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Isolation Amplifier
PM8940

Instruction Manual/Gerätehandbuch/Notice d'emploi et d'entretien

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GEBRAUCHSANLEITUNG

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NOTICE D'EMPLOI

1. GENERAL INFORMATION

1.1. INTRODUCTION

The isolation amplifier PM 8940 is a device used at the input of an oscilloscope for the safe measurement of circuits at high voltage levels; e.g. thyristor circuits at mains voltage levels in power circuits, industrial plant, washing machines, etc.

Fig. 2. Isolation amplifier with probe

1.2. CHARACTERISTICS

WARNING: Unless otherwise stated, the specifications listed apply for the PM8940 only; i.e. excluding the effects of the test oscilloscope used with the PM 8940 isolation amplifier.

The insulation between the PM 8940 and line (mains) fulfils the safety requirements of IEC-348 for metal encased Class 2 instruments.
This instrument has been supplied in a safe condition. The Present Operating Manual contains information and warnings that shall be followed by the purchaser to ensure safe operation and to retain the instrument in a safe condition.

- This specification is valid after the instrument has warmed up for 15 minutes (reference temperature 23 °C).
- Properties expressed in numerical values with tolerance stated, are guaranteed by the manufacturer. Numerical values without tolerances are typical and represent the characteristics of an average instrument.
- Inaccuracies (absolute or in %) relate to the indicated reference value.

1.2.1. Electrical characteristics

	Designation	*Specification*	*Additional information*
1.2.1.1.	*Frequency characteristics*		
	Bandwidth	DC: 0 ... 1.5 MHz (–3 dB) AC: 3 Hz ... 1.5 MHz (–3 dB)	Switch in "DC" position Switch in "AC" position
	Risetime	230 ns	
	Pulse aberrations	⩽ ± 3 % (⩽ 4 % p-p)	
	Propagation delay	120 ns	Typical value
1.2.1.2.	*Input HI x 10*	2.0 mm Ø	Max. wire diameter
	Deflection coefficient	50 mV/div ... 200 V/div	1-2-5 sequence Oscilloscope set to 20 mV/div and DC coupling
	Deflection accuracy	± 3 % or better	
	Max. diff. input voltage	650 $V_{r.m.s.}$	
	Diff. input impedance	10 Megohm//9 pF	
	Common-mode rejection (from d.c. to 60 Hz)	⩽ 0.5 div deflection	For 650 $V_{r.m.s.}$ common-mode input voltage (sine wave)
	For freq. ⩾ 60 Hz	see curve, Fig. 3	
	Max. common-mode input voltage	650 $V_{r.m.s.}$	Test voltage 2000 $V_{d.c.}$ for 10 sec.
1.2.1.3.	*Input HI*	2.0 mm Ø	Max. wire diameter
	Deflection coefficient	5 mV/div ... 20 V/div	1-2-5 sequence Oscilloscope set to 20 mV/div and DC coupling
	Deflection accuracy	± 3 % or better	
	Max. diff. input voltage	30 $V_{r.m.s.}$	
	Diff. input impedance	1 Megohm // 45 pF	
	Common-mode rejection (from d.c. to 60 Hz)	⩽ 0.5 div deflection	For 650 $V_{r.m.s.}$ common mode input voltage (sine-wave)
	For freq. ⩾ 60 Hz	see Fig. 3	
	Max. common-mode input voltage	650 $V_{r.m.s.}$	Test voltage 2000 $V_{d.c.}$ for 10 sec.

Designation	Specification	Additional information
1.2.1.4. *Output*		
Load	1 Megohm // 10 ... 40 pF	
Dynamic range	20 divisions	Oscilloscope set to 20 mV/div
Output offset	⩽ ± 0.25 div (at 23 °C)	Oscilloscope set to 20 mV/div
Drift	⩽ 0.05 div/°C	Oscilloscope set to 20 mV/div
Noise	⩽ 0.05 div	Oscilloscope set to 20 mV/div Tangentially measured

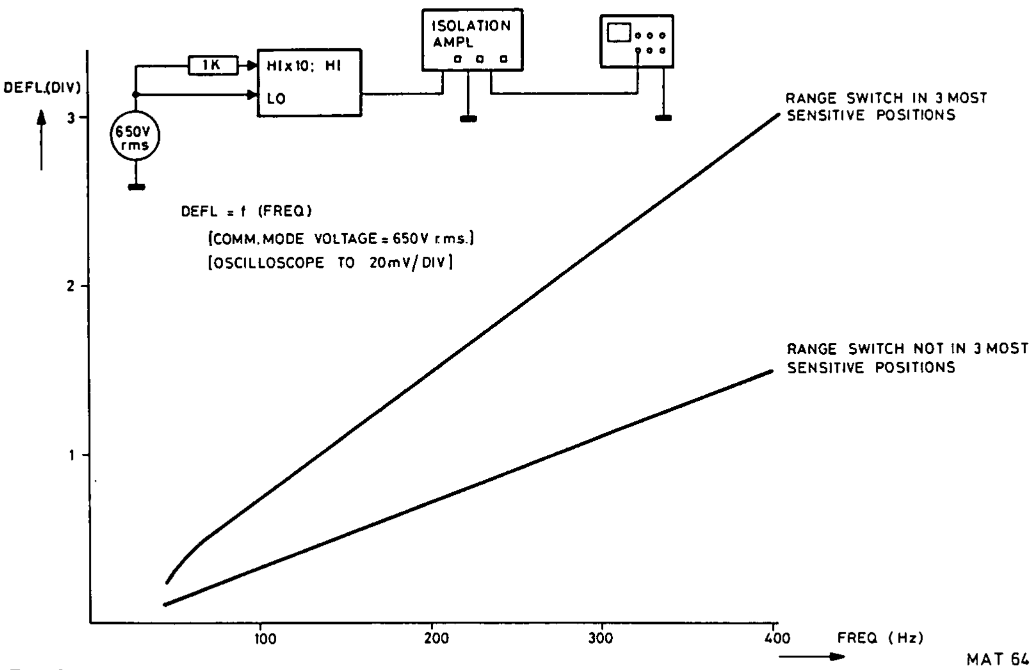

Fig. 3. Common mode rejection curve

1.2.1.5. *Power supply*		
A.C. supply	Double insulated	Safety class II, IEC 348
Nominal frequency range	50 ... 400 Hz ± 10 %	
Nominal voltage range	220 V +20 %, –10 % 100 V +30 %, –10 %	
Power consumption	10 VA Max.	
Battery supply	Two 9 V Batteries	Type 6F22P

1.2.2. Environmental characteristics

The environmental data are valid only if the instrument is checked in accordance with the official checking procedure. Details of these procedures and failure criteria are supplied on request by the PHILIPS Organisation in your country, or by N.V. PHILIPS' GLOEILAMPENFABRIEKEN, TEST & MEASURING DEPARTMENT, EINDHOVEN, THE NETHERLANDS.

Designation	*Specification*	*Additional information*
Temperature		Test procedure conforms to IEC 68, Ab and Bb
Storage	−40 °C to +70 °C (without batteries)	Recovery time from −40 °C to room temp. 1 hour; attached and power supply on
Operating	+5 °C to +40 °C	Probe operates within specified performance after occasional re-adjustment.
Humidity (non-operating)	Probe withstands 21 cycles of damp heat test: Temperature: 25 °C to 45 °C Rel. humidity: 90 % to 100 % Cycles: 24 hours	Test procedure conforms to IEC 68 Db
Altitude	To 5000 m	Operating within specs
	To 15000 m	Storage
Vibration	In accordance with IEC 68 FC	Operating
Shock	In accordance with IEC 68 Eb	Non operating

1.2.3. Mechanical characteristics

Dimensions	L	W	H	
Probe body (with hook)	236 mm	76 mm	38 mm	Max. dimensions
Probe cable	2300 mm			
Supply cable	1900 mm			Max. dimensions
Amplifier	155 mm	142 mm	42 mm	
Output cable	400 mm			Max. dimensions
Case	260 mm	340 mm	62 mm	
Mass	2.4 kg (5.3 lbs)			Without batteries

1.3. ACCESSORY (SUPPLIED WITH THE INSTRUMENT)

1 Instruction Manual

1.4. PRINCIPLE OF OPERATION (see Fig. 4)

The signal to be measured is connected into one or two fixed attenuators via the HI (attenuation factor 0.8) or the HI x 10 (attenuation factor 0.08) input sockets.
An AC/DC coupling RC network, switched by the relay switching circuit, connects the signal to the step attenuator, which is also controlled by the relay switching circuit to give attenuations of 1, 10, 100 and 1000.
The step attenuator output feeds a preamplifier having three gain steps (x3.25; x6.25 and x13) selectable by reed relay contacts for the appropriate ranges.
The signal from the preamplifier is fed via an opto-coupler amplifier, which gives the required isolation, to the output cable that connects to the input of the measuring oscilloscope.
The attenuator positions indicated on the PM 8940 apply only if the oscilloscope is set to the 20 mV/div range.
The attenuator positions and the AC/DC coupling selection are 'cold-switched' via the reed relay switching circuit. The required supply voltages for the probe circuits are provided by a battery supply.
A mains adaptor and voltage stabilising circuits provide the power for the timer control, relay switching circuits and output amplifier. The 10 minute timer that controls the battery power serves to limit unnecessary drain on the batteries. The LED, B1, which extinguishes below a certain voltage level, indicates whether the batteries must be replaced.

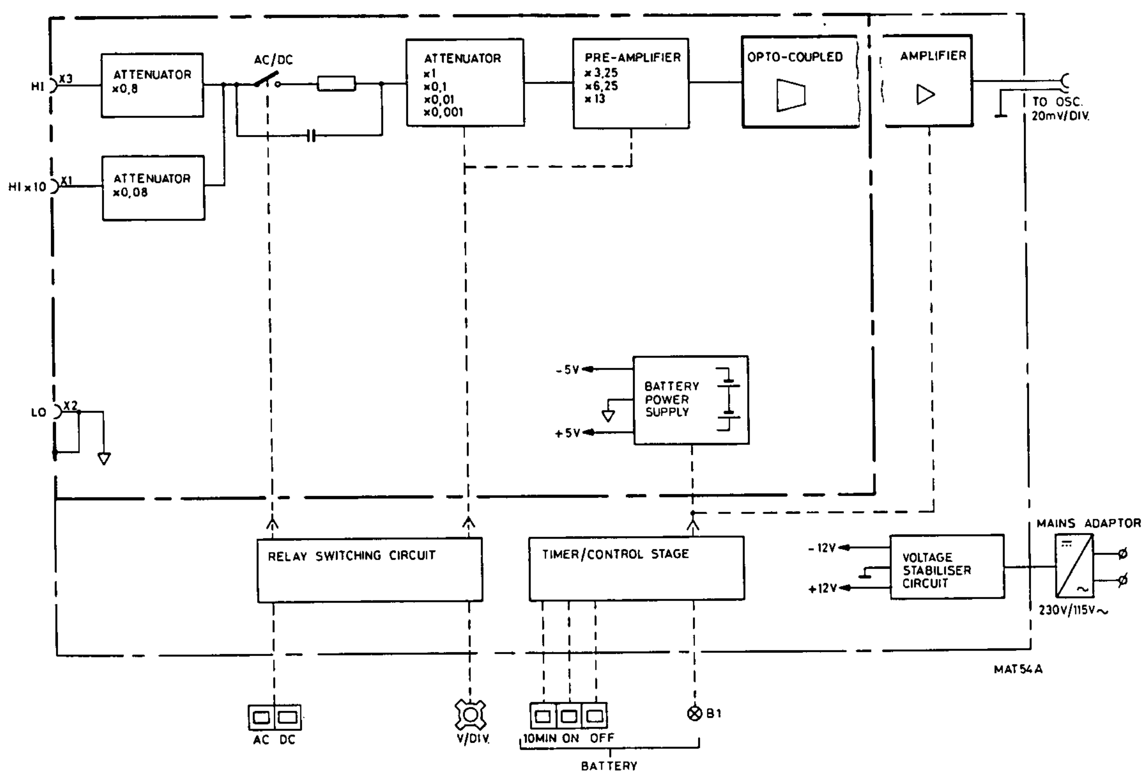

Fig. 4. Block diagram

2. INSTALLATION INSTRUCTIONS

2.1. IMPORTANT SAFETY INSTRUCTIONS (IN ACCORDANCE WITH IEC 348)

Before connecting the instrument to the mains (line), visually check the cabinet, controls and connectors, etc., to ascertain whether any damage has occured in transit. If any defects are apparent, do not connect the instrument to the mains (line).

CLAIMS
In the event of obvious damage or shortages, or if the safety of the instrument is suspect, a claim should be filed with the carrier immediately. A Philips Sales or Service organisation should also be notified in order to facilitate repair of the instrument.

The instrument must be disconnected from all voltage sources and any high voltage points discharged before any maintenance or repair work is carried out.
If adjustments or maintenance of the operating instrument with covers removed is inevitable, it must be carried out only by a qualified person who is aware of the hazards involved. In normal operation the double insulated mains adaptor obviates the need for a safety ground.

2.2. MAINS (LINE) VOLTAGE SETTING

Before inserting the mains adaptor into the mains socket, make sure that it is set to the local mains voltage. The instrument shall be disconnected from all voltage sources when the mains adaptor is to be adapted to a different mains voltage.

The instrument can be set to operate on the following mains voltages: 110 V and 220 Vac.
These nominal voltages can be selected by means of the mains voltage selector, located on the mains adaptor (see fig. 5).
For mains voltage selection, proceed as follows:
- Select one of the voltage ranges, as appropriate, by turning the selector with a screwdriver.
  On delivery, the instrument is set to 220 Va.c.

A thermal fuse is fitted in the mains transformer; if replacement is necessary, it must be carried out only by a qualified person who is aware of the danger involved.

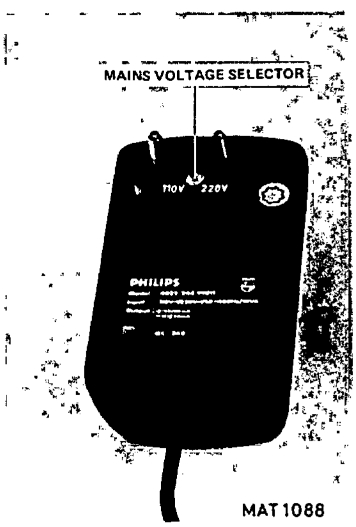

Fig. 5. Mains voltage selector

2.3. BATTERY SUPPLY

The required voltages for the probe circuits are provided by a battery supply.
These batteries must be replaced when the voltage is below a certain level, i.e. when indicator B1 is extinguished.

2.3.1. Replacing of the batteries

WARNING: Never remove screws to remove the probe cover if live wires are connected to input terminals LO, HI or HI x 10 (i.e. screw C or D).

- Loosen the screw which secures the probe-hook and the battery-holder to the probe (screw C of fig. 6).
- Slide the battery holder clear of the cable. At the same time, the metal case inside the battery holder is disconnected from the overall metal screen of the probe.
- Connect the batteries as indicated in fig. 7.
  To prevent that the wires will be damaged when the probe-holder is mounted on the probe, take care of the following:
  - The outputs of the battery terminals must point to each other.
  - Twist the wires of the battery-terminal by rotating both batteries together 2x (see (1)).
- Insert the batteries in the battery holder (see (2)).
- Mount the battery holder and hook on the probe and fasten screw C (fig. 6.)

Fig. 6. Replacing the batteries

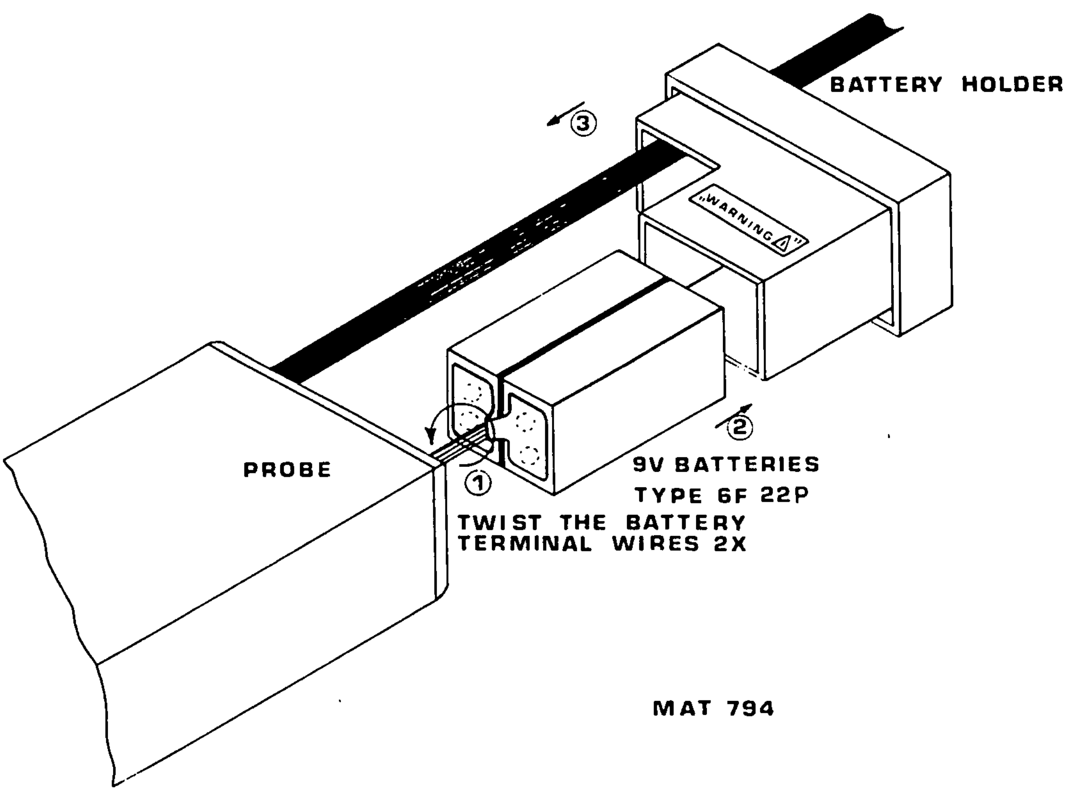

Fig. 7. Replacing the batteries

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3. OPERATING INSTRUCTIONS

3.1. GENERAL INFORMATION

This section outlines the procedures and precautions necessary for operation.
It identifies and briefly describes the functions of the front and rear panel controls and indicators, and explains the practical aspects of operation to enable an operator to evaluate quickly the instruments main functions.

3.2. SWITCHING ON

After the instrument has been connected to the mains (line) voltage in accordance with sections 2.2, 2.3 and 2.5 it can be switched on with the BATTERY ON switch.
The associated BATTERY ON indicator lamp is adjacent to BATTERY switches.

When switching on the instrument, it is immediately ready for use. With normal installation, according to section 2, and after a warming-up time of 15 minutes, the characteristics according to section 1.2. are valid.

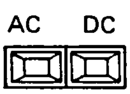
3.3. EXPLANATION OF CONTROLS AND SOCKETS (see fig. 8, fig. 9. and fig. 10.)

The controls and sockets are listed according to their sections and a brief description of each is given.

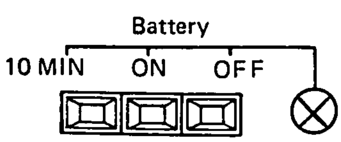
3.3.1. Amplifier

V/DIV
(Oscilloscope in 20 mV/DIV position)

Step control of the vertical deflection coefficients ranging from 5 mV/DIV to 200 V/DIV in a 1-2-5 sequence.
White text: 50 mV/DIV to 200 V/DIV, applies to HI x 10 input terminal of the probe.
Blue text: 5 mV/DIV to 20 V/DIV, applies to HI input terminal of the probe.



Coupling pushbuttons.
AC depressed: coupling via blocking capacitor
DC depressed: direct coupling
Also in direct coupling mode with both pushbuttons released.



Pushbutton control for battery-powered circuit.

10 MIN : Pushbutton with timer control giving 10 minute operating time with batteries (period can be varied by changing the timer capacitor).

ON : Pushbutton for continuous operation with batteries.

OFF : Pushbutton to switch off the batteries.

⊗ : LED indicator that lights up when the batteries are switched on and are sufficiently charged.
The LED is extinguished when the batteries are switched off or too low.

Note: If the input signal is well outside the dynamic range of the amplifier the LED is also extinguished.

⏚ (rear side)	Protective earth screw. The amplifier must be properly grounded if the input voltage of the probe exceeds 30 V.

3.3.2. Probe

LO	Low input: connected to the common zero of batteries.
HI x 10	Connection for HI input voltage (650 mV max.) relating to white vertical deflection coefficients.
HI	Connection for HI input voltage (30 V max.) relating to blue vertical deflection coefficients.

3.3.3. Mains adaptor

110 V ⊘ 220 V	Mains (line) selector

3.4. DETAILED OPERATING INFORMATION

3.4.1. Switching on the instrument

Before connecting the instrument to any supply, the instructions given in Section 2, Installation Instructions, should be carefully observed.
When the mains adaptor is connected to the appropriate mains socket and the 9 V batteries are inserted in the probe, the PM 8940 is immediately ready for use. Normally, after a 15-minute warm-up period, the PM 8940 will meet its specifications (see Section 1.2.). However, if the instrument has been subjected to an extremely cold environment (e.g. left in a car overnight in freezing conditions) and then brought into a warm room, a warm-up period of sufficient length should be allowed (see Section 1.2.2.).

3.4.2. Preliminary Settings and Connections

The isolation amplifier PM 8940 should be used together with an oscilloscope (or other measuring devices) set to the 20 mV/DIV range to obtain the correct deflection coefficient settings.

WARNING: When the probe is connected to voltages in excess of 30 V the amplifier must be properly grounded (earthed).

3.4.3. Input coupling AC/DC

The AC coupling (AC pushbutton depressed) is useful to block the d.c. component of a signal.
This choice limits the lower frequencies, which causes low-repetition-rate sinewaves to be attenuated and low-repetition-rate squarewaves to be distorted. The degree of attenuation is determined by the input RC time.

3.4.4. Measurements

Note: The calibrations of the PM 8940 input attenuator, i.e. the V/DIV front-panel markings, are only valid if the measuring oscilloscope is set to a sensitivity of 20 mV/DIV.
A higher sensitivity settings, the oscilloscope will produce a correspondingly higher overall sensitivity at the expense of an increment of noise.
At lower sensitivity settings, the oscilloscope will produce a correspondingly lower overall sensitivity and will limit the maximum trace deflection.
To facilitate measurement, the probe should be supplied with suitable measuring leads, which can be permanently attached to the probe by means of the isolated screw connectors, tightened to finger-force using a well-fitting screwdriver.

As previously stated, the hook attachment permits the probe to be located at a convenient point on the equipment during measurements.
Although the amplifier is 'floating' with respect to earth (ground), it has a single-ended input network; i.e. the input connector marked LO has a much higher capacitance to earth than the HI connection.

When performing measurements on a floating h.f. voltage that is asymmetrical with respect to earth, the probe should be attached in such a way that the LO input is connected to the pole having the lower impedance to earth, and the HI input is connected to the pole having the higher impedance to earth (see Fig. 11).

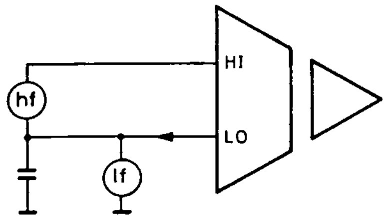


Fig. 11. Probe, input connections

To obtain a high input impedance, a 10 Megohm x10 attenuator is built-in. For voltages greater than 0.25 V, it is advisable to use this attenuator; i.e. connect the input voltage to be measured between HI x 10 and LO.
In this case, the white attenuator markings are valid.
Voltages of less than 0.25 V must be connected between HI and LO; in this case the blue attenuator markings are valid.

Note the restrictions regarding the maximum input voltage and input impedance in this range!

The floating amplifier in the probe is battery operated. For economic use of these batteries the PM 8940 is provided with a timer, which is actuated by depressing the 10 MIN pushbutton.
After an interval of 10 minutes the batteries are automatically switched off, the mains-operated sections of the PM 8940 remaining in the standby position.
For continuous operation, the ON pushbutton must be used, although for most measurements the 10 MIN pushbutton will be used to prevent battery drain.
When the battery voltages are too low, the batteries are automatically disconnected to prevent measuring errors.
An indicating LED confirms that the batteries are connected and of adequate potential, and that the input signal is not too far outside the amplifier dynamic limits.

4. PREVENTIVE MAINTENANCE

4.1. GENERAL INFORMATION

This instrument generally requires no maintenance, as it contains no components that are subject to wear. However, to ensure reliable and troublefree operation, the instrument should not be exposed to moisture, heat, corrosive elements or excessive dust.

4.2. CLEANING THE NEXTEL SUEDE COATING

WARNING: **The Nextel coating is ethanol-resistant, but is susceptible to methylated spirit, which will attack the surface (due to one of its denaturing substances).**

The bright appearance of the cabinet, lacquered with Nextel suede coating, will deteriorate after some time as the surface becomes soiled. Cleaning with a cloth soaked in water, ethanol or a common household cleansing agent does not always restore this lustre or remove all dirt from the holes and pores.
The 3M Company have developed a cleansing pad (White Cleansing Pad, Catalogue No. 8440) which when soaked in water, ethanol or a common household cleansing agent will also penetrate holes and pores.

This method is similar to the action of abrasive cleaning pads but is not abrasive. Abrasive cleaning pads should not be used, otherwise surface scratches will result.

4.3. RECALIBRATION

From experience, it is expected that the oscilloscope operates within its specification for a period of at least 1000 hours, or for six months if used infrequently.
In addition, replacement of components may necessitate recalibration of the affected circuits. The checking and adjusting procedure can also be helpful in localising certain troubles in the instrument.
In some cases, minor troubles may be revealed and/or corrected by recalibration.
Complete checking and adjusting instructions are given in the Checking & Adjusting Section.

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5. SERVICE MANUAL

5.1. CIRCUIT DESCRIPTION (see Figs. 12 and 24)

5.1.1. Attenuator

The signal to be measured, depending on its magnitude, is connected to either the HI input (X3) or the HI x 10 input (XI).
The HI x 10 input is connected to the RC network R203, C204 and R204 which has a fixed attenuation factor of 0.08.
The HI input is connected to the RC network R201, R202, C201, C202, C203 and R204, which has an attenuation factor of 0.8.
The resulting signal developed across R204 is fed to the AC/DC coupling network C206, R206.
In the DC position, i.e. with the DC pushbutton of S2A selected, the reed relay K101 is energised, via the S2A contacts from the –12 V supply. In the DC position, the coupling capacitor C206 is bypassed.
The contacts of K101 "make" and connect the incoming signal via R 206 with the attenuator stage comprising C209-C219, R207-R214. The three sections which are switched by reed relays K107, K102, K103, K104, K106 are controlled by the selected position of the front-panel range switch S1.
To reduce the amplitude of switch-off spikes, diodes are mounted in parallel with the relay-coils.

5.1.2. Preamplifier Stage

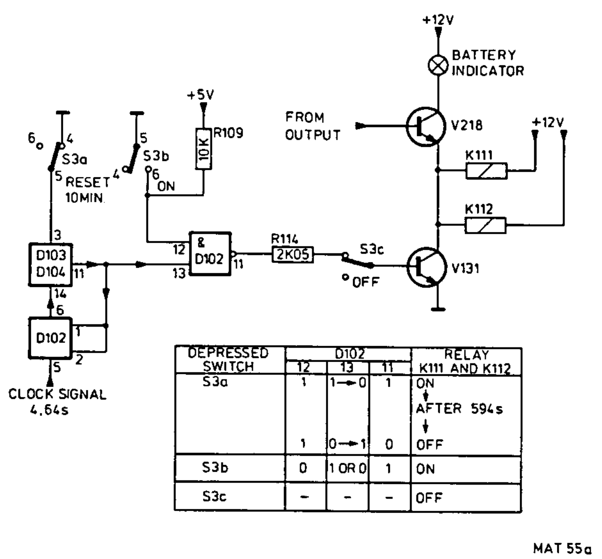
The preamplifier stage comprises transistors V201, V203, V204 and the integrated transistors D201, in a balanced amplifier circuit which serves as impedance transformer. The input signal is fed to one gate of input dual field-effect transistor V201.
The gain of the preamplifier stage is matched to the incoming signal amplitude by means of the preset resistor R223 and R226. These presets are switched into the emitter circuit of D201 for the appropriate ranges by means of reed relays K108, K109, selected by the position of S1. A constant current source is provided by D201/12, 13, 14 from the –5 V rail.
The signal on collector D201-11 is coupled via the common-base amplifier to the output transistor D201/1, 2, 3, the gain of this being limited by the feedback resistor R238.

5.1.3. Final Amplifier Stage

The signal on collector D201-1 is fed to the negative input (pin 2) of operational amplifier D202.
In this amplifier, and emitter-follower V212, the input signal is converted into a current with a dynamic range of 8 $mA_{p\text{-}p}$. This current is applied to opto-coupler D204 to give the required isolation property of the unit.
The feedback circuit via opto-coupler D204 serves to compensate for the non-linear current-ratio transfer inherent in these devices by applying its output to the positive input of operational amplifier D202-3. In this way, a linear collector current is obtained through opto-coupler D206 to the current/voltage converter circuit, V134, V136, V137. Consequently, the voltage at the output, across resistors R127, R128, changes in proportion to the input signal voltage applied to input 2 of the operational amplifier D202.
The dynamic range of 8 $mA_{p\text{-}p}$ (corresponding to 1 $V_{p\text{-}p}$) is adjusted by potentiometer R253 and the static range of 8 mA d.c. is adjusted by potentiometer R252. Potentiometer R258 and trimming capacitor C226 provide adjustment for the h.f. response. Potentiometer R128 in the output of the current to voltage converter permits adjustment of the dynamic range of 0.4 V. The d.c. offset at the output can be adjusted by potentiometer R124 in the emitter circuit of V134.
If the battery voltage is too low, the +VB supply to input 2 of operational amplifier D203 becomes lower than input 3. This makes the output pin 6 high and, via R249, thyristor V208 fires. As a result, the collector current of transistor V211 is reduced and its emitter voltage is at about 0 V. Since the control circuit always tries to make the collector voltage of opto-coupler D204 (via input 3 of D202) equal to the voltage on pin 2 of D202 (about 0 V), the currents through the diodes of the opto-couplers are very small, and therefore the collector currents of the opto-coupler are also small. Thus, less current flows from transistor V134 through transistor V136 and more flows through resistors R127 and R128. The potential across these resistors, i.e. the output voltage, therefore increases and the potential via R116 to input 2 of operational amplifier D106 becomes higher than that on input 3. The drop in output that occurs on pin 6 cuts off transistor V128 and also B1, the battery indicator LED, to show that the battery supply voltage is too low.
An input signal overload also results in a high output potential being fed via R116 to input 2 of D106, and causes the LED to extinguish.

5.1.4. Timer/Control Stage (see fig. 12 and fig. 24)

The timer consists of an oscillator formed by integrated circuit D101 operating with a period time of 4.64 seconds and a 128 counter formed by integrated circuits D103 and D104. The resulting period time 4.64 s x 128) is approximately 10 minutes (594 s).
The timer is always running when the PM 8940 is connected to the mains voltage.
A signal with a period-time of 4.64 seconds is generated in the integrated circuit D101 and is fed to D102/5 via transistor V127.
When D102/4 is "high" this signal is fed as a clocksignal to the 128 counter.
The 128 counter formed by D103 and D104 is resetted when the pushbutton 10 min. (S3a) is depressed.
When this pushbutton is depressed the output of D104 (pin 13 of D102) will change from "high" to "low".
This signal is also fed to D102/1 and 2 where it is inverted, so D102/4 becomes "high".
The inverted clock-signal with a period-time of 4.64 sec. is now fed to D103/14 (128 counter).
The output of the 128 counter (pin 11 of D104) is during 594 seconds "low" and is fed to D102/13.
Pin 12 of D102 is "high", so D102/11 is "high" during 594 sec. This results in swichting-on transistor V131 and the relays K111 and K112 are energised. After 594 seconds D104/11 becomes "high" again.
Pin 11 of D102 becomes "low" which switches-off transistor V131 and de-energises the relays K111 and K112 (batteries are switched-off).
The timer circuit D101 caused interference pulses (pulswidth ≈ 100 ns sec, frequency 0.2 Hz) on the output of the isolation amplifier.
To reduce these interference pulses resistor R105 is mounted between point 8 of D101 and the +12 V, and the electrolytic capacitor C113 between point 8 and point 1 of D101 (point 1 is at earth potential).
With the front-panel ON button S3-b depressed, the timer circuit still runs, but it is bypassed.
This is achieved by the logic 0 on S3-b, pin 6, which, via AND gate D102/12, 13 , 11 presents a logic 1 through the OFF switch contacts S3-c to hold on transistor V131.
When the front-panel OFF pushbutton switch S3-c is operated, V131 is cut off and relays K111 and K112 are de-energised, thus switching off the battery supplies.



DEPRESSED SWITCH	D102 12	D102 13	D102 11	RELAY K111 AND K112
S3a	1	1→0	1	ON ↓ AFTER 594s ↓
	1	0→1	0	OFF
S3b	0	1 OR 0	1	ON
S3c	-	-	-	OFF

Fig. 12. Timer/control stage, principle diagram

5.1.5. Power supplies

5.1.5.1. Battery Power Supply

Two 9 V batteries are switched by contacts K111 andK112 via voltage regulators D207, D208, to feed the circuits of the basic probe; i.e. the attenuator stage, the preamplifier and the isolated part of the opto-coupled amplifier.
The –5 V supply rail is on output pin 2 of D207, across electrolytic capacitor C227.
The +5 V supply rail is on output pin 2 of D208, across electrolytic capacitor C228.

5.1.5.2. Main Power Supply

The –12 V and +12 V d.c. supplies are derived from the mains supply via mains adaptor D109 and the voltage regulators D107 and D108 respectively.
These supplies feed the relay switching circuit, the timer/control stage and the output part of the final amplifier stage.
A built-in 12 V to 5 V converter, emitter-follower V126, provides the 5 V supply for integrated circuits D102, D103 and D104 in the timer/control stage.

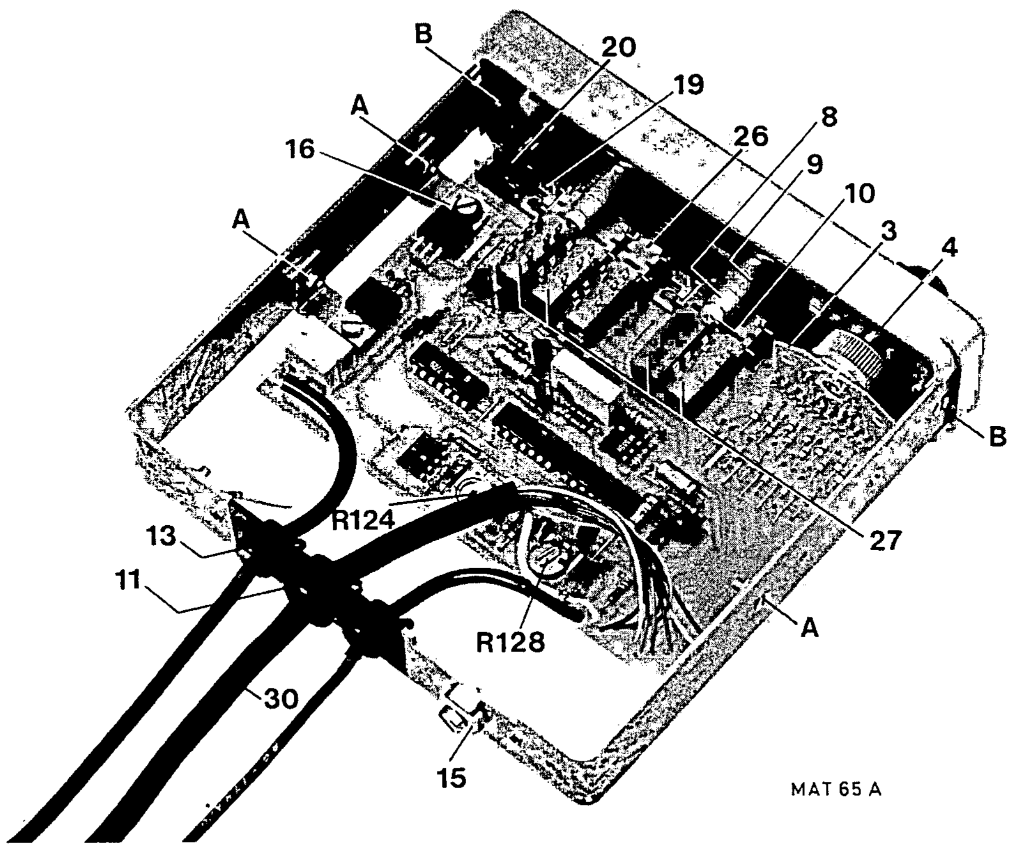


Fig. 13. Inside view, amplifier

5.2. DISMANTLING

WARNING: **The opening of covers or removal of parts, except those to which access can be gained by hand, is likely to expose live parts, and also accessible terminals may be live.**
The instrument shall be disconnected from all voltage sources before any adjustment, replacement or maintenance and repair during which the instrument will be opened. If afterwards any adjustment, maintenance or repair of the opened instrument under voltage is inevitable, it shall be carried out only by a qualified person who is aware of the hazard involved.
Bear in mind that capacitors inside the instrument may still be charged even if the instrument has been separated from all voltage sources.

ATTENTION: This section provides the dismantling procedures required for the removal of components during repair operations. When a circuit board is removed from the instrument, it should be adequately protected against damage, and all normal precautions regarding the use of tools must be observed. During dismantling procedures, a careful note must be made of all unsoldered leads that they may be soldered to their correct positions during assembly.

5.2.1. Dismantling the Amplifier (fig. 13)

- Remove the two screws at the rear of the cabinet.
- Slide the cabinet from the amplifier; all components on the printed-wiring board (p.w.b.) are now readily accessible.

To remove the printed-circuit board:

- Remove the screws (A).
- Unsolder the wire connections from the board.
- Remove the attenuator switch knob.
- Remove the two countersunk screws (item 10) that secure the pushbutton unit set to the front panel.
- Remove the two screws (B).

The printed-wiring board can now be taken out.

5.2.2. Dismantling the Probe (fig. 20)

- Loosen both screws (21) and slide the probe cover away from the case.

For probe adjusting:

- Remove the adhesive tape that covers the holes in the screening-plate.
  The adjustment points are now accessible (see fig. 15).
  After readjustment it is important to refit the adhesive tape again for screening purposes.

To replace a reed relay:

- Remove the reed relay p.w.b. at the rear of the probe case by loosening the two cross-head screws. The reed relays are now accessible.

To gain access to p.w.b. for attenuators and amplifiers:

- Loosen four screws (12) whilst holding the metal screen (13) to prevent the four retaining nuts (32) from dropping out.
- Carefully remove the metal screen. The p.w.b. is now accessible for adjustments and measurements.

For replacements, unsolder on p.w.b. side the two brown wires to the two HI terminals, and the bare earth wire. The rear of the p.w.b. is now accessible.
When re-assembling the probe, ensure good contact between the separate input terminal screening and the battery-holder screening. Also ensure good contact between the four lips of the central screening and the corresponding printed-wiring points on the board.
If necessary these lips should be bend to get good contact.

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5.3. CHECKING AND ADJUSTING

WARNING: The opening of covers or removal of parts, except those to which access can be gained by hand, is likely to expose live parts, and also accessible terminals may be live. The instrument shall be disconnected from all voltage sources before any adjustment, replacement or maintenance and repair during which the instrument will be opened. If afterwards any adjustment, maintenance or repair of the opened instrument under voltage is inevitable, it shall be carried out only by a qualified person who is aware of the hazard involved. Bear in mind that capacitors inside the instrument may still be charged even if the instrument has been separated from all voltage sources.

5.3.1. General Information

The following information provides the complete checking and adjusting procedure for the oscilloscope. As various control functions are interdependent, a certain order of adjustment is often necessary.
The procedure is, therefore, presented in a sequence which is best suited to this order, cross-reference being made to any circuit which may affect a particular adjustment.
Before any check or adjustment, the instrument must attain its normal operating temperature.

- Where possible, instrument performance is checked before an adjustment is made.
- Warming-up time under average conditions is 15 minutes.
- All limits and tolerances given in this section are calibration guides and should not be interpreted as instrument specifications unless they are also published in chapter 1.2. characteristics.
- Tolerances given are for the instrument under test and do not include test equipment error.
- Unless otherwise stated, the controls occupy the same position as in the previous check.
- The amplifier part should not be opened except where indicated in the following procedure.
- Always use fully-charged batteries.
- If during measurement, the generator signal is not required, **always** remove the connection on the generator side to ensure that the probe remains terminated with 50 ohms.

5.3.2. Recommended test equipment

- Signal Generator ~/⊓⊔ 30 V/1 MHz; e.g. PM 5127.
- Calibrated oscilloscope 10 MHz/20 mV with 'zero' facility; e.g. PM 3212.
- 50-ohm termination; e.g. PM 9585.
- BNC-input terminal assembly with soldered leads from BNC to separate connection wires (5322 267 10005 + 5322 290 34022).
- 50-ohm cable.
- 1:1 Measuring probe; e.g. PM 8921.

5.3.3. The checking and adjusting procedure

For the location of test points and adjusting elements, refer to figs. 14 and 15.

IMPORTANT: During adjusting the probe, it is required that the screening-plate stays in position. For adjusting the trimmers C201-C208-C209-C213-C214 the adhesive tape must be removed (see fig. 15). After adjustment it is important to refit the adhesive tape for screening purposes.

5.3.3.1. Power Supply

- Check supply voltages from the voltage stabiliser circuit. These should +12 V ± 5% and −12 V ± 5%.

5.3.3.2. Pre-adjustments

Offset voltage

- Make measuring set-up as in fig. 14.
- Remove the connecting cable on the generator side.
- Switch S1 (V/DIV - mV/DIV) on amplifier to position .05.
- Measure offset voltage at point B with the oscilloscope; it should be 0.4 V ± 0.2 V (use probe PM 8921).
- Check ranges .1 and .2 repeatedly for equal levels, adjusting with potentiometer **R218** if necessary.
- Remove any oscillations by means of trimmer **C226**.

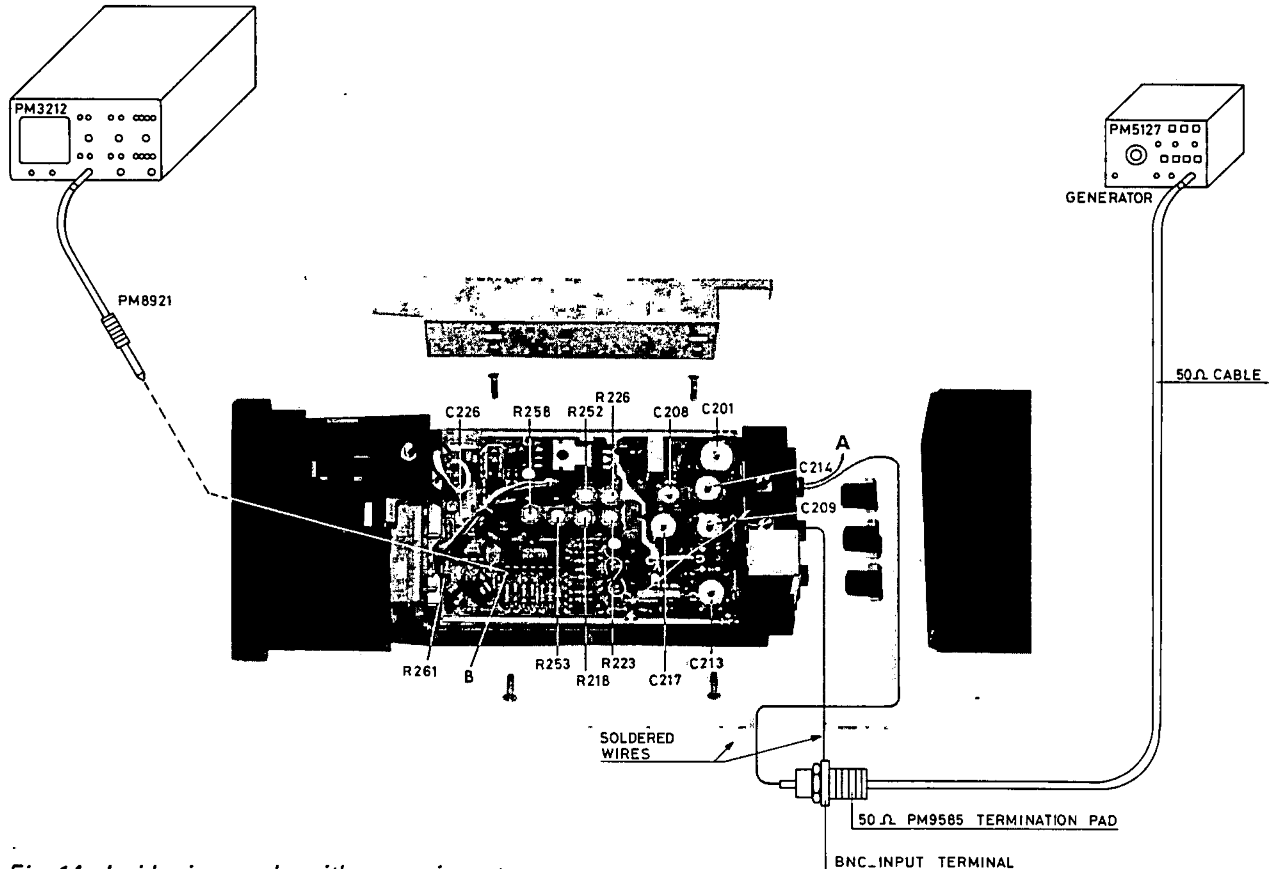

Fig. 14. Inside view, probe with measuring set-up

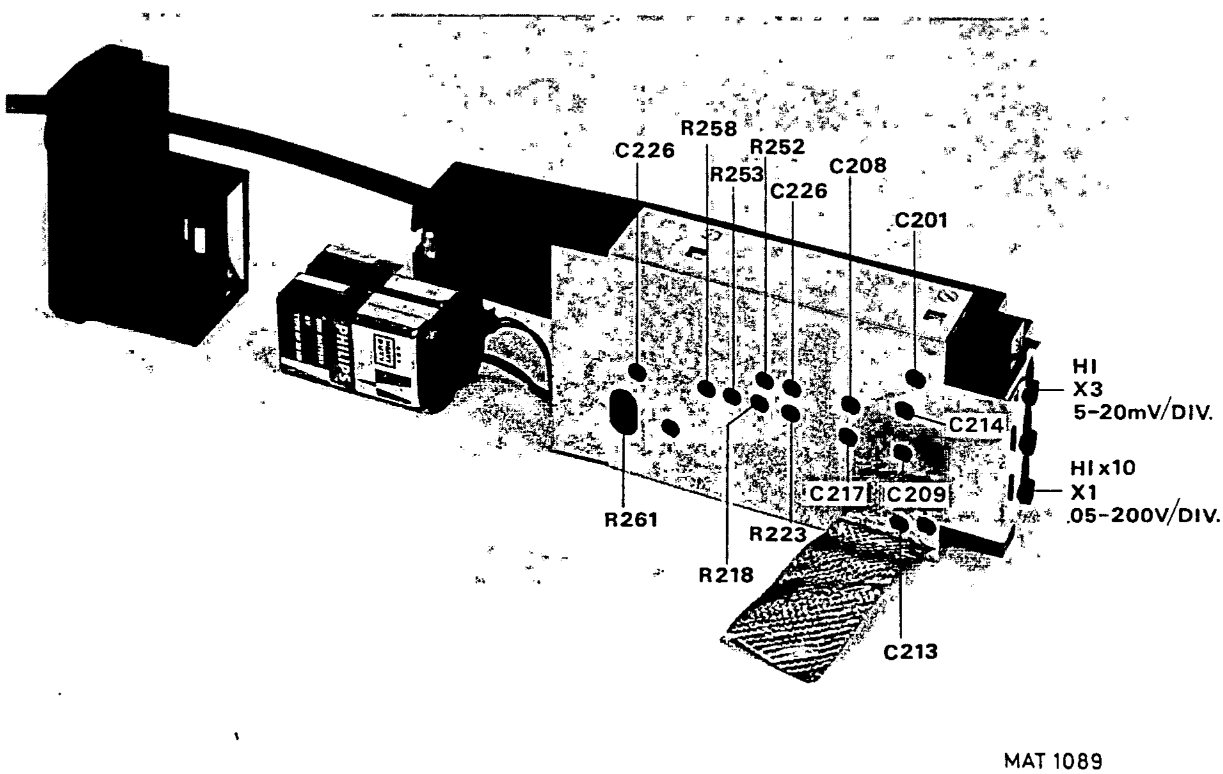

Fig. 15. Probe with screening

d.c. and a.c. current adjustments for opto-couplers (static and dynamic range) at 10 divisions.

- Reconnect cable to signal generator.
- Rotate amplifier switch S1 to .2 position (20 mV/DIV for the HI input).
- Feed a squarewave signal of 10 kHz to point A with such amplitude that 500 mV_{p-p} is measured at point B.
- Adjust the a.c. current to 4 mA by measuring the voltage developed across resistor **R261**, which should be 100 mV_{p-p}; adjust if necessary with potentiometer **R253**.
- Remove connection cable on the generator side.
- Adjust d.c. current to 8 mA (200 mV across resistor R261), adjusting with potentiometer **R252** if necessary.
- Repeat a.c. and d.c. current adjustments, if necessary. Disconnect measuring probe from point B.

Gain adjustment.

- Connect amplifier output cable to channel A of the calibrated oscilloscope.
- Remove the amplifier cabinet (see section 5.2.1.).
- Adjust output level to zero by means of potentiometer **R124** (amplifier board).
- Reconnect cable on signal generator.
- Measure the signal at the HI-input on channel B (calibrated oscilloscope) via 1:1 probe PM 8921.
- Switch S1 to position 20 V/DIV.
- Channel B to position 2 V/DIV.
- Adjust channel B to 6 DIV with generator amplitude.
- Channel A to position 20 mV/DIV.
- Adjust channel A to 6 DIV (equal to channel B) with potentiometer **R128**.
- Remove connection cable on generator side.
- Adjust d.c.-output level to 0 V with potentiometer **R124**.
- Remove the probe cover (see section 5.2.2.).
- Reconnect cable on signal generator.
- Switch S1 to position 10 V/DIV.
- Channel B to position 1 V/DIV.
- Adjust channel B to 6 DIV with generator amplitude.
- Adjust channel A to 6 DIV (equal to channel B) with potentiometer **R223**.
- Switch S1 to position 5 V/DIV.
- Channel B to position 500 mV/DIV.
- Adjust channel B to 6 DIV with generator amplitude.
- Adjust channel A to 6 DIV (equal to channel B) with potentiometer **R226**.

LF squarewave response

- Connect 1 kHz squarewave generator signal to point A.
- Set switch S1 to the .05 position (5 mV/DIV for the HI input).
- Adjust signal generator output amplitude until the oscilloscope signal is 6 divisions.
- Increase signal generator output amplitude x10 by means of the built-in step attenuator.
- Set switch S1 to the .05 position.
- Adjust trimmer **C217** for optimum squarewave response in the centre of the c.r.t. screen.
- Set switch S1 to the 5 position.
- Increase the signal generator output x10.
- Adjust trimmer **C209** for optimum squarewave response.
- Set switch S1 to the 50 position.
- Set signal generator for maximum output (3 divisions max. can be obtained).
- Adjust trimmer **C213** for optimum squarewave response.
- Disconnect the signal from point A and connect it to the HI x 10 input.
- Set switch S1 to the .05 V position (5 mV/DIV for the HI input).
- Adjust generator output signal until the oscilloscope trace amplitude of channel A is 6 divisions.
- Adjust trimmer capacitor **C208** to obtain minimum undershoot/overshoot.
- Set switch S1 to the .5 position.
- Increase the signal generator amplitude x10.
- Adjust capacitor **C214** for minimum undershoot/overshoot.
- Disconnect the signal from input HI x 10 and connect it to the HI input (point A).
- Set switch S1 to the .05 position.
- Adjust the signal generator amplitude until the oscilloscope trace amplitude of channel A is 6 divisions.
- Adjust trimmer capacitor **C201** for minimum undershoot/overshoot.

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HF adjustment

- Connect the generator signal with the HI input (point A).
- Set signal generator to 10 kHz squarewave output.
- Set switch S1 to the 5 position.
- Set oscilloscope to the 20 mV/DIV position.
- Adjust the generator output until the oscilloscope trace amplitude of channel A is 6 divisions.
- Adjust potentiometer **R258** and trimmer **C226** for minimum trace aberrations; these should be less than 3%.

Measurements:

- Increase the signal generator amplitude for a trace height of 8 divisions.
- Change vertical deflection on oscilloscope from 20 mV/DIV to 10 mV/DIV.
  The trace height should now be 16 divisions, each with 5 sub-divisions.
  Each sub-division represents 1.25%.
- Return oscilloscope to the 20 mV/DIV position.
- Disconnect the connection cable on the generator side.
- Check the d.c. balance on all ranges of S1.
- Switch off the amplifier to conserve the batteries.

5.3.3.3. Final Adjustment

- Fit the cover of the probe section.
- Switch on the amplifier.
- Allow a 15 minute warm-up period.
- Connect a signal generator signal of 1 kHz squarewave to the HI x 10 input.
- Set oscilloscope to the 20 mV/DIV position.
- Connect the amplifier output to the Y_A input of the oscilloscope.
- Set switch S1 to the .2 position.
- Adjust the signal amplitude to 6 DIV trace height (channel A).
- Connect the Y_B input of the oscilloscope to the HI x 10 input by means of the measuring probe PM 8921.
- Set the channel B AMPL/DIV switch to .2 V.
- Adjust potentiometer **R128** so that the amplifier output signal on Y_A is equal to that on Y_B.
- Disconnect the cable on the signal generator side.
- Adjust the d.c. level to 0 V by means of potentiometer **R124**.

6. CORRECTIVE MAINTENANCE

**WARNING: The opening of covers or removal of parts, except those to which access can be gained by hand, is likely to expose live parts, and also accessible terminals may be live.
The instrument shall be disconnected from all voltage sources before any adjustment, replacement or maintenance and repair during which the instrument will be opened.
If afterwards any adjustment, maintenance or repair of the opened instrument under voltage is inevitable, it shall be carried out only by a qualified person who is aware of the hazard involved.
Bear in mind that capacitors inside the instrument may still be charged even if the instrument has been separated from all voltage sources.**

6.1. IMPORTANT NOTES

Damage may result if the instrument is switched on when a printed circuit board has been removed, or if a circuit board is removed within one minute after switching off the instrument.
How to open the instrument is outlined in chapter 5.2. "Dismantling".

6.2. REPLACEMENTS

6.2.1. Standard parts

Electrical and mechanical part replacements can be obtained through your local Philips organisation or representative. However, many of the standard electronic components can be obtained from other local suppliers.
Before purchasing or ordering replacement parts, check the parts list for value tolerance, rating and description.

NOTE: Physical size and shape of a component may affect instrument performance, particularly at high frequencies. Always use direct-replacement components, unless it is known that a substitute will not degrade the instrument's performance.

6.2.2. Special parts

In addition to the standard electronic components, some special components are used.
These components are manufactured or selected by Philips to meet specific performance requirements.

6.2.3. Transistors and integrated circuits

Transistors and IC's (integrated circuits) should not be replaced unless they are actually defective.
If removed from their sockets during routine maintenance return them to their original sockets.
Unnecessary replacement or switching of semiconductor devices may affect the calibration of the instrument. When a transistor is replaced, check the operation of the part of the instrument that may be affected.
Any replacement component should be of the original type or a direct replacement. Bend the leads to fit the socket and cut the leads to the same length as on the component being replaced.

WARNING: Silicone grease is used to facilitate the conduction of heat between power transistors and their heatsink. Handle silicone grease with care. Avoid getting silicone grease in the eyes. Wash hands thoroughly after use.

6.2.4. Removing a single push-button segment

To remove a push-button switch, the Hexagon screws that secure it to the front panel must be removed. To replace one switch-section of a push-button set, refer to fig. 16, and proceed as follows:

- Remove the printed-circuit board for replacing a switch in this unit.
- Straighten the 4 retaining lugs of the relevant switch as shown in fig. 16.
- Break the body of the relevant switch by means of a pair of pliers and remove the pieces. The soldering pins are then accessible.
- Remove the soldering pins and clean the holes in the printed-wiring board (e.g. with a suction soldering iron).
- Solder the new switch on the printed-circuit board.
- Band the 4 retaining lugs back to their original positions.

Before a push-button switch is refitted to the front panel, it is advisable to stick the two parts of the clamping device together by means of adhesive tape or non-hardening glue, in order to facilitate replacement, refer to fig. 17.

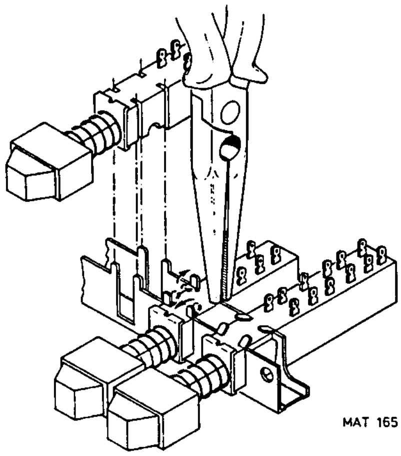


Fig. 16. Replacing a switch-segment of a push-button set

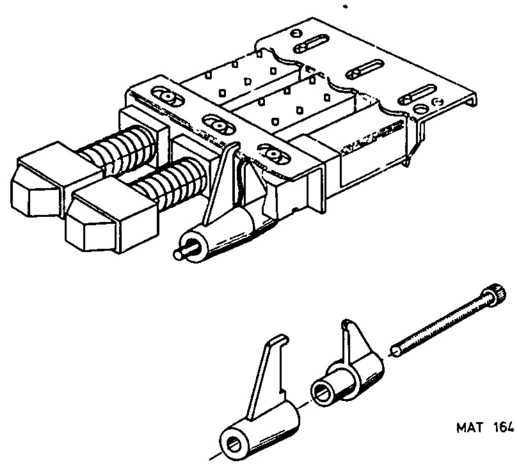


Fig. 17. Push-button set clamping device

6.2.5. Soldering techniques

Ordinary 60/40 solder and a 35 ... 40 Watt pencil type soldering iron can be used for the majority of the soldering. If a higher wattage-rating soldering iron is used on the etched circuit boards, excessive heat can cause the etched circuit wiring to separate from the base material.

6.3. RECALIBRATION AFTER REPAIR

After any electrical component has been replaced the calibration of that particular circuit should be checked, as well as the calibration of other closely related circuits.
Since the power supply affects all circuits, calibration of the entire instrument should be checked if work has been done on the power supply.

6.4. INSTRUMENT REPACKING

If the instrument is to be shipped to a Service Centre for service or repair, attach a tag showing owner (with address) and the name of an individual at your firm who can be contacted. The Service Centre needs the complete instrument serial number and a fault description.
Save and re-use the packing in which your instrument was shipped. If the original packing is unfit for use or not available, repack the instrument in such a way that no danger occurs during transport.

6.5. TROUBLE-SHOOTING

6.5.1. Introduction

The following information is provided to facilitate trouble-shooting. Information contained in other sections of this manual should be used along with the following information to aid in locating the defective component.
An understanding of the circuit operation is helpful in locating troubles, particularly where integrated circuits are used. Refer to the Circuit Description section for this information.

6.5.2. Trouble-shooting hints

If a fault appears, the following test sequence can be used to find the defective circuit part:

- Check if the settings of the controls are correct. Consult the operating instructions in the operating manual.
- Check the equipment to which the PM 8940 is connected and the interconnection cables.
- Check if the PM 8940 is well-calibrated. If not refer to section 5.3. (checking and adjusting).
- Visually check the part in which the fault is suspected. In this way, it is possible to find faults such as bad soldering connections, bad interconnection plugs and wires, damaged components or transistors and IC's that are not correctly plugged into their sockets.
- Location of the circuit part in which the fault is suspected: the symptom often indicates this part of the circuit. If the power supply is defective the symptom will appear in several circuit parts.

After having carried out the previous steps, individual components in the suspected circuit parts must be examined:

- Transistors and diodes. Check the voltage between base and emitter (0.7 Volt approx. in conductive state) and the voltage between collector and emitter (0.2 Volt approx. in saturation) with a voltmeter or oscilloscope.
  When removed from the p.c.b. it is possible to test the transistor with an ohmmeter since the base/emitter and base/collector junctions can be regarded as diodes. Like a normal diode, the resistance is very high in one direction and low in the other direction. When measuring take care that the current from the ohmmeter does not damage the component under test.
  Replace the suspected component by a new one if you are sure that the circuit is not in such a condition that the new one will be damaged.
- Integrated circuits. In circuit testing can be done with an oscilloscope or voltmeter. A good knowledge of the circuit part under test is essential. Therefore first read the circuit description.
- Capacitors. Leakage can be traced with an ohmmeter adjusted to the highest resistance range.
  When testing take care of polarity and maximum allowed voltage. An open capacitor can be checked if the response for AC signals is observed. Also a capacitance meter can be used: compare the measured value with value and tolerance indicated in the parts list.
- Resistors. Can be checked with an ohmmeter after having unsoldered one side of the resistor from the p.c.b. Compare the measured value with value and tolerance indicated in the parts list.
- Coils and transformers. An ohmmeter can used for tracing an open circuit. Shorted or partially shorted windings can be found by checking the wave-form response when HF signals are passed through the circuit. Also an inductance meter can be used.

NOTE: *If a component must be replaced always use a direct-replacement. If not available use an equivalent after carefully checking that it does not degrade the instrument's performance. See also section 6.2. (replacement).*
After replacement of a component the calibration of the instrument may be affected due to component tolerances. If necessary do the required adjustments.

7.2. ELECTRICAL PARTS

ITEM	ORDERING NUMBER	FARAD	TOL (%)	VOLTS	REMARKS
CAPACITORS					
C 101	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 102	4822 121 40257				POLYESTER FOIL
C 103	4822 124 20687	15UF	-10+50	16	ELECTROLYTIC
C104	5322 124 14101	15UF	20	15V	ELECTROLYTIC TANTALUM
C 105	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 106	4822 124 20687	15UF	-10+50	16	ELECTROLYTIC
C 107	4822 124 20687	15UF	-10+50	16	ELECTROLYTIC
C 108	4822 121 40232				POLYESTER FOIL
C 109	4822 121 40232				POLYESTER FOIL
C 110	4822 122 30093	120PF	2	100	CERAMIC PLATE
C 111	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 112	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C113	4822 124 20728	10UF -	10+50	63V .	ELECTROLYTIC
C114	5322 121 40323	100NF	10	000000	POLYESTER FOIL
C 201	5322 125 54056				TRIMMER
C 202	4822 122 30093	120PF	2	100	CERAMIC PLATE
C203	4822 122 31067	33PF	2		CERAMIC PLATE
C 206	5322 121 44137				POLYESTER FOIL
C 207	4822 122 31196	12PF	2	500	CERAMIC PLATE
C 208	5322 125 50049				TRIMMER
C 209	4822 125 50077				TRIMMER
C 210	4822 122 31196	12PF	2	500	CERAMIC PLATE
C 211	4822 122 31192	6,8PF	0,25PF	500	CERAMIC PLATE
C 212	4822 122 31192	6,8PF	0,25PF	500	CERAMIC PLATE
C 213	4822 125 50077				TRIMMER
C 214	4822 125 50077				TRIMMER
C 216	4822 122 31081	100PF	2	100	CERAMIC PLATE
C 217	4822 125 50088				TRIMMER
C 218	4822 121 50566				POLYSTYRENE FOIL
C 219	5322 121 54154				POLYSTYRENE FOIL
C 221	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C222	5322 124 14101	15UF	20	15V	ELECTROLYTIC TANTALUM
C 223	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C 224	4822 122 30114	2,2NF	-20+80	40	CERAMIC PLATE
C225	4822 122 31058	15PF	2%		CERAMIC PLATE
C 226	5322 125 50049				TRIMMER
C227	5322 124 14101	15UF	20	15V.	ELECTROLYTIC TANTALUM
C228	5322 124 14101	15UF	20	15V.	ELECTROLYTIC TANTALUM
C 229	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE
C230	4822 122 31172	180PF	10	100V.	CERAMIC PLATE
C 231	4822 122 30043	10NF	-20+80	40	CERAMIC PLATE

ITEM	ORDERING NUMBER	OHM	TOL (%)	TYPE	REMARKS
RESISTORS					
R 101	5322 116 50664	2,05K	1	MR25	METAL FILM
R 102	5322 116 50926	40,2	1	MR25	METAL FILM
R 103	5322 116 50728	1,87K	1	MR25	METAL FILM
R 104	5322 116 54386	249K	1	MR25	METAL FILM
R105	5322 116 54442	51,1	1	MR25 .	METAL FILM
R 106	4822 110 63214	10M	10	CR25	CARBON
R 107	4822 116 51253	10K	1	MR25	METAL FILM
R 108	4822 116 51253	10K	1	MR25	METAL FILM
R 109	4822 116 51253	10K	1	MR25	METAL FILM
R110	5322 116 50555	1K27	1	MR25 .	METAL FILM
R 111	4822 116 51253	10K	1	MR25	METAL FILM
R 112	5322 116 54623	11K	1	MR25	METAL FILM
R113	5322 116 50679	237	1	MR25 .	METAL FILM
R 114	5322 116 50664	2,05K	1	MR25	METAL FILM
R 116	5322 116 54653	28,7K	1	MR25	METAL FILM
R 117	4822 116 51253	10K	1	MR25	METAL FILM
R 118	4822 116 51235	1K	1	MR25	METAL FILM
R119	5322 116 55318	511	1	MR25 .	METAL FILM
R121	5322 116 50571	715	1	MR25 .	METAL FILM
R122	5322 116 51052	42,2	1	MR25 .	METAL FILM
R123	5322 116 54532	649	1	MR25 .	METAL FILM
R 124	5322 101 14252	3,3K	20	0,5W	TRIMMING POTM
R126	5322 116 50636	2K74	1	MR25 .	METAL FILM
R127	5322 116 54474	110	1	MR25 .	METAL FILM
R128	5322 101 14009	220	20	0,5W .	TRIMMING POTM
R 129	5322 116 54608	7,5K	1	MR25	METAL FILM
R 131	5322 116 55459	15,4K	1	MR25	METAL FILM
R 201	5322 116 55335	383K	1	MR25	METAL FILM
R 202	5322 116 55258	511K	1	MR25	METAL FILM
R 203	4822 116 60037	9M	1	SPEC	METAL OXIDE
R 204	5322 116 55275	1M	1	MR30	METAL FILM
R 206	4822 116 51246	3,01K	1	MR25	METAL FILM
R 207	5322 111 44203	9M	1	SPEC	CARBON
R 208	5322 116 55275	1M	1	MR30	METAL FILM
R 209	5322 111 44203	9M	1	SPEC	CARBON
R 211	5322 116 54694	90,9K	1	MR25	METAL FILM
R 212	5322 111 44203	9M	1	SPEC	CARBON
R 213	5322 116 55277	9,09K	1	MR25	METAL FILM
R 214	4822 110 73187	1M	5	CR25	CARBON PIN-HEAD
R 216	5322 116 55366	301	1	MR25	METAL FILM
R217	5322 116 54603	6K49	1	MR25 .	METAL FILM
R 218	5322 100 10135	470	20	0.75W	TRIMMING POTM
R219	5322 116 54603	6K49	1	MR25 .	METAL FILM
R 221	4822 116 51246	3,01K	1	MR25	METAL FILM
R222	5322 116 54569	1K91	1	MR25.	METAL FILM
R 223	5322 100 10135	470	20	0.75W	TRIMMING POTM
R224	5322 116 50561	590	1	MR25.	METAL FILM
R 226	5322 100 10138	100	20	0.75W	TRIMMING POTM
R 227	5322 116 50664	2,05K	1	MR25	METAL FILM
R 228	5322 116 55425	5,62K	1	MR25	METAL FILM
R 229	5322 116 55425	5,62K	1	MR25	METAL FILM
R 231	5322 116 50664	2,05K	1	MR25	METAL FILM
R 232	5322 116 55425	5,62K	1	MR25	METAL FILM
R 233	5322 116 54603	6,49K	1	MR25	METAL FILM
R 234	4822 116 51235	1K	1	MR25	METAL FILM
R 236	5322 116 50664	2,05K	1	MR25	METAL FILM
R 237	5322 116 54603	6,49K	1	MR25	METAL FILM
R 238	5322 116 50458	7,87K	1	MR25	METAL FILM
R 239	5322 116 54595	5,11K	1	MR25	METAL FILM
R 241	5322 116 54595	5,11K	1	MR25	METAL FILM
R 242	4822 116 51246	3,01K	1	MR25	METAL FILM
R 243	5322 116 50458	7,87K	1	MR25	METAL FILM
R 244	5322 116 54603	6,49K	1	MR25	METAL FILM
R 246	5322 116 54603	6,49K	1	MR25	METAL FILM
R247	5322 116 50664	2K05	1	MR25.	METAL FILM
R 248	5322 116 55419	20,5K	1	MR25	METAL FILM
R 249	5322 116 54595	5,11K	1	MR25	METAL FILM
R 251	5322 116 50415	1,15K	1	MR25	METAL FILM
R 252	5322 100 10144	2,2K	20	0.75W	TRIMMING POTM
R 253	5322 100 10135	470	20	0.75W	TRIMMING POTM
R 254	5322 116 55276	13,3K	1	MR25	METAL FILM
R256	5322 116 54506	287	1	MR25.	METAL FILM
R 257	4822 116 51253	10K	1	MR25	METAL FILM
R 258	5322 100 10143	1K	20	0.75W	TRIMMING POTM
R 259	5322 116 54459	75	1	MR25	METAL FILM
R 261	5322 116 50903	24,9	1	MR25	METAL FILM
R 262	5322 116 54442	51,1	1	MR25	METAL FILM

ITEM	ORDERING NUMBER	TYPE/DESCRIPTION
SEMI CONDUCTORS		
V 101	4822 130 30613	BAW62
V 102	4822 130 30613	BAW62
V 103	4822 130 30613	BAW62
V 104	4822 130 30613	BAW62
V105	4822 130 30613	BAW 62
V 106	4822 130 30613	BAW62
V 107	4822 130 30613	BAW62
V 108	4822 130 30613	BAW62
V 109	4822 130 30613	BAW62
V110	4822 130 30613	BAW 62
V 111	4822 130 30613	BAW62
V 112	4822 130 30613	BAW62
V 113	4822 130 30613	BAW62
V 114	4822 130 30613	BAW62
V115	4822 130 30613	BAW 62
V 116	4822 130 30613	BAW62
V 117	4822 130 30613	BAW62
V 118	4822 130 30613	BAW62
V 119	4822 130 30613	BAW62
V120	4822 130 30613	BAW 62
V 121	4822 130 30613	BAW62
V 122	4822 130 30613	BAW62
V 123	4822 130 30613	BAW62
V 124	4822 130 30613	BAW62
V125	4822 130 30613	BAW 62
V 126	4822 130 44196	BC548C
V 127	4822 130 44196	BC548C
V 128	4822 130 44196	BC548C
V 129	4822 130 30613	BAW62
V130	4822 130 30613	BAW 62
V 131	4822 130 44196	BC548C
V 132	4822 130 30613	BAW62
V 133	4822 130 30613	BAW62
V 134	4822 130 44197	BC558B
V135	4822 130 30613	BAW 62
V 136	4822 130 44196	BC548C
V 137	4822 130 44197	BC558B
V138	4822 130 30613	BAW 62
V139	4822 130 30613	BAW 62
V 201	5322 130 40709	ON561
V 202	5322 130 34037	BAV45
V 203	4822 130 44197	BC558B
V 204	4822 130 44197	BC558B
V 206	4822 130 30613	BAW62
V 207	4822 130 30613	BAW62
V 208	5322 130 40482	BRY39
V 209	4822 130 34047	BZX75-C1V4
V 211	4822 130 44196	BC548C
V 212	4822 130 44196	BC548C
V 213	4822 130 30613	BAW62
INTEGRATED CIRCUITS		
D 101	5322 209 85824	NE555N
D 102	5322 209 84823	N74LS00N
D 103	5322 209 84998	N74LS93N
D 104	5322 209 84998	N74LS93N
D 106	4822 209 80617	UA741CN
D 107	5322 209 85769	79M12CU
D 108	5322 209 86227	78M12CU
D 201	5322 209 86236	CA3086
D202	5322 209 86285	NE 5534 N
D 203	4822 209 80617	UA741CN
D204-206	5322 209 86427	OPTO COUPLER SEL
D 207	5322 209 85999	79M05CU
D 208	5322 209 86027	78M05CU
MISCELLANEOUS		
B1	4822 130 31144	CQY 24B-111
K101-104	5322 280 24135	REED CONTACT
K106-109	5322 280 24135	REED CONTACT
K111-112	5322 280 24135	REED CONTACT
X 4	5322 264 10025	BNC CONNECTOR
	5322 252 24006	THERMAL FUSE

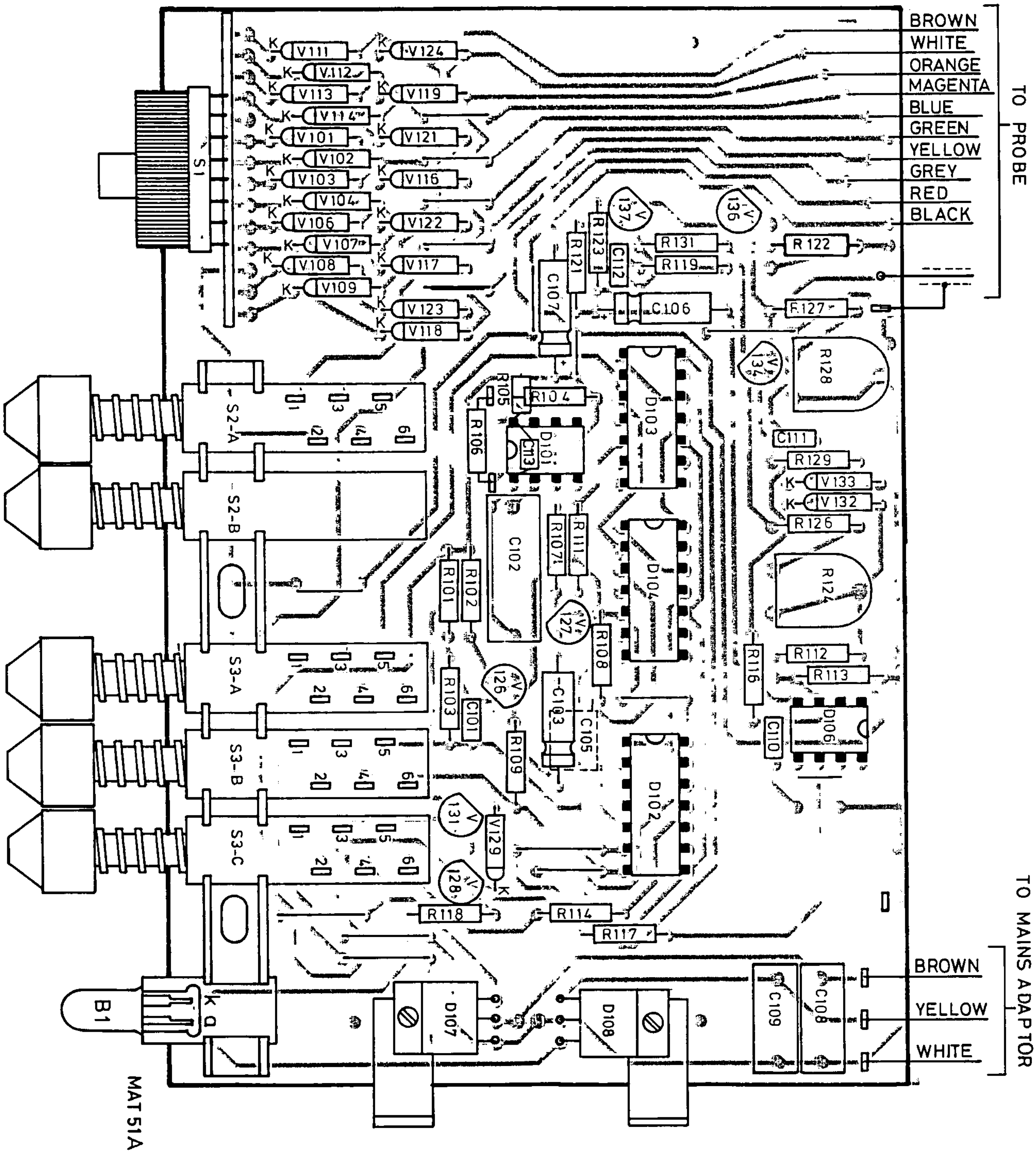


Fig. 21. Printed wiring board of amplifier

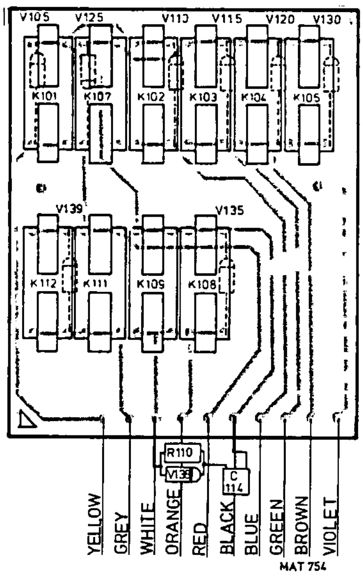


Fig. 22a. Version 1.

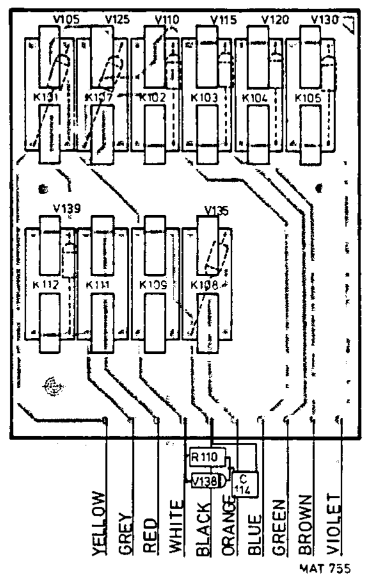


Fig. 22b. Version 2.

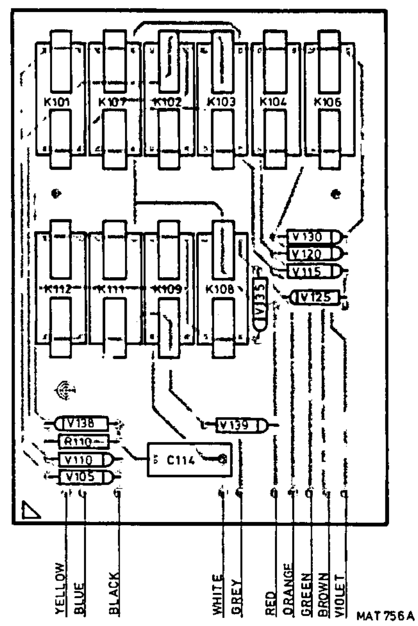


Fig. 22c. Version 3.

Fig. 22. Printed wiring board of relay driver

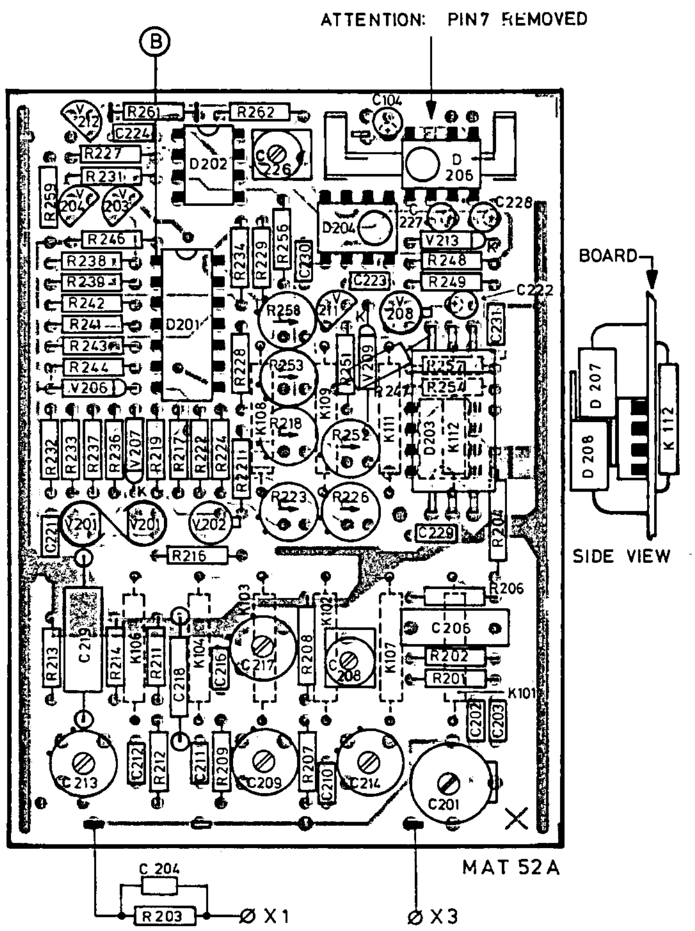
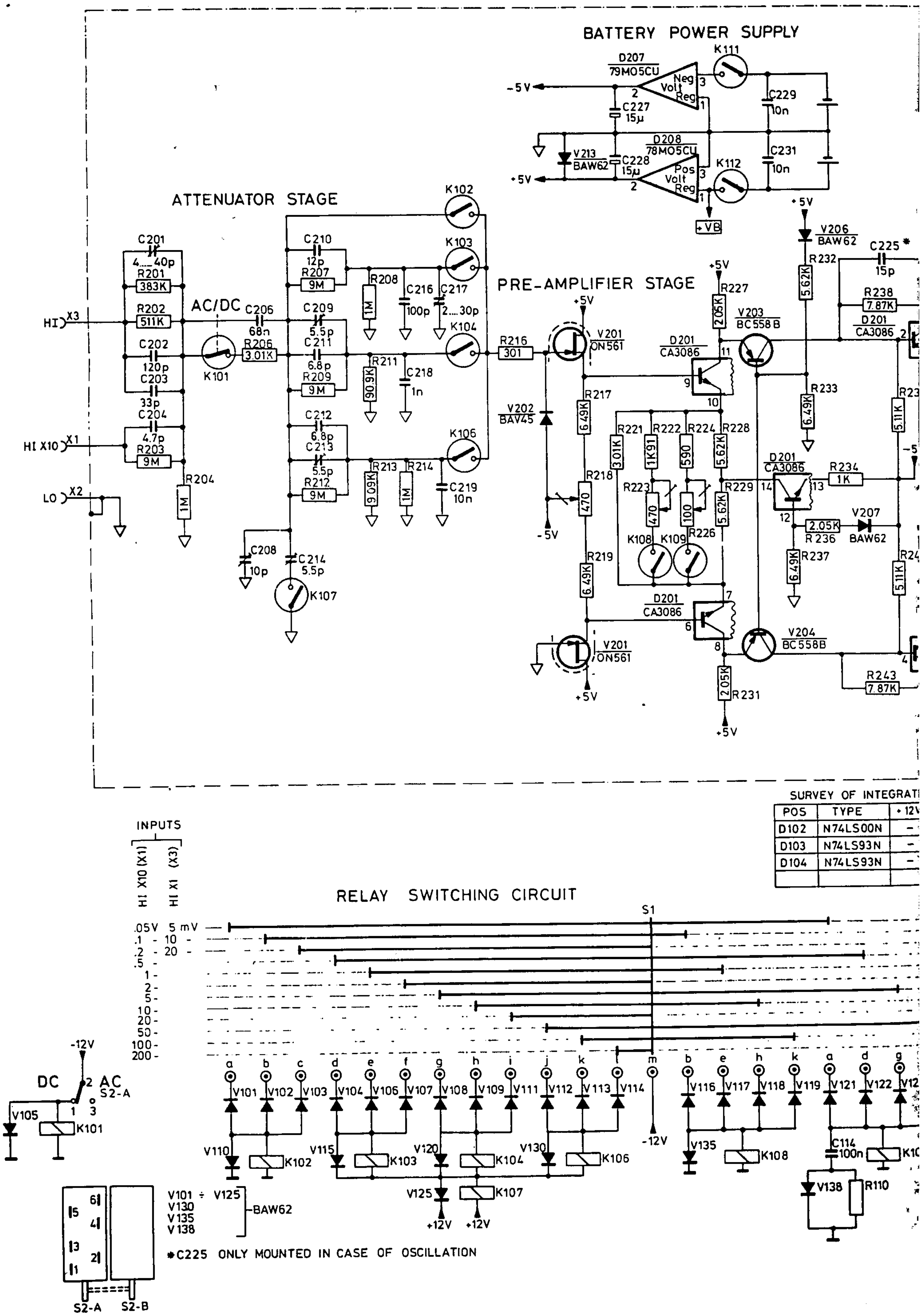


Fig. 23. Printed wiring board of probe



SURVEY OF INTEGRATI

POS	TYPE	+12V
D102	N74LS00N	–
D103	N74LS93N	–
D104	N74LS93N	–

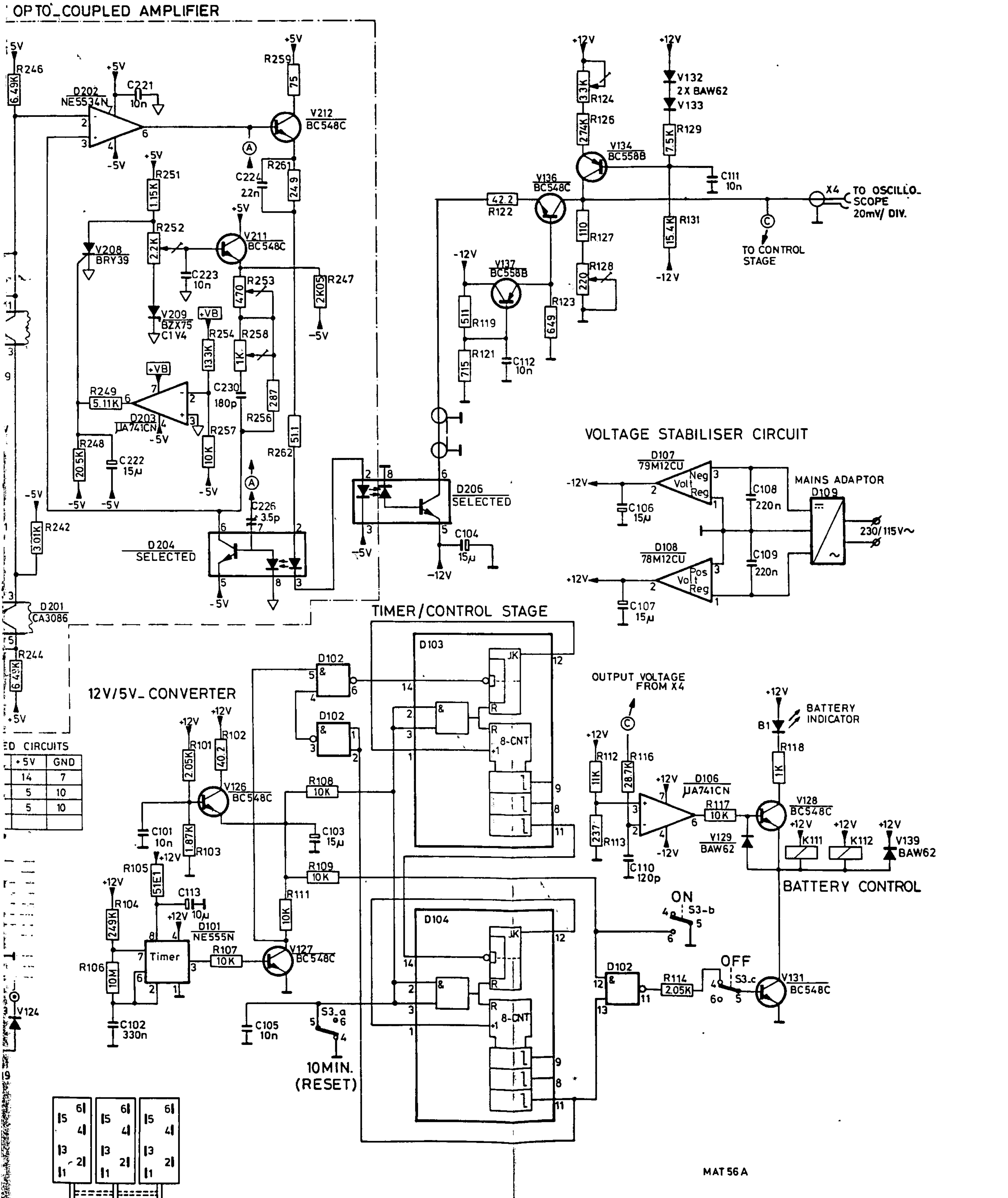


Fig. 24. Overall circuit diagram