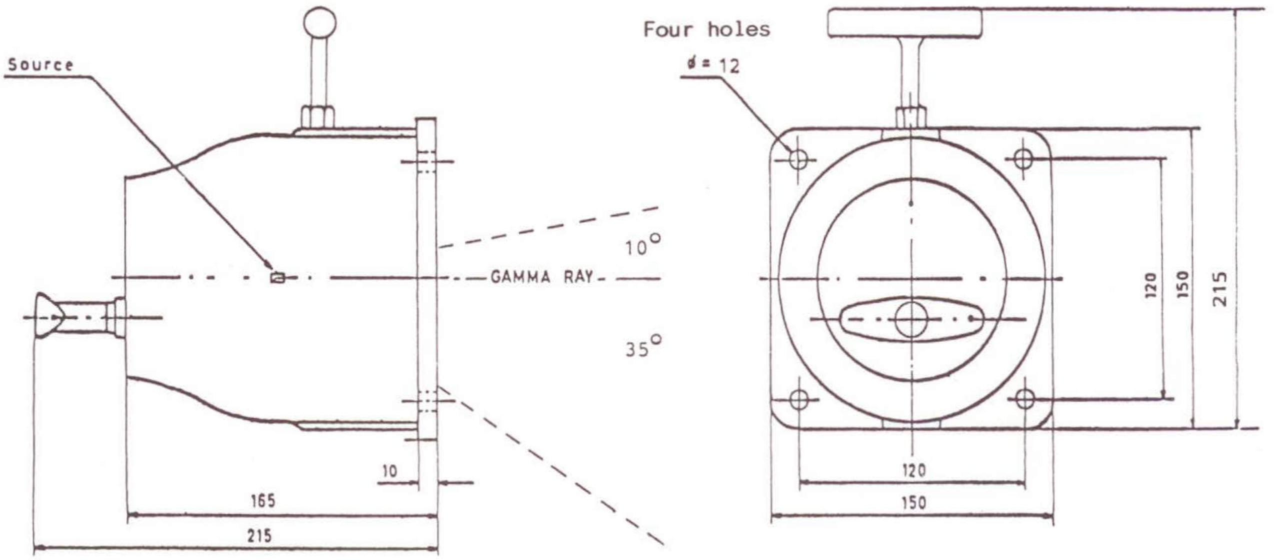


Fig. 41. Radiation source unit Q 4582B.

NOTE! The ON/OFF handle is shown at the OFF position.
It is ON when the green dots correspond.

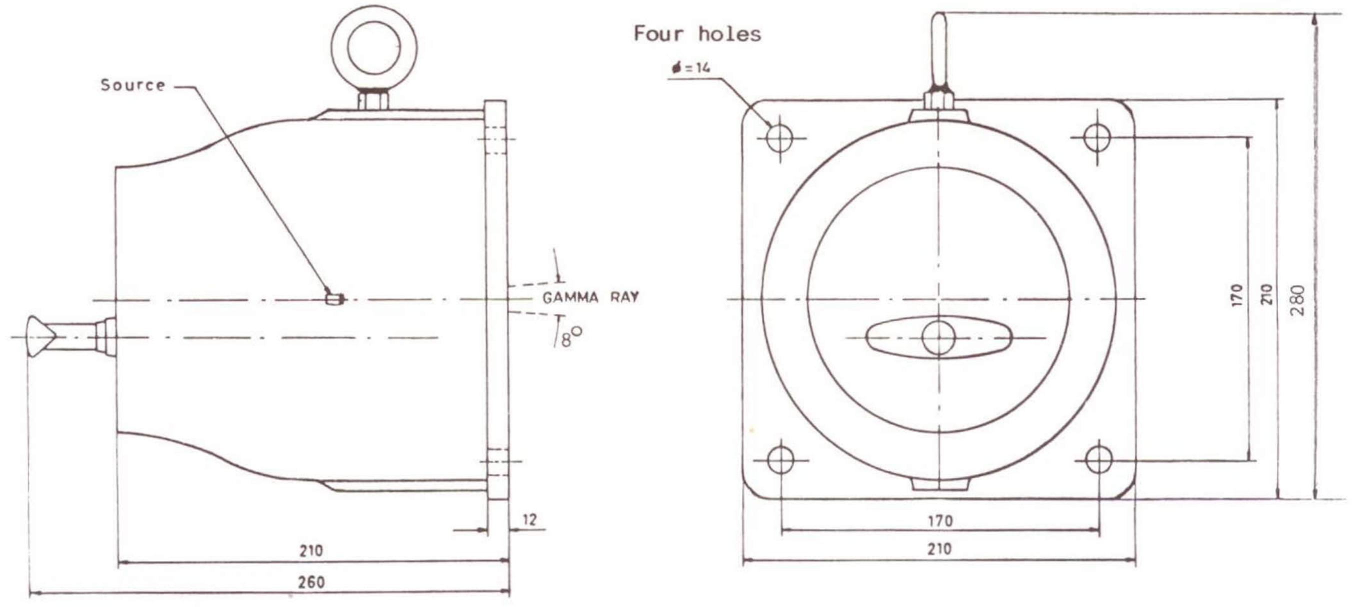


NOTE! The ON/OFF handle is shown at the OFF position.
It is ON when the green dots correspond.

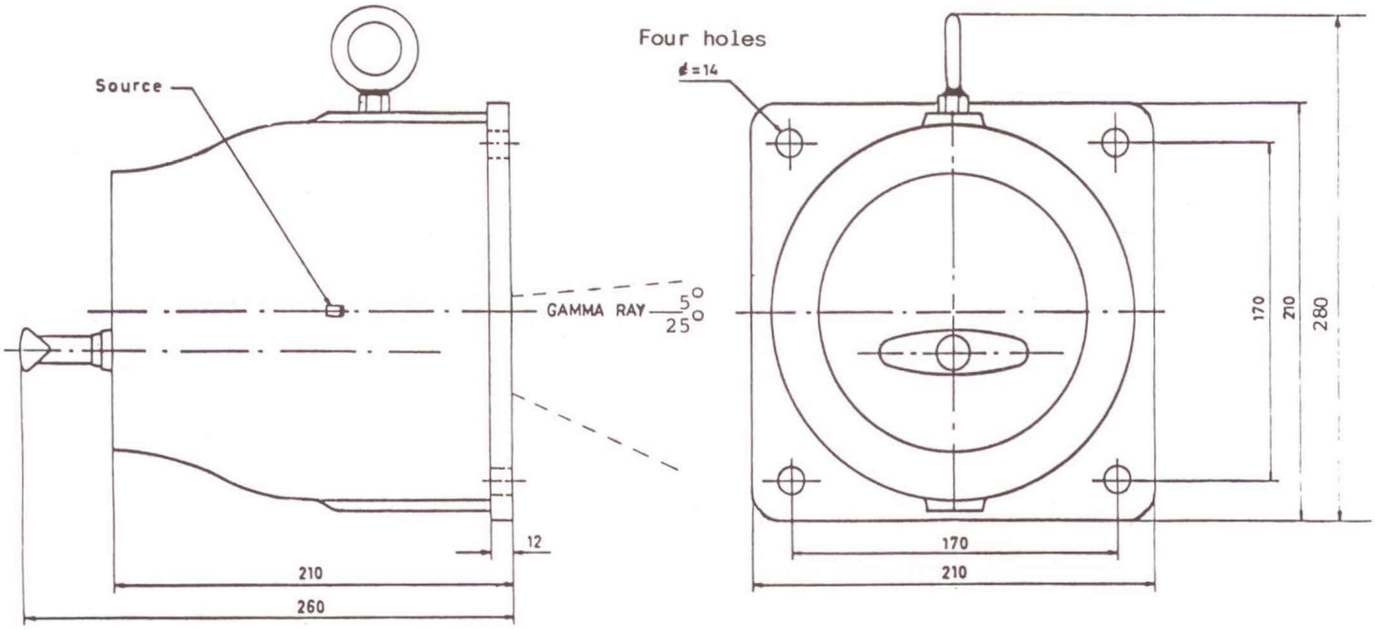


NOTE! The ON/OFF handle is shown at the OFF position.
It is ON when the green dots correspond.

Fig. 42. Radiation source units Q 4621 (at top) and Q 4621S.

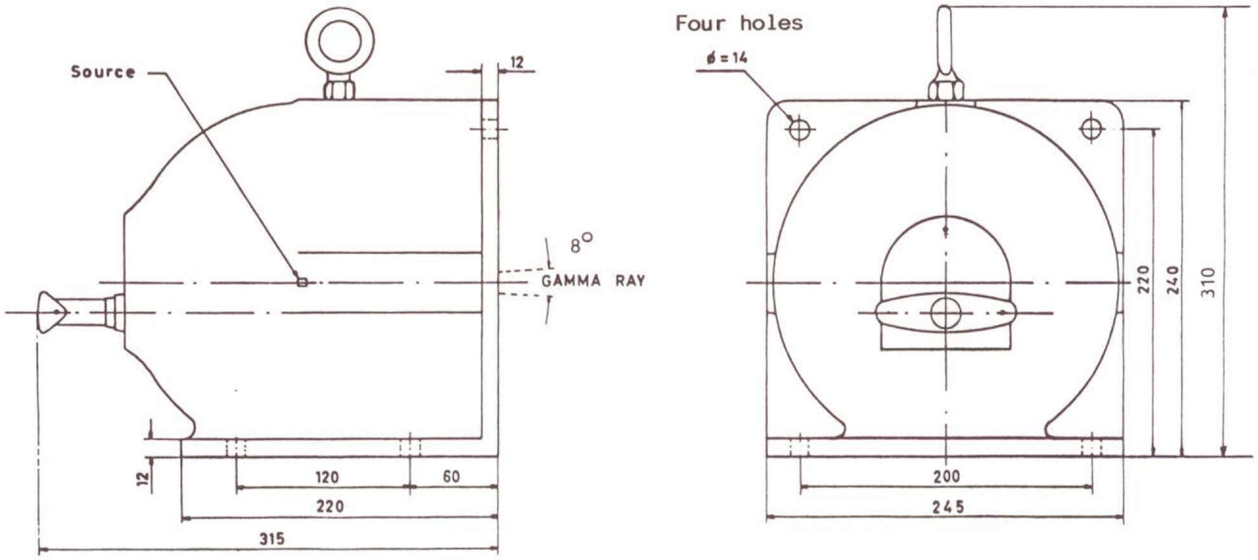


NOTE! The ON/OFF handle is shown at the OFF position.
It is ON when the green dots correspond.

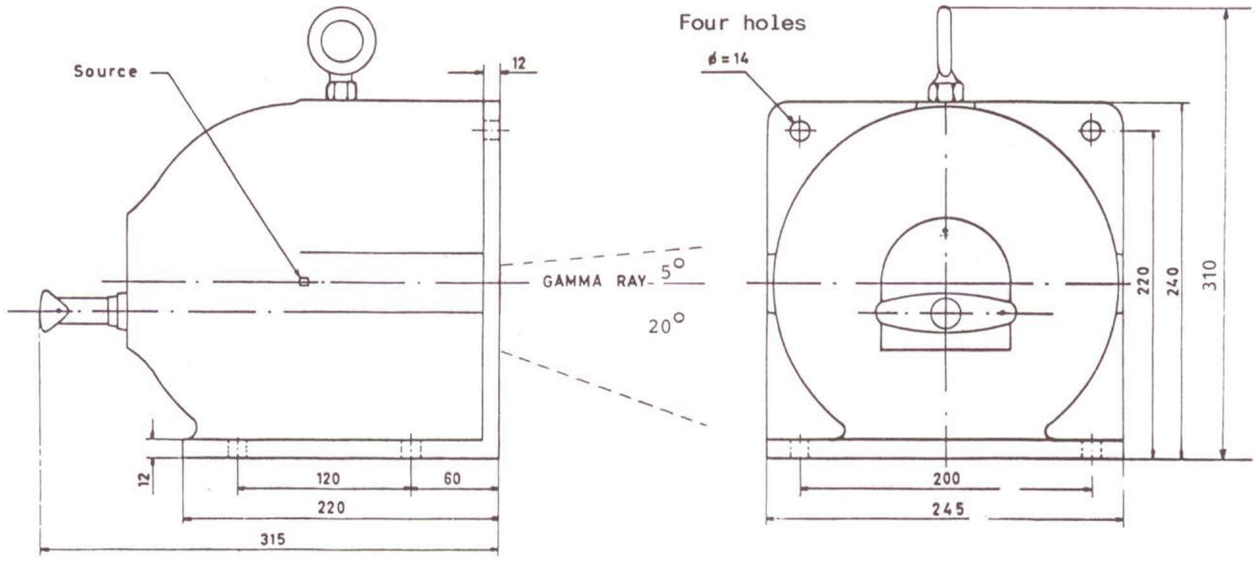


NOTE! The ON/OFF handle is shown at the OFF position.
It is ON when the green dots correspond.

Fig. 43. Radiation source units Q 4583 (at top) and Q 4583S.

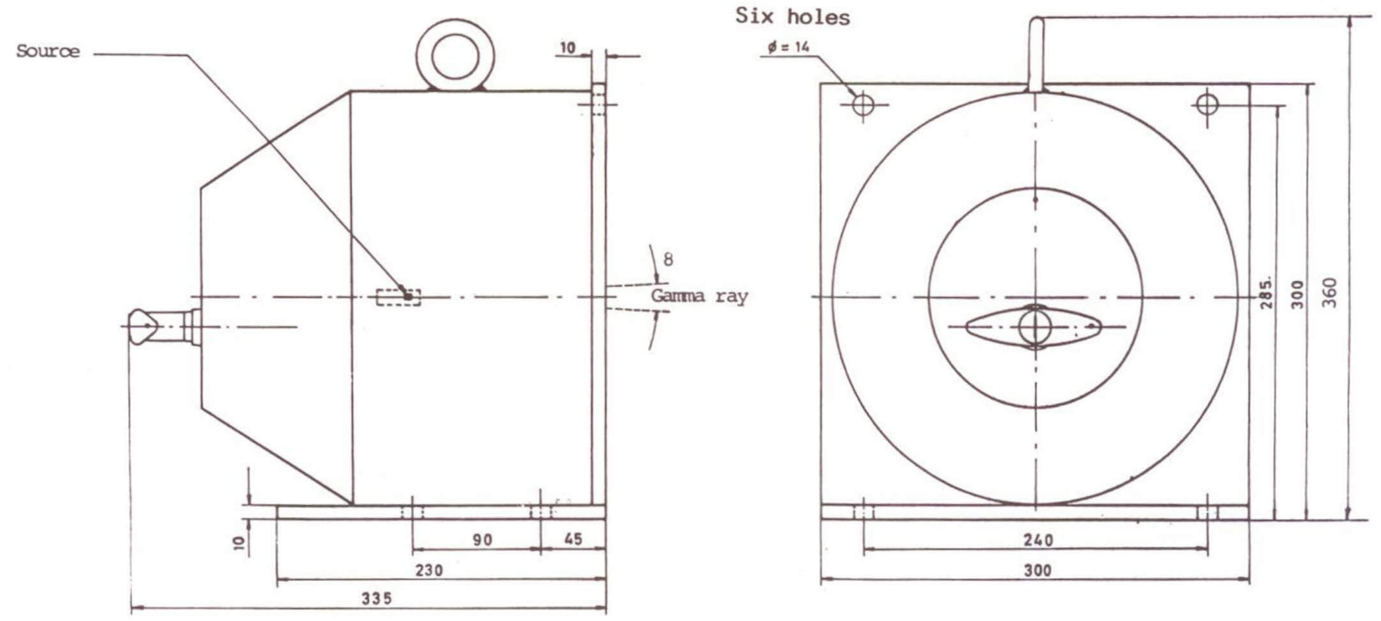


NOTE! The ON/OFF handle is shown at the OFF position.
It is ON when the green dots correspond.

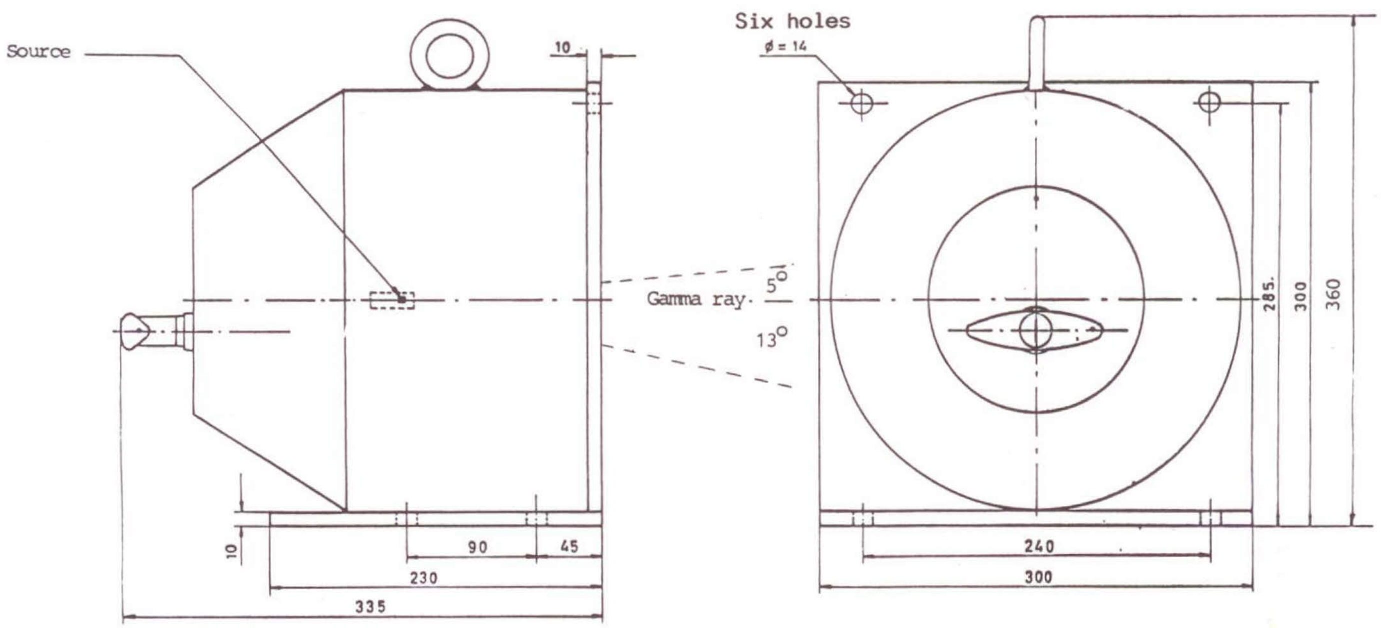


NOTE! The ON/OFF handle is shown at the OFF position.
It is ON when the green dots correspond.

Fig. 44. Radiation source units Q 4584 (at top) and Q 4584S.



NOTE! The ON/OFF handle is shown at the OFF position.
It is ON when the green dots correspond.



NOTE! The ON/OFF handle is shown at the OFF position.
It is ON when the green dots correspond.

Fig. 45. Radiation source units Q 4610 (at top) and Q 4610S.

12. COMPONENTS LIST

Panel board Q 4700/1

Item	*Description*	*Catalogue Number*
	Resistors (1% 0.4 W MR 25)	
R 101	383 ohms	2322 151 53831
R 102	681 ohms	2322 151 56811
R 103, 104	1 kohm	2322 151 51002
R 105	1 Mohm	2322 151 51005
R 106	562 kohms	2322 151 55624
R 107	383 kohms	2322 151 53834
R 108	90.9 kohms	2322 151 59093
R 109	21.5 kohms	2322 151 52153
R 110	5.11 kohms	2322 151 55112
R 111	1 Mohm	2322 151 51005
R 112	7.50 kohms	2322 151 57502
R 113	2.61 kohms	2322 151 52612
R 114	68.1 kohms	2322 151 56813
R 115	28.7 kohms	2322 151 52873
R 116, 117	28.7 kohms	2322 151 52873
R 118	10 kohms	2322 151 51003
R 119	215 kohms	2322 151 52151
R 120	46.4 kohms	2322 151 54643
R 121	10 kohms	2322 151 51003
R 122	5.11 kohms	2322 151 55112
R 123	2.61 kohms	2322 151 52612
R 124	10 kohms	2322 151 51003
R 125	2.7 kohms	2322 151 52373
R 126, 127	215 kohms	2322 151 52154
R 128	14.7 kohms	2322 151 51473
R 129	28.7 kohms	2322 151 52873
R 130	21.5 kohms	2322 151 52153
R 131, 132	383 kohms	2322 151 53834
R 133	110 kohms	2322 151 51104
R 134	7.5 kohms	2322 151 57502
R 135	215 ohms	2322 151 1473
	Trimmer pot (10% 0.5W)	
VR 101	500 kohms	2122 362 00735
VR 102, 103, 104	20 kohms	2122 362 00147
	Capacitors	
C 101 Folie	2,20 nF 2,5%	2012 326 10024
C 102 Folie	680 pF 1%	2222 431 86801
C 103 Elyt	10 µF 16V	2222 122 25109
C 104 Elyt	10 µF 16V	2222 122 25109
C 105 Elyt	10 µF 16 V	2222 122 25109
C 106 Keramik	33 pF 2%	2222 679 10339
C 107 Elyt	100 µF 25V	2222 108 36101
C 108 Elyt	33 µF 63V	2222 108 38339
C 109 Elyt	10 µF 16V	2222 122 25109
C 110 Elyt	2,2 µF 25V	2222 122 26228
C 111 Elyt	1 µF 40V	2222 122 27108

Item	Description	Catalogue Number
	Diodes	
GR 101 Zener	BZX79/C5V1	9331 177 20701
GR 102	BAW62/75	9331 012 20701
GR 103 Zener	BZX79/C24	9331 178 80701
GR 104	BAW62/75	9331 012 20701
GR 105	BAW62/75	9331 012 20701
GR 106	BAW62/75	9331 012 20701
GR 107	Red LED	4031 116 31950
GR 108	Red LED	4031 116 31950
GR 109	Green LED	4031 105 70880
	Transistors and ICs	
TS 101, 102	BC 337	9331 492 00701
TS 103	BC 327	9331 491 80701
TS 104, 105	BC 337	9331 492 00701
IC 101 Optocoupler	CNY 17 II	9334 311 80701
IC 102 CMOS	Hef 4538 BP	9335 079 50701
IC 103 OP.	LM 301 AN	9331 923 20701
IC 104 OP.	LM 324 N QUAD.	9334 405 50701
	Other	
BU 101	Flat cable	4031 100 42190
SK 101	Sliding switch	2422 126 01278
SK 102	Rotary switch	2419 130 00058
B 101	Pointer instrument	4031 100 42170

Baseboard 4700/2

Item	Description	Catalogue Number
	Capacitors	
C 201 Electrolytic	2200 uF 40V	2222 033 17222
C 202 Electrolytic	330 uF 40V	2222 108 37331
	Other	
GR 201 Bridge	SKB2/04L5A	2412 265 02079
GR 202 Diode	BYV27/200	9335 526 80701
IC 201 IC-regulator	MC 7815 CT	9334 704 20701
IC 202 IC-regulator	LM 7915 CT	9335 267 40701
SK 201 Switch	115/230V	2422 127 00162
VL 201 Fuse holder		2422 088 00156
Insert		2422 088 00157
Fuse 5x20	160mA Slow-blow	2422 086 01008
RE 201, 202, 203 Relays	24V	2422 132 05885
TR 201 Line transformer		4031 100 42150
BU 203 Flat cable connector		2432 022 19002

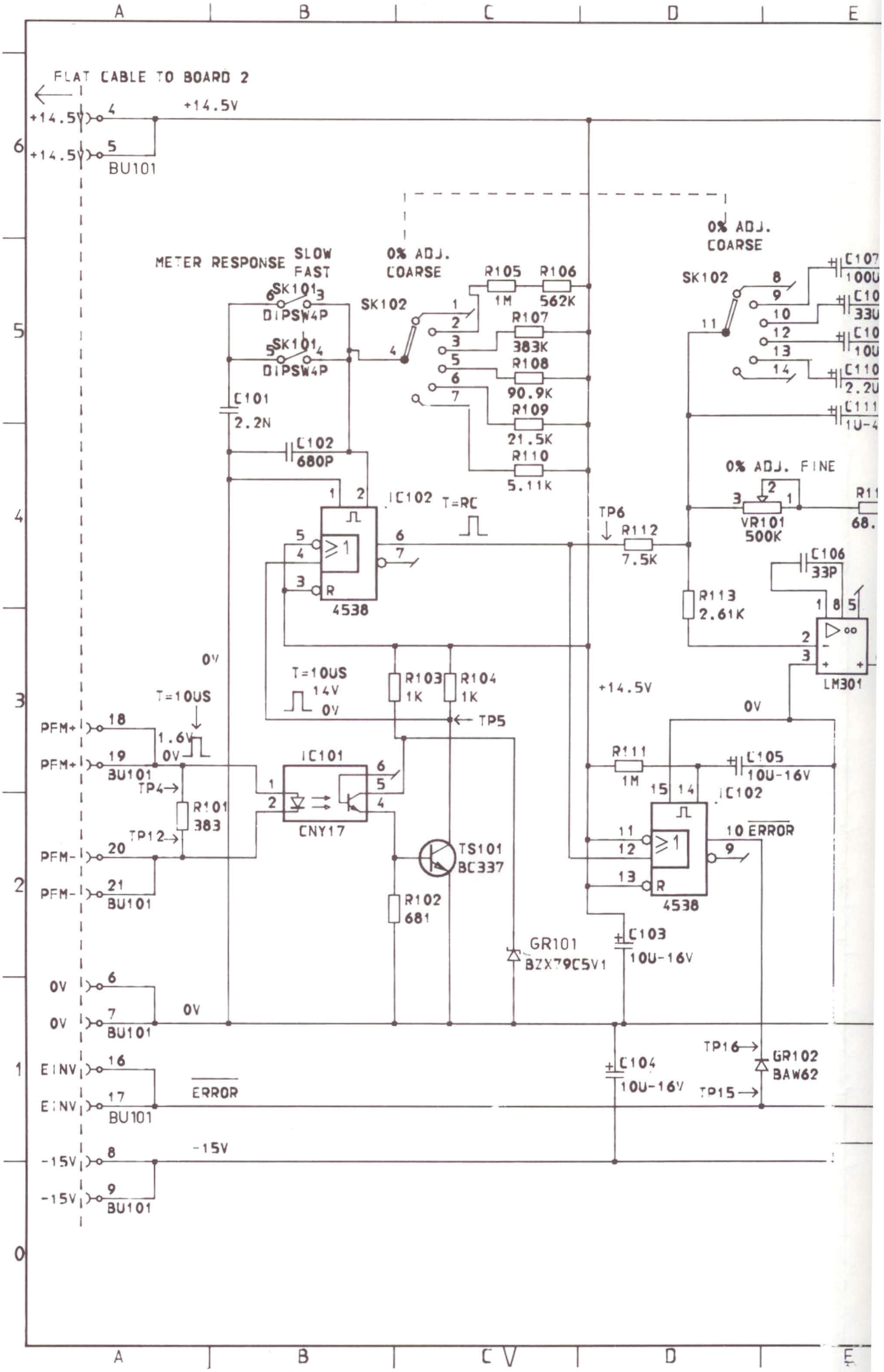
Detector Q 4700/5

Item	Description	Catalogue Number
	Resistors (1% 0.4 W MR 25)	
R 1, R 2	3.90 Mohms 5% 0.25 W	2322 241 13395
R 3	2.15 kohms	2322 151 52152
R 4, R 5, R 6	82.50 kohms	2322 151 58253
R 7	10 kohms	2322 151 51003
R 8	1 kohm	2322 151 51002
R 15, R 16	3.90 Mohms 5% 0.25 W	2322 241 13395
	Capacitors	
C 1 Ceramic	330 pF 10% 500V	2013 554 03635
C 2 Ceramic	1 nF 10%	2222 630 53102
C 3 Ceramic	220 pF 2%	2222 679 58221
C 4 Ceramic	1,5 nF 10%	2222 630 53152
C 5 Electrolytic	10 µF 16V	2222 122 25109
C 6 Plastic film	10 nF 10% 600V	2222 344 61103
C 7 Electrolytic	10 µF 16V	2222 122 25109
	Diodes	
GR 1 Zener	BZX79/C3V3	9331 176 70701
GR 2	BAW62/75	9331 012 20701
GR 3, GR 4 Zener	BZX79/B75	9331 670 80701
GR 5, GR 6	BY584 1500V	9336 123 20701
GR 7, GR 8, GR 9	BAW62/75	9331 012 20701
	Transistors and ICs	
TS 1 FET	BF256A	9331 905 20701
TS 2 MOS	VN2406M	9337 270 70682
IC 2 C MOS	HEF4538BP	9335 079 50701
IC 3 C MOS	4011PC	9332 764 10701
	Other	
TR 1 Transformer		4031 100 42160
TR 5 Fuse	100 mA Slow-blow	2422 086 00436
CT GM-tube	ZP 1210	9300 198 91394
BU 1 Connector	PTO 2E-10-6P	2422 026 03424

Detector Q 4700/9

Item	*Description*	*Catalogue Number*
	Resistors 1% 0.4 W MR 25	
R 1, R 2	3.90 Mohms 5% 0.25 W	2322 241 13395
R 3	2.15 kohms	2322 151 52152
R 4, R 5, R 6	82.5 kohms	2322 151 58253
R 7	10 kohms	2322 151 51003
R 8	1 kohm	2322 151 51002
R 9	1 Mohm	2322 151 51005
R 10	3.90 Mohms 5% 0.25 W	2322 241 13395
R 12	10 kohms	2322 151 51003
R 13	1 kohm	2322 151 51002
R 14	1 Mohm	2322 151 51005
R 15, R 16, R17	3.90 Mohms 5% 0.25 W	2322 241 13395
	Capacitors	
C 1 Ceramic	330 pF 10% 500 V	2013 554 03635
C 2 Ceramic	1 nF 10%	2222 630 53102
C 3 Ceramic	220 pF 2%	2222 679 58221
C 4 Ceramic	1,5 nF 10%	2222 630 53152
C 5 Electrolytic	10 µF 16 V	2222 122 25109
C 6 Plastic film	10 nF 10% 600 V	2222 344 61103
C 7 Electrolytic	10 µF 16 V	2222 122 25109
C 8 Ceramic	330 pF 10% 500 V	2013 554 03635
C 9 Ceramic	1 nF 10%	2222 630 53102
C 10 Electrolytic	10 µF 16 V	2222 122 25109
C 11, C12 Ceramic	47 pF	2222 679 10479
	Diodes	
GR 1 Zener	BZX79/C3V3	9331 176 70701
GR 2	BAW62/75	9331 012 20701
GR 3, 4 Zener	BZX79/B75	9331 670 80701
GR 5,6	BY 585 1500 V	9336 123 20701
GR 7, 8, 9	BAW62/75	9331 012 20701
GR 11, 12	BAW62/75	9331 012 20701
	Transistors and ICs	
TS 1 FET	BF 256 A	9331 905 20701
TS 2 MOS	VN2406M	9337 270 70682
IC 1, 2 CMOS	HEF 4538P	9335 079 50701
IC 3 CMOS	4011 PC	9332 764 10701
	Other	
TR 1 Transformer		4031 100 42160
TR 5 Fuse	100 mA Slow-blow	2422 086 00436
CT 1, 2 GM-tube	ZP 1220	9300 200 01394
BU 1 Connector	PT02E-10-6P	2422 026 03424

13. CIRCUIT DIAGRAMS



FLAT CABLE TO BOARD 2
+14.5V
BU101
METER RESPONSE
SLOW
FAST
SK101
DIPSW4P
0% ADJ.
COARSE
SK102
R105
1M
R106
562K
R107
383K
R108
90.9K
R109
21.5K
R110
5.11K
C101
2.2N
C102
680P
IC102
T=RC
4538
TP6
R112
7.5K
R113
2.61K
0% ADJ. FINE
VR101
500K
C106
33P
LM301
C105
10U-16V
R111
1M
ERROR
PFM+
PFM-
T=10US
1.6V
0V
TP4
R101
383
TP12
IC101
CNY17
T=10US
14V
0V
R103
1K
R104
1K
TP5
TS101
BC337
R102
681
GR101
BZX79C5V1
C103
10U-16V
C104
10U-16V
TP16
GR102
BAW62
TP15
EINV
-15V

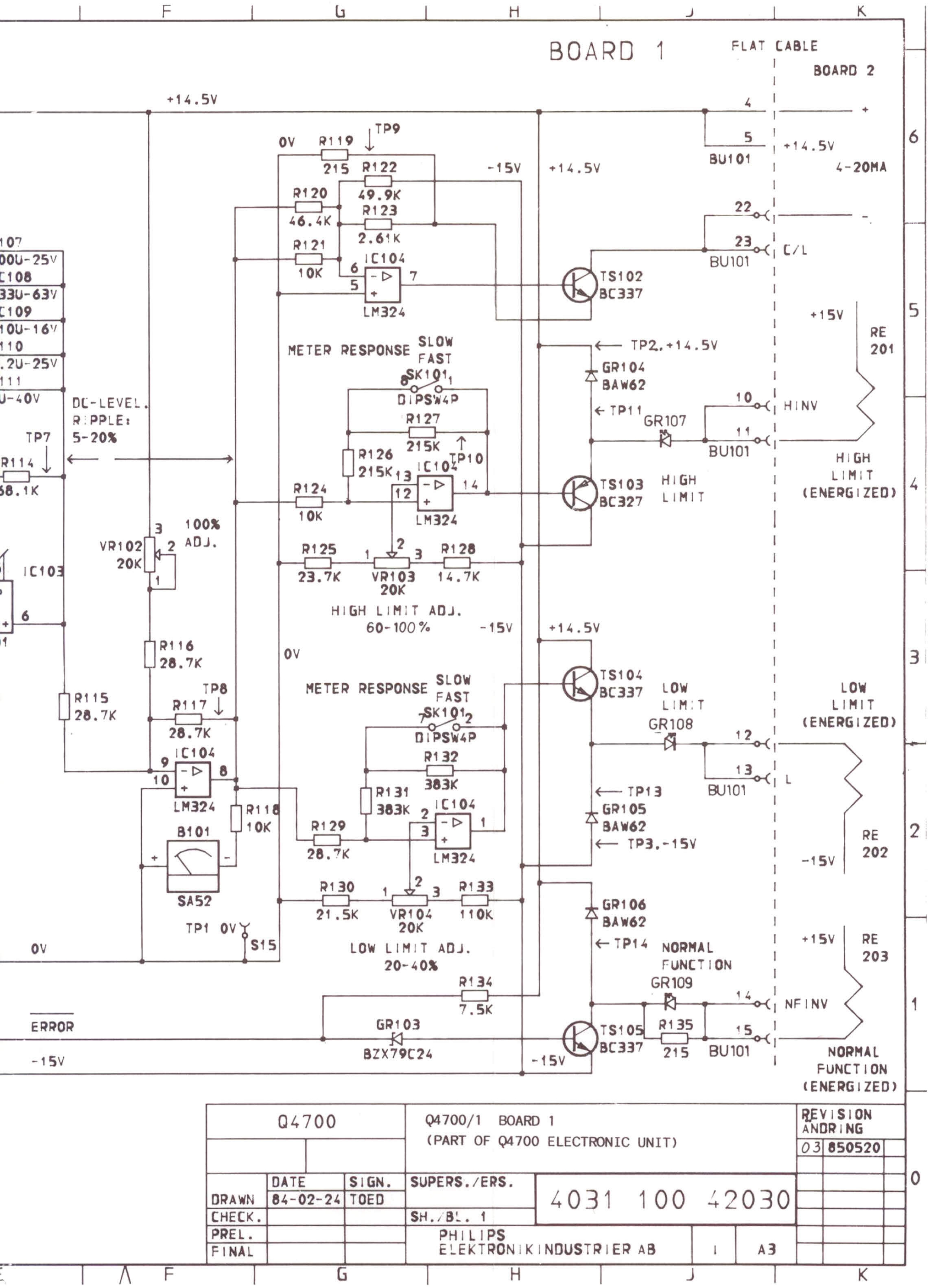
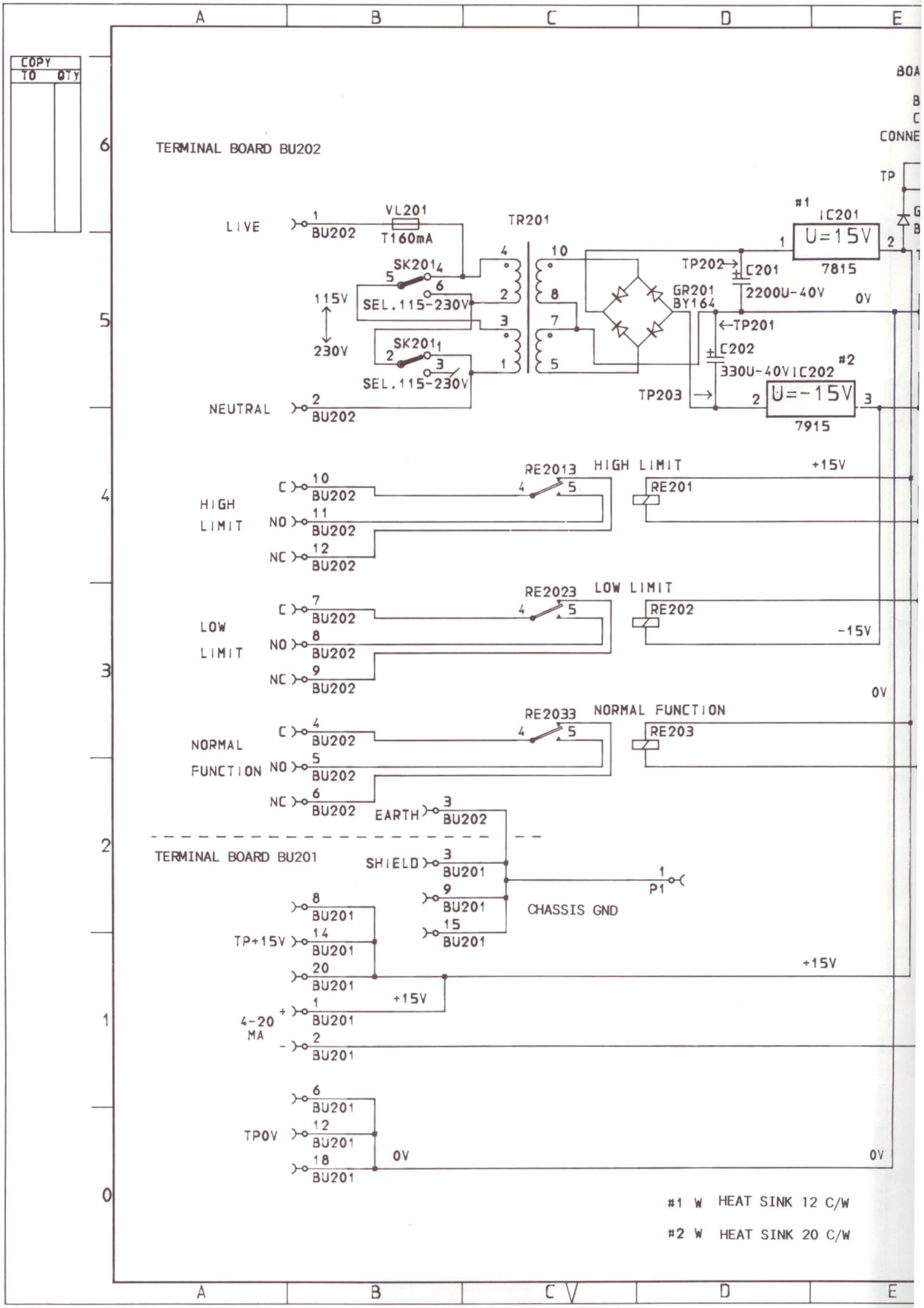


Fig. 46. Electronic unit, PC board No. 1.


A
B
C
D
E
COPY TO QTY
TERMINAL BOARD BU202
LIVE
1 BU202
VL201
T160mA
TR201
SK201
SEL.115-230V
115V
230V
NEUTRAL
2 BU202
TP202
C201
2200U-40V
GR201
BY164
TP201
C202
330U-40V
IC201
U=15V
7815
IC202
U=-15V
7915
TP203
#1
#2
0V
BOA
CONNE
HIGH LIMIT
C 10 BU202
NO 11 BU202
NC 12 BU202
RE2013
RE201
+15V
LOW LIMIT
C 7 BU202
NO 8 BU202
NC 9 BU202
RE2023
RE202
-15V
NORMAL FUNCTION
C 4 BU202
NO 5 BU202
NC 6 BU202
RE2033
RE203
EARTH 3 BU202
TERMINAL BOARD BU201
SHIELD 3 BU201
9 BU201
15 BU201
1 P1
CHASSIS GND
8 BU201
TP+15V 14 BU201
20 BU201
+15V
4-20 MA
+ 1 BU201
- 2 BU201
6 BU201
TPOV 12 BU201
18 BU201
0V
#1 W HEAT SINK 12 C/W
#2 W HEAT SINK 20 C/W

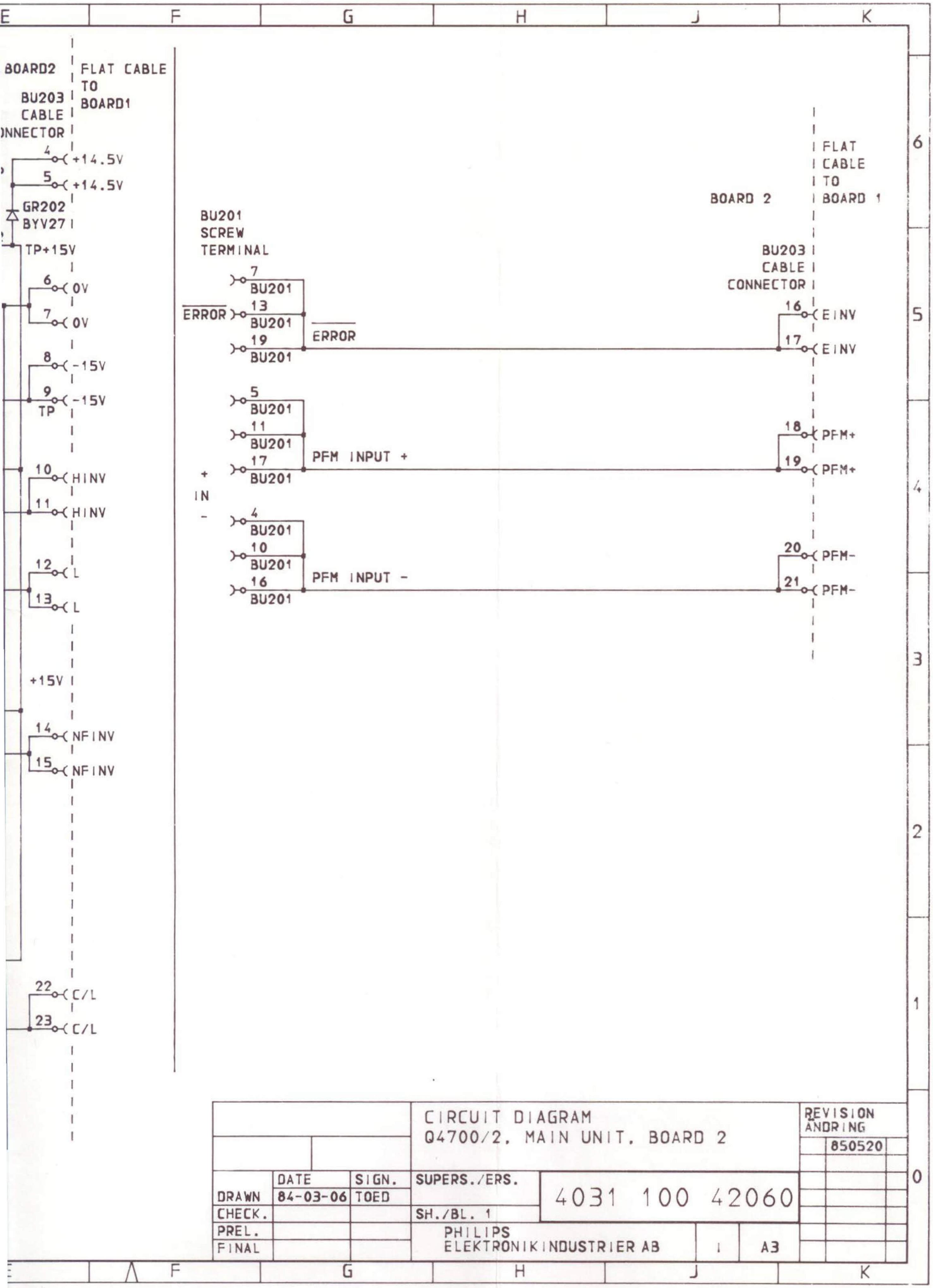
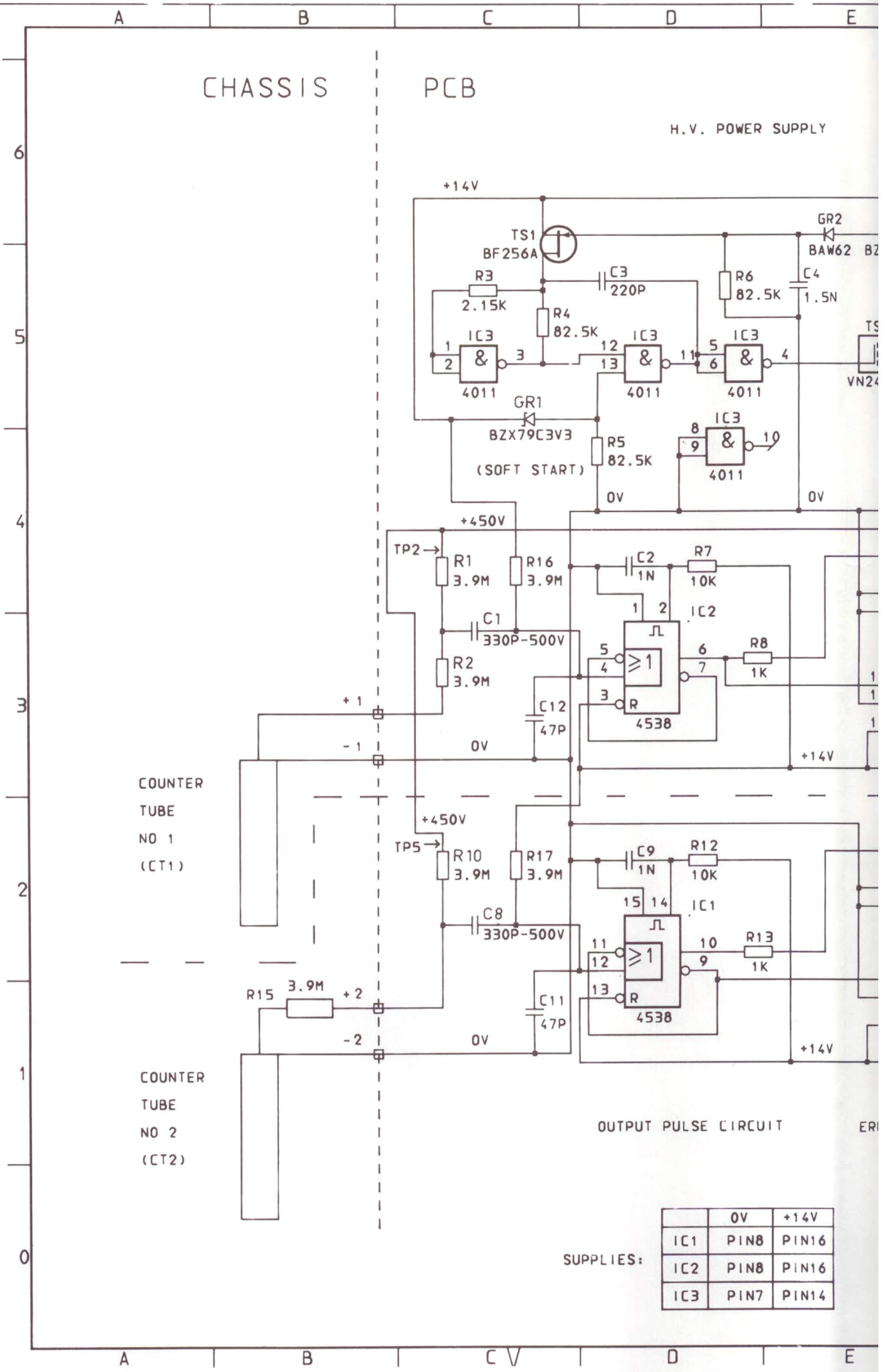


Fig. 47. Electronic unit, PC board No. 2.



	0V	+14V
IC1	PIN8	PIN16
IC2	PIN8	PIN16
IC3	PIN7	PIN14

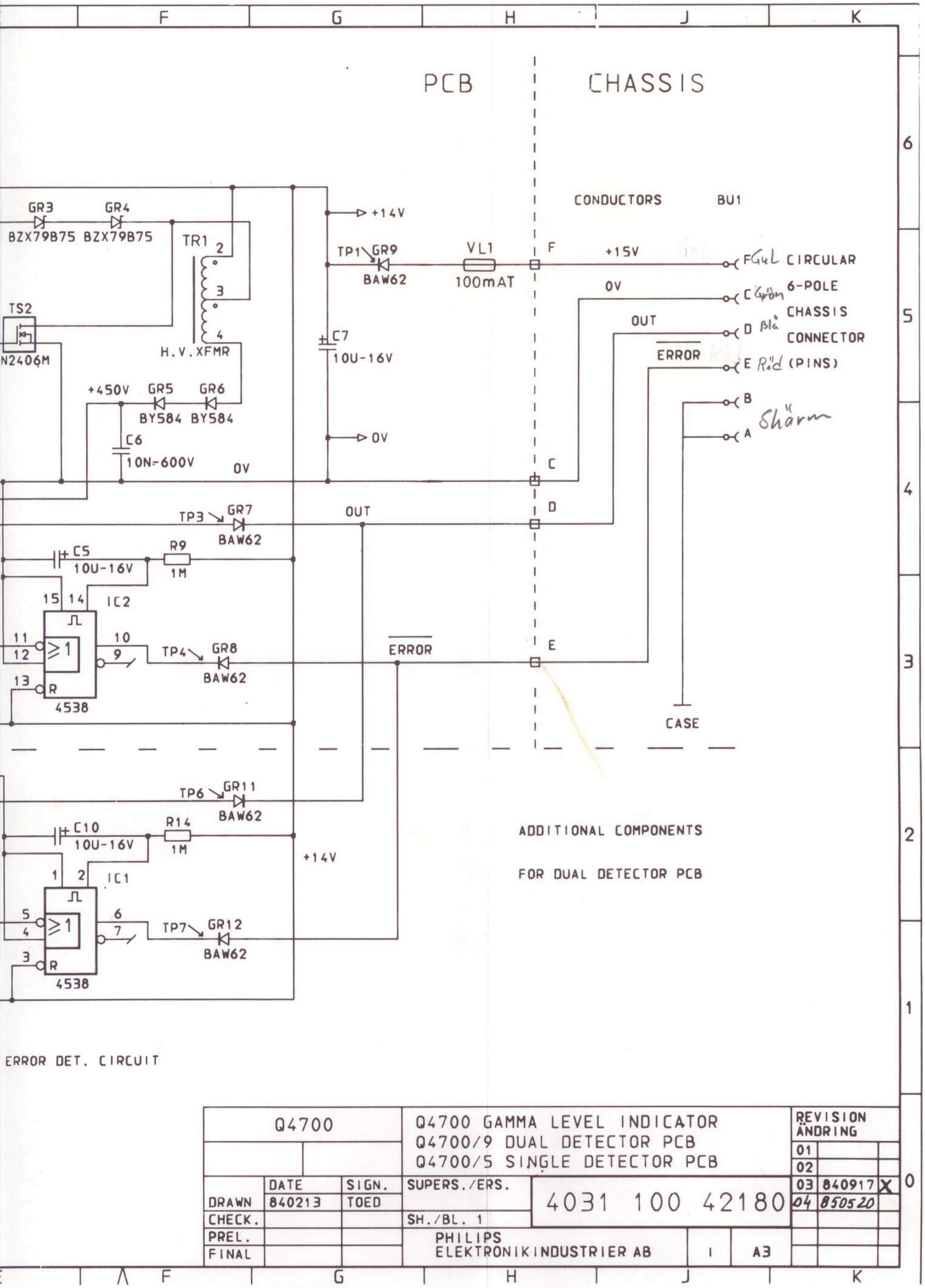


Fig. 48. PC boards: gamma level indicator, dual detector and single detector.

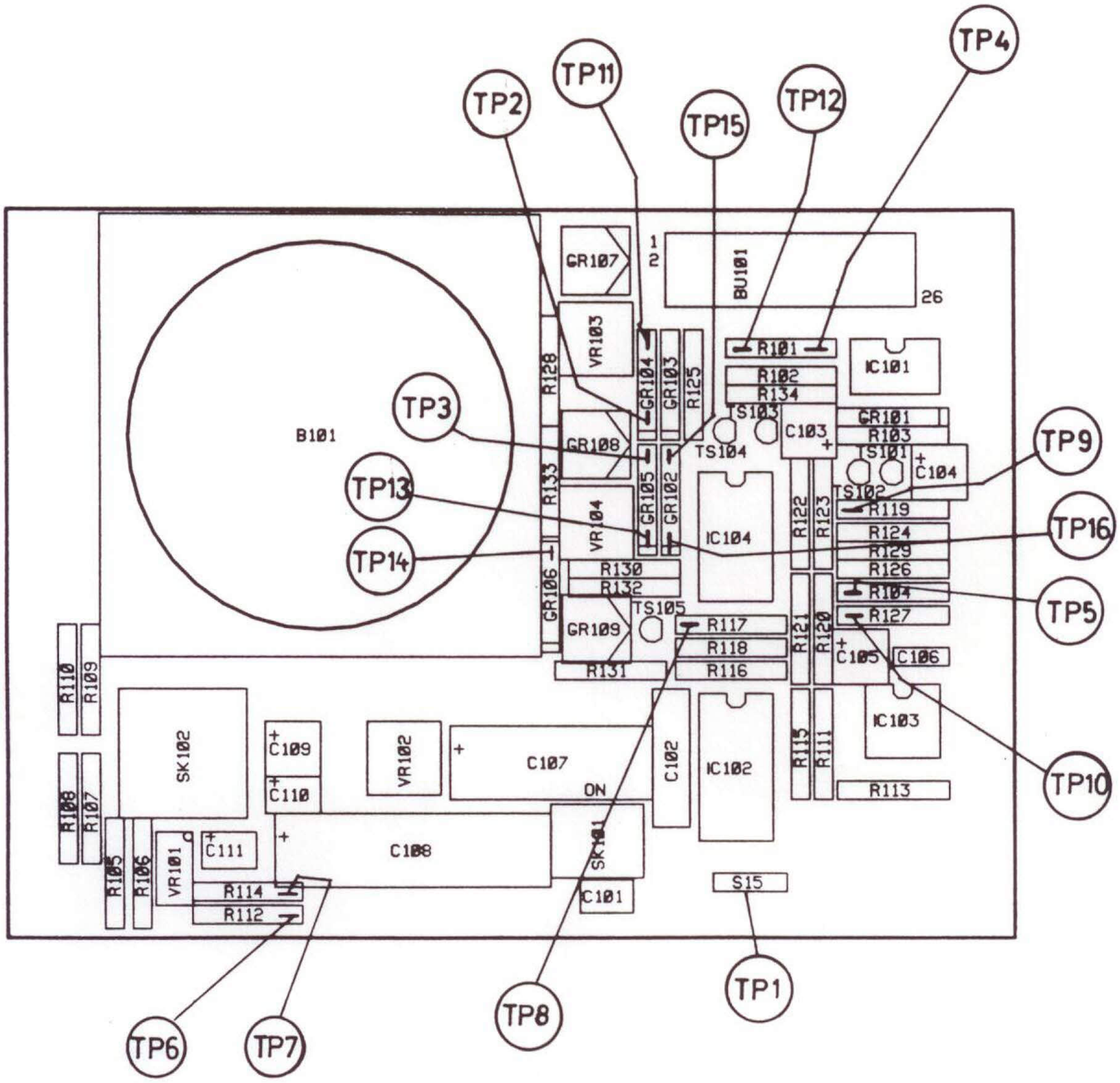


Fig. 49. Testpoints in Q 4700, PC board No. 1.

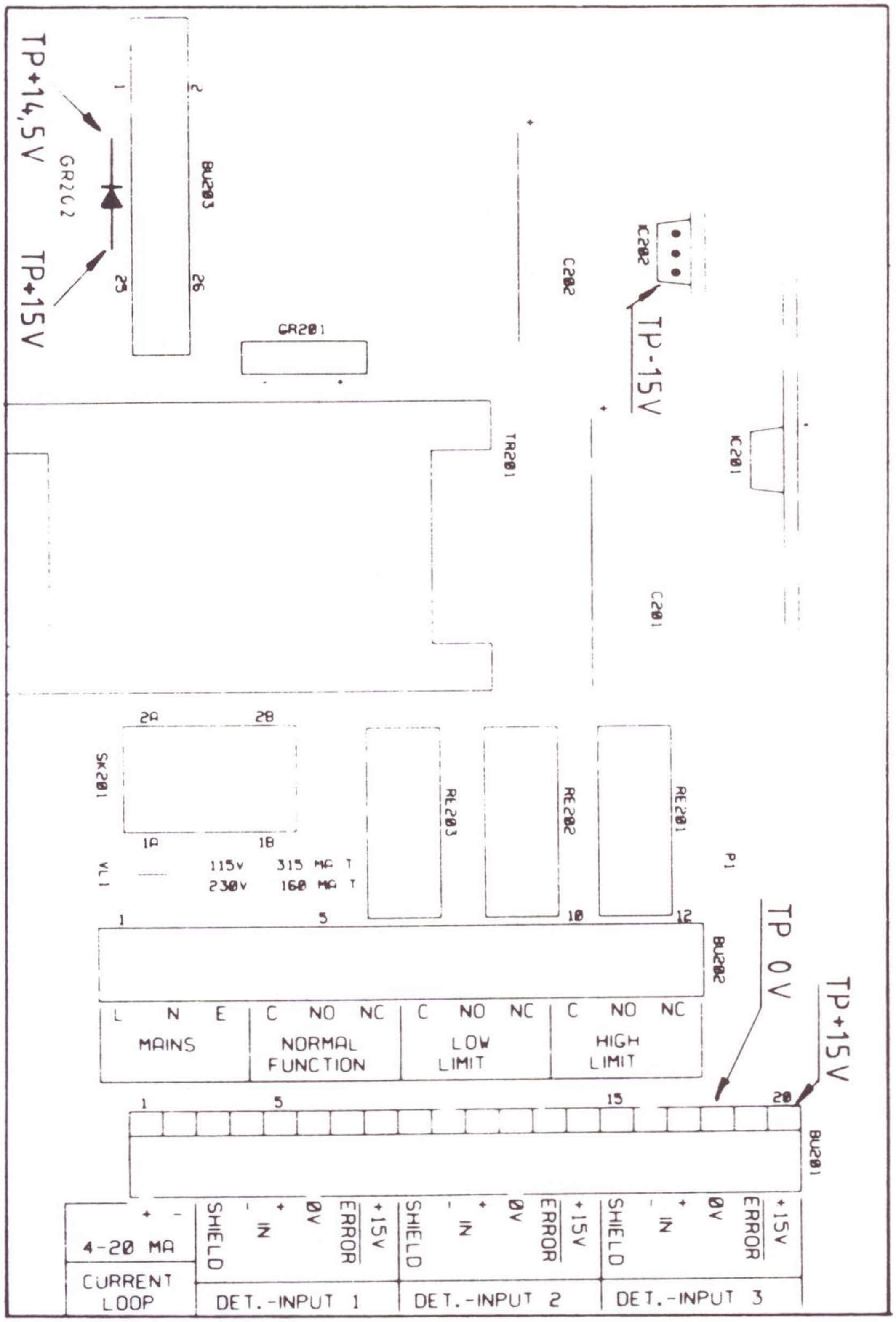
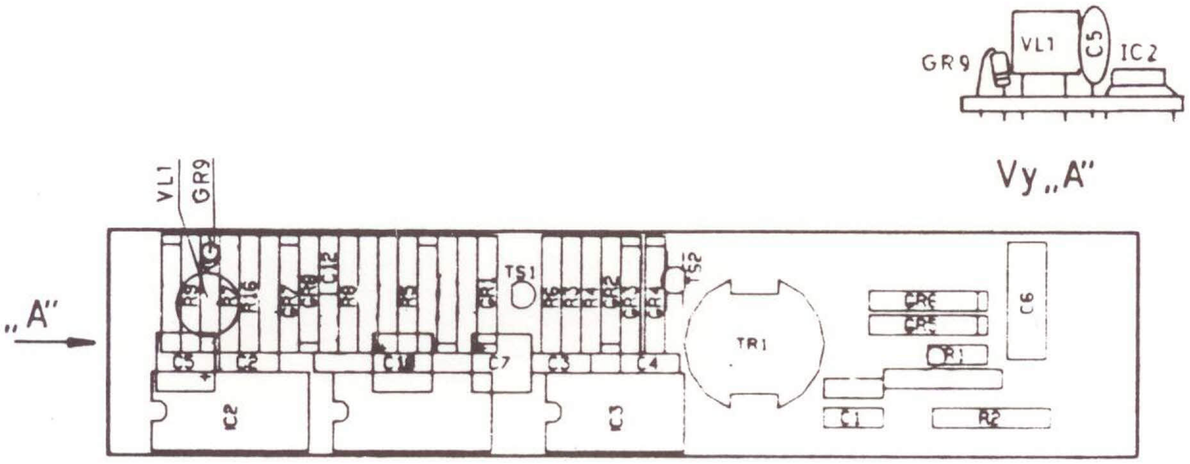
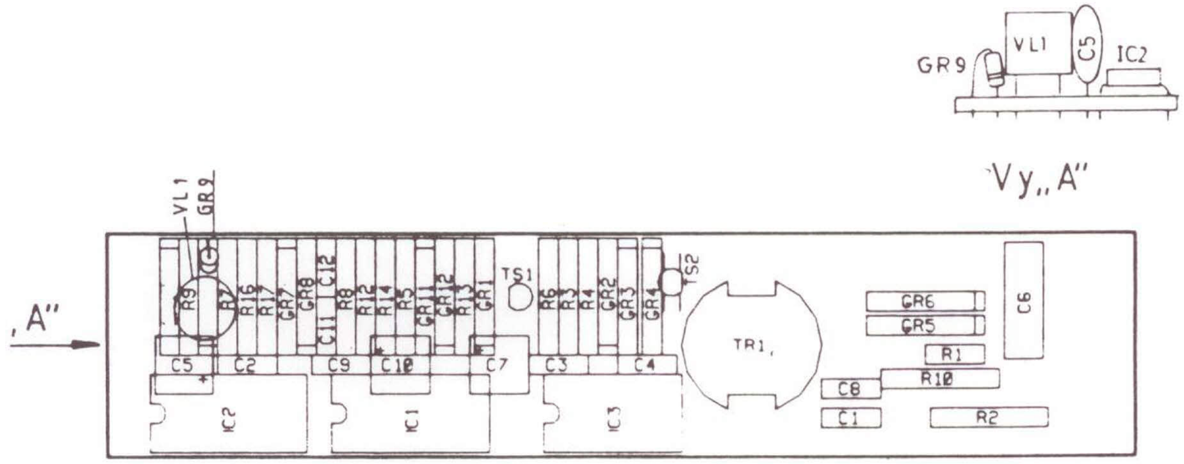


Fig. 50. Testpoints in Q 4700, PC board No. 2 (baseboard).



Single detector PCB 4031 100 42120-03

Enkel detektor kretskort 4031 100 42120-03



Dual detector PCB 4031 100 42130-03

Dubbel detektor kretskort 4031 100 42130-03

Fig. 51. Detector PC boards: Q 4700/5 (at top) and Q 4700/9.