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5002

WIDEBAND LEVEL METER

RACAL-DANA

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1.1 SPECIFICATION

1.1.1 The published specification for the Racal-Dana Wideband Level Meter Model 5002 is given in Table 1.1.

TABLE 1.1

Technical Specification

OPERATING MODES	
Measurement Functions:	The 5002 measures true r.m.s. voltage, mean voltage and positive or negative peak voltage. The measurements made may be displayed in voltage units, or converted, using a number of stored parameters, to provide a display of: (1) Average or peak power, in watts, computed from the measured voltage and a stored resistance value. (2) The ratio of the computed power to a stored power level. This displayed ratio may be numeric or expressed in dB. If the stored power level is 1 mW the computed power will be displayed in dBm. (3) The ratio of the measured voltage, r.m.s., peak or mean, to a stored voltage level. The ratio may be numeric or expressed in dB. If the stored voltage level and resistance value correspond to 1 mW, power ratios will be displayed in dBm. (4) The difference between the measured voltage and a stored voltage level. (5) The difference between the computed power and a stored power level. (6) The difference as in (4) expressed as a percentage of the stored voltage level. (7) The difference as in (5) expressed as a percentage of the stored power level.

TABLE 1.1 (Continued)

Technical Specification

ELECTRICAL CHARACTERISTICS	
Frequency Range:	DC and from 5 Hz to 20 MHz. For mean and peak measurements the frequency range is to 10 MHz.
Input Filter:	An internal single pole RC filter may be switched in to restrict the upper limit of the frequency range to 200 kHz (-3 dB).
Voltage Range:	Measuring r.m.s. voltage: 30 µV to 316 V Measuring peak or mean voltage: 1 mV to 316 V
Measurement Ranges:	The instrument has fourteen measurement ranges with full scale readings of: 100 µV 1 mV 1 V 316 µV 3.16 mV 3.16 V 10 mV 10 V 31.6 mV 31.6 V 100 mV 100 V 316 mV 316 V
Computed Power Range:	Using the limit values of stored resistance, True power range: 0.1 pW to 9 kW. Peak power range: 100 pW to 9 kW.
Input Resistance:	Approximately 1 MΩ.
Input Capacitance:	Approximately 40 pF on 1 V range and above. Approximately 65 pF on 316 mV range and below.
Maximum Permitted Input Levels:	The DC level plus peak AC level must not exceed 500 V on any range. The maximum r.m.s input must not exceed the values shown in Fig. 1.1.
Crest Factor:	The range of crest factor of the measured waveform over which the specified accuracy will be maintained is shown in Fig. 1.2.

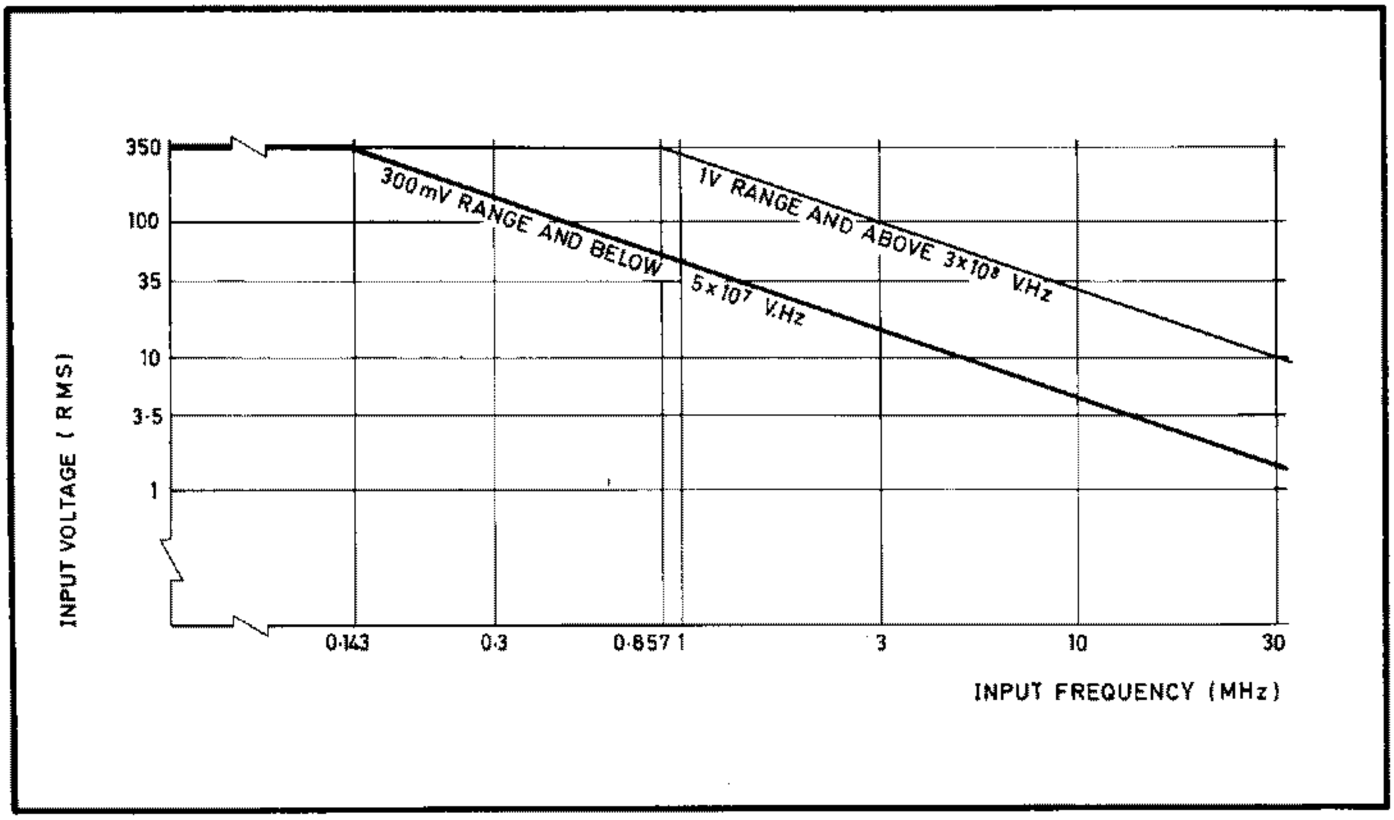


Fig. 1.1 Maximum RMS Input Levels

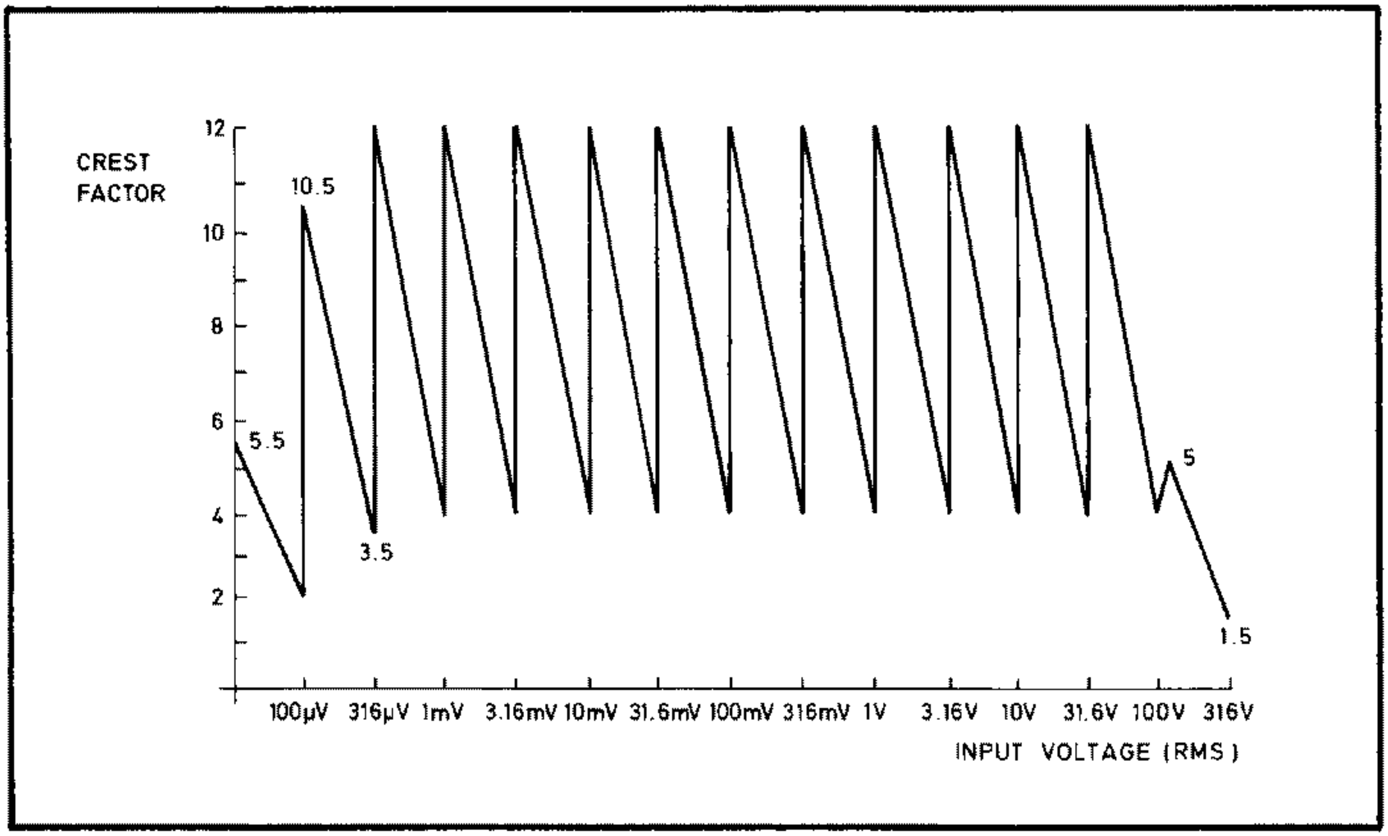


Fig. 1.2 Input Waveform Crest Factor Limits

TABLE 1.1 (Continued)

Technical Specification

ELECTRICAL CHARACTERISTICS (Continued)	
Voltage Measurement Accuracy:	The specified measurement accuracy for a sinusoidal input signal within the limits of 30% and 100% of the selected range, at an ambient temperature in the range from 18°C to 28°C, is ±0.5% of range ± (percentage of reading + zero error) as shown in Figs. 1.3, 1.4 and 1.5.
Digitising Error:	Add 0.1% of f.s.d. to the values given in Figs. 1.3, 1.4 and 1.5.
Temperature Coefficients:	When operating in the ambient temperature ranges from 0°C to 18°C and from 28°C to 55°C the following additional errors must be added to the figures obtained from Figs. 1.3, 1.4 and 1.5. AC measurement: ±0.04% per °C AC + DC measurement: ±0.1% per °C at 10 mV or above. Add a further ±10 μV per °C below 10 mV. DC measurement: ±0.1% per°C at 10 mV or above. Add a further ±10 μV per °C below 10 mV.
Power Measurement Accuracy:	Double the uncertainty for the equivalent voltage measurement.
Averaging Time:	The period between display updates, during which a number of measurements made are averaged, can be set in steps of 0.1 second between 0.1 second and 99.9 seconds (nominal). On switching on a value of 1 second is adopted automatically.
Analogue Settling Time:	The analogue settling time is 2 seconds. This is independent of the averaging time in use.

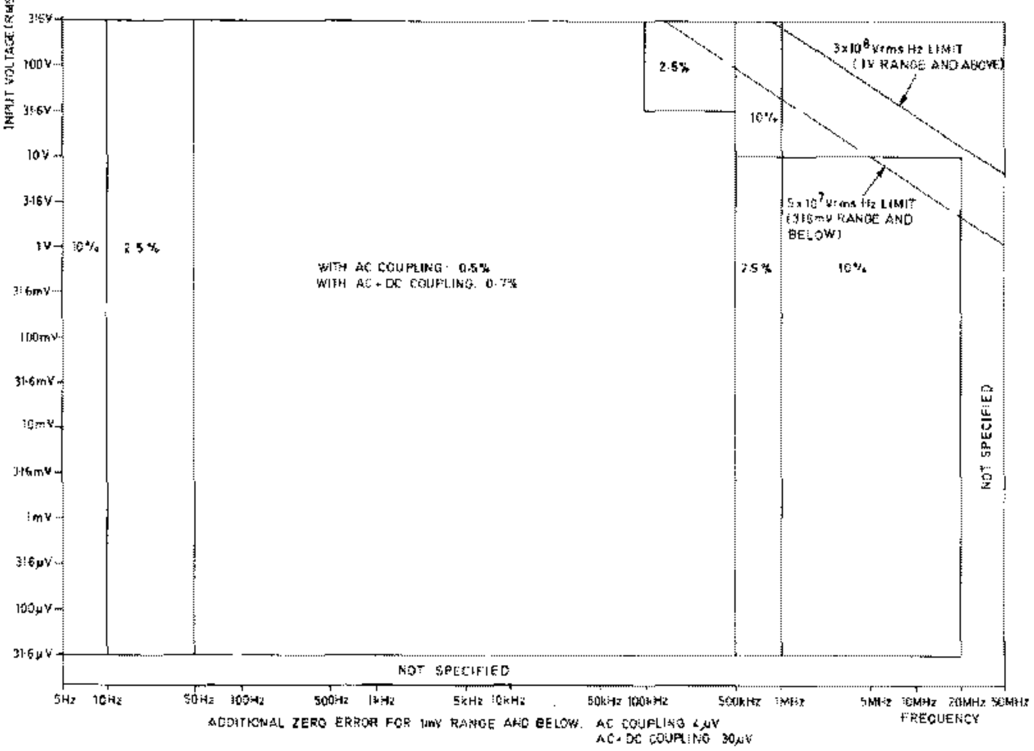


Fig. 1.3 Measurement Accuracy - R.M.S.

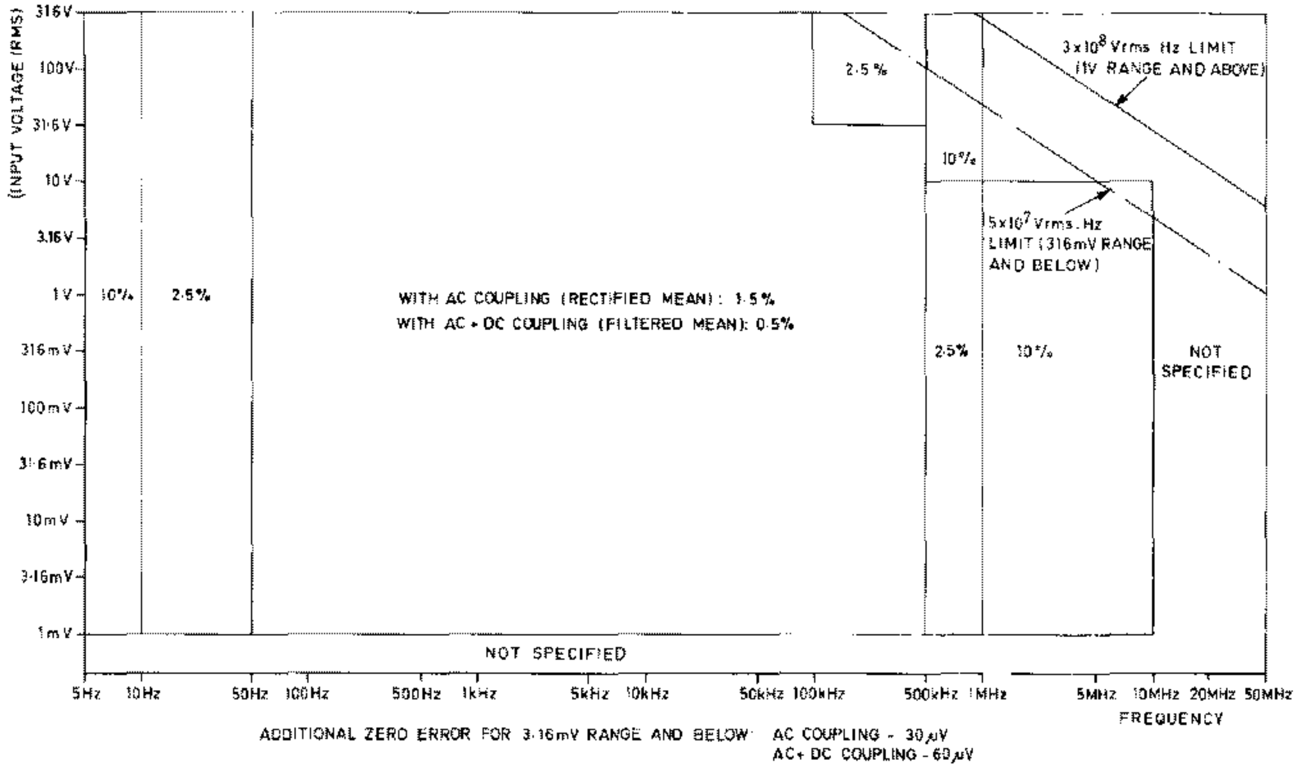


Fig. 1.4 Measurement Accuracy - Mean

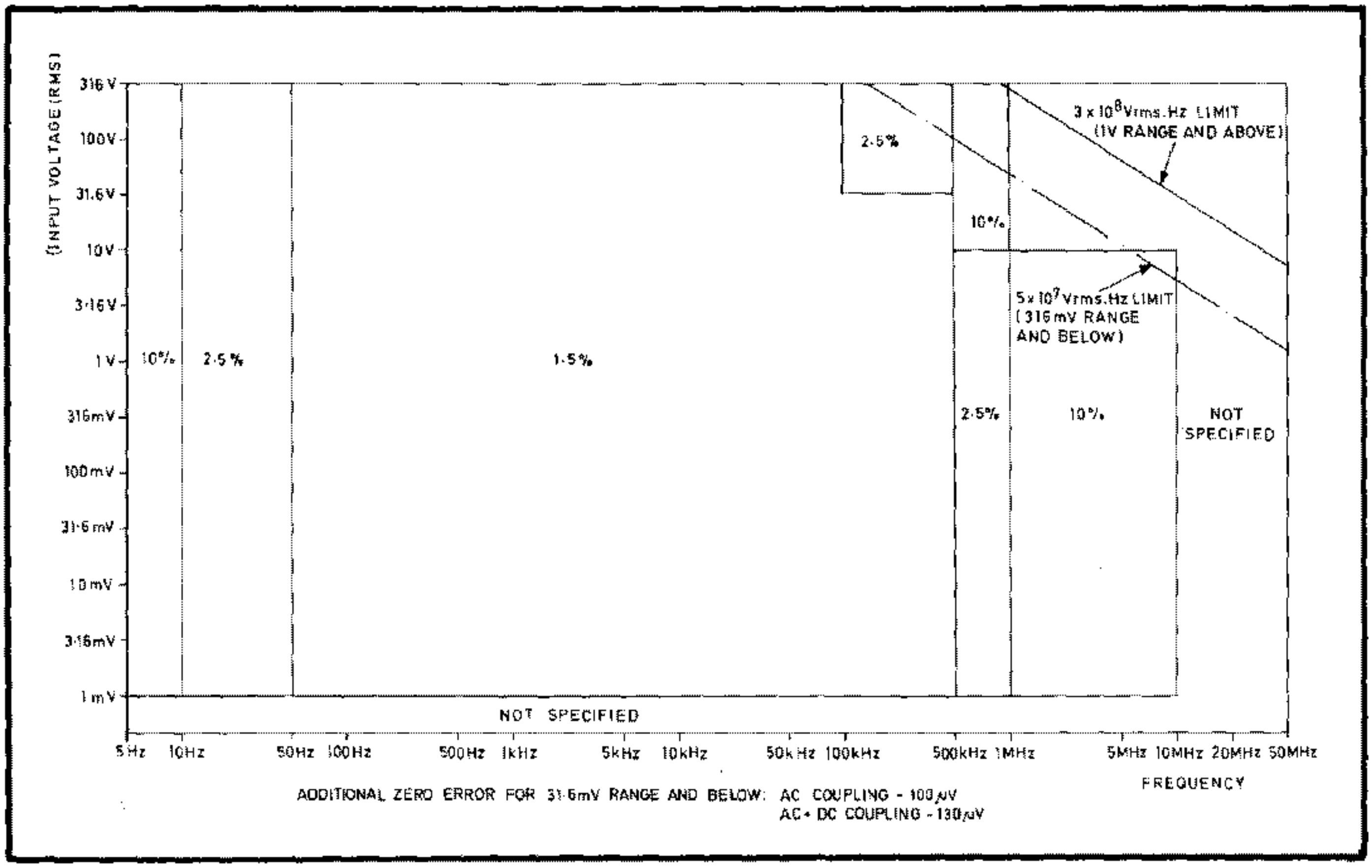


Fig. 1.5 Measurement Accuracy - Peak

TABLE 1.1 (Continued)

Technical Specification

ELECTRICAL CHARACTERISTICS (Continued)	
Input Connector:	A BNC connector is mounted on the front panel.
Input Isolation:	The input connector shell (common terminal) is isolated from chassis earth by a pair of back-to-back diodes. The permissible voltage difference is approximately 0.5 V. The maximum current between the common terminal and chassis earth must not exceed 5 A. A switch is provided to allow the common terminal to be held at chassis earth.

TABLE 1.1 (Continued)

Technical Specification

GPIB INTERFACE	
Function Subsets:	The interface operates in accordance with the following IEEE/IEC defined subsets: Source handshake SH1 Acceptor handshake AH1 Talker T5 Extended talker TE0 Listener L4 Extended listener LE0 Service request SR1 Remote local RL1 Parallel Poll PP0 Device Clear DC1 Device Trigger DT1 Controller C0
Interface Type:	The interface uses open collector drivers and is a type E1 interface as defined by IEEE standard 488.
Address Setting:	Five rear panel mounted switches allow the selection of any one of 31 pairs of addresses. Each pair consists of a talk and a listen address. The talk and listen addresses are distinguished by the logic levels on data lines DIO 6 and DIO 7. These logic levels are decoded by the 5002 without operator action. A sixth switch enables the 5002 to be put to the talk only mode.
Measurement Modes:	When addressed via the GPIB two measurement modes are available: (1) Continuous mode: The instrument performs continuous measurement cycles. The last measurement taken is put onto the bus when the instrument is put into the talk state. (2) Single mode: The instrument performs a single measurement cycle in response to a trigger command (which may be addressed or the GET command). The measurement taken is put onto the bus when the instrument is put into the talk state. The instrument can be set to generate a service request (SRQ) when the measurement is complete.

TABLE 1.1 (Continued)

Technical Specification

GPIB INTERFACE (Continued)	
	When in the talk only mode the instrument performs continuous measurement cycles in accordance with the front panel control settings. The last measurement made is put onto the bus in response to a signal on the NRFD control line.
Output Format:	The output data word consists of a string of twelve ASCII characters.
Optional Accessory:	Adaptor to convert to IEC 625-1 GPIB. Racal-Dana part number 23-3254

MECHANICAL CHARACTERISTICS	
Instrument Dimensions:	Height: 104 mm Width: 440 mm Depth: 403 mm
Instrument Weight:	Approximately 6.75 kg

POWER SUPPLIES	
Voltage:	A four range supply voltage selector is provided to accept 100 V, 115 V, 215 V or 230 V AC ±10%.
Frequency:	45 Hz to 440 Hz.
Power Consumption:	Approximately 40 VA.

TABLE 1.1 (Continued)

Technical Specification

ENVIRONMENTAL SPECIFICATION	
Operating Temperature:	$0^{o}C$ to $55^{o}C$
Storage Temperature:	$-40^{o}C$ to $+70^{o}C$.
Humidity:	95% RH at $+40^{o}C$.
Electromagnetic Compatability:	The instrument is designed to conform with TS 1400, Class A.

ACCESSORIES PROVIDED	
Power Lead:	Part Number 23-3227
Fuse for 90/127 V Operation:	Part Number 23-0022
Operator's Handbook:	

OPTIONAL ACCESSORIES	
19-inch Fixed Rack Mounting Kit:	Part Number 11-1496

REAR PANEL SIGNAL INPUT OPTION	
Availability:	A rear panel mounted signal input connector and isolation switch are available as a factory fitted option. These components replace the normal front panel mounted items.

2.1 INTRODUCTION

2.1.1 The Racal-Dana Wideband Level Meter Model 5002 is a light, portable, but extremely versatile, microprocessor controlled instrument. It permits measurements to be made with exceptional accuracy on waveforms having high crest factors. Special automatic zeroing and noise cancelling circuits permit measurements to be made over a range of signal amplitudes extending from 316 V r.m.s. down to 30 μV r.m.s. The instrument has an auto ranging facility, but provision is made for manual range selection.

2.1.2 Measurements may be made on DC signals, on AC signals in the frequency range from 5 Hz to 20 MHz and on signals having both DC and AC components. A low pass filter can be switched in to restrict the operating bandwidth to 200 kHz (-3dB).

2.1.3 The instrument measures true r.m.s., mean, positive peak or negative peak voltages of the applied signal. Operator set values of resistance, voltage and power may be stored in the instrument, and, in addition to display of the measured value in voltage units, displays of the following computed values can be obtained:

(a) Average or peak power, computed from V^2/R.

(b) The ratio of the computed power to the stored power level.

(c) The ratio of the measured voltage to the stored voltage level.

(d) The difference between the measured and stored voltage levels.

(e) The difference between the computed and stored power levels.

(f) The difference as in (d) expressed as a percentage of the stored voltage level.

(g) The difference as in (e) expressed as a percentage of the stored power level.

The instrument will also compute, and display, mean value scaled to r.m.s., peak-to-peak value, form factor and crest factor.

2.1.4 The input common line is isolated from chassis earth by back-to-back diodes, which permit a voltage difference of ±0.5 V. The common line can be connected to chassis earth, if required, by means of an isolation override switch.

2.1.5 The instrument features a large, four digit, liquid crystal display (LCD). Coarse and fine LCD bar and dot displays form part of the display, and provide a pseudo-analogue form of indication. Units annunciators, GPIB status indicators and instrument status indicators are also incorporated.

2.2 CREST FACTOR

2.2.1 The maximum permitted crest factor on any range increases in inverse proportion to the displayed measurement. Errors will arise if the measured waveform has a significant proportion of its energy in harmonics which lie outside the instrument's measurement bandwidth.

2.3 OPERATING PRINCIPLES

2.3.1 Following a common input attenuator the instrument has separate AC and DC measurement channels. The AC channel features separate detectors for r.m.s., mean, positive peak and negative peak measurements, so that these waveform parameters are all measured simultaneously.

2.3.2 The detector outputs are connected in turn to an analogue to digital converter. The microprocessor scans the converter output every 0.1 second, reading each detector output in turn. One detector output, determined by the measurement function selected, is either converted directly to a display drive signal or processed, together with the contents of various internal stores, to provide power, difference or percentage difference display signals.

2.4 REDUCTION OF DISPLAY JITTER

2.4.1 The instrument has a variable averaging time, which may be set by the operator to ensure minimum jitter of the measurement indication when measurements are made on waveforms of high crest factor. The period over which measurements are averaged may be varied in steps of 0.1 second between 0.1 second and 99.9 seconds (nominal).

2.4.2 The display updating rate is set by the averaging time in use. To avoid the necessity for unacceptably low updating rates, continuous averaging of the measurements can be introduced by means of a special function. In this mode the display is updated every 0.1 second, the new displayed value being formed by adding N% of the current displayed value to (100-N%) of the new measurement. The effect of this is similar to filtering successive measurements in a single pole RC filter. The value of N is related to the time constant of the effective filter, which can be set by the operator.

2.5 STORAGE OF FRONT PANEL SETTINGS

2.5.1 Provision is made for the storage of up to twelve complete sets of front panel control settings, including the values set in the computed function stores, in a non-volatile memory. Each setting is allocated a number, and is retrieved and set by recalling that number. The front panel control settings in use when the instrument is switched off are automatically stored, and may be recalled when the instrument is switched on again.

2.6 CALIBRATION TO AN EXTERNAL SOURCE

2.6.1 The instrument display may be set to a reference value, when measurements are made on a reference signal source, by means of an operator selected calibration factor. The calibration factor, which is a divisor, is stored in the instrument, and may be enabled and disabled as required when making measurements on other signal sources.

2.7 GPIB INTERFACE

2.7.1 An internally mounted interface board permits the instrument to be controlled from, and communicate with, the IEEE 488 GPIB. The instrument may be used in the addressed mode or in the talk only mode. An adaptor to permit use with the IEC 625-1 GPIB is also available.

2.8 MAINTENANCE

2.8.1 It is recommended that customers should take advantage of the servicing and calibration service offered by Racal-Dana Instruments Ltd., and their agents. For customers wishing to carry out their own servicing, a comprehensive Maintenance Manual is available from Racal-Dana Instruments Ltd. When ordering a manual, the serial number of the instrument for which the manual is required should be quoted.

3.1 INTRODUCTION

3.1.1 This section contains instructions concerning all tasks which must be performed before taking the 5002 into use for the first time, or when the instrument is used at a new location. It includes instructions for mounting the equipment in an equipment rack, if this is required, and for preparing the instrument for connection to a GPIB controlled system.

3.2 POWER SUPPLY

3.2.1 AC VOLTAGE RANGE SETTING

3.2.1.1 The supply voltage setting is varied by changing the position of a small drum, located under a hinged cover beside the input plug. The setting in use can be seen through a window in the cover.

3.2.1.2 If it is necessary to change the voltage setting, proceed as follows:

(a) Switch off the AC supply and remove the line power socket.

(b) Using a 1/4 in (5mm) flat-bladed screwdriver, prise open the hinged cover.

(c) Remove the voltage setting drum.

(d) Withdraw the fuse carrier by pulling the end, marked with an arrow, straight out of the aperture.

(e) Ensure that the fuse fitted is suitable for the voltage range to be used.

(f) Replace the fuse and carrier. Ensure that the arrow on the fuse carrier points in the same direction as those on the underside of the cover.

(g) Replace the voltage setting drum so that the required setting is outermost.

(h) Close the hinged cover and ensure that the required setting is visible in the window.

(j) Replace the line power socket.

3.2.2 LINE FUSE

3.2.2.1 Check that the line fuse rating is correct for the local AC supply voltage. The fuse is a 5 mm x 20 mm in glass cartridge, surge resisting type. The Racal-Dana part numbers for replacement fuses are:-

90 V to 127 V supply	500 mAT	23-0022
193 V to 253 V supply	250 mAT	23-0031

3.2.3 DC FUSE

3.2.3.1 Check that the DC fuse fitted to printed circuit board 19-1024 is serviceable, and of the correct rating. The fuse should be a 1.6 A, surge resisting, ¼ in x 1¼ in glass cartridge type, Racal-Dana part number 23-0055. Instructions for the removal and replacement of the covers are given in paragraph 3.4.

3.2.4 POWER LEAD

3.2.4.1 The power lead must be fitted with a suitable connector in accordance with the standard colour code.

	European	American
Live	Brown	Black
Neutral	Blue	White
Earth (Ground)	Green/Yellow	Green

3.3 FITTING THE FIXED RACK MOUNTING KIT 11-1496

3.3.1 The kit contains a pair of mounting brackets and four screws. The method of fitting the kit is shown in Fig. 3.1. The fitting procedure is as follows:

(a) Switch off the instrument and the AC supply. Remove the line power socket.

(b) Stand the instrument upside down on a bench, and remove the two screws from each of the plastic mouldings at the rear corners of the instrument. Remove the mouldings.

(c) Slide the bottom cover towards the rear of the instrument by about 1 inch, and lift the cover off.

(d) Remove the bench feet from the bottom cover by removing the retaining screw from each foot. Replace the bottom cover.

(e) Remove the side trim panels by sliding them to the rear of the instrument. Replace and secure the plastic mouldings removed in (b).

(f) Remove the two screws securing the handle at one side of the instrument. Do not remove the handle.

(g) Position a bracket from the kit at the side of the instrument, so that the two holes in a flange are positioned over the holes for the handle securing screws.

(h) Secure the handle and bracket, using two of the countersunk headed screws from the kit.

(j) Repeat (f) to (h) at the other side of the instrument.

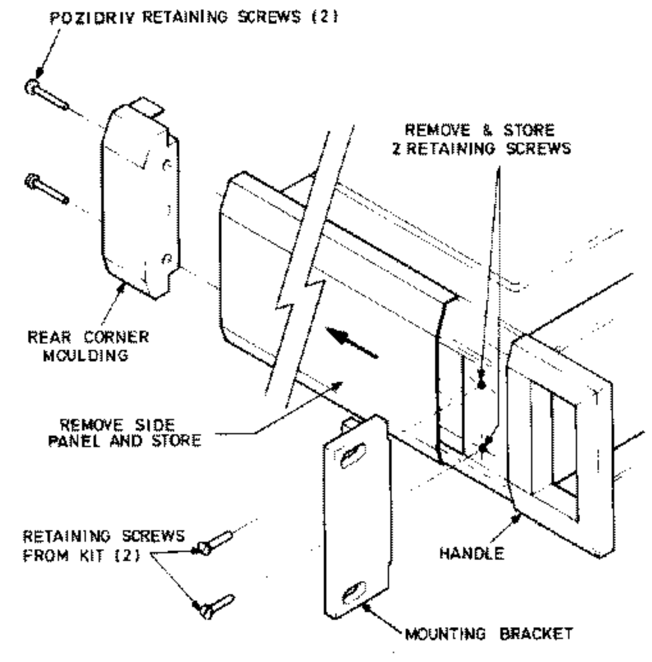


Fig. 3.1 Fitting the Fixed Rack Mounting Kit 11-1496

3.4 REMOVAL AND REPLACEMENT OF THE COVERS

WARNING: DANGEROUS AC VOLTAGE LEVELS ARE EXPOSED WHEN THE COVERS ARE REMOVED WITH THE AC SUPPLY CONNECTED

3.4.1 (a) Switch off the instrument and the AC supply. Remove the line power socket.

(b) Stand the instrument on its front handles, and remove the two screws from each of the plastic mouldings at the rear corners of the instrument. Remove the mouldings.

(c) The covers can now be removed by sliding them towards the rear of the instrument. Note that the removal of the plastic mouldings also releases the side trim panels, which should either be removed or secured by replacement of the mouldings.

(d) The covers are replaced in the reverse manner. Note that the straight, unfolded edge of the cover fits to the front of the instrument, and locates in a groove in the rear face of the front panel. The rear edge of the cover is folded under, and locates in a groove in the rear panel.

3.5 PREPARATION FOR USE WITH THE GPIB

3.5.1 INTERFACE CONNECTOR

3.5.1.1 Connection to the GPIB is made via an IEEE 488 standard connector. The pin assignment is given in Table 3.1. An adaptor, Racal-Dana part number 23-3254, to convert the connector to the IEC 625-1 standard is available as an optional accessory.

TABLE 3.1

GPIB Connector Pin Assignment

Pin	Signal Line	Pin	Signal Line
1	DIO 1	13	DIO 5
2	DIO 2	14	DIO 6
3	DIO 3	15	DIO 7
4	DIO 4	16	DIO 8
5	EOI	17	REN
6	DAV	18	Gnd.(6)
7	NRFD	19	Gnd.(7)
8	NDAC	20	Gnd.(8)
9	IFC	21	Gnd.(9)
10	SRQ	22	Gnd.(10)
11	ATN	23	Gnd.(11)
12	SHIELD	24	Gnd.(5 and 17)

3.5.2 ADDRESS SETTING

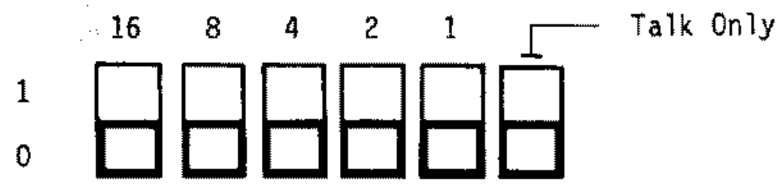
3.5.2.1 The interface address is set on five rear panel mounted switches. The right hand switch, as viewed from the rear of the instrument, is for bit 1, the least significant address bit. The permitted address settings, in decimal and ASCII character form, are given in Table 3.2. The instrument is despatched with the address switches set to ASCII , (listen) and ASCII L (talk). The address set, in decimal format, can be displayed by pressing

/RECALL//SHIFT//LOCAL/.

3.5.2.2 The sixth switch, when put to the logic '1' position, puts the interface into the talk only mode. With the switch in this position the settings of the first five switches are irrelevant.

<u>TABLE 3.2</u>

<u>Address Switch Settings</u>



SWITCH SETTINGS 16	8	4	2	1	DECIMAL (ADDRESS CODES)	ASCII LISTEN ADDRESS (ADDRESS CODES)	ASCII TALK ADDRESS (ADDRESS CODES)	
0	0	0	0	0	0	SP	@	
0	0	0	0	1	1	!	A	
0	0	0	1	0	2	"	B	
0	0	0	1	1	3	#	C	
0	0	1	0	0	4	$	D	
0	0	1	0	1	5	%	E	
0	0	1	1	0	6	&	F	
0	0	1	1	1	7	'	G	
0	1	0	0	0	8	(	H	
0	1	0	0	1	9	)	I	
0	1	0	1	0	10	*	J	
0	1	0	1	1	11	+	K	
0	1	1	0	0	12	,	L	Instrument despatched with this setting
0	1	1	0	1	13	-	M	
0	1	1	1	0	14	.	N	
0	1	1	1	1	15	/	O	
1	0	0	0	0	16	Ø	P	
1	0	0	0	1	17	1	Q	
1	0	0	1	0	18	2	R	
1	0	0	1	1	19	3	S	
1	0	1	0	0	20	4	T	
1	0	1	0	1	21	5	U	
1	0	1	1	0	22	6	V	
1	0	1	1	1	23	7	W	
1	1	0	0	0	24	8	X	
1	1	0	0	1	25	9	Y	
1	1	0	1	0	26	:	Z	
1	1	0	1	1	27	;	[	
1	1	1	0	0	28	<	\	
1	1	1	0	1	29	=	]	
1	1	1	1	0	30	>	^	

4.1 INTRODUCTION

4.1.1 The first part of this section contains instructions for operating the 5002 using the front panel controls. This information is given in two forms. The purpose of each control is given in paragraph 4.2. This is followed by specific instructions on how to set the instrument to make particular types of measurement.

4.1.2 Information regarding the control of the instrument using the GPIB is given, commencing at paragraph 4.22. It is essential that the operation of the instrument using the front panel controls is understood before operation using the GPIB is attempted.

4.2 DESCRIPTION OF CONTROLS, INDICATORS AND CONNECTORS

4.2.1 Each group of controls or connectors described is numbered to correspond with the indicators on Fig. 4.1 (front panel) or Fig. 4.2 (rear panel).

4.2.2 FRONT PANEL ITEMS

(1) Display: A custom built liquid crystal display is used. It incorporates the following indicators:

(a) Four digit alpha-numeric display.
This display, with decimal point and sign indicator, is used primarily to indicate the value of the measured quantity. It may also be used to display the values held in the instrument's internal stores, or to indicate certain types of error.

(b) Units annunciators.
These indicate the units of the measurement being displayed.

(c) Compute function indicators.
These indicate when the measurement functions requiring computation by the microprocessor (ratio, % difference, difference (null) or dB) are in use.

(d) CF indicator.
This provides an indication that one of the special functions for crest factor computation is enabled.

(e) FF indicator.
This indicates that the form factor of the input waveform is being displayed.

(f) SF Indicator.
This indicates that a special function other than crest factor or form factor has been selected.

(g) GPIB indicators.
These indicate whether the instrument is under remote or local control, whether it is talking or listening and whether it is generating a service request.

(h) Analogue display.
This is a two part, coarse and fine, LCD bar and dot display. The upper, coarse, section has ten segments and indicates the measured value to within -0%, +10% of full scale. The lower, fine, section also has ten dots, representing sub divisions of the coarse section. The overall indication is therefore within -0% and +1% of full scale. The coarse section of the display is enabled automatically when manual range selection is in use. The complete display may be enabled by pressing /METER//METER/

(2) Range Control Keys:

/MANUAL/
This key selects the auto-ranging and manual ranging modes on alternate operations. The appropriate indicator will light to show the mode in use. On switching from auto to manual no change of range will take place.

/STEP UP/ and /STEP DOWN/
These keys permit the next range above or below the one in use to be selected when in the manual ranging mode. If these keys are operated when the instrument is in the auto-ranging mode, the manual ranging mode will be selected and the appropriate change of range will occur.

(3) METER Key:

This switches the analogue display on and off on successive operations. The coarse part of the analogue display is switched on automatically when the manual ranging mode is selected. It will be switched off by the first operation of the METER key, subsequent operations of the key controlling the complete analogue display.

(4) Primary Measuring Function Keys:

These keys allow the measured or computed value to be displayed in voltage or power units. The appropriate indicator will light to show which function is in use.

The instrument measures voltage. When display in power units is demanded, the measured voltage is converted using the resistance value stored in the Ω store.

(5) Secondary Measuring Function Keys:

These keys select which of the AC measuring system detector outputs is displayed or used to produce a computed function display. The selection of a secondary measuring function cancels any secondary measuring function previously selected.

(6) Computed Measuring Function Keys:

These keys allow one of the four computed measuring functions to be selected. The appropriate indicator will light to show the function selected.

If the Voltage primary measuring function is in use the computations for all four functions will be performed in voltage units. If the Watts primary measuring function is in use the computations for the ratio, % difference and difference (null) functions will be performed in power units. The resistance value stored in the Ω store is used in the conversion from voltage to power units. The computation for the dB function is always performed in voltage units. The keys also act as the address keys for the computed function stores. The LED adjacent to the appropriate key will light when a stored value is recalled.

(7) CAL FACTOR and FILTER Key:

The key is used without /SHIFT/ for the following purposes:

(a) Successive operations will enable and disable the operator selected scaling factor. The indicator will light when the factor is enabled.

(b) The sequence /RECALL//CAL FACTOR/ will result in the display showing the current value held in the scaling factor store. The RECALL and CAL FACTOR indicators will both light when the scaling factor is recalled and displayed.

(c) The sequence /STORE//CAL FACTOR/ will store the number shown on the display in the scaling factor store. (The number displayed will have been set by means of the numeric keys or by ratio measurement).

When used with /SHIFT/ the key switches a single pole RC low pass filter into or out of the signal measurement path. The filter restricts the upper limit of the frequency range to 200 kHz (-3dB). The indicator lights when the filter is in circuit.

(8) Input Coupling Key: Successive operations of this key select AC or AC + DC coupling at the signal input. Indicators are provided to show the form of coupling in use.

(9) SHIFT Key: Pressing this key results in the next key pressed performing its shifted function. The shift operation affects the next key operation only, and cannot be continuously set.

(10) STORE Key: This key is used, in conjunction with a store address key, to enter values in the instrument's internal stores. The instrument returns to the measurement mode when storage is completed. The indicator lights when the key is pressed, and is extinguished when storage is completed.

(11) RECALL Key: This key is used, in conjunction with a store address key, to recall values from the instrument's internal stores. The use of the key stops the instrument measuring, so that the recalled information can be shown on the display, except in the case of recall of complete front panel settings. In this case the instrument returns to the measurement mode, with the recalled values set, as soon as the recall action is completed.

The indicator lights when the key is pressed, and is extinguished when the instrument returns to the measurement mode, or when a new value is entered into store.

(12) CONTINUE Key: Operation of this key returns the instrument to the measurement mode following the display of the contents of the instrument's internal stores.

(13) Numeric Keypad: These keys, used without /SHIFT/, provide the means of setting, on the display, values to be entered in the instrument's internal stores. Entries may be signed negative, using the +/- key to allow comparison with negative peak readings. The +/- key is used AFTER the required numeric entry and the entry of the appropriate units has been made.

The keys are used, with /SHIFT/, to add units annunciators to values to be stored, to address the Ω and AVERAGE stores, to display the full scale deflection value of the measurement range in use and to select the special functions (SF). Pressing /SHIFT//LOCAL/ will return the instrument to local control from remote control via the GPIB except when the instrument is in the remote control with lockout state (RWLS).

Pressing /RECALL//SHIFT//LOCAL/ will result in the current GPIB address, in decimal format, being displayed.

(14) INPUT Connector: The signal to be measured is connected to this BNC connector. The instrument can be supplied with the connector in an alternative position on the rear panel.

(15) ISOLATE Switch This switch is open in the ISOLATE position, when the INPUT connector shell (common terminal) is isolated from chassis earth.

When the switch is closed the common terminal is connected to chassis earth.

(16) LINE Switch This switch controls the AC supply to the instrument power supply circuit. The indicator lights when the instrument is switched on.

4.2.3 REAR PANEL ITEMS

(17) INPUT Connector and ISOLATE Switch: The instrument can be supplied with these components mounted on the rear panel as an alternative to front panel mounting.

(18) GPIB Socket: This socket is wired for direct connection to the IEEE 488 bus. An adaptor to permit the instrument to be used with the IEC 625-1 bus is available as an optional accessory.

(19) Address Switches: The five left hand switches allow one of 31 Listen/Talk address pairs to be selected. Putting a switch to the up position represents a logic '1'. The right hand switch represents the least significant bit (bit 1, on DIO 1).
The sixth switch, when put to the up position, selects the talk only mode. The setting of the remaining address switches is then irrelevant.

(20) Supply Voltage Range Selector: This allows the selection of one of four line voltage ranges. The range selected can be read on the selecting plate through the clear plastic cover.

(21) Line Fuse: The fuse is a 5mm x 20mm glass cartridge pattern, and should be of the surge resisting type.

(22) Line Power Plug: The power input plug incorporates a filter, and external supply filtering should be unnecessary.

4.3 SWITCHING ON

4.3.1 The equipment should be prepared for use in accordance with the instructions given in Section 3. If the instrument is being used for the first time, or at a new location, pay particular attention to the setting of the supply voltage range selector.

4.3.2 Connect the instrument to the AC supply, and set the LINE switch to ON. Check that the LINE indicator lights.

4.3.3 The front panel indicators will show:

(a) AUTO mode

(b) VOLTS primary measurement function selected

(c) RMS secondary measurement function selected

(d) AC coupling selected

The display will show 5002 for approximately one second. If no input signal is connected the display will then show the error code for under range signal, Ur.

4.4 INPUT ISOLATION

4.4.1 The instrument may be operated with the input common terminal isolated from chassis earth by putting the ISOLATE switch to ISOLATE. The permissible voltage difference is ±0.5 V.

4.5 SETTING OF AVERAGING TIME

4.5.1 When the equipment is first switched on the averaging time, which sets the display updating rate, is set to 1 second. This can be reset to provide a higher updating rate, or to give a lower updating rate with less jitter. The range of averaging times is from 0.1 second to 99.9 seconds in steps of 0.1 second. Irrespective of the averaging time used, a settling time of two seconds must be allowed after applying the measured signal before the specified accuracy is achieved.

4.5.2 The averaging time set can be displayed by pressing

/RECALL//SHIFT//AVERAGE/.

The RECALL indicator will light to indicate that a stored value is being displayed. If no change to the averaging time is required, press

/CONTINUE/.

The RECALL indicator will be extinguished and the instrument will return to the measurement mode.

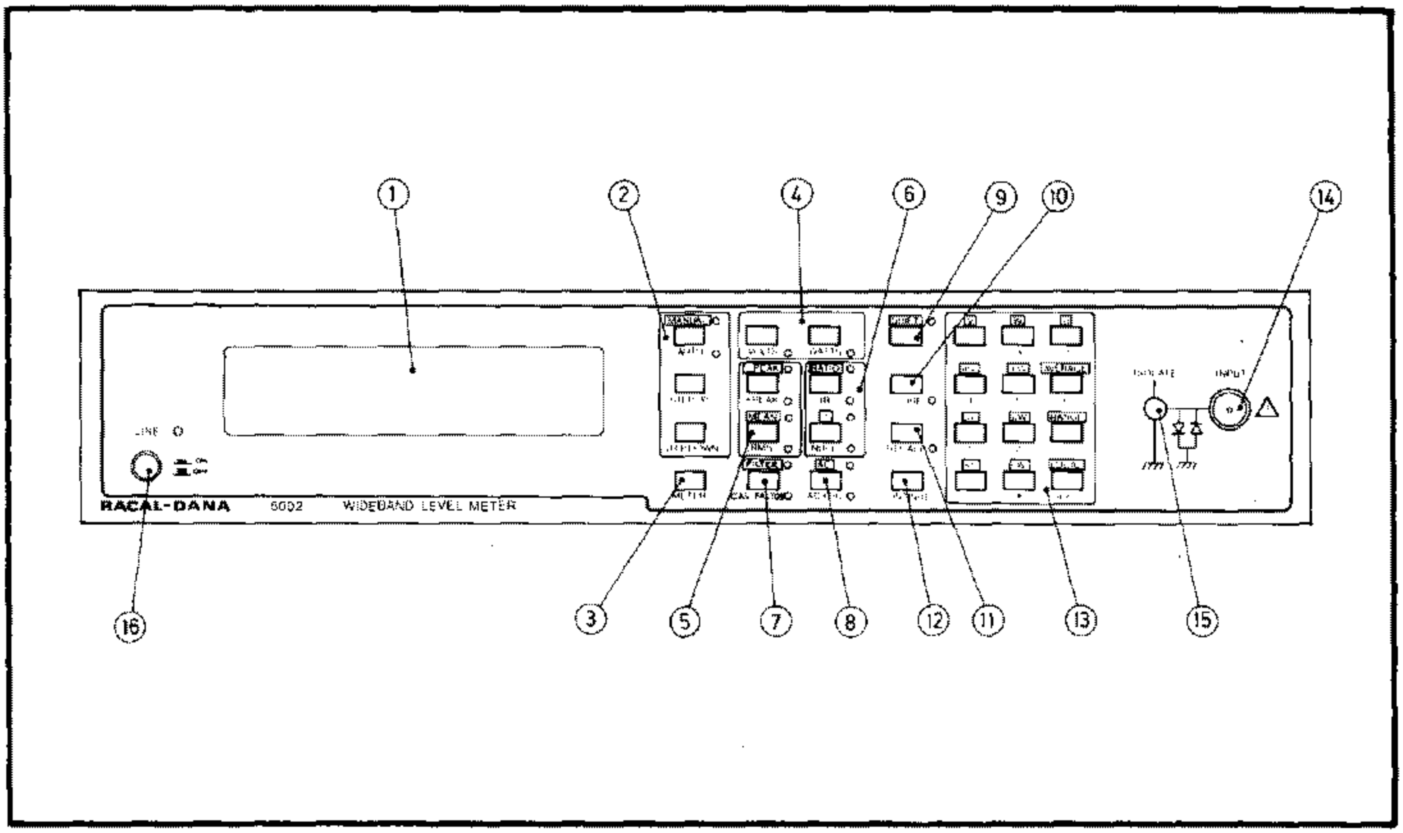


Fig. 4.1 Front Panel

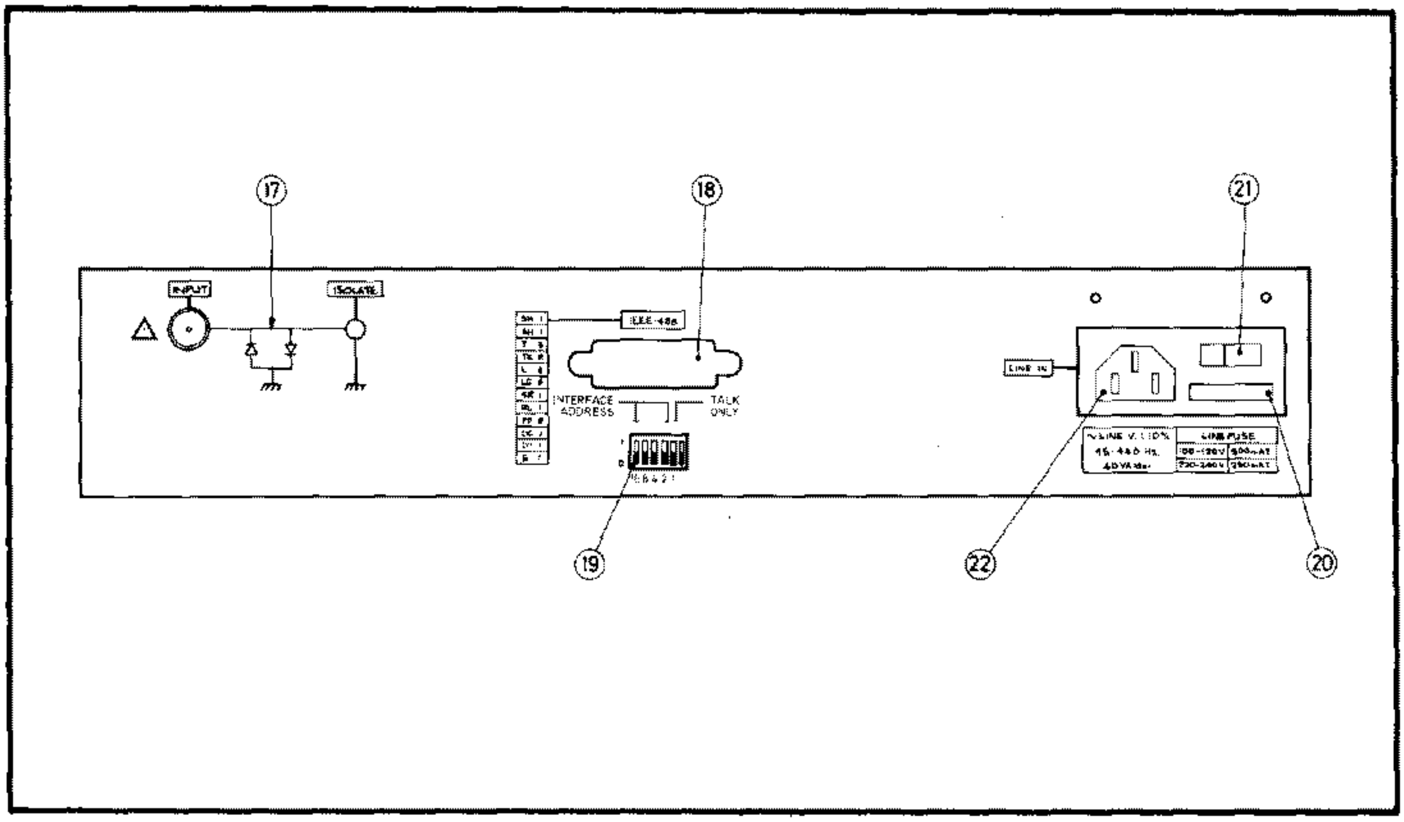


Fig. 4.2 Rear Panel

4.5.3 If the averaging time is to be reset, set the required value on the display, using the numeric keys. The RECALL indicator will be extinguished when the first numeric key is pressed. When the required averaging time is correctly set, press

/STORE//SHIFT//AVERAGE/.

The STORE indicator will light when the key is pressed. It will be extinguished, and the instrument will return to the measurement mode, when the storage of the new value is complete.

4.5.4 At any time up to the point where

/AVERAGE/

is pressed, the procedure can be aborted by pressing

/CONTINUE/.

The instrument will return to the measurement mode with the averaging time unchanged.

4.6 CONTINUOUS AVERAGING MODE

4.6.1 The use of this mode avoids the low display updating rates which are caused by the use of long averaging times. The display is updated every 0.1 second to a value obtained partly from the current displayed value and partly from the new measured value. The overall effect is similar to that which would be obtained if successive measured values were filtered in a single pole RC filter.

4.6.2 The mode is enabled and disabled using SPECIAL FUNCTIONS 60.1 and 0 (see paragraph 4.20). The mode will be disabled automatically if +PEAK or -PEAK is selected as the secondary measurement function, but, if the special function is not cancelled, will be re-enabled when RMS or MEAN is subsequently selected.

4.6.3 The time constant of the effective filter will be the value set in the AVERAGE store. This value may be viewed, and, if required, changed, using the procedure given in paragraph 4.5.

4.6.4 The mode is automatically disabled during any measurement cycle in which the current displayed value and the new measured value differ by more than 5%. This results in a rapid change of the displayed value in response to large step changes of input level.

4.7 INPUT FILTER

4.7.1 An input filter, which restricts the upper limit of the frequency range to 200 kHz (-3dB), may be inserted into and removed from the measured signal path by successive operations of

/SHIFT//FILTER/.

The FILTER indicator lights when the filter is in circuit.

4.8 RANGING MODE SETTING

4.8.1 On switching on, the instrument will be set to the auto-ranging mode. To put the instrument into the manual ranging mode without changing the range in use, press the AUTO/MANUAL key. This key selects manual ranging and auto-ranging on successive operations. The indicator for the mode in use will light. The instrument may be switched from the auto-ranging mode to the manual ranging mode, accompanied by a change to an adjacent range, by means of the STEP UP or STEP DOWN key. When manual ranging is selected an analogue indication of the measured signal as a fraction of full scale appears in the display.

4.8.2 When in the manual ranging mode the range in use may be changed by pressing

/STEP UP/ or /STEP DOWN/.

The full scale value for the range in use can be displayed by pressing

/RECALL//SHIFT//RANGE/.

The RECALL indicator will light when the key is pressed. To return the instrument to the measurement mode, press

/CONTINUE/.

4.8.3 If the input signal is outside the limits of 31.6% and 114.9% of full scale of the range in use, the display will alternate between the measured value and an under-range or over-range error indication. When in the auto-ranging mode a range change will occur if the input signal is outside the limits of 31.7% and 114.9% of full scale, so that error indications are obtained on the highest and lowest ranges only.

4.9 VOLTAGE PRIMARY MEASUREMENT FUNCTION

4.9.1 When first switched on the instrument will be set to the voltage measuring function. If the instrument has been in use and is set for some other measuring function, press

/VOLTS/.

The VOLTS indicator will light. No change to the secondary measurement functions selected will occur, but any computed function selected will be cancelled.

4.10 POWER PRIMARY MEASUREMENT FUNCTION

4.10.1 The 5002 measures in voltage units, but can convert measurements made into power units by squaring the measured voltage and dividing by the resistance value held in the Ω store. To select the power measuring function, press

/WATTS/.

The WATTS indicator will light. No change to the secondary measurement functions selected will occur, but any computed function selected will be cancelled.

4.10.2 The value in the Ω store will be set to 600 Ω on switching on. The number in the store can be displayed by pressing

/RECALL//SHIFT//Ω/.

The RECALL indicator will light when the key is pressed to show that a stored value is being displayed.

4.10.3 If no change to the resistance value is required, press

/CONTINUE/.

The RECALL indicator will be extinguished, and the instrument will return to the measurement mode. If the resistance value is to be changed, set the required value on the display, using the numeric keys, followed by

/SHIFT//Ω/.

The RECALL indicator will be extinguished when the first numeric key is pressed. When the required resistance value is set, press

/STORE//SHIFT//Ω/.

The STORE indicator will light when the key is pressed. It will be extinguished, and the instrument will return to the measurement mode, when the storage of the new value is complete.

4.10.4 At any time up to the point where

/Ω/

is pressed, the procedure can be aborted by pressing

/CONTINUE/.

The instrument will return to the measurement mode with the resistance value unchanged.

NOTE: The values held in the %, RATIO, NULL and dB stores are in voltage units. The values may have been computed from keybord inputs or displayed power measurements, using the resistance value in the Ω store at the time of entry. These values are NOT automatically updated when the resistance value in the Ω store is changed.

4.11 SECONDARY MEASUREMENT FUNCTION SELECTION

4.11.1 The r.m.s., mean, positive peak and negative peak detectors in the AC measuring system operate simultaneously. The r.m.s. detector is selected when the instrument is first switched on. To select a different detector operate the appropriate secondary measurement function key.

4.11.2 Each of the secondary measurement function keys toggles between the two functions associated with it. When changing from the function controlled by one key to those controlled by the other, the function having the legend above the key may be obtained either by making use of the SHIFT key or by operating the secondary function key twice.

4.11.3 The output of the DC detector is added to that of the selected AC detector when AC + DC coupling is selected. The following points should be noted:

(a) With AC + DC coupling selected, use of the MEAN secondary measurement function will result in a display of the filtered mean, not the rectified mean, of the measured signal. A display of the rectified mean can be obtained by using SPECIAL FUNCTION 50.1 (see paragraph 4.20).

(b) With AC + DC coupling and MEAN secondary measuring function selected the instrument can be used for direct voltage measurements.

(c) If the measured waveform has a DC level more positive than the negative peak value of the AC component, the selection of AC + DC coupling and the -PEAK secondary measurement function will result in a display of the waveform trough value, which will be shown as having a positive polarity. Similarly, with a DC level more negative than the positive peak value of the AC component, use of AC + DC coupling and the +PEAK secondary measurement function will give a negative polarity display.

4.11.4 Three forms of peak measurement, applicable to both positive and negative peak measurements, are available. These are:

(a) True Peak Measurement

The selected peak detector output is sampled every 0.1 second throughout a measurement period equal to the value stored in the AVERAGE store. At the end of the measurement period the greatest detector output which has occurred is displayed.

(b) Averaged Peak Measurement

The selected peak detector output is sampled every 0.1 second throughout successive measurement periods equal to the value stored in the AVERAGE store. At the end of the measurement period the average of all the measured detector outputs is displayed.

(c) Peak Hold Measurement

The selected peak detector output is sampled every 0.1 second over a measurement period started and terminated by operations of /CONTINUE/. The display indicates the greatest detector output which has occurred during the current measurement period.

NOTE: (1) The first measurement period commences immediately this form of peak measurement is selected, and does not require operation of /CONTINUE/.

(2) When peak hold measurement is selected the manual ranging mode is automatically selected and the generation of error code 03 is inhibited.

(3) If error code 02 is generated the indication will be held on the display until /CONTINUE/ is pressed or the peak hold measurement mode is cancelled.

4.11.5 The true peak measurement function is selected automatically on switching on. The averaged peak measurement function and peak hold measurement function are enabled by means of SPECIAL FUNCTIONS 70.1 and 70.2 and disabled by means of SPECIAL FUNCTION 0 (see paragraph 4.20). The form of peak measurement selected is not automatically cancelled when RMS or MEAN is selected as the secondary measurement function, and will be returned to when the peak measurement function is re-selected.

4.12 COMPUTED FUNCTIONS

4.12.1 One of four computed measurement functions, ratio, percentage ratio, dB and null, may be selected by means of the computed function keys. The SHIFT key is used to obtain the function having its legend above the key. The operation of either primary measurement function key cancels any computed measurement function selected, so the required primary measurement function must be set before a computed function is selected. The computed function selected is not, however, affected by change of the secondary measurement function.

4.13 RATIO MEASUREMENTS

4.13.1 With the ratio function selected the instrument computes

$$\frac{\text{measured voltage}}{\text{voltage value held in RATIO store}}$$

To select the ratio function, press

/SHIFT//RATIO/.

The RATIO indicator will light. Note that the display will indicate a ratio of voltages or powers according to whether the voltage or power primary measuring function is selected. The conversion to power units uses the current resistance value in the Ω store. The measured voltage used in the computation may be r.m.s., mean, +peak or -peak, according to the secondary measuring function selected.

4.13.2 When the instrument is first switched on the RATIO store will be loaded with 1 volt. The value in the store can be displayed by pressing

/RECALL//SHIFT//RATIO/.

The RECALL indicator will light when the key is pressed to show that a stored value is being displayed. The displayed value will be in voltage or power units, according to the primary measuring function selected.

4.13.3 If no change to the stored level is required press

/CONTINUE/.

The RECALL indicator will be extinguished, and the instrument will return to the measurement mode.

4.13.4 If the stored value is to be reset to a specified figure, set the required value on the display using the numeric keys. The RECALL indicator will be extinguished when the first numeric key is pressed. The value set on the display may be in voltage or power units. When the required digits have been set, press

/SHIFT//APPROPRIATE UNITS//STORE//SHIFT//RATIO/.

The appropriate display annunciator will light when the units are entered. The STORE indicator will light when the key is pressed. It will be extinguished, and the instrument will return to the measurement mode, when the storage of the new value is complete.

4.13.5 The RATIO store may also be reset to the current displayed value when voltage or power measurements are being made. To reset the stored value to the current displayed value, press

/STORE//SHIFT//RATIO/.

The STORE indicator will light when the key is pressed, and will be extinguished when the storage of the new value is completed.

4.13.6 At any time up to the point where

/RATIO/

is pressed either store updating procedure can be aborted by pressing

/CONTINUE/.

4.14 PERCENTAGE DIFFERENCE MEASUREMENTS

4.14.1 With the percentage difference function selected the instrument computes

$$\frac{\text{measured voltage - voltage value in \% store}}{\text{voltage value in \% store}} \times 100$$

To select the percentage difference function, press

/SHIFT//%/.

The % indicator will light. Note that the display will indicate a percentage difference of voltages or powers according to whether the voltage or power measuring function is selected. The conversion to power units uses the current resistance value in the Ω store. The measured voltage used in the computation may be r.m.s., mean, +peak or -peak, according to the secondary measuring function selected.

4.14.2 When the instrument is first switched on the % store will be loaded with 1 volt. The value in the store can be displayed and, if necessary, changed using the same procedures as those described for the RATIO store. The keyboard address of the % store is

/SHIFT//%/.

4.15 NULL MEASUREMENTS

4.15.1 With the null function selected the instrument computes

measured voltage - voltage value in NULL store.

To select the null function, press

/NULL/.

The NULL indicator will light. The current displayed value will be entered into the NULL store, and the display will indicate zero. When the input level is changed the display will indicate a difference of voltages or powers, according to whether the voltage or power primary measuring function is selected. The conversion to power units uses the current resistance value in the Ω store. The measured voltage used in the computation may be r.m.s., mean, +peak or -peak, according to the secondary measuring function selected.

4.15.2 When the null function is selected the contents of the NULL store can be displayed and, if required, changed using the same procedures as those described for the RATIO store. This allows the difference between the measured value and an operator set value to be displayed. The keyboard address of the NULL store is

/NULL/

Note that, if the instrument leaves and re-enters the null measurement function, the value in the NULL store will be over-written with the measured value current when the mode is re-entered.

4.16 dB MEASUREMENTS

4.16.1 With the dB function selected the instrument computes

$$20 \log \frac{\text{measured volts}}{\text{voltage value in dB store}}$$

The calculation does not involve the resistance value held in the Ω store. However, if the voltage value in the dB store and the resistance value in the Ω store represent a power of 1 mW, the display units annunciator will indicate dBm. To select the dB function, press

/dB/.

The dB indicator will light. The measured voltage used in the computation may be r.m.s., mean, +peak or -peak, according to the secondary measuring function selected.

4.16.2 When the instrument is first switched on the dB store will be loaded with 774.6 mV. The value in the store can be displayed and, if necessary, changed using the same procedures as those described for the RATIO store. The keyboard address of the dB store is

/dB/.

4.17 ANALOGUE DISPLAY

4.17.1 The analogue display will be found to be particularly useful for obtaining peak or trough indications but may be used with all the measurement functions. The display is switched on and off by successive operations of

/METER/.

The coarse part of the display is automatically switched on when the manual ranging mode is selected. To obtain the full display press

/METER//METER/.

4.18 CALIBRATION TO AN EXTERNAL SIGNAL

4.18.1 To set the instrument display to a reference level the following procedure should be used:

(a) Connect the external source to the 5002 and select the required primary and secondary measurement functions. The instrument will measure and display the selected parameter of the input signal.

(b) Use the numeric keys to enter the level which the 5002 is required to display in respect of the signal being measured.

(c) Press /STORE//SHIFT//RATIO//SHIFT//RATIO/.

This will store the keyed-in reference level in the RATIO store, and return the instrument to the measurement mode with the ratio function selected. The display will indicate the ratio between the measured value of the signal from the external source and the reference level, held in the RATIO store.

(d) Press /STORE//CAL FACTOR/.

This will store the ratio appearing on the display for use as a calibration factor. The instrument will return to the measurement mode, with the ratio function selected, when the storage of the calibration factor is completed.

(e) Press /CAL FACTOR/.

The CAL FACTOR indicator will light and the calibration factor will be enabled. The display will now read 1.000, as the measured voltage is scaled to equal the reference value in the RATIO store.

4.18.2 Measurements may now be made on other signal sources using alternative primary, secondary and computed measurement functions. When the calibration factor is enabled the measured voltage is scaled before the calculation of computed function values. The factor is enabled and disabled by successive operations of

/CAL FACTOR/.

4.19 STORAGE OF FRONT PANEL SETTINGS

4.19.1 Up to 12 complete sets of front panel settings may be stored for later recall. The settings stored are:

(a) Primary measurement function.

(b) Secondary measurement function.

(c) Computed measurement function.

(d) Ranging mode.

(e) Measurement range.

(f) Calibration factor.

(g) Calibration factor enablement.

(h) Contents of Ω, RATIO, %, NULL, dB and AVERAGE stores.

(j) Form of input coupling selected.

(k) Input filter switching.

(l) Enablement of one special function.

Each set of front panel settings should be allocated a numeric address in the range 01 to 12. To store the front panel settings, press

/STORE//ALLOCATED NUMBER/.

Note that the leading zero must be entered for addresses 01 to 09. The STORE indicator will light when the key is pressed. It will be extinguished, and the instrument will return to the measurement mode with panel settings unchanged, when storage is completed.

4.19.2 The front panel settings can be recalled by pressing

/RECALL//ALLOCATED NUMBER/.

The RECALL indicator will light when the key is pressed. It will be extinguished, and the instrument will return to the measurement mode with the recalled front panel settings, when the recall is complete. The pressing of

/RECALL//0//0/

will recall the switch-on state (initialisation) settings. The stored front panel settings are not lost on recall, so that stored patterns may be recalled as often as required. Individual settings in the stored pattern cannot be amended, so changes must be made by over-writing the stored pattern with a complete, revised pattern.

4.19.3 When the power to the instrument is switched off the front panel settings are automatically stored. They can be recalled immediately after switching on again by pressing

/RECALL//9//9/.

The first change of front panel settings after switching on over-writes the data stored in location 99. The facility of recalling the settings in use when the instrument was switched off is then lost.

4.20 SPECIAL FUNCTIONS

4.20.1 A number of special functions are available to the operator. These are listed in Table 4.1, and are called by pressing

/X//X//.//X//SHIFT//SF/.

where X X.X is the special function number

4.20.2 Only one special function may be used at a time. The entry of a second special function number will automatically cancel any special function previously selected. To display the number of the special function selected press

/RECALL//SHIFT//SF/.

4.20.3 All the special functions can be cancelled by pressing

/O//SHIFT//SF/.

In addition, special functions having numbers 50.1 and below can be cancelled by pressing any primary or secondary function key. This provides an easy method of reversion to the normal measurement mode, as, for example, when a special function is used to check the crest factor of a signal during a sequence of other measurements.

4.20.4 Special functions 60.1, 70.1 and 70.2 are not cancelled by the operation of the primary and secondary function keys. This allows the continuous average mode or one of the special peak measurement modes to be retained when changes to the secondary measurement function are made.

TABLE 4.1

Special Functions

Special Function Number	Function
0	Cancels all special functions.
10.1	Enables crest factor (highest peak/r.m.s)
10.2	Enables crest factor (positive peak/r.m.s)
10.3	Enables crest factor (negative peak/r.m.s)
20.1	Enables form factor (r.m.s/rectified mean)
30.1	Enables mean scaled to r.m.s (mean x 1.111)
40.1	Enables peak-to-peak.
50.1	Enables AC + DC rectified mean
60.1	Enables continuous average mode
70.1	Enables averaged peak measurement
70.2	Enables peak hold measurement
80.0	Enables Or and Ur error indications
80.1	Disables Or and Ur error indications
81.0	Recalls software issue number. NOTE: (1) To return to the measurement mode, press /CONTINUE/. (2) The software issue number is displayed in the format XY.Z. The number XY is the last two digits of the Racal-Dana part number of one of the ROMs fitted, and identifies the hardware compatible set in use. The number Z is the issue number. (Early model instruments display the number Z only).

NOTE: Special functions with numbers 50.1 and below may be cancelled by operation of any primary or secondary measurement function key.

4.21 ERROR CODES

4.21.1 The instrument is able to detect a number of error states, some of which are indicated on the display. The meanings of the error codes are given in Table 4.2.

4.21.2 The error codes relating to over-range and under-range inputs depend upon the signal output levels from the detectors, not on the value displayed. For example, if the ratio function is being used to display the ratio of a r.m.s value to a stored value, an error code will be generated if the r.m.s detector output is out of range, although the display may still be capable of showing the computed ratio.

4.21.3 The circumstances under which the over-range and under-range error codes are generated are as follows:

(a) Error 03 - Or

AC + DC coupling, and either
DC detector output and selected AC detector output over range, or
special function 50.1 in use and overall mean over range.

(b) Error 04 - AC Or

AC + DC or AC coupling, and
selected AC detector output only over range.

(c) Error 05 - DC Or

AC + DC coupling, and
DC detector output only over range.

(d) Error 06 - P HI

AC or AC + DC coupling, and
non-selected peak detector output over range.

(e) Error 07 - Ur

AC or AC + DC coupling, and either
selected measurement detector output under range, or
special function 50.1 in use and overall mean under range.

This error code may also occur when the auto-ranging mode is in use, the selected AC detector output is under range, and one peak detector is at a level which will become over range if the instrument down ranges. Under these circumstances down ranging is inhibited.

NOTE: When special functions are used to measure crest factor or form factor the under-range and over-range error codes will be generated as though r.m.s. measurement were selected.

4.21.4 The under-range and over-range error codes are generated if the input signal is less than 31.6% or more than 114.9% of the full scale value of the range in use.

TABLE 4.2

Error Codes

Error	Error Code
Non-volatile memory corrupted	01
Input close to destructive overload level	02
AC and DC inputs over range	03
AC input over range	04
DC input over range	05
AC peak excessive for range selected	06
Input under range	07
Computed result to be displayed exceeds display capacity	11
Invalid entry	12
Attempt made to store zero	13
GPIB syntax error	18
RAM failure	20
ROM failure, IC16 on 19-1024	23
ROM failure, IC17 on 19-1024	24
ROM failure, IC18 on 19-1024	25
ROM failure, IC19 on 19-1024	26

NOTE: (1) Error 02 is displayed as OUCH

Error 03 is displayed as Or

Error 04 is displayed as AC Or

Error 05 is displayed as dC Or

Error 06 is displayed as P HI

Error 07 is displayed as Ur

Error 18 is not displayed

Error 20 is indicated by switching on all LED elements of the display

The remaining errors are displayed as Er followed by the two digit error code.

(2) The display of error codes other than Er 01 and OUCH can be inhibited by setting switch 3 of switch bank S30 on assembly 19-1024 to the closed position (where the slider is moved in the direction of the arrow moulded on it or towards the switch section number).

4.22 CONTROL VIA THE GPIB

4.22.1 The 5002 can be operated via the GPIB in either the addressed mode or the talk only mode. In the former the instrument makes measurements in response to commands, prefaced by the instrument's listen address, sent via the bus by the controller. The last measured value is loaded onto the bus when the instrument is addressed to talk.

4.22.2 In the talk only mode the 5002 will take measurements continually, at a rate determined by the averaging time in use, in accordance with instructions entered using the front panel controls. At the end of each measurement cycle the measured value is entered into a buffer store, from where it is loaded onto the bus in response to a signal on the NRFD line (commencement of the handshake sequence). If a measurement cycle is completed while data transfer is in progress, the updating of the buffer store is delayed until the data transfer is completed.

4.23 REMOTE/LOCAL CHANGEOVER

4.23.1 LOCAL TO REMOTE CONTROL CHANGEOVER

4.23.1.1 The 5002 is switched from local to remote control by the following sequence of control and data line messages:

(a) Remote enable (REN) true (low).	This primes the remote control enable, but the 5002 remains in local control. REN must remain true if any instrument on the bus is to remain in remote control.
(b) Attention (ATN) true (low)	
(c) Listen address	The 5002 enters the listener addressed state (LADS) on recognition of its listen address.
(d) ATN false (high)	The 5002 enters the listener active state (LACS) after a delay, and enters the remote state (REMS) on receipt of the first data byte.

4.23.1.2 No change to any of the 5002 control settings occurs on changeover from local to remote control.

4.23.2 REMOTE TO LOCAL CONTROL CHANGEOVER

4.23.2.1 The 5002 will be switched from remote to local control on:

(a) Operation of the front panel LOCAL key. This is effective only if local lockout is not set.

(b) Receiving the go to local (GTL) command when in the LADS.

(c) Receiving the REN message false (high). This is independent of the addressed state of the 5002.

4.23.2.2 No change to any of the 5002 control settings occurs on changeover from remote to local control.

4.23.3 LOCAL LOCKOUT (LLO)

4.23.3.1 Operation of the front panel LOCAL key during the transfer of data to the 5002 could result in the instrument being switched from remote to local control with the control settings in an unknown state. To prevent this the LOCAL key can be disabled by setting local lockout.

4.23.3.2 Local lockout may be set at any time when the REN message is true (low). The recognition of the LLO message is not dependent on the addressed state of the instrument. Apart from the disablement of the LOCAL key it causes no changes to the operation of the 5002. The only method of cancelling LLO is to send the REN message false (high). This affects all instruments on the bus, putting them to the local control state (LOCS).

4.24 COMMAND CODES FOR ADDRESSED MODE OPERATION

4.24.1 Once the 5002 has been addressed the instrument functions can be set by means of device dependent commands, consisting of pairs of alpha and numeric characters, as listed in Tables 4.4 to 4.18. If more than one command is to be sent no delimiter is required. The end of message may be signalled by sending any of the terminating groups shown in Table 4.3. The changes in 5002 operation are implemented at the end of the message.

TABLE 4.3

Permitted Terminating Groups

1	2	3	4	5
CR EOI true	LF	CR,LF	CR,LF EOI true	LF EOI true

TABLE 4.4

Primary Measurement Function Commands

Function	Code
Volts	FØ
Watts	F1

TABLE 4.5

Ω Store Commands

Function	Code
Store contents of numerical input buffer in Ω store.	Q1
Load contents of the Ω store into the output buffer.	Q2

NOTE: After loading the contents of a store into the output buffer the 5002 must be put to the talker active state for the data to be put onto the bus. The instrument will return to the measurement mode once the output buffer is loaded, but failure to read the buffer contents will prevent measurement data being entered.

TABLE 4.6

Secondary Measurement Function Commands

Function	Code
RMS	DØ
Mean	D1
+Peak	D2
-Peak	D3

TABLE 4.7

Compute Function Commands

Function	Code
Select RATIO	G1
Store the contents of the numerical input buffer in the RATIO store. If the numerical input buffer is empty, store the last measured value.	G2
Load the RATIO store contents into the output buffer.	G3
Select dB	L1
Store the contents of the numerical input buffer in the dB store. If the numerical input buffer is empty, store the last measured value.	L2
Load the dB store contents into the output buffer.	L3
Select NULL	N1
Store the contents of the numerical input buffer in the NULL store. If the numerical input buffer is empty store the last measured value.	N2
Load the NULL store contents into the output buffer.	N3
Select %	P1
Store the contents of the numerical input buffer in the % store. If the numerical input buffer is empty, store the last measured value.	P2
Load the % store contents into the output buffer.	P3

NOTE: (1) Selection of one compute function will automatically cancel any other compute function. Cancellation code CØ allows cancellation of all computed functions.

(2) The numerical input buffer is cleared, if required, by means of cancellation code C1.

(3) After loading the contents of a store into the output buffer the 5002 must be put to the talker active state for the data to be put onto the bus. The instrument will return to the measurement mode once the output buffer is loaded, but failure to read the buffer contents will prevent measurement data being entered.

TABLE 4.8

Range Commands

Range	Code
Autorange	RØØ
100 μV	RØ1
300 μV	RØ2
1 mV	RØ3
3 mV	RØ4
10 mV	RØ5
30 mV	RØ6
100 mV	RØ7
300 mV	RØ8
1 V	RØ9
3 V	R10
10 V	R11
30 V	R12
100 V	R13
300 V	R14
Manual Range	RM
Load the output buffer with the full scale value of the range in use	RZ

NOTE: (1) The use of code RM will take the instrument from the autorange mode to the manual range mode without changing the range in use.

(2) After loading the contents of a store into the output buffer the 5002 must be put to the talker active state for the data to be put onto the bus. The instrument will return to the measurement mode once the output buffer is loaded, but failure to read the buffer contents will prevent measurement data being entered.

TABLE 4.9

Input Coupling Commands

Input Coupling	Code
AC	HØ
AC + DC	H1

TABLE 4.10

Control Setting Storage Commands

Function	Code
Store current control settings and store values in stores numbered 01 to 12	AØ1 to A12

NOTE: Storage location ØØ always contains the values set when the instrument is first switched on, and cannot be overwritten.

TABLE 4.11

Control Setting Recall Commands

Function	Code
Recall and set initial control settings	BØØ
Recall and set control settings from stores numbered 01 to 12	BØ1 to B12
Recall control settings in use when instrument was last switched off	B99

NOTE: (1) The data stored in location 99 is overwritten as each change of instrument setting is made. The facility for recalling the settings in use when the instrument was switched off is only available immediately after switching on.

(2) Either the Device Clear (DCL) or the Selective Device Clear (SDC) command may be used instead of BØØ.

TABLE 4.12

Calibration Factor Commands

Function	Code
Disable calibration factor	U0
Enable calibration factor	U1
Store contents of numerical input buffer in calibration factor store	U2
Load contents of calibration factor store into the output buffer	U3

NOTE: After loading the contents of a store into the output buffer the 5002 must be put to the talker active state for the data to be put onto the bus. The instrument will return to the measurement mode once the output buffer is loaded, but failure to read the buffer contents will prevent measurement data being entered.

TABLE 4.13

Interrupt Commands

Function	Code
No service requests generated	I0
Service request generated when measured value is available	I1
Service request generated when error is detected	I2
Service request generated when measured value is available or when error is detected	I3
Load error code number into output buffer	I4

NOTE: (1) After loading the error number into the output buffer the 5002 must be put to the talker active state for the data to be put onto the bus. The instrument will return to the measurement mode once the output buffer is loaded, but failure to read the buffer contents will prevent measurement data being entered.

(2) The loading of the error code into the output buffer does not cancel the error code. Error codes other than 01, 20, 23, 24, 25 and 26 are cancelled using the cancellation code C2.

TABLE 4.14

Measurement Averaging Mode and Timing Selection Commands

Function	Code
Select fixed averaging mode	SØ
Select continuous averaging mode	S1
Select true peak measurement	S2
Select averaged peak measurement	S3
Select peak hold measurement	S4
Store contents of numerical input buffer in the AVERAGE store	S5
Load contents of AVERAGE store into the output buffer	S6
Store contents of numerical input buffer in the TRIGGER DELAY store	S7
Load contents of the TRIGGER DELAY store into the output buffer	S8

NOTE: After loading the contents of a store into the output buffer the 5002 must be put to the talker active state for the data to be put onto the bus. The instrument will return to the measurement mode once the output buffer is loaded, but failure to read the buffer contents will prevent measurement data being entered.

TABLE 4.15

Input Filter Commands

Function	Code
Filter out	JØ
Filter in	J1

TABLE 4.16

Trigger Commands

Function	Code
Perform continuous measurement cycles, updating the output buffer at the end of each cycle	TØ
Leave the continuous measurement mode and enter the triggered measurement mode	T1
If in the triggered measurement mode, perform one measurement and update the output buffer	T2
If in the triggered measurement mode, perform one measurement after a delay, equal to the value in the trigger delay store, and update the output buffer	T3

NOTE: (1) After a change of range a three second delay, additional to that held in the trigger delay store, is automatically inserted after the trigger command.

(2) The Group Execute Trigger (GET) command may be used instead of code T2 using the following procedure:

a) Send command T1.

b) Send command T2. The 5002 will perform one measurement cycle.

c) Send the GET command each time a further measurement cycle is required. Note that when using the GET command, the 5002 must be put to the talker active state after each measurement cycle.

(3) The use of the GET command after code TØ has been used will terminate the current measurement cycle. A new cycle will begin immediately.

(4) The instrument will revert to continuous measurement if the continuous averaging mode is selected (see Table 4.14). If the continuous averaging mode is cancelled the instrument will return to the last trigger mode enabled.

TABLE 4.17

Cancellation Commands

Function	Code
Cancel compute functions	CØ
Clear numerical input buffer	C1
Clear error code	C2

NOTE: Code C2 will not cancel error codes 01, 20, 23, 24, 25 or 26.

TABLE 4.18

Special Function Commands

Special Function Number	Function	Code
0	Cancel special function	YØ
10.1	Crest factor (highest peak/r.m.s.)	Y1
10.2	Crest factor (positive peak/r.m.s.)	Y2
10.3	Crest factor (negative peak/r.m.s.)	Y3
20.1	Form factor (r.m.s./rectified mean)	Y4
30.1	Mean scaled to r.m.s. (mean x 1.111)	Y5
40.1	Peak-to-peak	Y6
50.1	AC+DC rectified mean	Y7
60.1	Continuous average mode	S1
70.0	True peak measurement	S2
70.1	Averaged peak measurement	S3
70.2	Peak hold measurement	S4
/RECALL//SF/	Load the number held in the SPECIAL FUNCTION store into the output buffer	Y8

NOTE: After loading the contents of a store into the output buffer the 5002 must be put to the talker active state for the data to be put onto the bus. The instrument will return to the measurement mode once the output buffer is loaded, but failure to read the buffer contents will prevent measurement data being entered.

4.25 ENTRY OF NUMERICAL VALUES

4.25.1 The format for numbers to be entered in the numerical input buffer for subsequent loading into the internal stores is given in Table 4.19.

TABLE 4.19

Numerical Input Format

Byte	Interpretation	Permitted ASCII Characters
1	Sign of mantissa	Space, + or -
2	Most significant digit	Up to four digits, with a
3	Digit/decimal point	decimal point if required,
4	Digit/decimal point	may be entered. Unused
5	Digit/decimal point	bytes need not be filled.
6	Least significant digit	Excess spaces are ignored.
7	Exponent indicator	E or e
8	Sign of exponent	Space, + or -
9	Exponent digit	Ø to 9

NOTE: (1) An unsigned mantissa or exponent is assumed positive. Bytes 1 and/or 8 may be omitted when the sign is positive.

(2) The string may be terminated with CR, LF or by the first byte of the succeeding command.

(3) If the exponent group is not required bytes 7 to 9 may be omitted.

(4) The exponent group replaces the units keys used when entering values in local control. The units assumed by the numbers held in store are given in Table 4.20.

TABLE 4.20

Stored Value Units

Store	Units	
	VOLTS Mode	WATTS Mode
Ohms	Ω	Ω
Ratio	Volts	Watts
%	Volts	Watts
Null	Volts	Watts
dB	Volts	Watts
Average	Seconds	Seconds
Time Out	Seconds	Seconds
Calibration Factor	Number	Number

4.26 OUTPUT MESSAGE FORMAT

4.26.1 The same output message format is used for the transmission of measured values, error code numbers or the values held in the instrument's internal stores. The message consists of a string of 12 ASCII characters for each value transmitted. These are to be interpreted as shown in Table 4.21. No parity check is included. Each byte is accompanied by the full handshake procedure on the NRFD, DAV and NDAC control lines.

TABLE 4.21

Interface Output Message Format

Byte No	Interpretation	Permitted ASCII Characters
1	Sign of measurement	+ or -
2	Most significant digit	0 to 9
3	Decimal point	.
4	Digit	0 to 9
5	Digit	0 to 9
6	Least significant digit	0 to 9
7	Exponent indicator	E
8	Sign of exponent	+ or -
9	More significant digit	0 to 9
10	Less significant digit	0 to 9
11	Carriage return	CR
12	Line Feed	LF

4.27 STATUS BYTE FORMAT

4.27.1 The data line usage for the status byte, generated in response to a serial poll, is given in Table 4.22.

TABLE 4.22

Status Byte

DIO Line	Function
1	Not used
2	Not used
3	Not used
4	Not used
5	'1' indicates that the instrument is busy
6	'1' indicates that an error has been detected
7	'1' indicates that service was requested
8	Not used

NOTE: The status byte does not provide information about the nature of any error which has been detected. The addressed command I4 can be used to have the error number loaded into the output buffer. This will then be transmitted via the bus when the instrument is addressed to talk.

4.28 SERVICE REQUEST (SRQ) OUTPUT

4.28.1 The instrument can be instructed via the bus to generate an SRQ output as follows.

(a) SRQ generation inhibited

(b) SRQ sent true when data are available

(c) SRQ sent true when an error is detected

(d) SRQ sent true when data are available or when an error is detected.

The codes used are given in Table 4.13.

4.28.2 When the 5002 is being used in the triggered mode a delay, equal to the value set in the AVERAGE store, will occur between the generation of the SRQ output and the appearance of the SRQ annunciator on the front panel.

4.29 LOGIC LEVELS

4.29.1 The control, handshake and data lines operate at standard +5 V TTL levels. Negative logic is used, i.e. logic '1' is represented by a level $\leqslant$0.8 V and logic '0' by a level $\geqslant$2 V.

5.1 INTRODUCTION

5.1.1 This section is written in two parts. Paragraph 5.2 covers the operating principles of the 5002 in general terms, with reference to the block diagram, fig. 5.1. Paragraph 5.3 describes the operation of the circuits in greater detail, with reference to the circuit diagrams given in Section 7. It is essential that the principles of operation are understood before the detailed circuit description is read.

5.1.2 In the circuit description the integrated circuits are referred to by the circuit reference given on the appropriate circuit diagram. Note that a separate series of numbers, starting at IC1, is allocated to each assembly. Where an integrated circuit package contains more than one circuit, suffix letters are used to distinguish between them. Where it is required to identify a particular pin of an integrated circuit the circuit reference, with suffix letter if appropriate, is followed by an oblique stroke and the required pin number.

5.2 PRINCIPLES OF OPERATION

5.2.1 FUNCTIONAL SYSTEMS

5.2.1.1 The instrument contains four functional systems. These are:

(a) An analogue signal processing system

(b) A microprocessor system, which operates both as a digital signal processor and a control system.

(c) A keyboard/display system

(d) An interface to the IEEE 488 GPIB.

5.2.2 THE ANALOGUE SIGNAL PROCESSING SYSTEM

5.2.2.1 The analogue processing system accepts the signal to be measured from the INPUT connector. The input signal line may be connected to, or isolated from, chassis earth, according to the setting of a mechanical switch adjacent to the connector. The coupling may be AC or AC+DC, according to the control signal fed to the input coupling selection circuit from the microprocessor system.

5.2.2.2 The system uses five separate detectors to make simultaneous measurements of the true r.m.s, positive peak, negative peak, mean and DC component values of the input signal. Each of the detector outputs is sampled every 100 ms by the microprocessor system, although only one output is used to provide the display.

5.2.2.3 The DC detector has three outputs. These are:

(a) An output proportional to the filtered mean of the signal applied to the detector. This output is used as the measured value when the MEAN secondary measurement function is selected with AC+DC input coupling.

(b) An output indicating the polarity of output (a).

(c) An output similar to output (a), but at a lower level. This output is used in the mean detector.

5.2.2.4 The AC component of the input signal is fed to the remaining four detectors. The RMS detector and the two peak detector outputs are provided with auto-zeroing, which reduces the errors due to noise and offsets within the measuring system.

5.2.2.5 The mean detector gives an output proportional to the rectified mean of the sum of the AC and DC signals applied to it. This output is used as the measured value when the MEAN secondary measurement function is selected with AC input coupling. In this case any DC component of the input signal is blocked by the coupling. The input from the DC detector is zero, so that the mean detector output is the rectified mean of the AC component only.

5.2.2.6 The use of a special function allows the output of the mean detector to be used as the measured value when AC+DC coupling is used. In this case the input from the DC detector is proportional to the filtered mean (DC component) of the input signal, and the mean detector output is therefore the rectified mean of the total input signal.

5.2.2.7 To permit measurements to be made over a wide range of input levels while maintaining a restricted range of operation at the detectors, the gain of the analogue signal paths can be varied. A relay switched attenuator, of value 30 dB or 60 dB, can be inserted immediately after the input coupling selector. This attenuator affects the inputs to all the detectors. Fine control of the AC and DC signal paths is exercised over each path separately in the switched gain AC and DC amplifiers.

5.2.2.8 In the case of the DC amplifier the gain is controlled by inserting attenuators into the feedback path. An electronically switched 40 dB attenuator and relay switched 20 dB and 10 dB attenuators are provided. In the AC amplifier, three attenuators of 20 dB and one of 10 dB are provided. In all cases the insertion and removal of attenuators into and from the signal path is controlled by the microprocessor via five control lines.

5.2.2.9 A low pass filter can be switched into the AC signal path. This restricts the upper frequency limit of the system to 200 kHz (-3dB).

5.2.3 THE MICROPROCESSOR SYSTEM

5.2.3.1 The microprocessor system is contained on assembly 19-1024. The system performs two separate functions:

(a) It converts the output of the voltage measuring circuits to digital form. The result is operated upon arithmetically to provide the measured value to be displayed.

(b) It provides signals to control the operation of the instrument in accordance with instructions entered by the operator.

The microprocessor is interrupt controlled, interrupt requests being generated every 100ms by the measured signal peripheral interface adaptor (PIA), at every operation of a key in the keyboard/display system and for every data byte received or transmitted by the GPIB interface.

5.2.3.2 Digital Signal Processing

5.2.3.2.1 The outputs of the detectors are connected in turn to the analogue to digital converter. When conversion to digital form is complete an IRQ is generated by the PIA, and the converter output is stored. In the case of the r.m.s, mean and DC detectors, a number of successive values, determined by the value held in the AVERAGE store, are then averaged. The signal originating in the detector corresponding to the secondary measurement function selected is processed, in accordance with the primary and computed measurement functions in use, to provide the value which is to be displayed. This value is used to set up a 96-bit serial data string, which is fed to the keyboard/display system on assembly 19-1023. The system also converts the value to be displayed into the nine data bytes of the GPIB interface output word. The exponent indicator byte and the CR and LF terminating bytes are incorporated to complete the output word, which is fed to assembly 19-1017 after the display has been updated.

5.2.3.3 Instrument Control

5.2.3.3.1 The majority of the instructions governing the operation of the instrument are internal to the microprocessor system, and govern such matters as the manner in which measurement data are processed, the selection of data to be displayed, the storage of data displayed or entered via the keyboard, range setting, error detection, etc. External control lines are provided for:

(a) Attenuator control (5 lines)
(b) DC/Mean detector output selection
(c) Low-pass filter control
(d) Input coupling selection

In addition the microprocessor system provides a timing signal for the auto-zero circuits.

5.2.4 THE KEYBOARD/DISPLAY SYSTEM

5.2.4.1 The keyboard/display system incorporates a custom built liquid crystal display (LCD). At display update the fresh data to be displayed, which may be the output of the digital signal processor, the contents of a store or an error code, is fed to assembly 19-1023 in the form of a 96-bit serial data string. This is fed into three 32-bit shift registers to convert it from serial to parallel form, the shift register outputs being latched until the next display update occurs. Each element of the LCD is controlled from a separate shift register output. The time taken to update the display is extremely short, and display blanking during updating is unnecessary. The 30 Hz alternating supply for the LCD is obtained from an oscillator on assembly 19-1024.

5.2.4.2 The input section of the system is formed by a 7 x 4-line keyboard. This may be used to give instructions to the control system or to enter values into the stores used during the digital signal processing. Each key operation generates an IRQ, and is serviced individually by the microprocessor. The first of a series of numeric key operations puts the display to the numbers mode. In this mode the instrument continues to make measurements, but the display continues to show the numbers entered until the instrument is returned to the measurement mode.

5.2.5 THE GPIB INTERFACE

5.2.5.1 The following functions are carried out by the GPIB interface without involvement of the microprocessor system.

(a) Distinguishing between universal and addressed commands occurring on the bus.

(b) Talk and listen address recognition.

(c) Generation of the signals required by the handshake protocol.

5.2.5.2 The interface passes device dependent data and certain universal bus commands between the bus and the microprocessor. An interrupt is generated for each of the following situations:

(a) A device dependent data byte is held in the data-in register for the microprocessor to read.

(b) The last data byte loaded into the data-out register has been read by the bus.

(c) DCL or SDC received.

(d) GET received.

(e) SPE or SPD received.

(f) Instruction to change remote/local status (RLC) received. This may be the REN message received false or the GTL command received when in the remote control mode, or REN and the listen address received when in the local control mode.

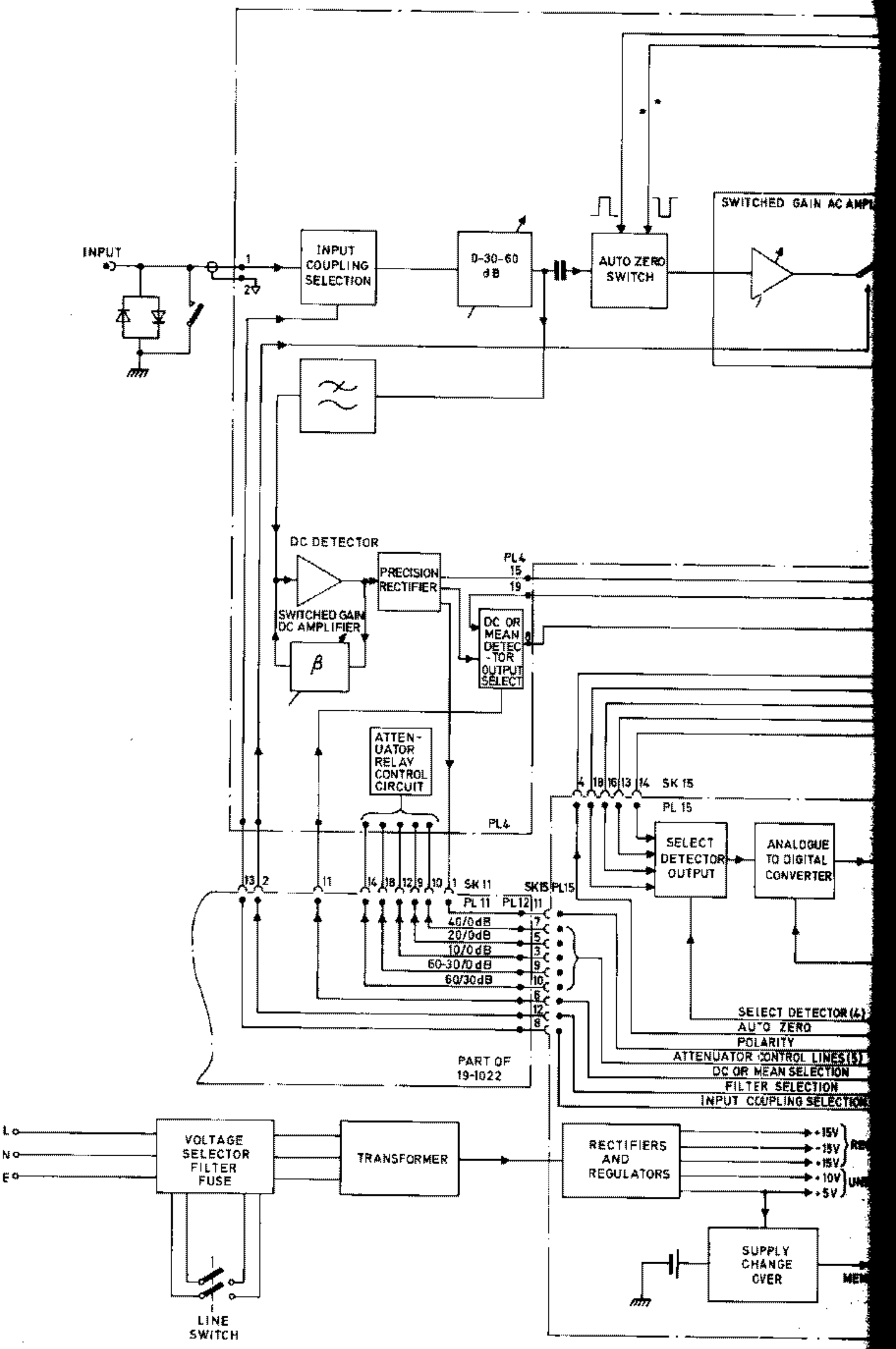


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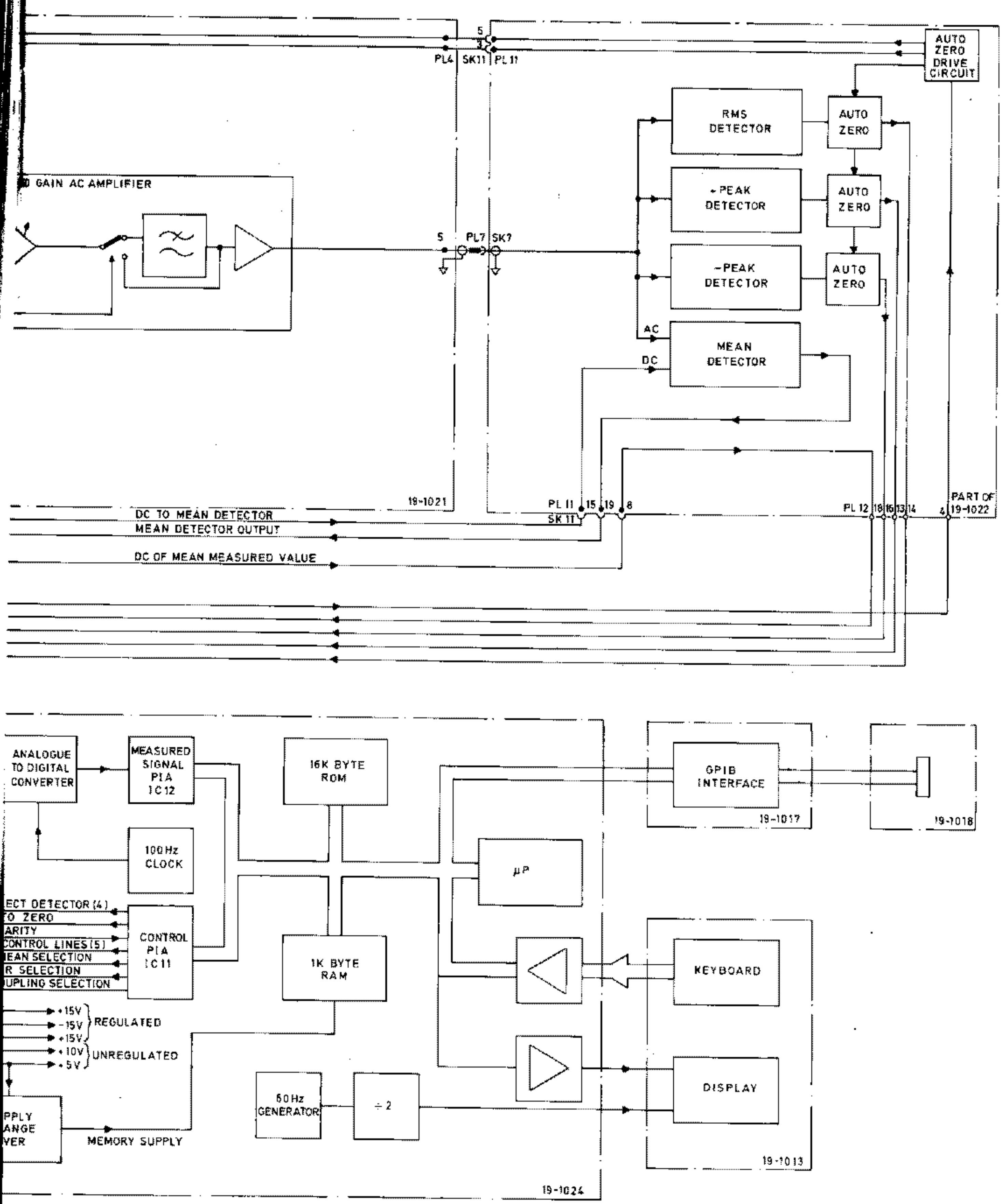
Fig. 5.1 Block D



1 Block Diagram

5.3 TECHNICAL DESCRIPTION

5.3.1 ANALOGUE SIGNAL PROCESSING SYSTEM

5.3.1.1 The analogue signal processing system is carried on two PCBs, the amplifier assembly 19-1021 and the detector assembly, 19-1022. The circuit diagrams for these assemblies are given in Fig. 9 and Fig. 11 in Section 7 of this manual.

5.3.1.2 Input Circuit

5.3.1.2.1 The instrument INPUT socket is normally mounted on the front panel, but may be mounted on the rear panel as an optional alternative. The body of the socket is connected to the earth plane of assembly 19-1021 (signal earth) but is isolated from chassis earth by two sets of back-to-back diodes contained in the diode bridge D1. The signal earth can be held at chassis earth, if required, by closure of the ISOLATE switch S1.

5.3.1.3 Input Coupling Selection

5.3.1.3.1 The signal to be measured enters assembly 19-1021 at pins 1 and 2 (pin 2 is signal ground). With RLA de-energised, the signal is AC coupled to the measuring circuits via C1. Selecting AC+DC energises RLA, and gives DC coupling. R2 limits the current surge in RLA which occurs when the contacts are closed with C1 charged.

5.3.1.3.2 When AC+DC is selected a logic '1' level is set in the input coupling control line latch by the microprocessor. The level held in the latch enters assembly 19-1021 at PL4 pin 13, and is applied to IC3/11. A logic '1' level here will result in IC3/14 being internally connected to IC3/13, providing +15 V to energise RLA.

5.3.1.4 First Attenuator

5.3.1.4.1 The first attenuator provides attenuation of 0 dB, 30 dB or 60 dB according to the states of RLB, RLC and RLD and RLE. The relay states for different attenuation levels are shown in Table 5.1.

TABLE 5.1

First Attenuator Relays

Ranges	Attenuation	Relay State (1 = Energised)			
		B	C	D	E
30 V, 100 V and 300 V	60dB	1			1
1 V, 3 V and 10 V	30dB	1		1	
100 µV to 300 mV	0dB		1		

5.3.1.4.2 The relay state is governed by the logic levels set in the 60-30/0 dB and 60/30 dB control line latches by the microprocessor. The levels held in the latches enter assembly 19-1021 at PL4 pins 18 and 14, and are shown in Table 5.2.

TABLE 5.2

First Attenuator Logic Levels

Attenuation	60-30/0 Line	60/30 Line
60 dB	1	1
30 dB	1	0
0 dB	0	0

5.3.1.4.3 The control line logic levels are applied to IC3/9 and 10. When IC3/10 is at logic '0', the +15 V at IC3/15 is connected to IC3/2 and RLC is energised, giving 0 dB. When IC3/10 is at logic '1', the +15 V is transferred to IC3/1. This de-energises RLC and switches on Q11, so energising RLB. At the same time +15 V is applied to IC3/4. If IC3/9 is at logic '0' this is connected to IC3/5, energising RLD, but if it is at logic '1' the connection is to IC3/3 and RLE is energised.

5.3.1.4.4 Each of the paths through the attenuator is provided with a trimming capacitor to allow adjustment of the high frequency attenuation. The base/emitter junctions of transistors Q1 and Q2 are connected back-to-back across the attenuator output to provide protection against excessive voltage levels.

5.3.1.5 Auto-Zero Switch

5.3.1.5.1 The attenuator output is passed to the AC amplifier via C13 and an opto-coupler IC1. IC1 open circuits the input signal line during the auto-zero period, so that the signal input to the AC measuring circuits is reduced to zero. This action also disconnects the noise signal generated in the instrument circuit between the INPUT socket and IC1, and would reduce the effectiveness of the noise cancellation. To overcome this a second opto-coupler, IC2, driven in anti-phase with IC1, connects an equivalent noise source formed by C14 and R17 to the AC amplifier input.

5.3.1.6 The Gain Controlled Amplifiers

5.3.1.6.1 The AC channel amplifier consists of an input buffer, Q3/Q4, and four feedback amplifier stages. The first three amplifier stages are preceded by 20 dB attenuators, while the fourth stage is preceded by a 10 dB attenuator. The attenuators are switched into and out of the signal path by relays, being inserted when the associated relay is energised. The relay states for different attenuation levels are shown in Table 5.3.

TABLE 5.3

AC Amplifier Attenuator Relays

Ranges	Attenuation	Relay State (1 = Energised)			
		F	G	H	J
300 mV, 10 V and 300 V	70	1	1	1	1
100 mV, 3 V and 100 V	60	1	1	1	
30 mV, 1 V and 30 V	50		1	1	1
10 mV	40		1	1	
3 mV	30			1	1
1 mV	20			1	
300 µV	10				1
100 µV	0				

5.3.1.6.2 The relay states are governed by the logic levels set in the 40/0 dB, 20/0 dB and 10/0 dB control line latches by the microprocessor. These logic levels enter assembly 19-1021 at PLA pins 10, 9 and 12, and switch the three relay control transistors in each of IC5, IC6 or IC7. It will be seen that RLH can be energised by IC5, under control of the 40/0 dB line or by IC6, via D1, under control of the 20/0 dB line. RLF is energised only when Q5 is switched on by the 40/0 dB line and a path for the relay current is provided through IC6 by a logic '1' on the 20/0 dB line.

5.3.1.6.3 The circuit of the third amplifier stage is shown in fig. 5.2. The other stages are of similar form, but do not contain frequency response adjustment circuits such as C36, R48, R45 and C33.

5.3.1.6.4 The fourth amplifier stage is formed by Q9 and Q10, and incorporates a switchable low-pass filter. The filter control line enters the assembly at PL4 pin 2. When this line is at logic '1' Q7 conducts, switching Q8 off. When the control line is at logic '0' Q7 is cut off, Q8 conducts and the filter formed by C43 and the ferrite bead FX1 is inserted into the amplifier circuit.

5.3.1.6.5 The overall gain of the amplifier from TP6 to TP23 with no attenuators in circuit and the filter switched out is approximately 70dB.

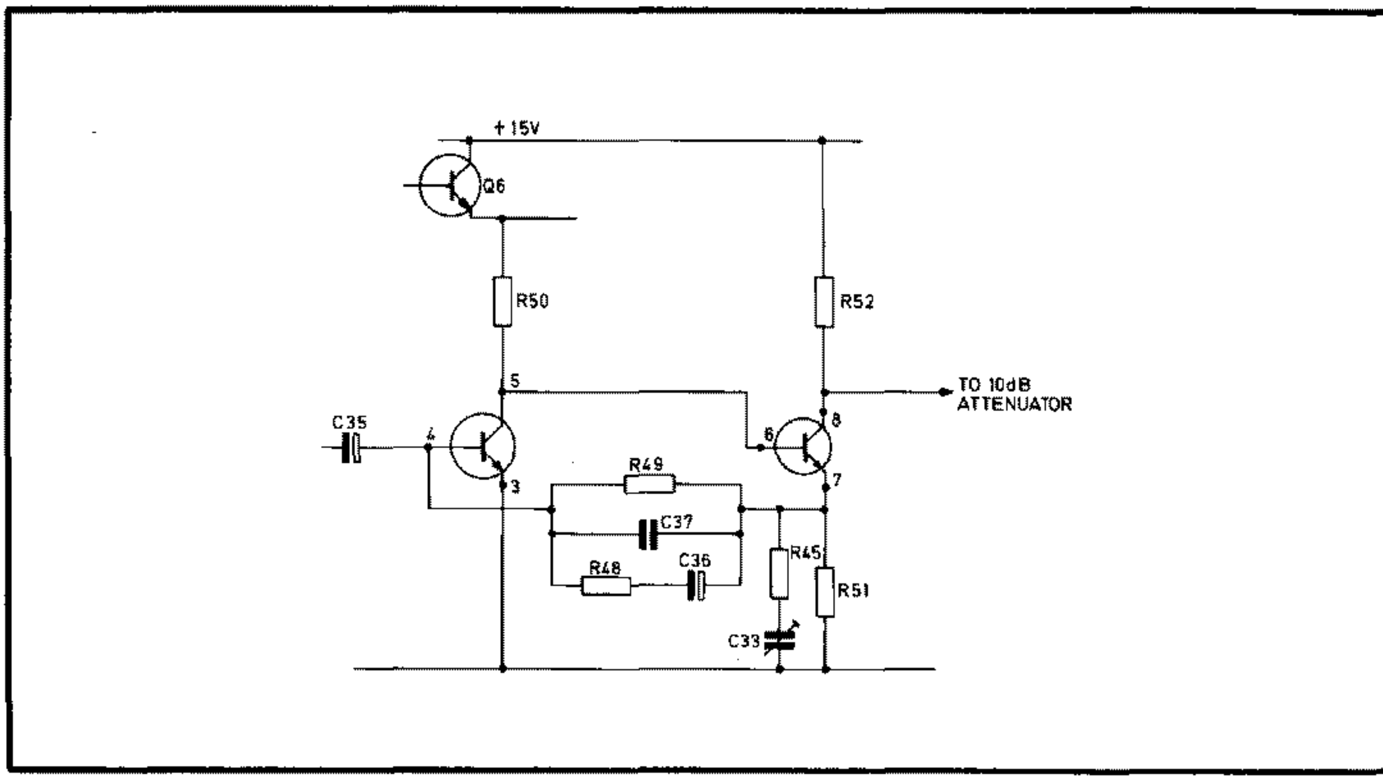


Fig. 5.2 Third Stage Amplifier Circuit

5.3.1.6.6 The DC channel amplifier is fed via the low pass filter formed by R15 and C52, so that the input to IC4 is the filtered mean of the signal to be measured. IC4 is connected as a feedback amplifier having switched attenuators of 40 dB, 20 dB and 10 dB in the feedback path. The gain is reduced by switching the attenuators out. The 10 dB and 20 dB attenuators are switched by relays RLL and RLK, but the 40 dB attenuator is switched electronically by Q12 and Q13. The relay and FET states for different attenuation levels are shown in Table 5.4.

TABLE 5.4

DC Amplifier Attenuator Switching

Ranges	Attenuation	Relay or FET State (1 = Energised or ON)			
		RLK	RLL	Q12	Q13
300 mV, 10 V and 30 V	70	1	1		1
100 mV, 3 V and 100 V	60	1			1
30 mV, 1 V and 30 V	50		1		1
10 mV	40				1
3 mV	30	1	1	1	
1 mV	20	1		1	
300 µV	10		1	1	
100 µV	0			1	

5.3.1.6.7 As with the AC amplifier, the relay and FET states are set by the logic levels on the 40 /0 dB, 20/0 dB and 10/0 dB control lines. Relays RLK and RLL are energised, when required, by transistors in IC6 and IC7, while the control voltages for Q12 and Q13 are set by IC9. With the 40/0 dB control line at logic '0', IC9/9 and 10 are pulled up to +15 V via the coil of RLG. Under these conditions IC9/15 is connected to +15 V via IC9/1, while IC9/4 is connected to the junction of R91 and an element of R90 via IC9/3, so that Q12 is switched on and Q13 switched off. When the 40/0 dB line is at logic '1', IC9/9 and 10 are pulled down by a transistor in IC5, connecting IC9/4 to +15 V via IC9/5 and IC9/15 to the R90/R91 junction via IC9/2. This reverses the states of Q12 and Q13.

5.3.1.6.8 The effects of any offset at the input to IC4 can be corrected by adjustment of R66.

5.3.1.7 The DC Detector

5.3.1.7.1 The output from IC4/10 is fed to a precision rectifier formed by IC8a and b and Q14. This acts as a bipolar to unipolar converter, giving an output at IC8b/7 proportional to the magnitude of the DC component of the signal to be measured.

5.3.1.7.2 If the output from IC4/10 is positive the output from IC8a/1 will be negative and Q14 will be cut off. The DC amplifier output is applied to IC8b/5 and 6, and the amplifier has a net gain of +5. If, however, the DC amplifier output is negative, the output from IC8a allows Q14 to conduct. This holds IC8b/5 at 0 volts, so that the only input to IC8b is via R84, and the net gain is -5. The output at IC8b/7 is therefore always positive, and proportional to the magnitude of the detector input.

5.3.1.7.3 The output of the DC detector is taken from the wiper of R88, which permits adjustment of the output level during the instrument calibration procedure. The effects of any offset at the input to IC8b can be corrected by adjustment of R80.

5.3.1.7.4 The output from IC8a/1 switches Q15 to provide the DC detector input polarity indication. For positive inputs Q15 is cut off and the polarity indication line is pulled to logic '1' by R79 on assembly 19-1022. For negative inputs Q15 conducts, clamping the line to OV.

5.3.1.7.5 The output from IC4/10 is fed to assembly 19-1022 via PL4 pin 15 and SK15. This forms the DC input to the mean detector.

5.3.1.8 The RMS Detector

5.3.1.8.1 The r.m.s. detector is mounted on assembly 19-1022. It provides a DC output proportional to the true r.m.s. of the AC component of the measured signal. When AC+DC input coupling is selected the DC component of the measured signal, as measured by the DC detector, is added to the r.m.s. detector output in the digital signal processing system.

The inputs to the multiplier are $(V_S + V_R)$ and $(V_S - V_R)$

The multiplier output is therefore $(V_S + V_R)(V_S - V_R)$

$$= (V_S^2 - V_R^2)$$

The integrator output is the mean value of the multiplier output

$$= \overline{(V_S^2 - V_R^2)}$$

The amplifier output is therefore $A\overline{(V_S^2 - V_R^2)}$

But the amplifier output is V_R, so $\frac{V_R}{A} = \overline{(V_S^2 - V_R^2)}$

If the amplifier gain is large $\frac{V_R}{A}$ approximates to zero, so that

$$\overline{V_S^2} = \overline{V_R^2}$$

Since V_R is a direct voltage $\overline{V_R^2} = V_R^2$, and

$V_R = \sqrt{\overline{V_S^2}}$, the r.m.s. value of Vs.

A more complete analysis of the loop operation, taking account of noise and multiplier input offsets is given in Appendix 1 to this section.

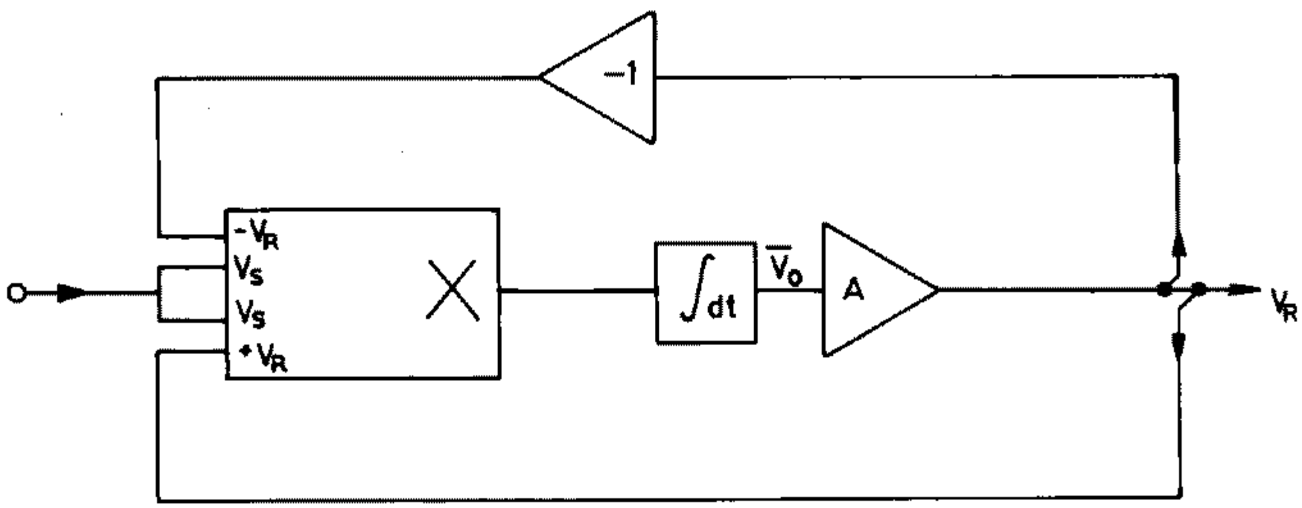


Fig. 5.3 Feedback Loop Operation

5.3.1.8.2 The detector is fed with the output from the AC switched gain amplifier, which enters assembly 19-1022 at SK7. The measuring circuit is in the form of a feedback loop containing a differential multiplier, an integrator and an amplifier, and features an auto-zeroing system which cancels out noise and the effects of the multiplier input offsets. A simplified circuit of the loop and a simplified analysis of the operation of the circuit, ignoring the multiplier input offsets and noise, is given in Fig. 5.3.

5.3.1.8.3 The loop multiplier is of the linearised transconductance type, a schematic circuit diagram being given in Fig. 5.4. The operation of the multiplier is described in Appendix 2 to this Section.

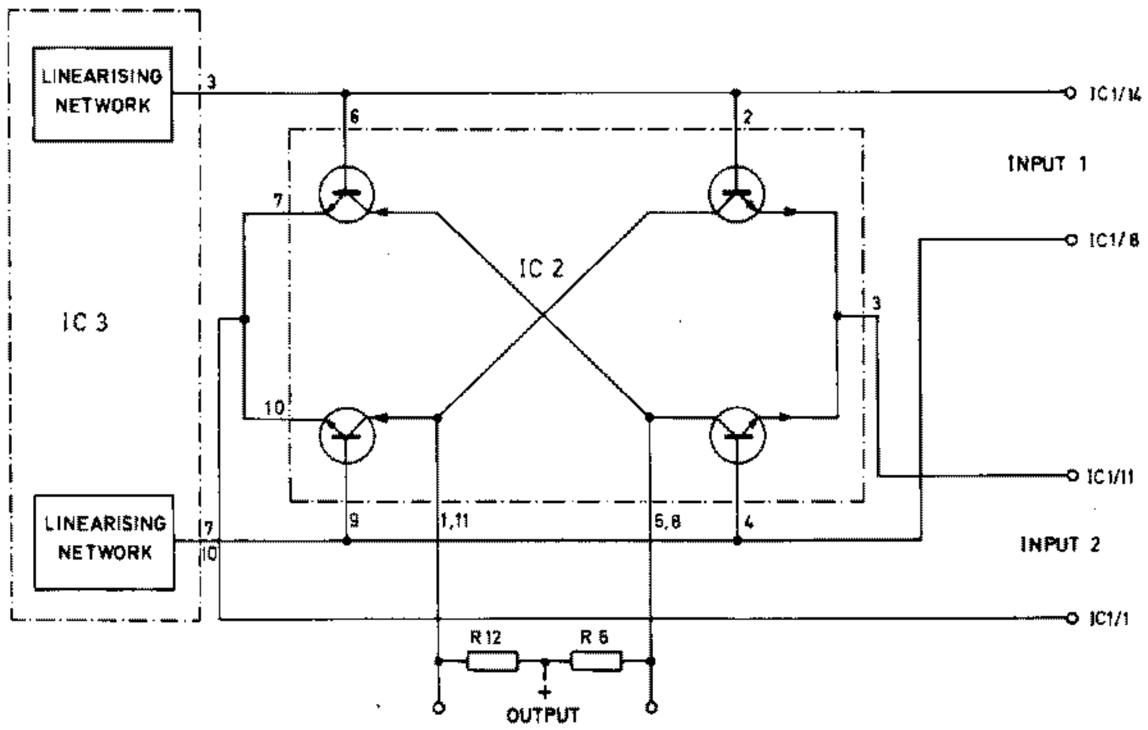


Fig. 5.4 Loop Multiplier

5.3.1.8.4 The transistors of the multiplier are contained in IC2. The use of the transistor array rather than discrete components affords close matching of the transistor characteristics. IC2 is specially selected to obtain the degree of matching required. The multiplier linearising networks are formed by the transistors in IC3. This array is also specially selected to obtain the required degree of matching. The base/emitter diodes of these transistors form the loads for the input currents from IC1 pins 8 and 14. They provide an exponential relationship between the input currents and the voltages applied at IC2 pins 4, 9,2 and 6 which offsets similar non-linearities in the transistors of IC2.

5.3.1.8.5 The multiplier inputs are driven by the transistors in IC1, which are connected with Q3 and Q4 to form two long-tailed-pair differential amplifiers. Good matching of these transistors is essential, and IC1 is specially selected to achieve this. When measuring signals of high crest factor the differential signal at the amplifier inputs becomes large, and the transistors may be driven close to cut off at the signal peaks. This results in non-linearity. The effect is overcome by means of D1 and D2, which conduct when the differential signal is large, reducing the emitter coupling resistor value and increasing the amplifier gain.

5.3.1.8.6 The differential output of the multiplier is fed to IC4d. Except during the auto-zeroing period Q7 and Q8 are held in the conducting state, while Q10 is held in the high impedance state. Feedback is therefore applied to IC4d via C12, and the circuit acts as an integrating amplifier. The voltage at TP7 is proportional to the mean level of the multiplier output, and to the true r.m.s. value of the measured signal.

5.3.1.8.7 The output of IC4b is fed back to the input of the multiplier at IC1/2 and IC1/12. The feedback circuit is shown in Fig. 5.5.

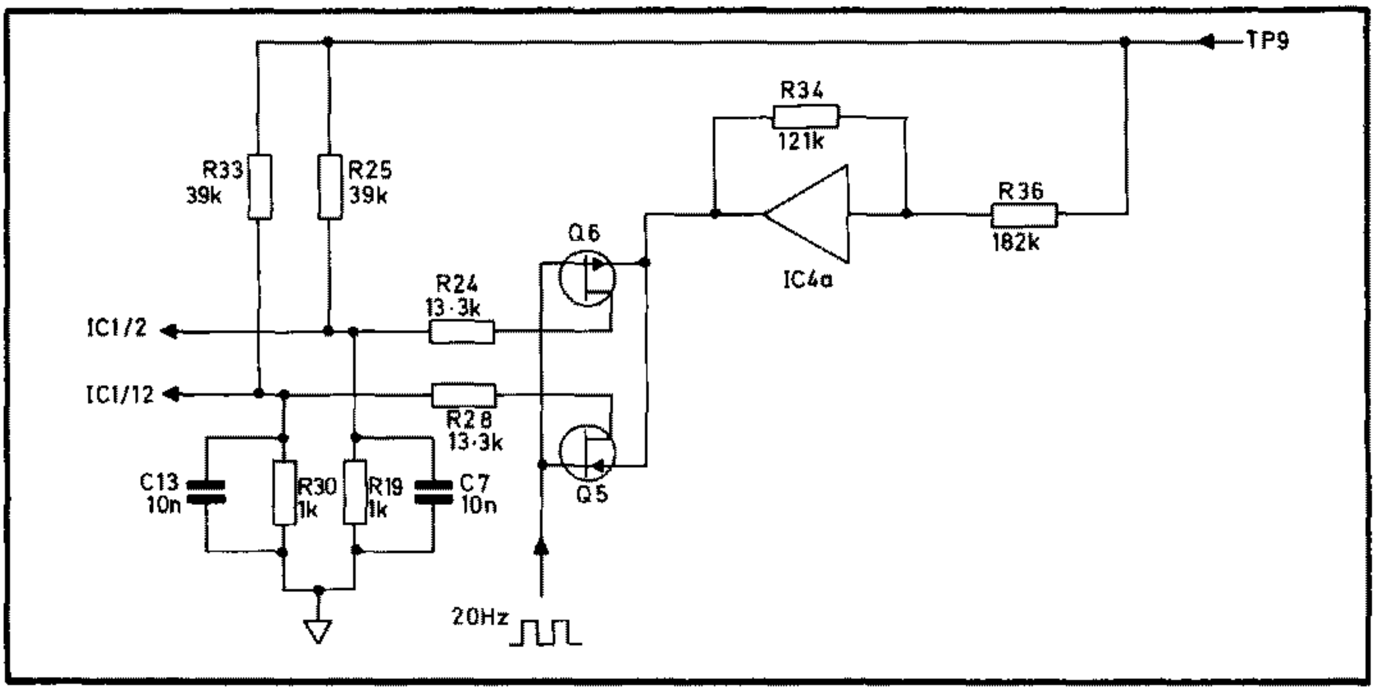


Fig. 5.5 Feedback Switching

5.3.1.8.8 The feedback from TP9 to IC1/2 and IC1/12 is in two parts.

(a) A positive voltage, fed to both IC1/2 and IC1/12 via R25 and R33.

(b) A negative voltage fed via IC4a, Q5/Q6 and R24/R28. This is fed to IC1/2 or IC1/12, according to whether Q5 or Q6 is conducting, and is switched between these inputs at 20 Hz.

5.3.1.8.9 The gain of IC4a is set by R34 and R36 to 0.665. The ratios R28/R33 and R24/R25 are chosen to make the negative signal from IC4a twice the positive signal, so that the total feedback signals at IC1/2 and IC1/12 are of equal amplitude but opposite sign. The feedback switching circuit is driven by the clock circuit containing IC5b.

5.3.1.9 <u>RMS Detector Sample and Hold</u>

5.3.1.9.1 Except during the auto-zeroing period, Q11 is in the low impedance state and C16 charges to the voltage at TP9. This voltage is fed to the digital signal processing system via IC4b. During the auto-zeroing period Q11 is put to the high impedance state, and the output voltage is maintained at the level held in C16.

5.3.1.9.2 The gain of IC4b can be adjusted by means of R45 to permit calibration of the r.m.s. detector output.

5.3.1.10 <u>RMS Detector Auto-Zeroing</u>

5.3.1.10.1 Every 500 ms an auto-zeroing cycle, lasting 1 ms, is performed. During this period the measured signal input is reduced to zero, and the residual signal at the output of IC4d is used to generate a correction voltage, which is stored. During the measurement period which follows, this voltage is injected into the feedback loop of the r.m.s. detector, cancelling the zero error.

5.3.1.10.2 The timing for the auto-zeroing system is derived from the microprocessor system. The drive signal enters assembly 19-1022 at PL12 pin 4, and is applied to the two comparators, IC5c and IC5d. The outputs at TP11 and TP14 are in antiphase, the signal at TP11 being low during the measurement period and high during auto-zeroing.

5.3.1.10.3 At the commencement of the auto-zeroing period the following actions take place:

(a) The anti-phase signals from TP11 and TP14 are fed out to assembly 19-1021 via PL11 pins 3 and 5. This output drives the auto-zero switch at the input to the AC switched gain amplifier, as described in paragraph 5.3.1.5.

(b) The negative signal at TP14 is applied to Q8 and Q7 via D7, breaking the normal feedback path for IC4d.

(c) The positive signal at TP11 allows Q10 to go to the conducting state. This connects the residual loop output, which exists at IC4d/14 when the loop input is open circuited, to the integrator IC4c. The output of IC4c is applied to IC4d/12, providing an input which drives the output of the loop to 0V.

5.3.1.10.4 At the end of the auto-zeroing period the circuit is reset to the measurement mode. The input of IC4c is disconnected from the signal path as Q10 reverts to the high impedance state, but the zero error correction voltage at TP10 remains connected to the input of IC4d. This maintains the zero correction during the following measurement period.

5.3.1.11 The Prevention of Lock Up

5.3.1.11.1 When the instrument is operated with no input signal to the r.m.s. detector there may be a tendency for the output of the loop to drift negative. If such an output is fed back to the multiplier the effect is cumulative, and the loop locks up with the output driven negative. This is prevented by D4, which becomes reverse biased if the voltage at TP7 is negative, so open circuiting the feedback path.

5.3.1.12 The Peak Detectors

5.3.1.12.1 Two peak detectors are mounted on assembly 19-1022, and provide DC outputs proportional to the positive and negative peak values of the AC component of the signal which occur during a measurement interval. Each detector uses the basic feedback loop, shown in Fig. 5.6, which acts as a unidirectional voltage tracking circuit. The connections shown are those for the negative peak detector. It should be noted that there is signal inversion in the AC switched gain amplifier, and the negative peak detector is required to measure the positive peak of the waveform at the comparator input.

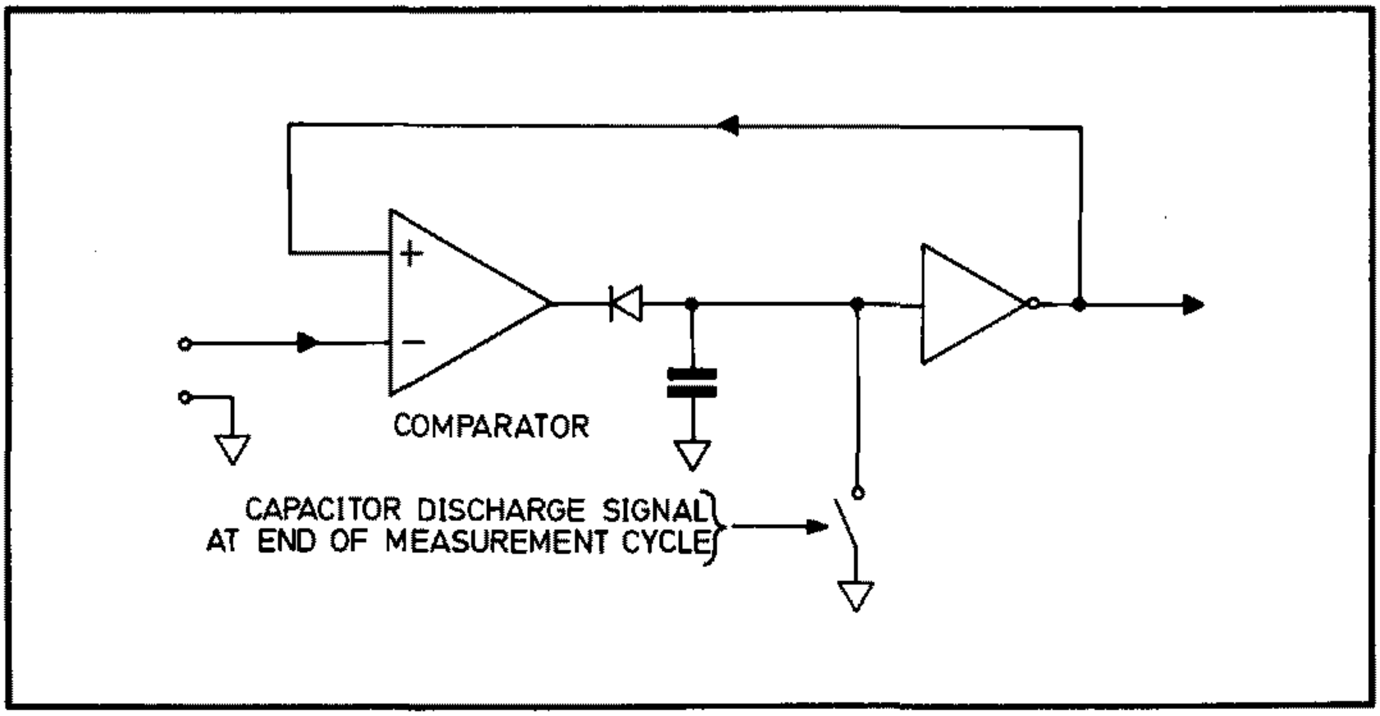


Fig. 5.6 The Negative Peak Detector

5.3.1.12.2 At any time during a measurement cycle when the comparator input is more positive than the inverter output, the reservoir capacitor is charged more negative with respect to 0 V, making the inverter output more positive. Charging continues until the feedback reduces the comparator differential input to zero, so that the output voltage tracks the input voltage. If at any time the signal input goes less positive than the feedback, the comparator output goes positive and the diode is reverse biased. The peak value measured so far is then held in the capacitor, so that voltage tracking occurs in one direction only. At the end of the measurement cycle the circuit is reset by discharging the capacitor.

5.3.1.12.3 The positive peak detector has the signal input and feedback connections to the comparator reversed, so that the capacitor is charged more negative when the comparator input is more negative than the feedback voltage. The polarity of the feedback is reversed by taking it from the input to the inverter. The detector output is still taken from the inverter output, so that both detectors have positive going outputs.

5.3.1.12.4 The input to the detectors is taken from the AC switched gain amplifier via SK7, C32 and the filter circuit formed by R138, C46, R135, C43 and R81. This circuit provides a measure of HF boost.

5.3.1.12.5 The detector comparators, IC11 and IC12 are high speed types, having differential outputs. The outputs are converted to unipolar form in the differential amplifiers formed by Q12/Q13 and Q18/Q19. Diode connected FETs, Q14 and Q20, are used as detector elements to ensure low leakage when they are reverse biased. The reservoir capacitors are C35 and C41, the capacitor voltages being amplified by approximately four in IC13b and IC14b before inversion in IC13a and IC14a. The inverted signals are finally amplified by a factor of two in IC15a and IC16a.

5.3.1.12.6 At the end of each measurement cycle C35 and C41 are discharged by the FET switches Q15 and Q21. The discharge timing signal originates in the microprocessor system and enters assembly 19-1022 at PL12 pin 2. At the end of each measurement cycle a positive pulse occurs on this line, switching Q16 on and putting Q15 and Q21 to the conducting state.

5.3.1.12.7 The detectors are calibrated by adjusting the feedback path attenuation by means of R83 and R111.

5.3.1.13 <u>Peak Detector Auto Zeroing</u>

5.3.1.13.1 Each of the peak detectors is provided with an auto-zeroing circuit which operates for 1 ms every 500 ms. At the commencement of the auto-zeroing period the measured signal input to the AC switched gain amplified is reduced to zero by the auto-zero switch, so that the measured signal input to the peak detectors is also zero. In the negative peak detector, the auto-zero timing signal from the microprocessor, which enters assembly 19-1022 at PL12 pin 4, puts Q17 to the conducting state, and any residual signal at TP32 is applied to the integrator, IC15b. The integrator output ramps up or down, injecting a signal at IC15a/3 which drives TP32 to 0 V. At this point the action ceases.

5.3.1.13.2 At the end of the auto-zeroing period Q17 is returned to the non-conducting state, but the zero error correction voltage at IC15b/7 is maintained during the following measurement period. The zero error correction voltage can be set, by adjusting R107, to ensure that TP32 is set to exactly 0 V by the system.

5.3.1.13.3 The positive peak detector auto-zeroing system operates in an identical manner.

5.3.1.14 The Mean Detector

5.3.1.14.1 The mean detector gives an output proportional to the rectified mean of the sum of:

(a) The AC component of the measured signal.

(b) A DC level, generated in the DC detector, proportional to the DC component of the measured signal.

When AC coupling is selected the DC input to the mean detector is held at zero by Q2, which is switched to the conducting state by the microprocessor.

5.3.1.14.2 The detector incorporates the balanced modulator, IC9. This switches the detector input signals, applied at IC9/1 and IC9/4, between the differential outputs, IC9/6 and IC9/9. The voltages at IC9/6 and IC9/9 are filtered, to obtain the mean values, and the outputs are combined in the differential input amplifier IC10. The action of the circuit with an AC input only is shown in Fig. 5.7. The action with both AC and DC inputs is shown in Fig. 5.8. The waveforms take no account of the filtering action of C20 and C22, and cannot be observed at TP18 and TP22.

5.3.1.14.3 The outputs of the crossing detector, IC6, change level whenever the AC input at IC6/2 crosses the DC input level at IC6/3. These outputs form the switching signals for IC9, and are applied at IC9/7 and 8. In one state the AC input at IC9/1 is routed to IC9/9 (inverted) and to IC9/6 (non-inverted). For the other state the routeing is reversed. Signal path switching occurs when the AC and DC signals, and therefore the outputs of IC9, are at the same voltage. It can be seen that the difference between the outputs is the same as the measured signal with those parts of the waveform below 0 V inverted, so that the system operates as a precision rectifier. The mean value of the difference waveform is the rectified mean value required.

5.3.1.14.4 The outputs of IC9 are filtered by C20 and C22, and applied to the differential inputs of the integrator, IC10. Since IC10/2 is an inverting input the output is positive, as required.

5.3.1.14.5 The DC level applied to IC9 is calibrated by means of R49, while the effect of offsets in IC6 can be nulled using R60. The outputs of IC9 can be balanced by adjusting R65, and calibrated by means of R56. Adjustment of R78 permits the mean DC level of the IC9 outputs to be set.

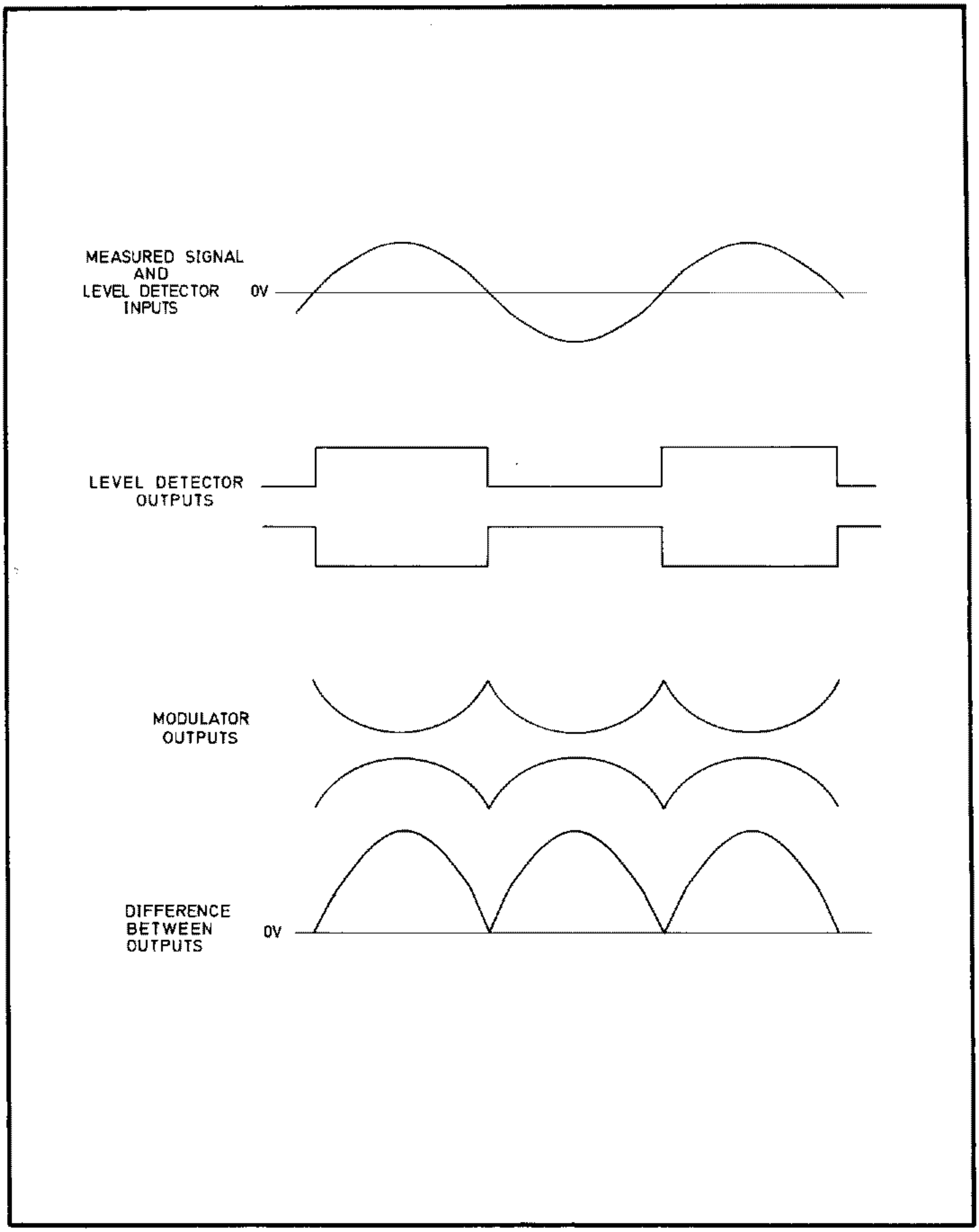


Fig. 5.7 Mean Detector Operation, AC

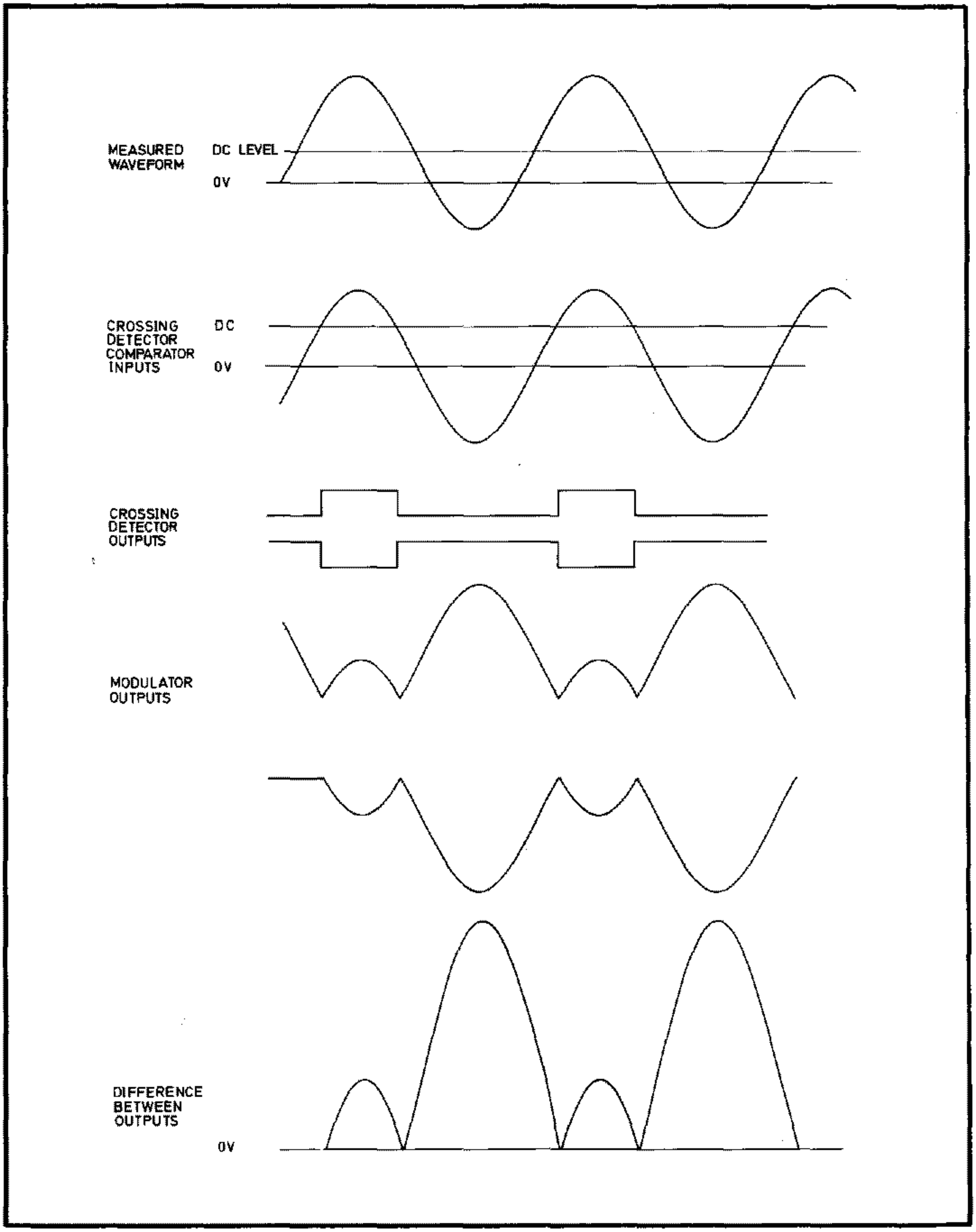


Fig. 5.8 Mean Detector Operation, AC + DC

5.3.1.15 DC/MEAN Detector Output Selection

5.3.1.15.1 The output of the mean detector is taken via PL11 pin 19 to assembly 19-1021, where it forms one input to the multiplexer, IC9. The output of the DC detector forms the second multiplexer input. The output of IC9/14 will be the DC detector output if DC input coupling is in use, and the mean detector output if AC input coupling or if special function 50.1 is used. The output at IC9/14 is passed to the digital signal processing system via PL4 pin 8.

5.3.2 THE MICROPROCESSOR SYSTEM

5.3.2.1 The microprocessor system acts as a digital signal processing system and as the instrument control system. The digital processing function includes the following:

(a) Conversion of the detector outputs to digital form, and storing the digitised measurements.

(b) Averaging a number of measurements, or selecting the greatest measurement, made in a time interval set in the AVERAGE store.

(c) Arithmetic processing in accordance with the primary and computed measurement functions set by the control system.

(d) Conversion of the processed data into a serial data string for the display.

(e) Conversion of the processed data into the 12-byte data word to be fed to the GPIB.

(f) Transmission of the serial data string to the display, accompanied by the clock pulses for the display shift registers.

5.3.2.2 The instrument control function includes the following:

(a) Acceptance of control instructions from the keyboard or the GPIB interface.

(b) Acceptance and storage of numerical data from the keyboard or the GPIB interface.

(c) Setting the attenuator control line logic levels.

(d) Setting the low pass filter selection line logic level.

(e) Setting the input coupling selection line logic level.

(f) Providing the auto-zero system timing pulses.

(g) Providing the peak detector discharge pulses.

5.3.2.3 The microprocessor system is carried on assembly 19-1024. The circuit is shown in Fig. 13 in Section 7 of this manual.

5.3.2.4 Detector Output Selection

5.3.2.4.1 The four detector outputs enter assembly 19-1024 at PL15 pins 13, 14, 16 and 18, and pass to the quad bilateral switch, IC8. The microprocessor enables each switch element in turn, every 20 ms, via the control PIA, IC11. This feeds each detector output in turn to the analogue to digital converter, IC9.

5.3.2.5 Analogue to Digital Conversion

5.3.2.5.1 The analogue signal fed to IC9 is converted to 3½ digits of BCD on 13 output lines, and is fed to the measured signal PIA, IC12 at pin2 2 to 14. Additional signals are fed to IC12/16, 17 and 18 to indicate that the conversion cycle is completed, and to IC12/15 to indicate that the output data from IC9 is valid.

5.3.2.5.2 A 100 Hz clock signal for IC9 is taken from an astable circuit at IC3/14, and used to drive a monostable circuit in IC14b. The output pulses at IC14/5 have a duration controlled by R9 and C7.

5.3.2.5.3 The positive and negative supply voltages for IC9 are derived from the +15 V and -15 V supply rails across D15 and D14. The reference current at IC9/13 can be adjusted by means of R15 to set the full scale gain of the converter.

5.3.2.6 Digital Data Input

5.3.2.6.1 The digital data output from IC9 is fed to the data-in registers of the PIA, IC12. At the end of each analogue-to-digital conversion cycle of IC9, IC12/18 is put to logic '0'. This results in the generation of an $\overline{IRQ}$ signal at IC12/37. The microprocessor enters its interrupt routine, during which it establishes that IC12 was the source of the interrupt, and then reads the data from the PIA.

5.3.2.7 DC Polarity Input

5.3.2.7.1 The DC POLARITY indication generated in the DC detector is read by the microprocessor every 100 ms via the control PIA, IC11.

5.3.2.8 Digital Data Processing

5.3.2.8.1 The digital data processing is carried out by the microprocessor in accordance with instructions in the system software, where necessary using numeric values held in memory. A description of the software is considered unnecessary for the purposes for which this manual is intended.

5.3.2.9 Serial Data Output to the Display

5.3.2.9.1 Once the value to be displayed has been determined it is used, together with data regarding the non-numeric items to be displayed, to set up the 96-bit data string used to update the display. This data string is fed to the display on the microprocessor data line D0, via IC36 a to d and IC33c.

5.3.2.9.2 A series of 96 clock pulses is sent in synchronism with the data string, 32 pulses being directed to each of the display clock lines in turn. The clock pulses are directed to the required lines by IC32, according to the levels set on IC32/1, 2 and 3 by the address lines A0, A1 and A2. The enablement of IC32 is controlled by the chip select circuit, which sets the logic level at IC32/4.

5.3.2.10 Parallel Data Output to the GPIB Interface

5.3.2.10.1 After the display has been updated, the measured value is converted to the format required for the GPIB interface output message. The first byte is passed to the data-out register of the General Purpose Interface Adaptor (GPIA) chip on assembly 19-1017.

5.3.2.10.2 When the first data byte has been read from the data-out register to the bus the GPIA chip generates an interrupt request. The microprocessor then transfers a further byte. This process is repeated until the final byte has been transferred.

5.3.2.11 Data Input from the GPIB Interface

5.3.2.11.1 The data input from the GPIB interface also takes place byte by byte under interrupt control. When a byte has been written into the data-in register of the GPIA chip from the bus, an interrupt request is generated. The microprocessor establishes the reason for the interrupt, and the data is read by the microprocessor.

5.3.2.11.2 When the first byte has been read the GPIA chip is able to accept a further byte from the bus. When this has been written into the data-in register a further interrupt request is generated. The process is repeated until no further data are available.

5.3.2.12 Data Input from the Keyboard

5.3.2.12.1 Each operation of a key generates an interrupt request. The microprocessor interrupt routine establishes the keyboard as being the source of the interrupt, and the keyboard servicing routine which follows detects which key has been operated. A data byte, determined by the key operated, is stored, and the $\overline{IRQ}$ line is reset.

5.3.2.12.2 The LED indicator associated with the control keys are operated immediately the data input occurs, and the digits associated with a numerical data input are displayed as the bytes are stored. In other respects the processing of a multi-byte input does not commence until a valid terminating byte is recognised.

5.3.2.12.3 The generation of the $\overline{IRQ}$ signal is performed by IC27 and IC31a. The key row lines are normally held at logic '0' by IC37a, b, c and d, while the column lines are pulled to logic '1' by the resistors in R30. The operation of a key pulls one on the column lines to logic '0' and puts IC27/8 to logic '1', clocking IC31a/b to logic '0'. This output, buffered by IC33d, forms the $\overline{IRQ}$ signal.

5.3.2.12.4 The keyboard servicing routine commences with IC28/1 and 19 being put to logic '0', and IC37/2, 5, 9 and 12 being put to logic '1' by the chip select circuit. Both devices are then in the enabled state. The microprocessor address lines A0, A1, A2 and A3 are first put to logic '1' and then used to set each keyboard row line to logic '0' in turn via IC37 a, b, c and d. When the row line associated with the key which has been operated is put to logic '0', the column line for that switch will also be put to logic '0'. The corresponding output of IC28 will go to logic '1', providing a data byte on the bus which, considered in conjunction with the logic levels on address lines A0, A1, A2 and A3, is unique to the operated key. This byte is transferred into the microprocessor.

5.3.2.12.5 When the byte from the keyboard has been loaded, IC31a is cleared by a logic '0' level applied to IC31a/1 from the chip select circuit. This clears the interrupt request.

5.3.2.13 Control Line Logic Level Setting

5.3.2.13.1 The logic levels for all the control lines external to the microprocessor system are set by transferring data into the data-out register of the control PIA, IC11. The logic levels in this register are put onto the control lines via the peripheral data bus ports. The levels remain set when IC11 is deselected at the completion of the data transfer. The attenuator control lines, and the lines carrying the auto-zero timing and the DC/mean detector output selection signal, are buffered in IC5 and IC6.

5.3.2.14 The Chip Select Circuit

5.3.2.14.1 The logic levels for chip selection within the system are generated in a circuit containing IC25, IC26 and IC34. The valid memory address (VMA) line from IC30/5 is used to enable IC25 whenever chip selection is required.

5.3.2.14.2 The ROM enabling signals (logic '0' level) are obtained directly from IC25/7, 9, 10 and 11, according to the logic levels applied to IC25/1, 2 and 3 by the microprocessor via address lines A12, A13 and A14. For all other chip enabling signals these address lines are set to give a logic '0' at IC25/15, which is used to enable IC26.

5.3.2.14.3 When enabled, IC26 generates one of the following outputs, according to the logic levels set on address lines A10, A9 and A8 by the microprocessor.

(a) The RAM selection signal ($\overline{M}$)

(b) The keyboard servicing enablement for IC28 and IC37

(c) The display clock enablement ($\overline{OPE}$) for IC32

(d) The enablement for IC22 or IC29

(e) The enablement for IC34.

5.3.2.14.4 When enabled, IC34 generates the enabling signal for the PIAs, IC11 and IC12, or for the GPIA chip in the GPIB interface ($\overline{GCS}$), according to the logic levels set on address lines A6, A5 and A4.

5.3.2.14.5 When the RAM is selected the $\overline{M}$ line takes IC15d to logic '0'. The RAM is then enabled by the $\overline{E}$ signal from IC13a/2.

5.3.2.15 Reset and Memory Supply Changeover Circuit

5.3.2.15.1 When the power supply to the instrument is off IC43, IC44, IC45, IC42 and IC15 are powered from the battery, B1. The voltage level detectors IC44 and IC45 detect the low voltage on the +5 V supply rail, and both IC45/6 and IC44/5 are at logic '0'. As a result IC42a/3 and IC42d/13 are at logic '1'. The bistable circuit formed by IC15b and IC15c will have been reset when the instrument supply was switched off, leaving IC15c/8 at logic '1'. Both inputs to IC42d are therefore at logic '1', and IC42d/11 ($\overline{RESET}$) is held at logic '0'. The logic '1' at IC15c/8 also holds the R/$\overline{W}$ line in the read condition and the RAM select line at logic '1', via IC43b and IC43c, so preventing access to the memory.

5.3.2.15.2 When power is applied the potential on the +5 V rail increases until IC45/6 and IC44/5 go to logic '1', and IC42a/3 goes to logic '0'. As a result IC42d/11 goes to logic '1', releasing the microprocessor from reset, while IC42c/10 goes to logic '1'. As part of its start-up procedure the microprocessor sets a logic '1' at IC11/19, and, therefore, at IC42c/9. The bistable circuit, IC15b and IC15c, is put to the set state, with IC15c/8 at logic '0', releasing the R/$\overline{W}$ and $\overline{CS}$ lines.

5.3.2.15.3 When power to the instrument is switched off or fails the reduction in the voltage on the +5 V supply rail is sensed by IC44, and IC44/6 goes to logic '1'. Since IC15d/12 is already held at logic '1' by IC15b, IC15d/11 goes to logic '0', providing a non-maskable interrupt ($\overline{NMI}$) at IC30/6. At the completion of the current instruction the microprocessor enters its non-maskable interrupt routine. As part of this routine a logic '0' is set at IC11/39, and applied to IC15c/9. This puts the bistable circuit formed by IC15b and IC15c to the reset state, with IC15c/8 at logic '1'. The R/$\overline{W}$ line is held in the read state and the RAM select line is held at logic '1' via IC43b and IC43c, so preventing corruption of the memory contents with spurious data which may be generated during the power fade period.

5.3.2.16 Test Switchbank S30

5.3.2.16.1 The switchback S30 is used to set a pattern onto the data bus for test purposes and to indicate that the GPIB interface is fitted. In normal operation switches 1 to 7 must be set to the open position (where the slider is furthest from the switch section number). Switch 8 must be closed.

5.3.3 THE KEYBOARD/DISPLAY SYSTEM

5.3.3.1 The system comprises a 7 x 4-line keyboard, a liquid crystal display (LCD) and a number of light emitting diode (LED) indicators. Although the LED indicators are related to particular keys, all connection between the keyboard and the display is via the microprocessor system.

5.3.3.2 A 30 Hz switching waveform for the LCD is generated by IC3d and IC31b on assembly 19-1024. The remainder of the system is mounted on assembly 19-1023. The circuits of these assemblies are given in Fig. 13 and Fig. 3 in Section 7 of this manual.

5.3.3.3 <u>The Keyboard</u>

5.3.3.3.1 The keyboard switches are of the mechanical, push-operated type. When the microprocessor is not servicing the keyboard all four row lines, entering assembly 19-1013 at pins 7, 8, 11 and 12, are held at logic '0', while the seven column lines, entering the assembly at pins 13 to 19, are held at logic '1'.

5.3.3.3.2 Closure of any switch will result in the corresponding column line being pulled to logic '0'. This action generates an IRQ for the microprocessor, which will then service the keyboard. The generation of the IRQ and the keyboard servicing procedure are described in the description of the microprocessor system.

5.3.3.4 <u>The Liquid Crystal Display</u>

5.3.3.4.1 The LCD is a custom built device having 79 segments. The information to be displayed is fed from the microprocessor in the form of a 96-bit data string. This enters assembly 19-1023 at pin 22, and is applied to the data input pins of the shift registers, IC1, IC2 and IC3, in parallel. The clock lines for the shift registers enter the assembly at pins 20, 21 and 10. The waveforms on these lines are controlled by the microprocessor system such that 32 bits of the data string are clocked into each register.

5.3.3.4.2 All the shift register outputs are switched between logic '0' and logic '1' at 30 Hz by the TRUE/COMPLEMENT signal applied to each register at pin 1. Shift register outputs loaded with logic '0' from the 96-bit data string change level in phase with the signal at pin 1, while those loaded with logic '1' are in antiphase.

5.3.3.4.3 The back plane of the LCD is driven from IC2/36 via R1, while the display segments are driven from the remaining shift register outputs. Those segments driven in antiphase to IC2/36 will darken.

5.3.3.5 <u>The LED Indicators</u>

5.3.3.5.1 With the exception of the LINE indicator LP1, which lights whenever the +5 V supply is available, the LED indicators are controlled by the shift registers, IC4, IC5 and IC6. An indicator will light when the associated shift register output is held at logic '0'.

5.3.3.5.2 When a change in the indicator pattern is required, suitable data strings are generated in the microprocessor system. These enter the assembly at pin 4, and are applied to the data inputs of the three registers in parallel. The clock lines of the shift registers enter the board at pins 3, 5 and 6, and carry waveforms, generated in the microprocessor system, which clock the data into the appropriate register.

5.3.4 <u>THE GPIB INTERFACE</u>

5.3.4.1 The GPIB interface is carried in assembly 19-1017. The circuit is given in Fig. 5 in Section 7 of this manual.

5.3.4.2 Address Setting and Recognition

5.3.4.2.1 When the interface address is set on the bus by the controller it is recognised by the General Purpose Interface Adaptor (GPIA), IC2, as being the same as the contents of an internal address register. The address set on the rear panel switches is read by the microprocessor and written into the GPIA address register every 10 ms.

5.3.4.2.2 The microprocessor sees the address switches as an addressable register within the GPIA. When the GPIA receives the appropriate address it responds by generating an enable signal ($\overline{ASE}$) at IC2/4. This enables IC12, putting the logic levels set by the address switches onto the data bus.

5.3.4.3 Operation as a Listener

5.3.4.3.1 When the interface is addressed to listen the GPIA conducts the handshake procedure up to the point where the ready for data (RFD) indication is given. At this point IC2/27 is at logic '0', setting the data bus buffers in IC3 and IC13 to the receive condition. Data from the bus enters the GPIA data-in register, and an interrupt request is generated by IC2/40 going to logic '0'. This puts IC18/8 to logic '1' and enables IC9c, which pulls the microprocessor $\overline{IRQ}$ line to 0 V.

5.3.4.3.2 The microprocessor interrupt routine will establish the reason for the interrupt. The GPIA and IC19 are enabled by the $\overline{GCS}$ signal and the direction of data transfer through IC19 is set by the R/$\overline{W}$ signal. The GPIA data-in register is addressed, and the data are transferred to the microprocessor.

5.3.4.3.3 When the data transfer is complete the GPIA cancels the interrupt request and allows the data accepted (DAC) line to go high. The handshake routine then continues, and a further byte, if available, is loaded into the data-in register. The interrupt and data transfer sequence is then repeated.

5.3.4.4 Operation as a Talker

5.3.4.4.1 When the GPIA is addressed to talk the data-out register will normally be empty. Under these conditions an interrupt request is generated by putting IC2/40 to logic '0'. This output is used to generate an interrupt request for the microprocessor, via IC18, IC14d and IC9c, and to set IC10a. When IC10a is set a logic '1' is applied to IC11/10. Since IC10b is normally reset and IC2/27 is at logic '1' when the GPIA is addressed to talk, IC11/9 and 11 are also at logic '1', giving logic '0' at IC11/8. This open circuits the bilateral switches between TP1 and TP2, breaking the RFD line to IC2/18. Even if the listening device asserts that it is ready for data the GPIA will not attempt to load the contents of its data-out register onto the bus, as IC2/18 is held at logic '0' by the bilateral switch in IC6 which is driven by IC4b.

5.3.4.4.2 The microprocessor interrupt routine will establish the reason for the interrupt. The GPIA data-out register is addressed and a data byte is written into the register.

5.3.4.4.3 Following the data transfer the microprocessor sets data bus line BD0 to logic '0' and addresses IC15, using address lines A0, A1 and A2, so that the microprocessor enable (E) pulse is directed to IC10a/11. This clocks IC10a to the reset condition, giving a logic '0' at IC11/10. The bilateral switches in IC6 reconnect the RFD line to the GPIA, and release IC2/18 from 0V. When the RFD line puts IC2/18 to logic '1' the GPIA loads the contents of the data-out register onto the bus and continues with the handshake sequence.

5.3.4.4.4 If, for any reason, the GPIA is taken out of the talk state part way through a message, the data-out register will be left containing an untransmitted data byte. This situation can arise, for example, if the controller stops the message in order to conduct a serial poll.

5.3.4.4.5 When the GPIA is readdressed to talk, either of two requirements may apply. The GPIA may be required to continue with the interrupted message, or may be required to transmit a byte (e.g. the status byte) other than that held in the data-out register. The two situations are distinguished by whether there has, or has not, been a data transfer between the GPIA and the microprocessor since the GPIA left the talk state.

5.3.4.4.6 In the latter case IC10a will be in the reset condition, giving a logic '0' at IC10a/9 and a logic '1' at IC11/8. The bilateral switches of IC6 between TP1 and TP2 will be in the conducting condition, so the RFD line to IC2/18 is unbroken. When the GPIA is addressed to talk the byte in the data-out register will be transmitted, followed by the remainder of the interrupted message.

5.3.4.4.7 If a data transfer from the GPIA to the microprocessor has occurred since the GPIA left the talk state, IC10a will have been set by the last interrupt request from IC2/40. This will be the situation if, for example, a serial poll is to be conducted, as the serial poll enable (SPE) message byte will have been received and transferred. When the GPIA is addressed to talk, IC2/27 goes to logic '1' and, because IC11/9 and 10 are at logic '1', the RFD line is broken by IC6. When the listener sets the RFD line high IC18/1 is put to logic '1'. Since IC18/2 and 13 are at logic '1' an interrupt request to the microprocessor is generated via IC14d and IC9c. The microprocessor will see this as a demand for fresh data from the GPIA, and will update the byte held in the status byte register.

5.3.4.4.8 After transferring the status byte to IC2, the microprocessor addresses IC15 to direct the enable (E) signal to IC10b, clocking it to the set state. IC11/8 will go to logic '1', the RFD input will be connected by IC6 to IC2/18, and the status byte will be transmitted.

5.3.4.5 Detection of the Serial Poll Disable Message

5.3.4.5.1 When a serial poll sequence has been completed the controller sends the serial poll disable (SPD) message. This is detected by IC8b, c and d and IC1, giving a logic '0' at IC1/8. This returns IC10b to the reset condition, giving a logic '1' at IC11/9 and disconnecting the RFD line from IC2/18 at IC6.

APPENDIX 1

ANALYSIS OF RMS MEASURING CIRCUIT

5.A.1.1 The block diagram of the measuring circuit is shown in Fig. 5.9. The voltages Vs and Vn represent the signal and noise inputs from the preceding circuit, while Vox and Voy are the input offset voltages occurring at the multiplier inputs. The input Vc is a voltage generated during the auto-zero period and injected into the circuit during the following measurement period.

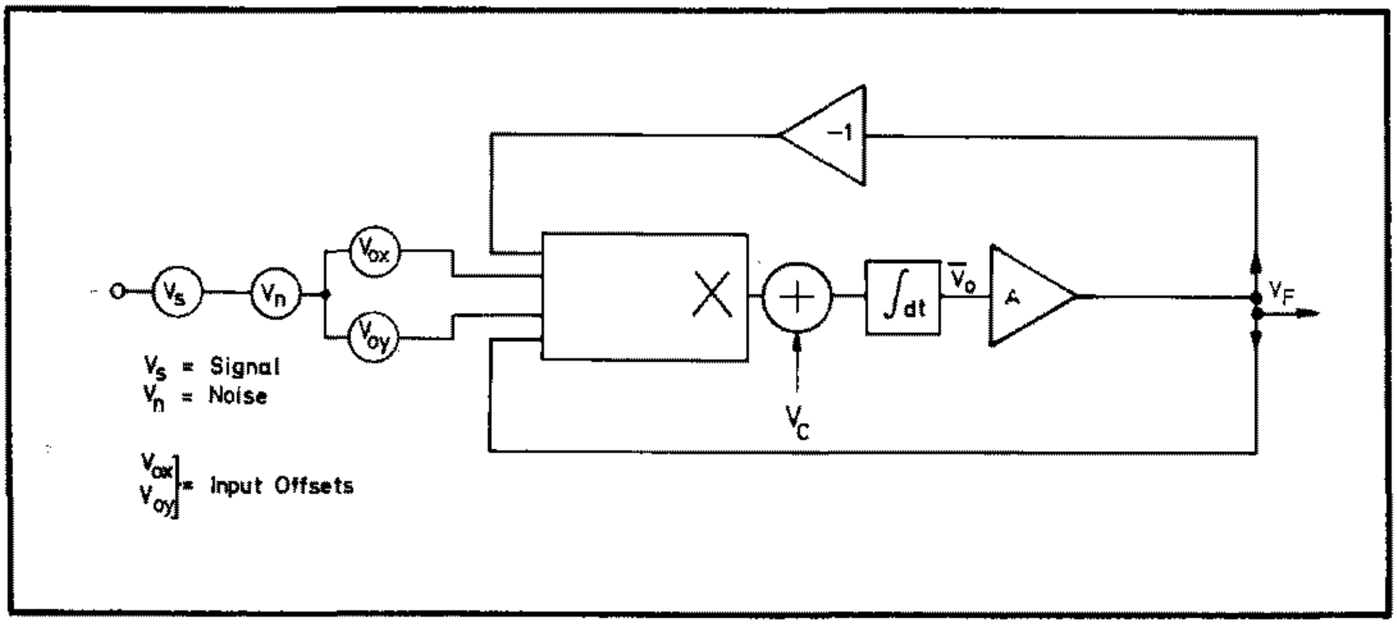


Fig. 5.9 Loop Block Diagram

5.A.1.2 At the multiplier output:

$$V_o = (V_s + V_n + V_{ox} + V_F)\ (V_s + V_n + V_{oy} - V_F)$$

$$= (V_s + V_n + V_{ox})\ (V_s + V_n + V_{oy}) - V_F\ (V_s + V_n + V_o x) + V_F\ (V_s + V_n + V_{oy}) - V_F^2$$

$$= (V_s + V_n)^2 + (V_{ox} + V_{oy})\ (V_s + V_n) + V_{ox}V_{oy} - V_F\ (V_{ox} - V_{oy}) - V_F^2$$

$$= V_s^2 + V_n^2 + 2V_sV_n + V_s\ (V_{ox} + V_{oy}) + V_n\ (V_{ox} + V_{oy}) + (V_{ox}V_{oy}) - V_F\ (V_{ox} - V_{oy}) - V_F^2$$

Since V_s and V_n are AC quantities, and so have mean values of zero, at the amplifier input

$$\overline{V_o + V_c} = \overline{V_s^2 + V_n^2 + V_{ox}\ V_{oy} - V_F\ (V_{ox} - V_{oy}) - V_F^2 + V_c}$$

But $V_F = A\ \overline{(V_o + V_c)}$, and if A is large $\overline{V_o + V_c} = \frac{V_F}{A} = 0$

$$0 = \overline{V_F^2 + V_F\ (V_{ox} - V_{oy}) - (V_s^2 + V_n^2 + V_{ox}V_{oy} + V_c)}$$

5.A.1.3 If the sense of the feedback voltages to the x and y inputs is reversed the last expression becomes

$$0 = \overline{V_F^2 - V_F\,(V_{ox} - V_{oy}) - (V_s^2 + V_n^2 + V_{ox}\,V_{oy} + V_c)}$$

The difference between the two expressions is the sign of the second term. Thus, if the feedback sense is switched at a rate such that the integrator provides adequate averaging, the mean value of this term is zero, and it can be ignored. Such feedback switching thus reduces the effect of the offsets at the multiplier input.

Solving $0 = \overline{V_F^2 - (V_s^2 + V_n^2 + V_{ox}\,V_{oy} + V_c)}$ for V_F gives

$$V_F = \sqrt{\overline{V_s^2 + V_n^2 + V_{ox}V_{oy} + V_c}}$$

The required output from the circuit is

$$V_F = \sqrt{\overline{V_s^2}}$$

so the actual output shows an error of $\sqrt{\overline{V_n^2 + V_{ox}V_{oy} + V_c}}$

5.A.1.4 The voltage V_C is generated in the auto-zero circuit. During auto-zeroing V_S is made zero, and the residual value of V_F is integrated. This integral is injected as V_C, such that the residual value of V_F is driven to zero. At this point

$$\overline{V_c} = -\overline{(V_n^2 + V_{ox}V_{oy})}$$

V_C is maintained during the measurement period, so that the unwanted input to the amplifier due to noise and the multiplier input offsets is cancelled.

APPENDIX 2

OPERATION OF LINEARISED TRANSCONDUCTANCE MULTIPLIER

5.A.2.1 A schmatic circuit of the multiplier is given in Fig. 5.10. The inputs are the differential current inputs at 1 and 2. It is a property of this circuit that the ratios I_P/I_Q and I_S/I_R are equal and are equal to the ratio of the currents in the linearising networks. (Proof of this property is unnecessary for the purposes of this manual).

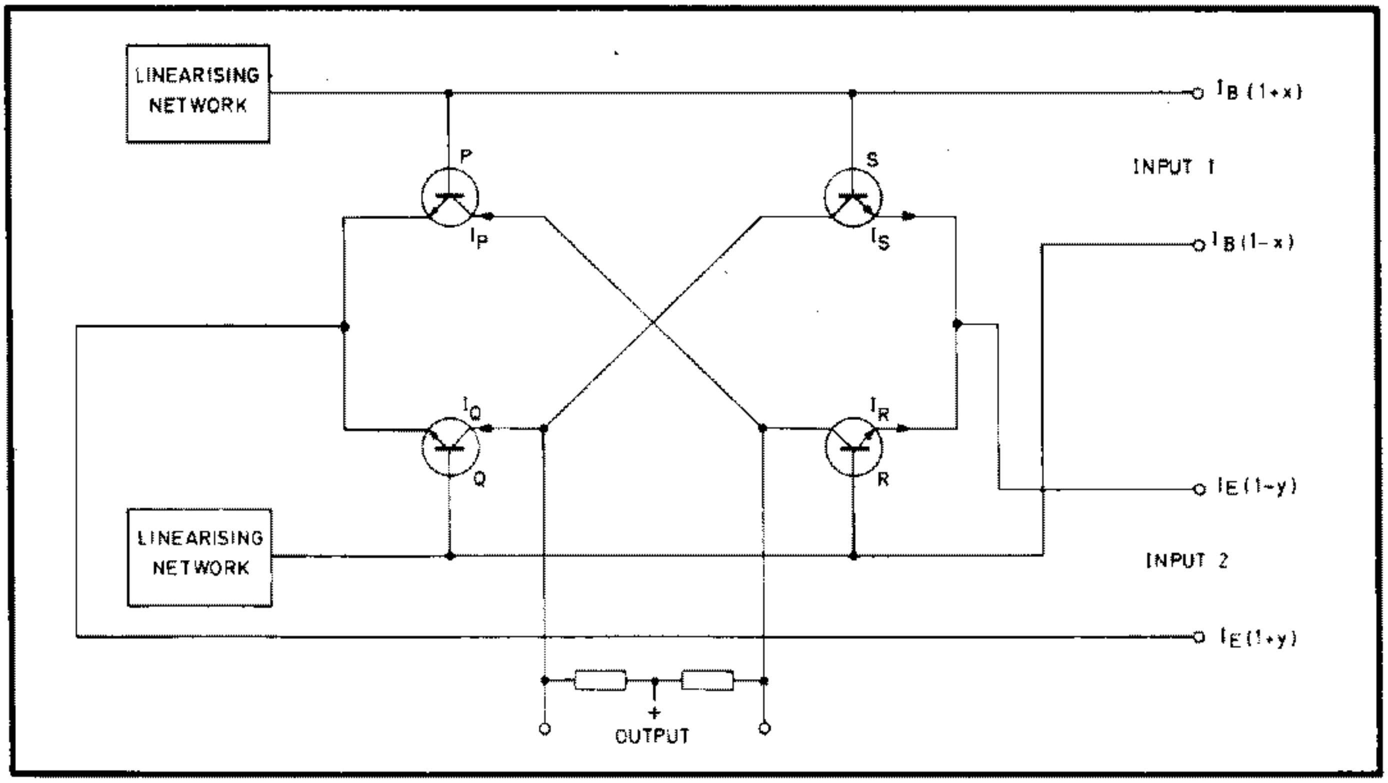


Fig. 5.10 Multiplier Operation

5.A.2.2 If the currents at input 1 with zero input signal are both I_B, then the currents with an applied signal of $2I_Bx$ will be I_B (1 + x) and I_B (1 - x). The currents at input 1 form the currents in the linearising networks, and so set the ratios of the collector currents I_P/I_Q and I_S/I_R to 1 + x/1 - x.

5.A.2.3 The currents at input 2 with a signal of $2I_Ey$ will be I_E (1+y) and I_E (1-y). The collector currents of the multiplier transistors will then be:

$I_P = \frac{1}{2} I_E (1 + y) (1 + x)$
$I_Q = \frac{1}{2} I_E (1 + y) (1 - x)$
Two currents having a total of I_E (1 + y) and a ratio 1 + x/1 - x (equal to the ratio of currents in the linearising networks).

$I_S = \frac{1}{2} I_E (1 - y) (1 + x)$
$I_R = \frac{1}{2} I_E (1 - y) (1 - x)$
Two currents having a total of I_E (1 - y) and a ratio 1 + x/1 - x.

5.A.2.4 The multiplier output is the differential current given by

$(I_P + I_R) - (I_Q + I_S)$ and is proportional to

$\frac{1}{2} I_E \; (1 + y)(1 + x) + (1 - y)(1 - x) - (1 + y)(1 - x) - (1 - y)(1 + x).$

$= \frac{1}{2} I_E \quad 4 \; x \; y$

$= \frac{1}{2I_B} \quad (2I_B x \; . \; 2I_E y)$

The differential output current is therefore proportional to the product of the differential input currents.

6.1 INTRODUCTION

6.1.1 This section is written in five parts which relate to

(a) General maintenance information

(b) Fault finding procedures for assemblies 19-1024 and 19-1017.

(c) Signature analysis on assemblies 19-1024 and 19-1017.

(d) Setting up and calibration procedures.

(e) Dismantling and reassembly of the 5002.

6.2 GENERAL MAINTENANCE INFORMATION

6.2.1 BATTERY REPLACEMENT

6.2.1.1 The non-volatile memory is maintained by means of a lithium primary cell, Racal-Dana part number 23-2513, having an expected in-service life of two years. The battery voltage is not an indication of the remaining life, and it is recommended that the cell be changed on a preventive maintenance basis.

6.2.1.2 Whenever possible the battery should be changed with the instrument switched off and disconnected from the AC supply. This will result in corruption of the non-volatile memory contents. If it is essential that the contents of the non-volatile memory are preserved, it is possible to change the battery with the instrument connected to the AC supply and switched on.

WARNING: (1) DANGEROUS AC VOLTAGE LEVELS ARE EXPOSED WHEN THE COVERS ARE REMOVED WITH THE AC SUPPLY CONNECTED.

(2) BATTERY REPLACEMENT SHOULD ONLY BE CARRIED OUT BY PERSONS SKILLED IN THE REPAIR OF ELECTRONIC EQUIPMENT.

(3) IF THE BATTERY IS TO BE CHANGED WITH THE INSTRUMENT SWITCHED ON, THE TIP OF THE SOLDERING IRON USED MUST BE ISOLATED FROM EARTH.

(4) LITHIUM BATTERIES CAN BE DANGEROUS IF WRONGLY TREATED. FOLLOW THE INSTRUCTIONS GIVEN ON THE WARNING PAGE AT THE FRONT OF THIS MANUAL REGARDING THEIR HANDLING AND DISPOSAL.

6.2.1.3 The battery is mounted at the left hand side of the upper surface of the processor board, 19-1024, towards the front of the instrument. Two different types of battery are supplied by Racal-Dana Instruments. These are electrically interchangeable, but are connected to the circuit in different ways. All instruments will accept both types of battery.

6.2.1.4 The procedure for changing the battery is as follows:

(a) Remove the top and bottom covers from the instument as instructed in paragraph 6.6.2.

(b) Cut the tie wrap securing the battery to the processor board. Retain the insulating pad which is held by the tie wrap to the underside of the board.

(c) Unsolder the NEGATIVE connection of the battery. This is the end of the battery furthest from the front panel of the instrument. It may be secured to pin 22, or to a through hole in the board adjacent to pin 22, according to the battery type.

(d) Unsolder the POSITIVE connection of the battery. This may be secured to pin 23, or to a through hole in the board adjacent to pin 23.

(e) Solder the POSITIVE connection of the replacement battery into position.

(f) Solder the NEGATIVE connection of the replacement battery into position.

(g) Measure the voltage between pin 22 and ground. The voltage difference must not be more than 40 mV, with pin 22 negative with respect to ground.

IF THIS CONDITION IS NOT MET DISCONNECT THE BATTERY IMMEDIATELY. CHECK THAT THE BATTERY POLARITY IS CORRECT, AND THAT IT IS NOT SHORT CIRCUITED.

(h) When the voltage between pin 22 and ground is correct, secure the battery and the insulating pad to the board using a new tie wrap, Racal-Dana part number 24-0140. The insulating pad must cover the track in the vicinity of the battery on the underside of the board.

6.2.2 <u>SPECIAL FUNCTIONS FOR MAINTENANCE PURPOSES</u>

6.2.2.1 The special functions listed in Table 6.1 are provided for use during maintenance and calibration. They are additional to the special functions for operator use, which are listed in Table 4.1 of Section 4, and are called by pressing.

/X//X//.//X//SHIFT//SF/,

where XX.X is the special function number, or by means of the special GPIB code.

TABLE 6.1

Additional Special Functions

Special Function Number	GPIB Code	Function
81.0	Z4	Displays software issue number, and loads software issue number into the output buffer.
97.1	Z1	Clears display of Er01 resulting from corruption of non-volatile memory contents.
98.1	Z2	Display test. All LED and LCD elements turned on.
99.1	Z3	Selects 3 V range using 60 dB, 20 dB and 10 dB attenuators. (Relays RLB, RLD, RLH, RLJ, RLK and RLL energised on assembly 19-1021).

NOTE: (1) Return to the measurement mode from special function 97.1, 98.1 or 99.1 can be obtained by

(a) operation of any primary or second measurement function key.
(b) pressing /O//SHIFT//SF/.
(c) sending a primary or secondary measurement function command via the GPIB.
(d) sending the GPIB command YØ

(2) When in local control, return to the measurement mode from special function 81.0 can be obtained by pressing /CONTINUE/.

(3) After loading the software issue number into the output buffer the 5002 must be put to the talker active state for the data to be put onto the bus. Failure to read the buffer contents will prevent measurement data being entered.

6.2.3 TEST SWITCHES

6.2.3.1 A bank of eight switches, S30, is mounted on assembly 19-1024. It provides the special facilities shown in Table 6.2 for use during testing and calibration. The function shown in the table is provided when the relevant switch is in the closed position (where the slider is moved in the direction of the arrow moulded on it or towards the switch section number).

TABLE 6.2

Test Switch Functions

Switch Section	Function
1	Provides the NO OPERATION instruction on the bus during signature analysis
3	Inhibits all error indications except error 01 and error 02.
8	Indicates the GPIB interface is fitted

6.2.3.2 For normal operation switches 1 to 7 should be set to the open position, but switch 3 may be set to the closed position if the display of error codes is not required. If the GPIB interface is to be used switch 8 must be closed.

6.3 FAULT FINDING ON ASSEMBLIES 19-1024 AND 19-1017

6.3.1 INTRODUCTION

6.3.1.1 The procedure given in the following paragraphs provides a means of fault finding on assemblies 19-1024 and 19-1017, involving the technique of signature analysis. The signatures given are those obtained using the Hewlett-Packard 5004 signature analyser.

6.3.2 ASSEMBLY 19-1024

6.3.2.1 Suggested procedures to be followed in the event of certain forms of equipment failure are given in Table 6.3. Where required, signature analysis should be carried out in accordance with the instructions in paragraph 6.4.

6.3.3 ASSEMBLY 19-1017

6.3.3.1 Suggested procedures to be followed in the event of malfunction of the GPIB interface are given in Table 6.4. Limited signature analysis can be carried out on assembly 19-1017, as an aid to fault finding, in accordance with the instructions given in paragraph 6.4. No fault finding on assembly 19-1017 should be attempted unless assembly 19-1024 is known to be functioning correctly.

TABLE 6.3

Fault Finding Procedure, Assembly 19-1024

Fault	Procedure
Random LCD elements or LED indicators come on when 5002 is switched on. Keyboard is inoperative.	(a) Check that $\overline{\text{RESET}}$ pulse occurs at IC30/40 when 5002 is switched on. (b) Check that TP9 is at logic '0'. (c) Check address bus signatures at IC16, 17, 18 and 19 sockets. (d) Check data bus signatures. (e) Check the $\overline{\text{OPE}}$ signal signature at IC32/4. (f) Check the display and LED clock signatures at IC32/10, 11, 12, 13, 14 and 15.
All LCD elements on. Keyboard is inoperative.	Check that TP9 is at logic '0'.
Er20 permanently displayed	(a) Check address bus signatures at IC20 and IC21 sockets. (b) If signatures are correct, change IC20 and/or IC21.
Er23, Er24, Er25 or Er26 permanently displayed	(a) Check address bus signatures at IC16, 17, 18 and 19 sockets. (b) If signatures are correct, change IC16, 17, 18 and/or 19.
Display or LED's not operating	(a) Check signatures at IC32/1, 2, 3, 4, 10, 11, 12, 13, 14 and 15. (b) Check for 30 Hz waveform of exact 1:1 mark/space ratio at IC33/10.
Keyboard inoperative or partially operative	(a) Check KEY ENABLE and $\overline{\text{KEY ENABLE}}$ signatures at IC28/19 and IC37/9. (b) Check row scan signal signatures at IC27/8.
Incorrect selection of range, detector, input coupling or filter. Incorrect selection of digital output of IC9. Failure of auto-zero or peak discharge.	Check signatures at IC34/1, 2, 3, and 4, IC11/23 and IC12/23.

TABLE 6.4

Fault Finding Procedure, Assembly 19-1017

Fault		Procedure
Instrument will not go into Talk, Listen or Remote.	(a)	Set the TALK ONLY address switch to logic '1' and check that the TALK annunciator appears in the display. If it does not check that switch 8 of S30 on assembly 19-1024 is closed. Reset the TALK ONLY address switch to logic '0'.
	(b)	Carry out the signature analysis procedure for assembly 19-1017.
	(c)	Set the instrument's address to 00000.
	(d)	Connect a GPIB monitor, set to act as a controller, to the 5002 GPIB connector.
	(e)	Set the DAV message false (high).
	(f)	Set the REN and ATN messages true (low).
	(g)	Check that the 5002 responds and puts NRFD and NDAC true, followed by NRFD false.
	(h)	Set DI08 to DI01 to 00100000, and set DAV true. The 5002 should respond by setting NRFD true. The 5002 should set NDAC false.
	(j)	Set DAV false. The 5002 should respond as in step (g).
	(k)	Set ATN false (high). The 5002 should go to the remote state, and the REMOTE indicator should light.
In the event of failure at any stage, check that the logic levels at IC2 on assembly 19-1017 are the same as those at the controller.		

TABLE 6.4 (Continued)

Fault Finding Procedure, Assembly 19-1017

Fault	Procedure
Instrument will go to listen but not remote.	(a) Carry out steps (a) to (g) as instructed above. (b) Set DI08 to DI01 to 0100000 and set DAV true. The 5002 should respond by setting NRFD true and NDAC false. (c) Set NRFD false and NDAC true by means of the GPIB monitor. (d) Set ATN false. The 5002 should respond by setting DAV true.
In the event of failure at any stage, check that the logic levels at IC2 on assembly 19-1017 are the same as those at the controller. If failure occurs at step (d) check the functioning of the interrupt circuitry.	
Instrument sends incorrect data when talking.	Check data bus lines and bus transceivers on assembly 19-1017 to ensure both logic levels are possible.

6.4 SIGNATURE ANALYSIS

6.4.1 PREPARATION FOR SIGNATURE ANALYSIS

6.4.1.1 Switch off the instrument and disconnect the AC supply. Remove the covers, as instructed in paragraph 6.6.2, and carry out the following operations on assembly 19-1024:

(a) Remove ICs 11, 12, 20 and 21

(b) Short circuit TP8 to TP4

(c) Set switch 1 on switchbank S30 to the closed position. Set the remaining switches of S30 to the open position.

6.4.1.2 If analysis is to be carried out on assembly 19-1017, IC2 on that assembly must be removed in addition to the operations given in paragraph 6.4.1.1.

6.4.2 CONNECTION OF THE SIGNATURE ANALYSER

6.4.2.1 Connect the signature analyser as follows:

(a) CLOCK input to TP5, negative edge trigger.

(b) START and STOP to TP11, positive edge trigger.

(c) GROUND to TP4.

6.4.3 ANALYSIS PROCEDURE

WARNING: THIS PROCEDURE REQUIRES THE INSTRUMENT TO BE OPERATED WITH THE COVERS REMOVED. LETHAL VOLTAGE LEVELS ARE EXPOSED UNDER THESE CONDITIONS.

6.4.3.1 Connect the 5002 to the AC supply and switch the instrument on. Apply the probe of the analyser to the points given in Table 6.5, and check that the correct signatures are obtained.

NOTE: (1) The same ROW SCAN signature is obtained when any key in a row is pressed. A check of every key should be made.

(2) A signature is obtained at IC27/8 when any key is pressed. Although the probe is applied to a single point, each key row has its own signature.

6.4.3.2 If signature analysis on assembly 19-1017 is required it should be carried out at this stage, before carrying out the data bus analysis on assembly 19-1024. Apply the probe of the analyser to the points given in Table 6.6 and check that the correct signatures are obtained.

<u>TABLE 6.5</u>

<u>Address Bus Signatures for Assembly 19-1024</u>

Test Point	Signal Name	Signature
IC29/9	Data Bus	0001
IC29/3, 5, 7, 12, 14, 16 and 18	Data Bus	0000
IC23/9	A0	5555
IC23/12	A1	CCCC
IC23/7	A2	7F7F
IC23/14	A3	5H21
IC23/5	A4	0AFA
IC23/16	A5	UPFH
IC23/3	A6	52F8
IC23/18	A7	HC89
IC23/3	A8	2H70
IC24/14	A9	HPP0
IC24/9	A10	1293
IC24/7	A11	HAP7
IC25/1	A12	3C96
IC25/2	A13	3827
IC16/18	R1	F2A6
IC17/18	R2 ROM	PC01
IC18/18	R3 ENABLE	12U3
IC19/18	R4	4P0A
TP6	IC26 ENABLE	6H49
IC26/9	IC22/29 ENABLE	H814
IC26/12	KEYBOARD SERVICE ENABLE	HFP6
IC36/12	$\overline{\text{KEYBOARD SERVICE ENABLE}}$	HFP7
IC37/8	ROW 1 SCAN	6F34
IC37/6	ROW 2 SCAN See	495C
IC37/11	ROW 3 SCAN Note 1	AP72
IC37/3	ROW 4 SCAN	U45A
	ROW 1 SCAN	6F35
IC27/8	ROW 2 SCAN See	495A
	ROW 3 SCAN Note 2	AP73
	ROW 4 SCAN	U45C
IC26/11	$\overline{\text{OPE}}$	47F9
IC32/15		HFU5
IC32/14		C73F
IC32/13	SERIAL DATA	PHFP
IC32/12	CLOCKS	3C72
IC32/11		FPHH
IC32/10		C3C6
IC26/4	RAM ENABLE	A8C1
IC26/10	IC34 ENABLE	86F3
IC34/15	IC12 ENABLE	0P84
IC34/14	IC11 ENABLE	UFUA
IC34/12	GPIB ENABLE	PHH0

TABLE 6.6

System Signatures for Assembly 19-1017

Test Point	Signal Name	Signature
IC14/4	$\overline{A3}$	5H20
IC14/6	GPIB ENABLE	PHH1
IC11/6	IC2 SELECT	341A
IC15/15	IC10b CLOCK	053A
IC15/14	IC10a CLOCK	3HA8
IC15/13	IC9a ENABLE	3052
IC15/12	IC7a RESET	0F15
IC15/11	IC9b ENABLE	8304

6.4.3.3 The data bus signatures for assembly 19-1024 depend upon the hardware build state of the instrument and the issue number of the software fitted. For this reason no table of signatures is given. It is essential that the ROMs fitted belong to the same hardware compatible set, that they are of the same issue number, and that they are fitted in the correct positions, as shown in Table 6.7. It should be noted that the part numbers for the ROMs in a set are the same for all software issue numbers, but the issue number is marked on the component body.

TABLE 6.7

Integrated Circuit Locations

IC Number	Type	Racal-Dana Part Number	
		Build State 1	Build State 2
16	2732	22-8519	22-8566
17	2732	22-8518	22-8565
18	2732	22-8517	22-8564
19	2732	22-8516	22-8563

6.4.3.4 When the signature analysis is completed, switch off the 5002 and disconnect the analyser. On assembly 19-1024 remove the link from between TP8 and TP4. On switch bank S30, return switch 1 to the open position and set switch 8 to the closed position. Set switch 3 to the closed position if the display of error codes is not required. Replace the instrument covers.

6.5 CALIBRATION PROCEDURE

WARNING: THIS PROCEDURE REQUIRES THE INSTRUMENT TO BE OPERATED WITH THE COVERS REMOVED. LETHAL VOLTAGE LEVELS ARE EXPOSED UNDER THESE CONDITIONS.

6.5.1 INTRODUCTION

6.5.1.1 The procedure given in the following paragraphs provides the means of calibrating the 5002. It is essential that the tests be carried out in the order given, since the results obtained depend, in many cases, on successful completion of previous tests. The procedure should always be followed before returning the 5002 to use after repair. It may also be used as the basis for testing to check the functioning of the instrument.

6.5.2 TEST EQUIPMENT REQUIRED

6.5.2.1 The test equipment required is listed in Table 6.8. A particular model of instrument is recommended in some cases, but other instruments having the required parameters may be used.

6.5.3 TEMPERATURE DURING CALIBRATION

6.5.3.1 Throughout the calibration procedure the ambient temperature must be maintained within the range from 18°C to 28°C. During the setting up of the range attenuators the ambient temperature must not be allowed to vary by more than ±½°C.

6.5.4 SIGNAL SOURCE LEVEL SETTING

6.5.4.1 At several points in the procedure instructions are given to set the output level of a signal source to a prescribed level. Except where other tolerances are given for a specific setting, all settings must be made to a tolerance of ±1%. Additional test equipment, not shown in Table 6.8, may be required to set the level to the required accuracy.

6.5.5 ISOLATION TEST

6.5.5.1 Test equipment required:

Description	Table 6.8 Item No
Multimeter	1

6.5.5.2 Disconnect the supply lead from the AC supply. Ensure that the supply lead socket is fully mated with the rear panel plug. Set the multimeter to measure resistances of approximately 1 Ω, and connect it to measure the resistance between the earth connection of the supply lead and the shell of the INPUT socket.

TABLE 6.8
Test Equipment Required for Calibration

Item	Description Recommended Model	Required Parameters
1	Multimeter AVO Model 8	AC Volts: 90 V to 264 V Ohms: 1 Ω to 50 kΩ
2	Digital Voltmeter Racal-Dana Model 4005	DC Volts: 15 V with 100 mV resolution 5 V with 0.1 mV resolution 50 mV with 0.01 mV resolution 7 mV with 1μV resolution
3	Oscilloscope with Qty 1 X10 Probe	Bandwidth 10 MHz
4	Signal Generator Racal-Dana Model 9084 and Exact Model 119	Frequency range: 5 Hz to 35 MHz Output level: +13 dBm into 50 Ω above 10 MHz Spectral Purity: Harmonics more than 40 dB below carrier.
5	Pulse Generator	PRF: 1 kHz Mark/Space Ratio: 1:15 Pulse Amplitude: 4 V Polarity: Reversible
6	Signal Amplifier	Gain: 20 dB Output level: To give 3 V r.m.s into 50 Ω at 20 MHz.
7	Switchable Attenuator	0-90 dB in 1 dB steps Accuracy ±0.01 dB from DC to 35 MHz 50 Ω
8	DC Power Supply	5 V settable to ±0.5 mV 50 mV settable to ±0.15 mV
9	50 Ω Load	50 Ω ±1% BNC termination and BNC T piece.
10	T piece	BNC, 50 Ω.
11	Thermocouple Ballantine 1395A-1	Input impedance 50 Ω ±1%. To accept +13 dBm. Reversal error not more than ±0.1%. Output to be not more than 0.02 dB down at 10 MHz, relative to output at DC.
12	Low Pass Filters (2)	Corner Frequencies: 1 MHz and 10 MHz. Roll Off: 20 dB/octave.
13	Variac	To supply 0 V to 264 V from 240 V supply or 0 V to 132 V from 110 V supply at 40 VA.
14	Resistor	1 kΩ

6.5.5.3 Set the ISOLATE switch to the ground position. Check that the resistance indicated on the multimeter is not more than 1 Ω.

6.5.5.4 Set the multimeter to measure resistances of approximately 50 kΩ. Set the ISOLATE switch to the ISOLATE position. Check that the resistance indicated on the multimeter is between 50 kΩ and 500 kΩ.

6.5.5.5 Disconnect the multimeter. The ISOLATE switch should remain in the ISOLATE position throughout the calibration procedure.

6.5.6 SETTING UP THE POWER SUPPLIES

6.5.6.1 Test equipment required:

Description	Table 6.8 Item No.
Multimeter	1
Digital Voltmeter	2
Variac	13

6.5.6.2 (a) Disconnect the power lead from the power input plug.

(b) Put the LINE switch to ON.

(c) Set the supply voltage selector to each of the positions shown in Table 6.9 in turn. Measure the resistance between the line and neutral points on the rear of S29 on assembly 19-1024, and ensure that the correct values are obtained. Ensure that the value obtained for the 120 V setting is greater than that obtained for the 100 V setting, and that the value obtained for the 240 V setting is greater than that for the 220 V setting.

(d) Set the voltage selector to suit the local AC supply. Check that the correct supply fuse for this setting is fitted.

TABLE 6.9

Power Input Resistance

Voltage Selector Setting	Resistance
100 V	6 Ω - 11 Ω
120 V	6 Ω - 11 Ω
220 V	24 Ω - 37 Ω
240 V	26 Ω - 41 Ω

6.5.6.3 On assembly 19-1024:

(a) Set all sections of the switch bank S30 to the open position (where the slider is furthest from the switch section number).

(b) Measure the resistance from IC39/3 to ground, with the current source lead of the meter to IC39/3. The resistance must be greater than 30 Ω.

(c) Measure the resistance from IC38/3 to ground, with the current source lead of the meter to ground. The resistance must be greater than 30 Ω.

(d) Measure the resistance from TP3 to ground, with the current source lead of the meter to TP3. The resistance must be greater than 30 Ω.

6.5.6.4 Set the 5002 LINE switch to OFF. Using the power supply lead, connect the earth pin of the power input plug to a good earth point. Connect the line and neutral pins to the output of the variac. Connect the multimeter to monitor the variac output.

6.5.6.5 (a) Switch on the AC supply to the variac. Adjust the variac to give an output equal to the setting of the supply voltage selector.

(b) Switch on the 5002. Using the DVM, measure the voltage, relative to 0 V, at TP16 on assembly 19-1022. Adjust R44 on assembly 19-1024 until the measured voltage is +15 V ±0.5 V.

(c) Transfer the DVM to measure the voltage, relative to 0 V, at TP2 on assembly 19-1022. Adjust R49 on assembly 19-1024 until the measured voltage is -15 V ±0.5 V.

(d) Transfer the DVM to measure the voltage at TP3 on assembly 19-1024 relative to 0 V. The voltage must be +5 V ±0.25 V.

(e) Transfer the DVM to measure the voltage at pin 1 of R34. The voltage must be +9.3 V ±1 V.

(f) Transfer the DVM to measure the voltage at TP10. The voltage must be 4.9 V ±0.4 V.

6.5.6.6 Adjust the variac to give an output equal to the upper voltage limit relating to the supply voltage selector setting, as given in Table 6.10. Measure the +15 V, -15 V, +5 V and +9.3 V supplies at the points given in the previous paragraph. Adjust the variac output to the lower voltage limit and repeat the measurements. The voltages must not have changed by more than 100 mV.

6.5.6.7 On assembly 19-1024, transfer the DVM to measure the voltage at TP9 relative to 0 V.

TABLE 6.10

Voltage Regulation Test Limits

Voltage Selector Setting	Upper Limit	Lower Limit
240 V	269 V	210 V
220 V	246 V	193 V
120 V	134 V	105 V
100 V	112 V	88 V

6.5.6.8 (a) Set the variac output to the figure shown in the Logic '0' column of Table 6.11 for the voltage selector setting in use.

(b) Check that the voltage at TP9 is less than +0.4 V.

(c) Reduce the variac output until the voltage at TP9 switches to a level greater than +2.4 V. The variac output must be greater than the minimum switching voltage given in Table 6.11.

TABLE 6.11

Switching Level

Voltage Selector Setting	Logic '0' Voltage	Minimum Switching Voltage
240 V	192 V	180 V
220 V	176 V	165 V
120 V	96 V	90 V
100 V	80 V	75 V

6.5.6.9 Switch off the 5002 and the supply to the variac. Disconnect the 5002 from the variac. Connect the 5002 to the AC supply.

6.5.7 SETTING UP ASSEMBLY 19-1024

6.5.7.1 Test equipment required:

Description	Table 6.8 Item No.
Digital Voltmeter	2
DC Power Supply	8

6.5.7.2 Remove SK15 from assembly 19-1024. Connect the 5 V DC supply between PL15 pin 16 and 0 V, positive to PL15 pin 16. Measure the voltage at TP2 with the DVM, and adjust the DC supply to give a voltage of 5 V ±0.5 mV.

6.5.7.3 (a) Switch on the 5002.

(b) Press /MANUAL/ and step through to the 1 V range.

(c) Adjust R15 until the 5002 indicates 1.000 ±0.001.

(d) Adjust the DC supply to give a voltage of 50 mV ±0.15 mV at TP2. Check that the 5002 indicates 0.013 ±0.001.

(e) Remove the DC supply from TP2. Short circuit TP2 to TP1 and check that the 5002 indicates 0 ±0.002. An error indication is normal.

(f) Switch the 5002 off. Remove the short circuit between TP2 and TP1 and replace SK15.

6.5.8 <u>RANGE ATTENUATOR SETTING</u>

6.5.8.1 Test equipment required:

Description	Table 6.8 Item No
Digital Voltmeter	2
Oscilloscope	3
Signal Generator	4
Signal Amplifier	6
Attenuator	7
DC Power Supply	8
50 Ω Load	9
Thermocouple	11

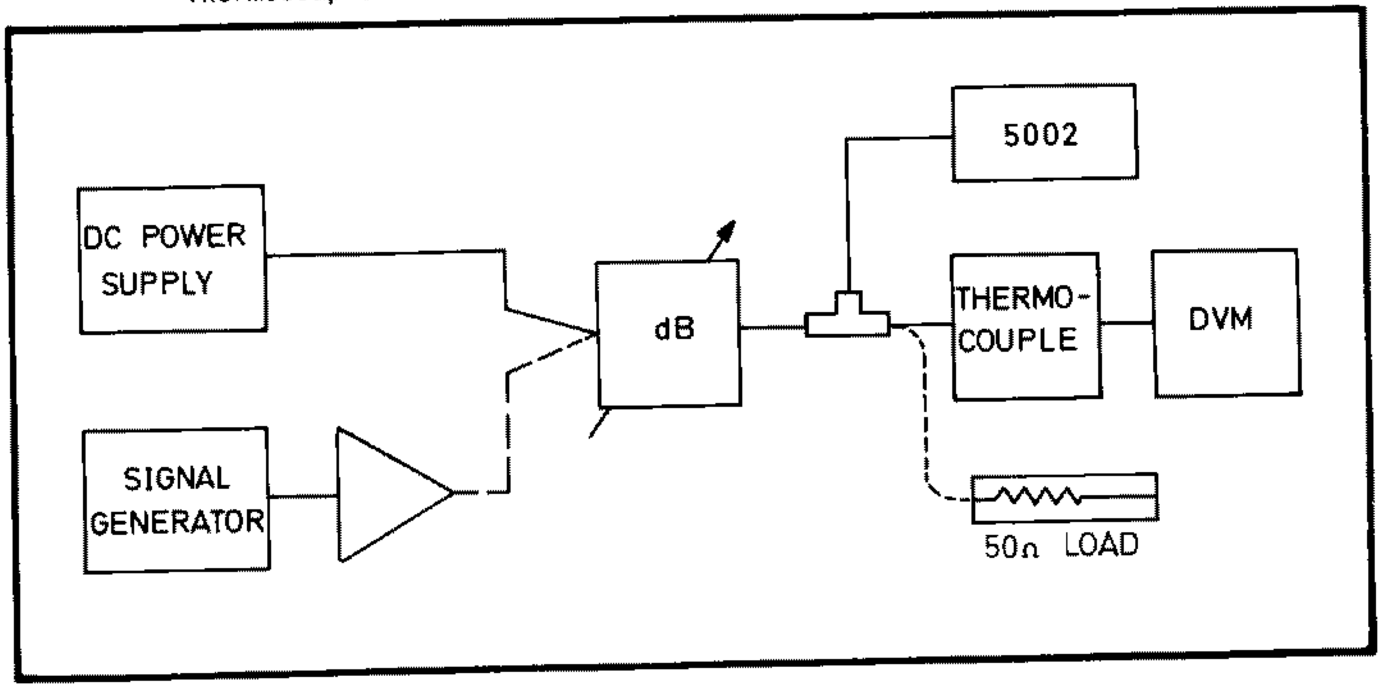


Fig. 6.1 Range Attenuator Setting

6.5.8.2 Connect the test equipment as shown in Fig. 6.1 with the DC power supply connected to the attenuator input. Connect the thermocouple to the attenuator using the T piece from the 50 Ω load. The amplifier should be used only when necessary to obtain the required output level from the signal generator in use.

6.5.8.3 (a) Set the attenuator to 10 dB.

(b) Set the DC power supply output to 3.0 V ±0.1 V.

(c) Switch on the 5002. Press /MANUAL/.

(d) Allow a 30 minute warm up time before making any adjustments. The ambient temperature must be in the range from 18°C to 28°C, and must not vary by more than ±½°C throughout the period over which adjustments to the attenuators are made.

(e) Note the DVM indication. A resolution of 1 μV will be required.

(f) Connect the signal generator to the attenuator input in place of the DC power supply.

(g) Set the signal generator output to a frequency of 1 kHz at a level which gives the same DVM indication as in (e).

(h) Set the attenuator to 70 dB.

(j) Monitor TP12 on assembly 19-1022 with the oscilloscope. Adjust R27 for minimum 20 Hz oscillation.

(k) Select the 1 mV range. Adjust R45 on assembly 19-1022 until the 5002 indicates 1.000 mV ±0.001 mV.

(l) Select the 3 mV range. Set the attenuator to 60 dB and adjust R58 on assembly 19-1021 until the 5002 indicates 3.162 mV ±0.003 mV. Set the attenuator to 70 dB.

(m) Repeat (k) and (l) until the required indication is obtained on both ranges.

(n) Select the 30 mV range. Set the attenuator to 40 dB and adjust R38 on assembly 19-1021 until the 5002 indicates 31.62 mV ±0.003 mV.

(p) Select the 300 mV range. Set the attenuator to 20 dB and adjust R27 on assembly 19-1021 until the 5002 indicates 316.2 mV ±0.3 mV.

6.5.8.4 (a) Change the signal generator frequency to 100 kHz. Set the attenuator to 10 dB, and adjust the signal generator output level until the DVM indication is the same as that obtained in 6.5.8.3(e).

(b) Set the attenuator to 30 dB. Select the 100 mV range, and adjust C11 on assembly 19-1021 until the 5002 indicates 100.0 mV ±0.1 mV.

(c) Disconnect the thermocouple from the T piece, and replace it with the 50 Ω termination.

(d) Select the 3 V range. Set the attenuator to 0 dB.

(e) Press /9//9//.//1//SHIFT//SF/. Adjust C5 on assembly 19-1021 until the 5002 indicates 3.162 V ±0.003 V.

(f) Press /0//SHIFT//SF/. Adjust C6 on assembly 19-1021 until the 5002 indicates 3.162 V ±0.003 V.

(g) Repeat (e) and (f) until the correct indication is obtained in both cases. Press /0//SHIFT//SF/.

(h) Reconnect the thermocouple to the T piece in place of the 50 Ω termination. Select the 1 V range.

6.5.8.5 (a) Change the signal generator frequency to 10 MHz. Set the attenuator to 10 dB, and adjust the signal generator output level until the DVM indication is the same as that obtained in 6.5.8.3(e).

(b) Set the attenuator to 20 dB. Select the 300 mV range and adjust C33 until the 5002 indicates 316.2 mV ±0.6 mV.

(c) Change the signal generator frequency to 20 MHz. Select the 1 V range. Set the attenuator to 10 dB and adjust the signal generator output level until the DVM indication is the same as that obtained in 6.5.8.3(e).

(d) Press /9//9//.//1//SHIFT//SF/. Set the attenuator to 0 dB. Check that the 5002 indication is 3.162 V ± 0.285 V. If necessary change R45 on assembly 19-1021 (a select-on-test resistor). Press /0//SHIFT//SF/ and select the 1 V range.

(e) Repeat (a) to (d) until the correct indication is obtained in both cases.

(f) Disconnect the test equipment.

6.5.9. RMS DETECTOR SETTING

6.5.9.1 Test equipment required:

Description	Table 6.8 Item No.
Signal Generator	4
Attenuator	7
50 Ω Load	9

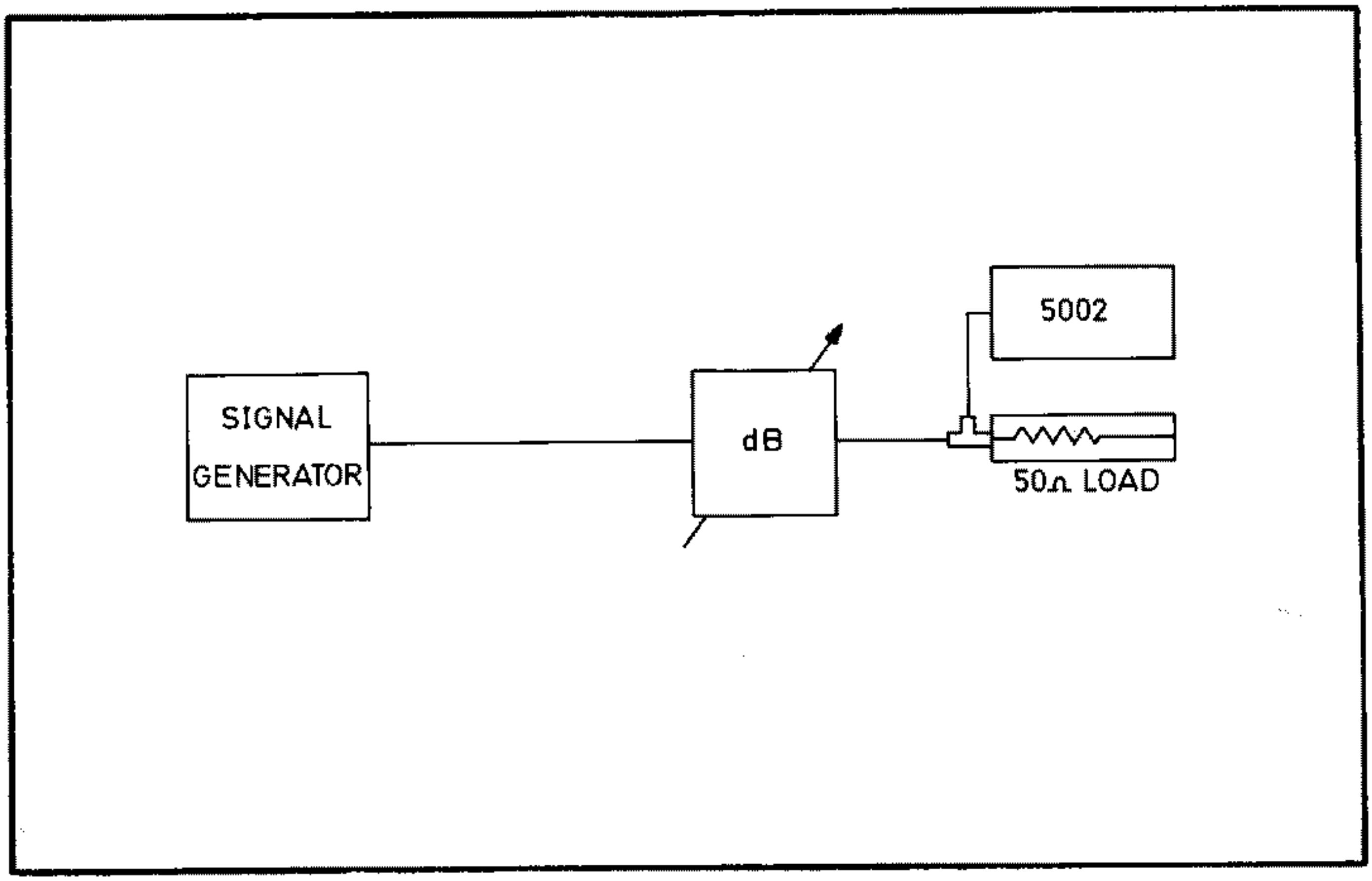


Fig. 6.2 RMS Detector Setting

6.5.9.2 Connect the test equipment as shown in Fig. 6.2

6.5.9.3 Set the attenuator to 20 dB. Set the signal generator output to a frequency of 1 kHz at a level which gives 100.0 mV ±0.2 mV at the attenuator output.

6.5.9.4 (a) Select the 100 mV range. Adjust R27 on assembly 19-1022 until the 5002 indicates 100.0 mV ±0.1 mV.

(b) Select the 300 mV range. Set the attenuator to 10 dB and adjust R45 on assembly 19-1022 until the 5002 indicates 316.2 mV ±0.3 mV. Set the attenuator to 20 dB.

(c) Repeat (a) and (b) until the correct indication is obtained in both cases.

(d) Disconnect the test equipment.

6.5.10 DC CHANNEL SETTING

6.5.10.1 Test equipment required

Description	Table 6.8 Item No.
Attenuator	7
DC Power Supply	8
50 Ω Load	9

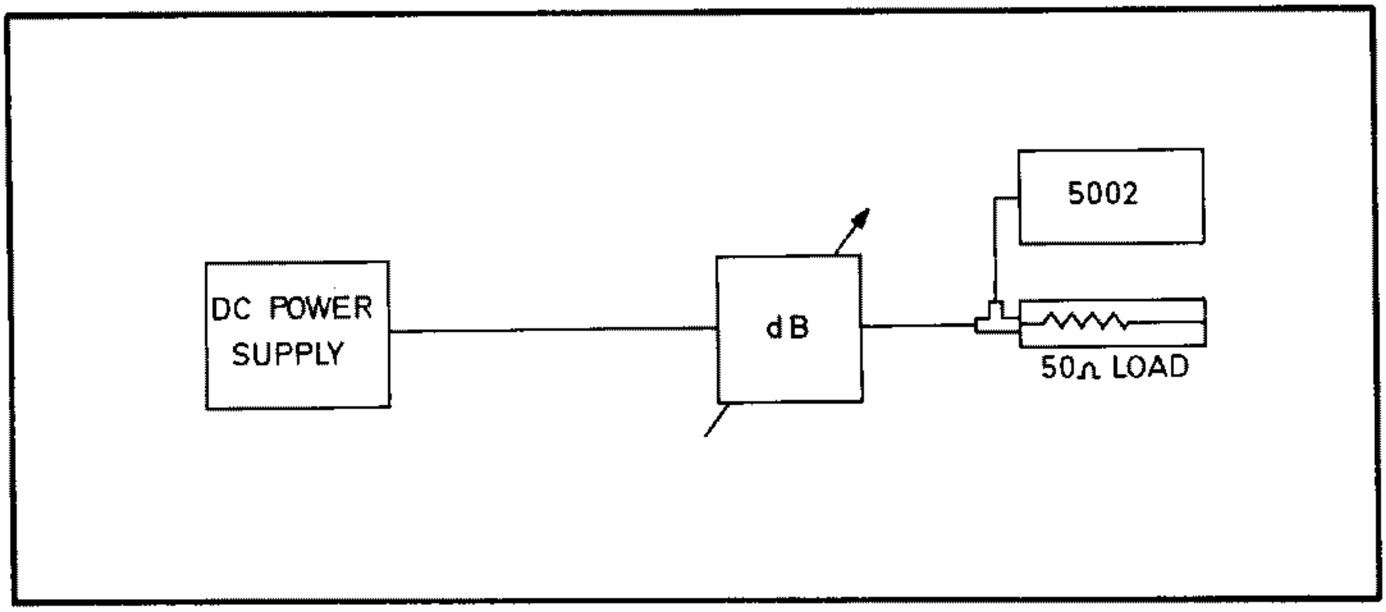


Fig. 6.3 DC Channel Setting

6.5.10.2 Connect the test equipment as shown in Fig. 6.3.

6.5.10.3 Set the attenuator to 20 dB. Set the DC supply output to a level which gives 316.20 mV ±0.3 mV at the attenuator output.

6.5.10.4 (a) Press /MEAN/ and /AC + DC/.

(b) Adjust R88 on assembly 19-1021 until the 5002 indicates 316.2 mV ±0.3 mV.

(c) Set the attenuator to 30 dB. Adjust R80 on assembly 19-1021 until the 5002 indicates 100.0 mV ± 0.1 mV. Set the attenuator to 20 dB.

(d) Repeat (b) and (c) until the correct indication is obtained in both cases.

(e) Disconnect the output of the attenuator from the 50 Ω load at the load input. Select the 1 mV range and adjust R66 on assembly 19-1021 until the 5002 indicates 0.000 mV ±0.001 mV.

(f) Disconnect the test equipment.

6.5.11 MEAN DETECTOR SETTING

6.5.11.1 Test equipment required:

Description	Table 6.8 Item No.
Oscilloscope	3
X10 Probe	
Signal Generator	4
Attenuator	7
DC Power Supply	8
50 Ω Load	9

6.5.11.2 Connect the oscilloscope to monitor TP20 on assembly 19-1022 via the X10 probe. Connect the probe earth lead to 0 V at TP25. Set the oscilloscope Y sensitivity to 100 mV per cm.

6.5.11.3 (a) Press /SHIFT//AC/. Select the 300 mV range.

(b) Adjust R60 on assembly 19-1022 until an oscillatory waveform is displayed.

(c) Adjust R60 clockwise until the displayed oscillation just ceases. Note the setting of R60.

(d) Adjust R60 anti-clockwise to the point where the oscillation again ceases. Note the setting of R60.

(e) Set R60 to the mid-point of the settings noted in (c) and (d).

(f) Disconnect the oscilloscope.

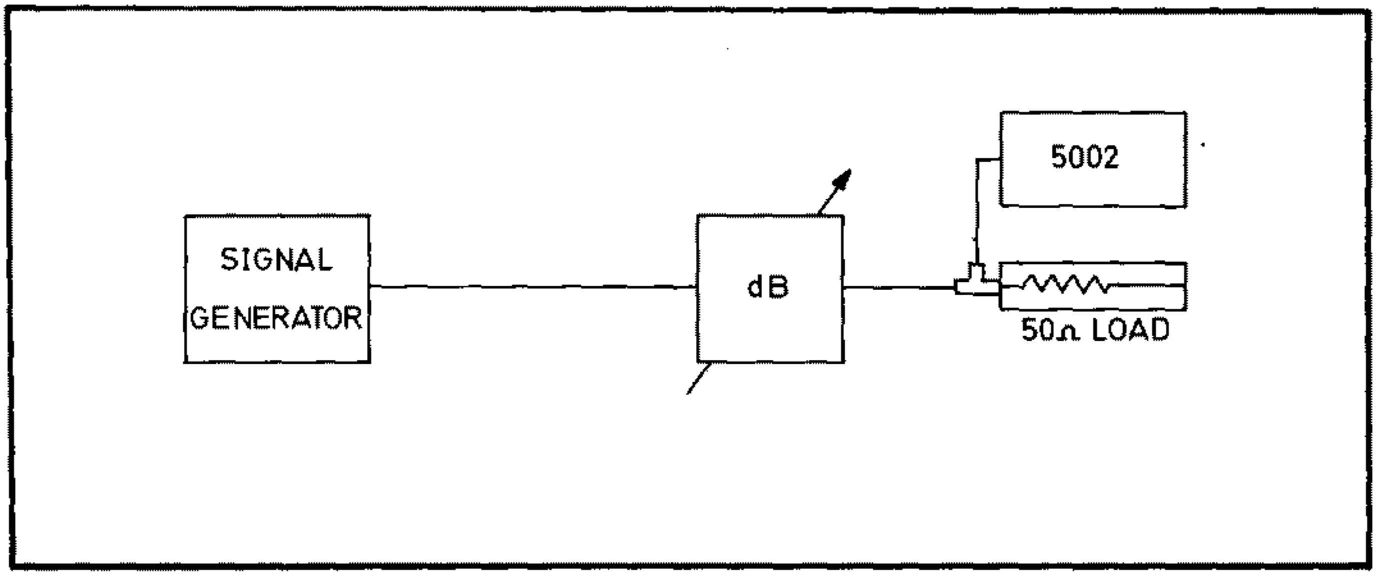


Fig. 6.4 Mean Detector Setting

6.5.11.4 Connect the test equipment as shown in Fig. 6.4.

6.5.11.5 Set the attenuator to 10 dB. Set the signal generator output to a frequency of 1 kHz at a level which gives 316.20 mV ±0.03 mV r.m.s at the attenuator output.

6.5.11.6 (a) Adjust R56 on assembly 19-1022 until the 5002 indicates 316.2 mV ±0.3 mV.

(b) Set the attenuator to 20 dB, and adjust R65 on assembly 19-1022 until the 5002 indicates 100.0 mV ±0.1 mV. Set the attenuator to 10 dB.

(c) Repeat (a) and (b) until the correct indication is obtained in both cases.

6.5.11.7 Disconnect the attenuator input from the signal generator and connect it to the DC supply output. Set the attenuator to 30 dB, and adjust the DC supply output to give 100.00 mV ±0.01 mV at the attenuator output.

6.5.11.8 (a) Press /AC + DC/ and /5//0//.//1//SHIFT//SF/.

(b) Note the 5002 indication obtained.

(c) Reverse the polarity of the DC supply.

(d) Note the 5002 indication obtained.

(e) Adjust R78 on assembly 19-1022 and repeat (b) to (d) until the magnitudes of the indications obtained differ by less than 0.2 mV.

(f) Connect the DC supply to obtain a positive indication on the 5002.

(g) Set the attenuator to 20 dB. Adjust R49 on assembly 19-1022 until the 5002 indicates 316.2 mV ±0.3 mV.

(h) Press /0//SHIFT//SF/.

(j) Disconnect the test equipment.

6.5.12 <u>PEAK DETECTOR SETTING</u>

6.5.12.1 Test equipment required:

Description	Table 6.8 Item No.
Signal Generator	4
Attenuator	7
50 Ω Load	9

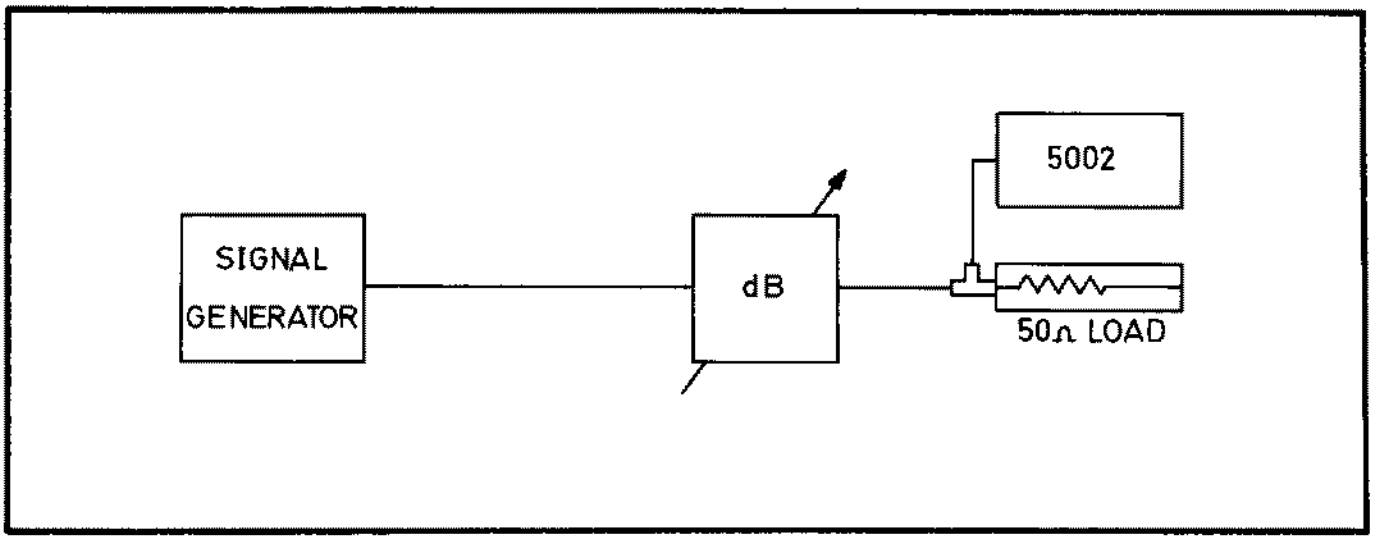


Fig. 6.5 Peak Detector Setting

6.5.12.2 Connect the test equipment as shown in Fig. 6.5.

6.5.12.3 Set the attenuator to 10 dB. Set the signal generator output to a frequency of 1 kHz at a level which gives 223.61 ±0.02 mV at the attenuator output.

6.5.12.4 (a) Press /AC/ and /+ PEAK/.

(b) Adjust R111 on assembly 19-1022 until the 5002 indicates 316.2 mV ±0.3 mV.

(c) Set the attenuator to 20 dB and adjust R133 until the 5002 indicates 100.0 mV ±0.1 mV. Set the attenuator to 10 dB.

(d) Repeat (b) and (c) until the correct indications are obtained in both cases.

(e) Select /-PEAK/. Set the attenuator to 10 dB.

(f) Adjust R83 on assembly 19-1022 until the 5002 indicates -316.2 mV ±0.3 mV.

(g) Set the attenuator to 20 dB and adjust R107 until the 5002 indicates 100.0 mV ±0.1 mV. Set the attenuator to 10 dB.

(h) Repeat (f) and (g) until the correct indications are obtained in both cases.

(j) Disconnect the test equipment. Switch off the 5002 and replace the instrument covers.

6.5.13 ATTENUATOR CHECK

6.5.13.1 Test equipment required:

Description	Table 6.8 Item No.
Signal Generator	4
Signal Amplifier	6
Attenuator	7
50 Ω Load	9

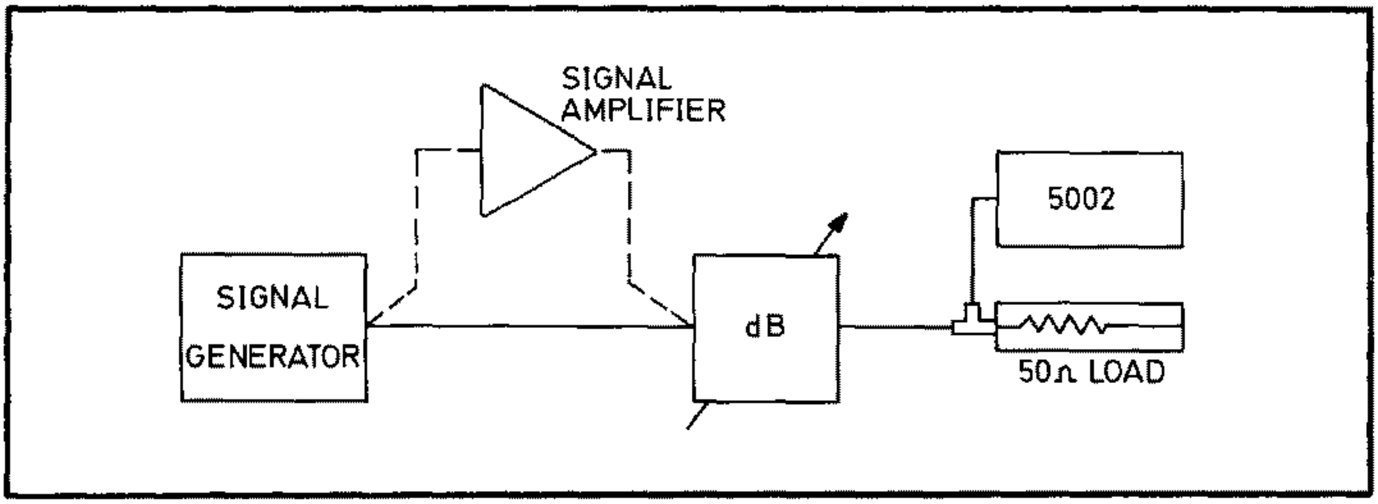


Fig. 6.6 Attenuator Check

6.5.13.2 Connect the test equipment as shown in Fig. 6.6. The signal amplifier is not required at this stage.

6.5.13.3 (a) Switch on the 5002. Press /MANUAL/.

(b) Set the signal generator frequency to 5 Hz.

(c) Set the attenuator and signal generator output level to give each value of attenuator output shown in Table 6.12, ±0.2%, in turn. For each level select the appropriate measurement range shown in the table, and check that the indications obtained are within the limits given in the 5 Hz column.

TABLE 6.12

Attenuator Check, Low Level

Attenuator Output Level		5002 Range	5002 Indication			
			Nominal	Tolerance		
dBV	dBm			5 Hz	1 kHz	20 MHz
-90	-77	100 μV	32 μV		±3.7 μV	
-80	-67	100 μV	100 μV	±13 μV	±4.8 μV	±10.6 μV
-70	-57	300 μV	316.2 μV	±34.8 μV	±6.6 μV	±28.4 μV
-60	-47	1 mV	1 mV	±0.094 mV	±0.013 mV	±0.08 mV
-50	-37	3 mV	3.162 mV	±0.285 mV	±0.028 mV	±0.241 mV
-40	-27	10 mV	10 mV	±0.9 mV	±0.09 mV	±0.9 mV
-30	-17	30 mV	31.62 mV	±2.85 mV	±0.28 mV	±2.85 mV
-10	+3	300 mV	316.2 mV	±28.5 mV	±2.8 mV	±28.5 mV

(d) Change the signal generator frequency to 1 kHz. Repeat (c), checking that the indications obtained are within the limits given in the 1 kHz column.

(e) Change the signal generator frequency to 20 MHz. Repeat (c), checking that the indications obtained are within the limits given in the 20 MHz column.

6.5.13.4 (a) Connect the signal amplifier between the signal generator output and the attenuator.

(b) Set the signal generator frequency to 20 MHz.

(c) Set the attenuator and signal generator output level to give each value of attenuator output shown in Table 6.13, ±0.2% in turn. For each level select the appropriate measurement range shown in the table, and check that the indications obtained are within the limits given in the 20 MHz column.

(d) Press /9//9//.//1//SHIFT//SF/. Check that the indication obtained for a level of +10 dBV is still within tolerance. Press /0//SHIFT/SF/.

(e) Change the signal generator frequency to 1 kHz. Repeat (c) and (d), checking that the indications obtained are within the limits given in the 1 kHz column.

(f) Change the signal generator frequency to 5 Hz. Repeat (c) and (d), checking that the indications obtained are within the limits given in the 5 Hz column.

(g) Disconnect the test equipment.

TABLE 6.13

Attenuator Check, High Level

Attenuator Output Level			5002 Range	5002 Indication			
dBV	dBm	Volts		Nominal	Tolerance		
					5 Hz	1 kHz	20 MHz
0	+13	1.000	1 V	1 V	±0.09 V	±0.009 V	±0.09 V
+10	+23	3.162	3 V	3.162 V	±0.285 V	±0.0285 V	±0.285 V

6.5.14 RMS DETECTOR CHECK

6.5.14.1 Test equipment required

Description	Table 6.8 Item No.
Digital Voltmeter	2
Oscilloscope	3
Signal Generator	4
Pulse Generator	5
Attenuator	7
DC Power Supply	8
50 Ω Load	9
BNC T piece	10
Thermocouple	11

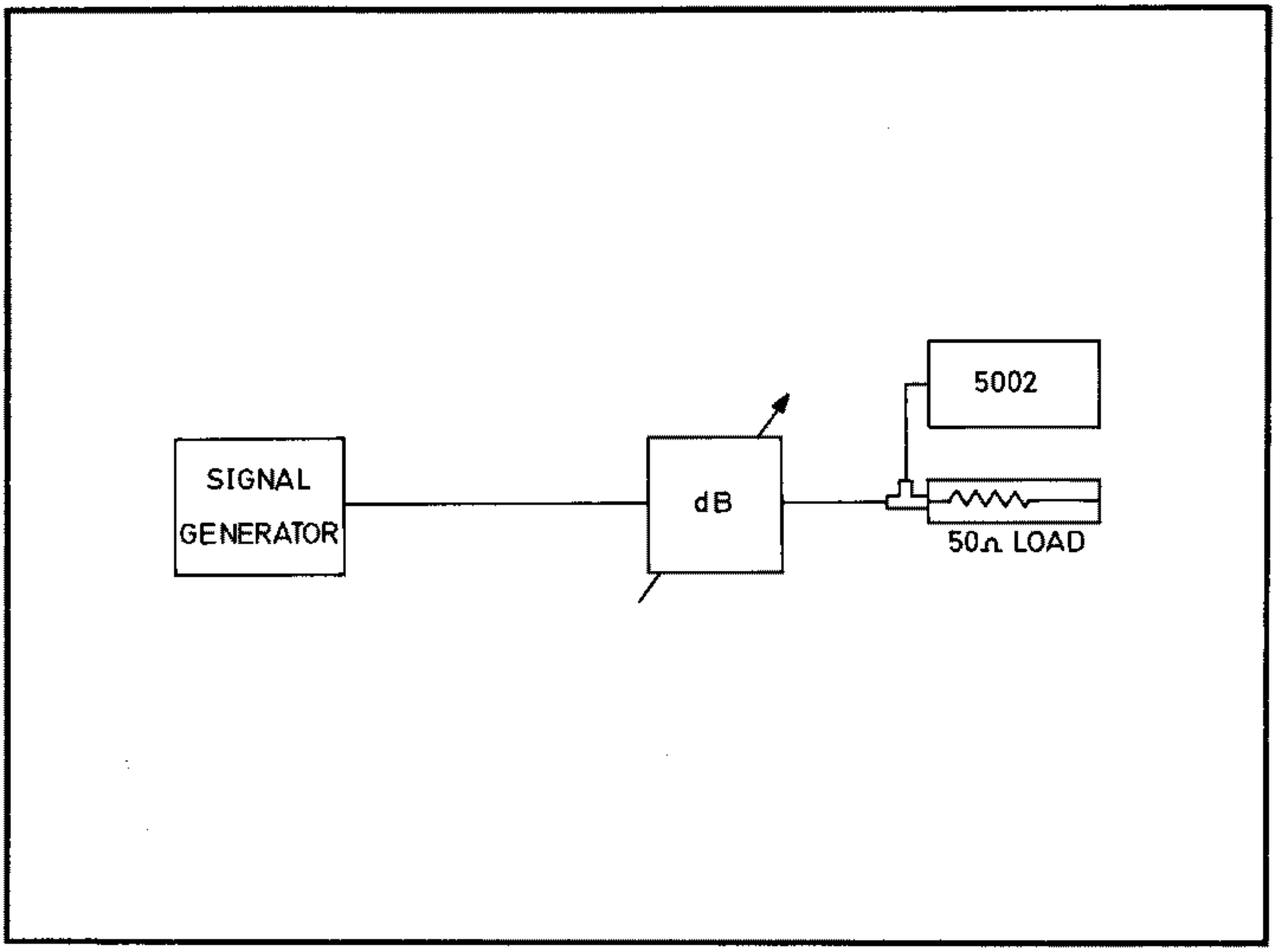


Fig. 6.7 RMS Detector Check, Sinewave

6.5.14.2 Connect the test equipment as shown in Fig. 6.7.

6.5.14.3 (a) Set the attenuator to 20 dB.

(b) Select the 100 mV range.

(c) By adjusting the signal generator frequency and output level, set the attenuator output to each of the frequency and level combinations shown in Table 6.14, ±0.2%, in turn. Check that the indications obtained are within the limits given.

(d) With the attenuator output at 500 kHz and a level of -20 dBV press /SHIFT//FILTER/.

(e) Check that the 5002 indication is 37.1 mV ±5.6 mV.

(f) Press /SHIFT//FILTER/.

(g) Disconnect the test equipment.

TABLE 6.14

RMS Detector Check

Frequency	Attenuator Output Level			5002 Indication
	dBV	dBm	mV	
5 Hz	-20	-7	100.0	91.0 mV to 109.0 mV
10 Hz	-20	-7	100.0	97.1 mV to 102.9 mV
50 Hz	-20	-7	100.0	99.1 mV to 100.9 mV
1 kHz	-20	-7	100.0	99.1 mV to 100.9 mV
1 kHz	-21.9	-8.9	80.0	79.2 mV to 80.8 mV
1 kHz	-26	-13	50.0	49.3 mV to 50.7 mV
1 kHz	-30.46	-17.46	30.0	29.3 mV to 30.7 mV
500 kHz	-20	-7	100.0	99.1 mV to 100.9 mV
1 MHz	-20	-7	100.0	97.1 mV to 102.9 mV
10 MHz	-20	-7	100.0	91.0 mV to 109.0 mV
20 MHz	-20	-7	100.0	91.0 mV to 109.0 mV

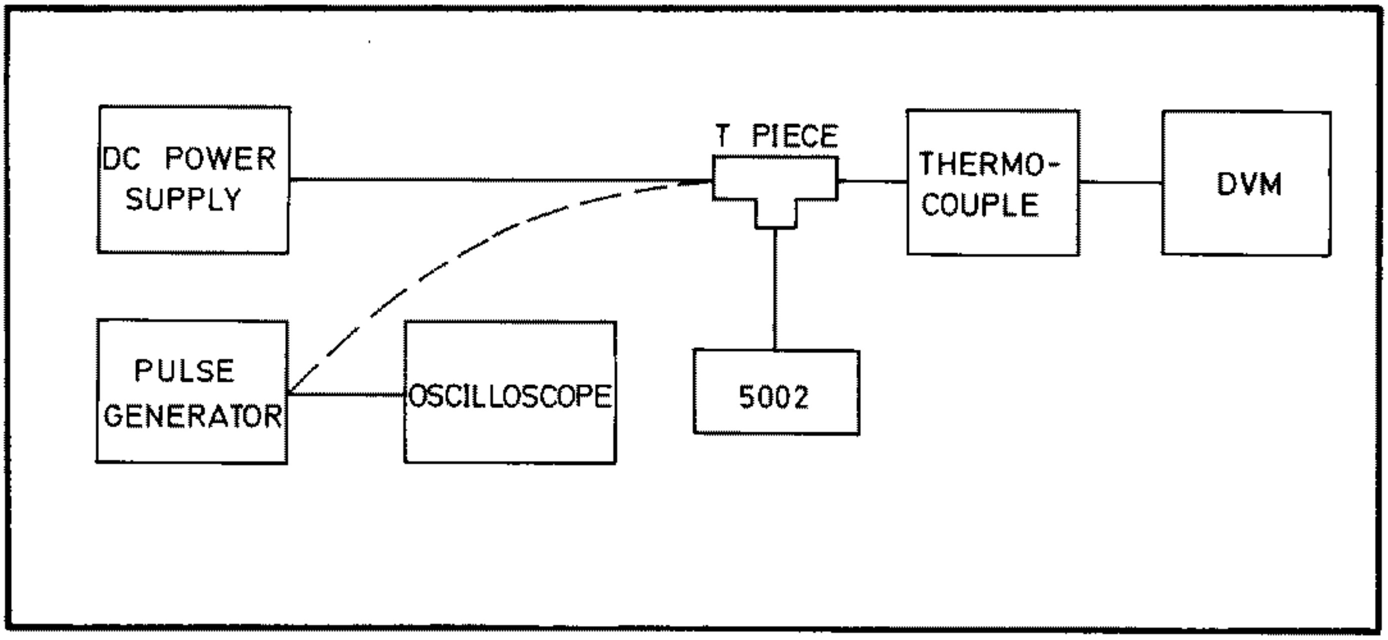


Fig. 6.8 RMS Detector Check, Pulse

6.5.14.4 Connect the test equipment as shown in Fig. 6.8.

6.5.14.5 (a) Select the 1 V range.

(b) Set the output of the DC supply to 1.00 V ±0.01 V. Note the actual level set.

(c) Note the DVM indication. A resolution of 1 µV will be required.

(d) Using the oscilloscope, set the pulse generator output to a repetition rate of 1 kHz and a mark/space ratio of 1:15. Reduce the pulse generator output to a minimum.

(e) Disconnect the pulse generator from the oscilloscope and connect it to the T piece in place of the DC supply.

(f) Slowly increase the pulse generator output amplitude until the DVM indicates the same value as in (c).

(g) Check that the 5002 indicates the level set in (b) ±0.009 V.

(h) Reverse the polarity of the pulse generator output. If necessary reset the output amplitude to obtain the same DVM indication as in (c).

(j) Check that the 5002 indicates the level set in (b) ±0.009 V.

(k) Disconnect the test equipment.

6.5.15 MEAN AND PEAK DETECTORS CHECK

6.5.15.1 Test equipment required.

Description	Table 6.8 Item No.
Signal Generator	4
Attenuator	7
50 Ω Load	9
Low Pass Filters	12

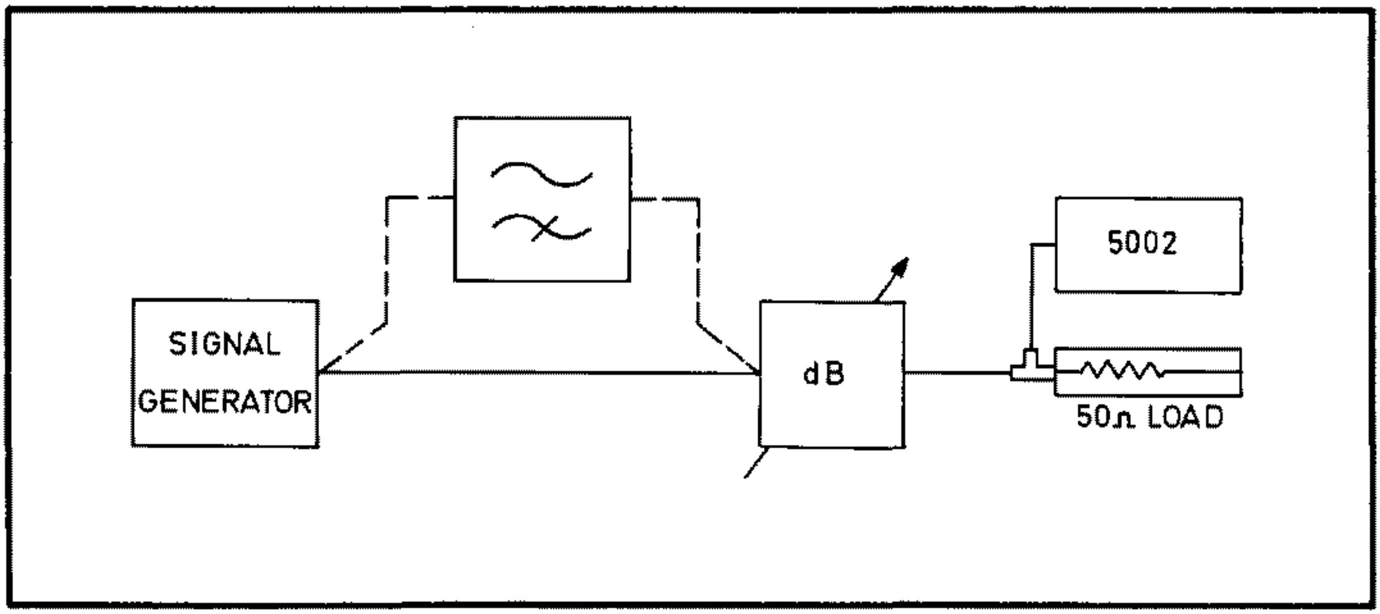


Fig. 6.9 Mean and Peak Detectors Check

6.5.15.2 Connect the test equipment as shown in Fig. 6.9. The low pass filters are required for the peak detector check only.

6.5.15.3 (a) Press /MEAN/.

(b) By adjusting the attenuator and the signal generator output level and frequency, set the attenuator output to each of the frequency and level combinations shown in Table 6.15, ±0.2%, in turn. For each setting, select the appropriate range and check that the indication obtained is within the limits given.

TABLE 6.15

Mean Detector Check

Attenuator Output				5002 Range	5002 Indication
Frequency	Level				
	dBV	dBm	mV		
1 kHz	-59.1	-46.1	1.11	1 mV	0.963 mV to 1.038 mV
1 kHz	-29.1	-16.1	35.09	100 mV	30.6 mV to 32.6 mV
1 kHz	-24.1	-11.1	62.38	100 mV	55.0 mV to 57.4 mV
1 kHz	-19.1	-6.1	110.94	100 mV	98.2 mV to 101.8 mV
100 kHz	-19.1	-6.1	110.94	100 mV	98.2 mV to 101.8 mV
1 MHz	-19.1	-6.1	110.94	100 mV	97.2 mV to 102.8 mV
10 MHz	-19.1	-6.1	110.94	100 mV	93.0 mV to 107 mV

(c) By adjusting the attenuator and the signal generator output level and frequency, set the attenuator output to the first frequency and level combination shown in Table 6.16, ±0.2%.

(d) Select the appropriate range. Press /+PEAK/, and check that the indication obtained is within the limits given.

(e) Press /-PEAK/, and check that the indication obtained is within the limits given.

(f) Set the attenuator output to the next value given in the table. Repeat (d) and (e).

NOTE: The appropriate low pass filter must be inserted in the circuit at 1 MHz and 10 MHz.

(g) Disconnect the test equipment.

TABLE 6.16

Peak Detector Check

Attenuator Output				5002 Range	5002 Indication
Frequency	Level				
	dBV	dBm	mV		
1 kHz	-63	-50	0.707	1 mV	0.882 mV to 1.118 mV
1 kHz	-33	-20	22.36	100 mV	30.6 mV to 32.6 mV
1 kHz	-28	-15	39.74	100 mV	55.0 mV to 57.4 mV
1 kHz	-23	-10	70.71	100 mV	98.2 mV to 101.8 mV
100 kHz	-23	-10	70.71	100 mV	98.2 mV to 101.8 mV
1 MHz	-23	-10	70.71	100 mV	97.2 mV to 102.8 mV
10 MHz	-23	-10	70.71	100 mV	93.0 mV to 107.0 mV

6.5.16 DC CHANNEL ATTENUATOR CHECK

6.5.16.1 Test equipment required:

Description	Table 6.8 Item No.
Attenuator	7
DC Power Supply	8
50 Ω Load	9

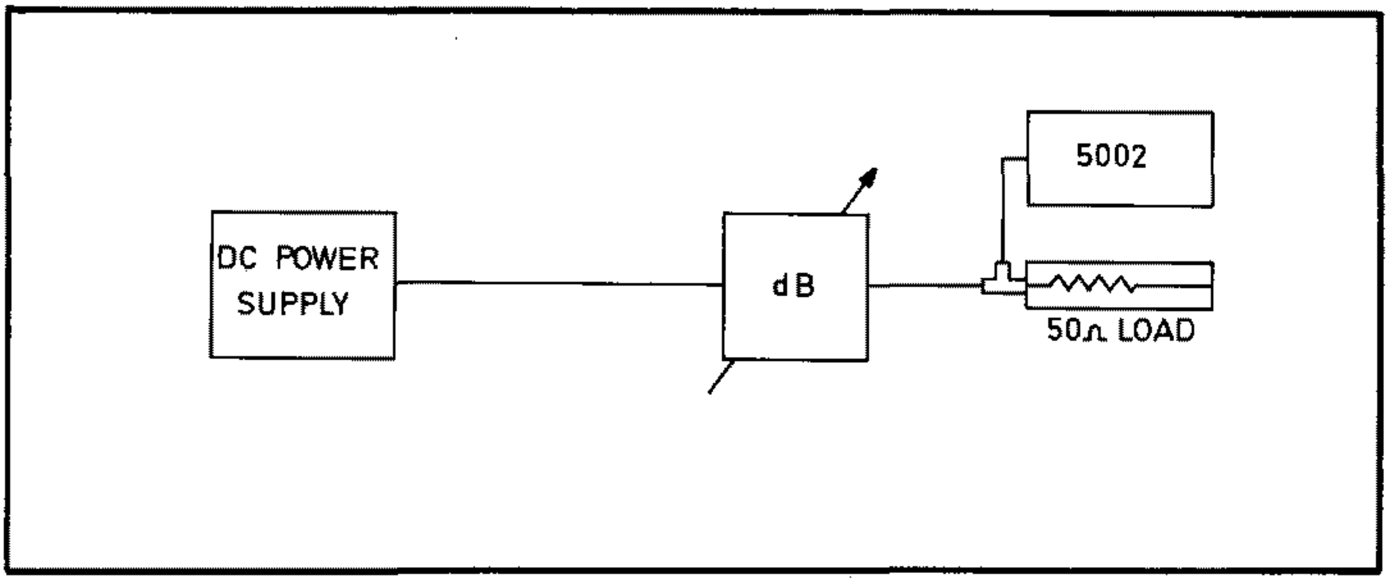


Fig. 6.10 DC Channel Attenuator Check

6.5.16.2 Connect the test equipment as shown in Fig. 6.10.

6.5.16.3 (a) Set the attenuator to 70 dB.

(b) Press /MEAN/ and /AC + DC/.

(c) Set the attenuator and the DC supply output level and polarity to give each value of attenuator output shown in Table 6.17, ±0.2%, in turn. For each setting, select the appropriate range and check that the indication obtained is within the limits given.

(d) Press /9//9//.//1//SHIFT//SF/. Check that the indication obtained for a level of +10 dBV is between 3.134 V and 3.190V.

(e) Press /0//SHIFT//SF/.

(f) Disconnect the test equipment.

TABLE 6.17

DC Attenuator Check

Attenuator Output			5002 Range	5002 Indication
dBV	mV	Polarity		
-60	1.000	+	1 mV	0.971 mV to 1.029 mV
-60	1.000	-	1 mV	-0.971 mV to -1.029 mV
-50	3.162	-	3 mV	-3.112 mV to -3.212 mV
-40	10.00	-	10 mV	-9.89 mV to -10.11 mV
-30	31.62	-	30 mV	-31.34 mV to -31.90 mV
-20	100.0	-	100 mV	-99.1 mV to -100.9 mV
-20	100.0	+	100 mV	99.1 mV to 100.9 mV
-21.94	80.0	+	100 mV	79.2 mV to 80.8 mV
-26.02	50.0	+	100 mV	49.3 mV to 50.7 mV
-30.46	30.0	+	100 mV	29.3 mV to 30.7 mV
-10	316.2	+	300 mV	313.4 mV to 319.0 mV
0	1000	+	1 V	0.991 V to 1.009 V
+10	3000	+	3 V	3.134 V to 3.190 V

6.5.17 RECTIFIED MEAN CHECK

6.5.17.1 Test equipment required:

Description	Table 6.8 Item No.
Signal Generator	4
DC Power Supply	8
50 Ω Load	9
T piece	10
Resistor	14

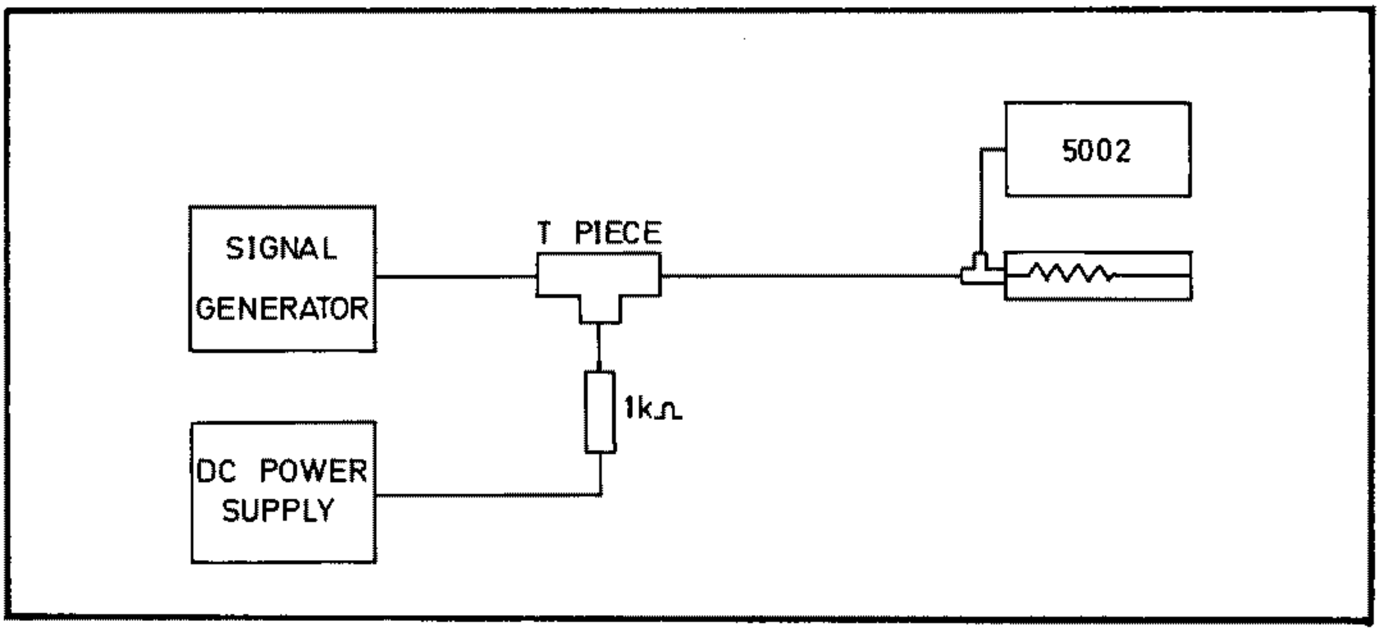


Fig. 6.11 Rectified Mean Check

6.5.17.2 Connect the test equipment as shown in Fig. 6.11.

6.5.17.3 (a) Select the 100 mV range.

(b) Press /AC/ and /MEAN/.

(c) Set the signal generator output to a frequency of 1 kHz at a level giving an indication of 63.7 mV ±0.1 mV on the 5002.

(d) Press /AC + DC/.

(e) Set the DC supply output level to obtain an indication of 70.7 mV ±0.7 mV.

(f) Press /5//0//.//1//SHIFT//SF/. Check that the indication is between 78.2 mV and 82.5 mV. Press /0//SHIFT//SF./.

(g) Reverse the polarity of the DC supply, and set the output level to obtain an indication of -70.7 mV ±0.7 mV.

(h) Repeat (f).

(j) Disconnect the test equipment.

6.5.18 <u>35 MHz FREQUENCY RESPONSE CHECK</u>

6.5.18.1 Test equipment required.

Description	Table 6.8 Item No.
Signal Generator	4
Attenuator	7
50 Ω Load	9

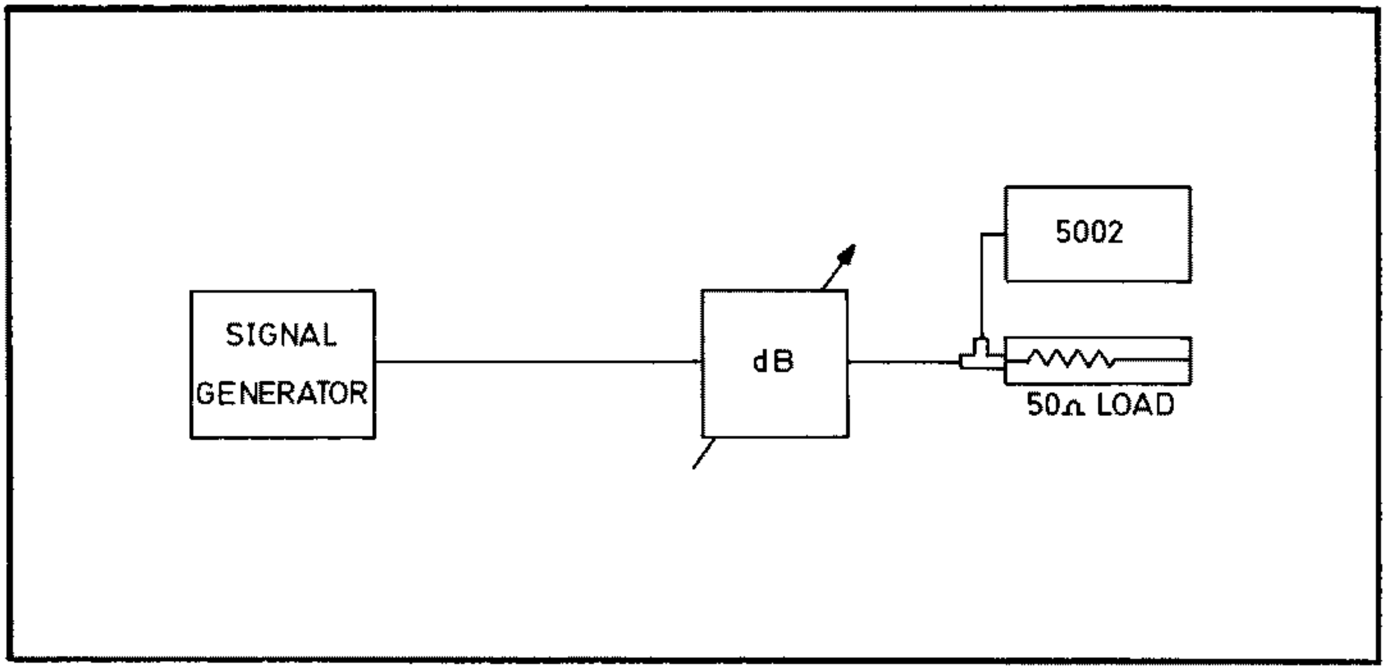


Fig. 6.12 35 MHz Frequency Response Check

6.5.18.2 Connect the test equipment as shown in Fig. 6.12.

6.5.18.3 Set the attenuator to 20 dB. Set the signal generator output to a frequency of 35 MHz at a level which gives 70.7 mV ±1% at the attenuator output.

6.5.18.4 (a) Press /AC/ and /MEAN/. Check that the indication on the 5002 is between 31.8 mV and 90.0 mV.

(b) Press /RMS/. Check that the indication is between 35.4 mV and 100 mV.

(c) Set the attenuator to 23 dB.

(d) Press /+PEAK/. Check that the indication is between 35.4 mV and 100.0 mV.

(e) Press /-PEAK/. Check that the indication is between 35.4 mV and 100.0 mV.

(f) Disconnect the test equipment.

6.6 DISMANTLING AND REASSEMBLY

6.6.1 INTRODUCTION

6.6.1.1 Instructions for dismantling and reassembling the 5002 are limited to those areas where special care is required or difficulty may be experienced.

WARNING: THE INSTRUMENT MUST BE SWITCHED OFF AND DISCONNECTED FROM THE AC SUPPLY DURING ALL DISMANTLING AND REASSEMBLY OPERATIONS.

6.6.2 REMOVAL AND REPLACEMENT OF THE COVERS

6.6.2.1 (a) Switch off the instrument and the AC supply. Remove the line power socket.

(b) Stand the instrument on its front handles, and remove the two screws from each of the plastic mouildings at the rear corners of the instrument. Remove the mouldings.

(c) The covers can now be removed by sliding them towards the rear of the instrument. Note that the removal of the plastic mouldings also releases the side trim panels, which should either be removed or secured by replacement of the mouldings.

(d) The covers are replaced in the reverse manner. Note that the straight, unfolded edge of the cover fits to the front of the instrument, and locates in a groove in the rear face of the front panel. The rear edge of the cover is folded under, and locates in a groove in the rear panel.

6.6.3 REMOVAL OF ASSEMBLIES 19-1021 and 19-1022

6.6.3.1 These assemblies are contained in the screening module. Once the instrument covers have been removed the appropriate module cover (the upper for 19-1022 and the lower for 19-1021) can be released by removing the six retaining screws. This will provide sufficient access for test purposes.

6.6.3.2 If access to the unexposed side of an assembly is required, proceed as follows:-

(a) If removing 19-1021, remove the three screws securing the screen. Unsolder cable assembly 10-2804 from pins 1 and 2 on assembly 19-1021.

(b) Remove the six screws holding the board onto its supports within the module. This will enable the assembly to be tilted and lifted out of the module to the extent of the remaining connections. This provides adequate access for servicing.

6.6.3.3 When replacing the assembly:

(a) Ensure that the board is properly located, flat on its supports, before tightening the retaining screws.

(b) On assembly 19-1021, reconnect connector 10-2804, outer braid to pin 2, and replace the screen.

(c) When replacing the module cover, align the threaded collets, which are free to slide in the module side rails, with the holes in the module cover. The head of the cover retaining screws should be tilted slightly towards the front-back centre line of the module when engaging the thread.

(d) Ensure that the module cover is flat on the module rim when the retaining screws are tightened.

6.6.4 REMOVAL OF THE FRONT PANEL

6.6.4.1 The front panel must be removed if access is required to the front face of assembly 19-1023. The panel is removed as follows:

(a) Remove the instrument covers and the side trim strips.

(b) Remove the two retaining screws from each front handle and slide the handles out towards the front of the instrument.

(c) Remove the two screws securing the LINE switch to the inside of the panel. This is most easily done with a round-the-corner screwdriver.

(d) Remove the screw securing the bracket at the centre front of assembly 19-1024. This screw is removed from the bottom of the instrument.

(e) Disconnect the ribbon cable between 19-1023 and 19-1014 from 19-1023.

(f) Unsolder the cable assembly 10-2804 from the INPUT socket.

(g) Disconnect the two earthing tags from the front of the module.

(h) Remove the two Taptite (self threading) screws from each end of the front panel. The panel can now be drawn forward.

6.6.4.2 To replace the panel follow the reverse of the above procedure.

CAUTION: Do not interchange the Taptite screws with machine threaded screws. The Taptite screws will damage the thread in any machine threaded holes into which they are inserted. Machine threaded screws will not hold the front panel securely.

6.6.5 REMOVAL OF ASSEMBLY 19-1023

6.6.5.1 To remove assembly 19-1023 proceed as follows:

(a) Remove the front panel from the front of the instrument, as instructed in paragraph 6.6.4. Lay the panel, front downwards, flat on the bench.

(b) Remove the three nuts securing the bracket to assembly 19-1023 and remove the bracket.

(c) Remove the 14 nuts securing assembly 19-1023 on its support pillars. The assembly can now be lifted clear of the front panel.

CAUTION: Do not touch the contacting surfaces of assembly 19-1023 or the elastomeric contact strips around the LCD on the front panel. Any contamination will lead to poor electrical contact and failure of the LCD elements to function. If the contact strips become contaminated they should be carefully pulled from the slots in the retainers and cleaned with soapy water. The strips must be thoroughly dried before being replaced. If necessary, the contacting surface of assembly 19-1023 should be cleaned using iso-propyl alcohol.

6.6.5.2 The assembly is replaced using the reverse of the above procedure. The securing nuts should be tightened to a torque of 0.34 Nm (3 lbf.in).

6.6.6 <u>REPLACEMENT OF THE LCD</u>

6.6.6.1 To remove the LCD proceed as follows:

(a) Remove the front panel, as instructed in paragraph 6.6.4.

(b) Remove assembly 19-1023, as instructed in paragraph 6.6.5.

(c) Lift the LCD support mouldings from the locating studs. The LCD can then be lifted from the aperture in the front panel.

CAUTION: (1) The elastomeric contact strips are free to move in the slots in the support mouldings. Take care they do not fall out.

(2) Avoid all contamination of the elastomeric contact strips with grease from fingers or tools.

6.6.6.2 The fitting of the LCD is illustrated in Fig. 6.13. The fitting procedure is as follows:

(a) Carefully clean the inside surface of the display viewing window in the front panel. Loose material may be removed using a dry brush. Greasy marks may be removed using a soft, lint-free cloth and iso-propyl alcohol. An anti-static spray may be used, if required, after cleaning.

(b) Clean the contact areas of the LCD using a soft, dry cloth. If necessary a cloth dampened with soapy water may be used to removed grease.

(c) Clean the display face of the LCD with a soft, dry cloth. An anti-static spray may be used, if required, after cleaning.

(d) Place the LCD in the front panel aperture, ensuring that the orientation is correct.

(e) Pull the elastomeric contact strips from the support mouldings and drop the mouldings over the studs. Ensure that they bed down on the front panel, and do not catch on the sides of the LCD.

(f) Clean the elastomeric contact strips using soapy water. Dry them thoroughly, and replace them in the slots in the support mouldings. Leave the contact strips standing proud of the upper surface of the support mouldings.

(g) Clean the contacting surface of assembly 19-1023 using iso-propyl alcohol. Refit the assembly as instructed in paragraph 6.6.5.

(h) Refit the front panel as instructed in paragraph 6.6.4.

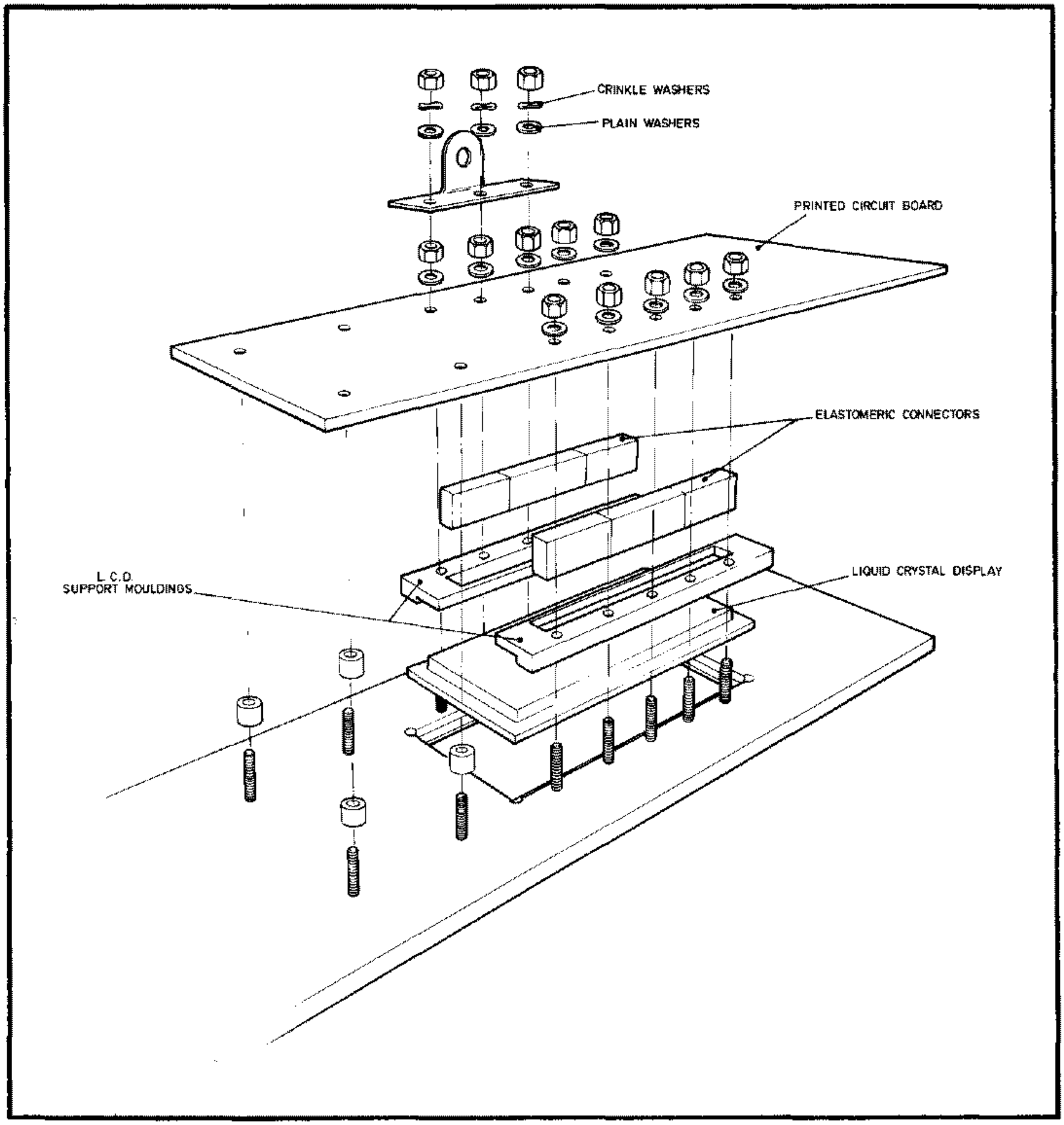


Fig. 6.13 Fitting the Liquid Crystal Display

PARTS LIST

FRONT AND REAR PANEL ASSEMBLIES

Fig. 1, Fig. 9 and Fig. 12

Cct. Ref.	Value	Description	Rat	Tol %	Racal-Dana Part Number
FRONT PANEL ASSEMBLY 11-1544					
		Liquid crystal display			17-1025
		Elastomeric connector			23-5600
D1		Bridge Rectifier			22-1662
SK1		BNC bulkhead receptacle			23-3198
		Coaxial cable assembly			10-2804
S1		Switch, toggle			23-4043
REAR PANEL ASSEMBLY 11-1545					
T1		Transformer, power			17-4097
IC41		Voltage regulator, +5 V (7805)			22-4270
FS2		Fuse link (99 V to 132 V) 500 mA surge resistant			23-0022
		Fuse link (198 V to 264 V) 250 mA surge resistant			23-0031
		AC power plug, filter and fuse holder			23-3420

PARTS LIST

KEYBOARD AND DISPLAY ASSEMBLY 19-1023

Fig 3

Cct. Ref.	Value	Description	Rat	Tol %	Racal-Dana Part Number
Resistors					
	Ω		W		
R1	1 k	Carbon Film	¼	5	20-2102
R2	13x330	DIL Array			20-5528
R3	13x330	DIL Array			20-5528
Capacitors					
	F		V		
C1	10 n	Ceramic	25	-20 +80	21-1545
C2	47 n	Ceramic	10	-20 +80	21-1548
Integrated Circuits					
IC1		MD4332			22-4760
IC2		MD4332			22-4760
IC3		MD4332			22-4760
IC4		74LS164			22-4595
IC5		74LS164			22-4595
IC6		74LS164			22-4595
Diodes					
LP1		LED, red (5082.4684)			26-5013
LP2		LED, red (5082.4684)			26-5013
LP3		LED, red (5082.4684)			26-5013
LP4		Not Used			
LP5		Not Used			
LP6		LED, red (5082.4684)			26-5013
LP7		LED, red (5082.4684)			26-5013
LP8		LED, red (5082.4684)			26-5013
LP9		LED, red (5082.4684)			26-5013
LP10		LED, red (5082.4684)			26-5013

Cct. Ref.	Value	Description	Rat	Tol %	Racal-Dana Part Number
LP11		LED, red (5082.4684)			26-5013
LP12		LED, red (5082.4684)			26-5013
LP13		LED, red (5082.4684)			26-5013
LP14		LED, red (5082.4684)			26-5013
LP15		LED, red (5082.4684)			26-5013
LP16		LED, red (5082.4684)			26-5013
LP17		LED, red (5082.4684)			26-5013
LP18		LED, red (5082.4684)			26-5013
LP19		LED, red (5082.4684)			26-5013
LP20		LED, red (5082.4684)			26-5013
LP21		LED, red (5082.4684)			26-5013
LP22		LED, red (5082.4684)			26-5013
Miscellaneous					
S1 to S28		Keyboard switch			23-4103
		Pushbutton for S1 to S28			15-0538
PL3		PCB Header, 26-way			22-3395

PARTS LIST

GPIB ASSEMBLY 19-1017

Fig. 5

Cct. Ref.	Value	Description	Rat	Tol %	Racal-Dana Part Number
Resistors					
	Ω		W		
R1	3.3 k	Carbon Film	¼	5	20-2332
R2	3.3 k	Carbon Film	¼	5	20-2332
R3	3.3 k	Carbon Film	¼	5	20-2332
R4	3.3 k	Carbon Film	¼	5	20-2332
R5	3.3 k	Carbon Film	¼	5	20-2332
R6	3.3 k	Carbon Film	¼	5	20-2332
R7	3.3 k	Carbon Film	¼	5	20-2332
R8	3.3 k	Carbon Film	¼	5	20-2332
R9	3.3 k	Carbon Film	¼	5	20-2332
R10	8x3.3 k	DIL Array			20-5525
R11	56	Carbon Film	¼	5	20-2560
Capacitors					
	F		V		
C1	10 n	Ceramic	25	-20+80	21-1545
C2	47 µ	Electrolytic	25	20	21-0789
C3	47 µ	Electrolytic	25	20	21-0789
C4	100 n	Ceramic	12	-20+80	21-1616
C5	100 n	Ceramic	12	-20+80	21-1616
C6	100 n	Ceramic	12	-20+80	21-1616
C7	100 n	Ceramic	12	-20+80	21-1616
C8	100 n	Ceramic	12	-20+80	21-1616
C9	100 n	Ceramic	12	-20+80	21-1616
C10	10 n	Ceramic	25	-20+80	21-1545
Integrated Circuits					
IC1		74LS30			22-4597
IC2		68488			22-8305
IC3		3447			22-8304
IC4		74LS86			22-4566
IC5		74LS30			22-4597

Cct. Ref.	Value	Description	Rat	Tol %	Racal-Dana Part Number
IC6		4066			22-4761
IC7		74LS74			22-4534
IC8		74LS02			22-4532
IC9		74LS125			22-4657
IC10		74LS74			22-4534
IC11		74LS10			22-4557
IC12		74LS240			22-4588
IC13		3447			22-8304
IC14		74LS04			22-4533
IC15		74LS138			22-4587
IC16		Not Used			
IC17		7805			22-4222
IC18		74LS10			22-4557
IC19		74LS245			22-4584

<u>Connectors</u>

PL21		PCB header, 34-way			23-3325
PL22		PCB header, 34-way			23-3325

PARTS LIST

GPIB CONNECTOR ASSEMBLY 19-1018

Fig. 7

Cct. Ref.	Value	Description	Rat	Tol %	Racal-Dana Part Number
SK21		Cableform Assembly			10-2703
		Socket, DIL, 16-way			23-3140
SK19		Receptacle, IEEE-488			23-3314
S30		Switch, DIL			23-4102

PARTS LIST

AMPLIFIER ASSEMBLY 19-1021

Fig. 9

Cct. Ref.	Value	Description	Rat	Tol %	Racal-Dana Part Number
Resistors					
	Ω		W		
R1	18	Carbon Film	0.1	5	20-1525
R2	470	Carbon Film	0.1	5	20-1532
R3	947 k	Metal Film	½	0.1	20-7509
R4	26.06 k	Metal Film	¼	0.1	20-7502
R5	851	Metal Film	¼	0.1	20-4998
R6	820	Carbon Film	¼	5	20-2821
R7	820	Carbon Film	¼	5	20-2821
R8	2.2	Carbon Film	¼	5	20-2004
R9	169 k	Metal Film	½	¼	20-7506
R10	5.6 k	Carbon Film	¼	5	20-2562
R11	1.5 M	Carbon Film	¼	5	20-2155
R12	825 k	Metal Film	¼	¼	20-7508
R13	330	Carbon Film	¼	5	20-2331
R14	330	Carbon Film	¼	5	20-2331
R15	1 M	Metal Film	¼	½	20-4965
R16	100	Carbon Film	0.1	5	20-1514
R17	33	Carbon Film	¼	5	20-2330
R18	2.7 k	Carbon Film	¼	5	20-2272
R19	5.6 M	Metal Glaze	½	5	20-7314
R20	3.3 M	Carbon Film	¼	5	20-2335
R21	499 k	Metal Film	¼	¼	20-7507
R22	324 k	Metal Film	¼	0.1	20-4944
R23	33	Carbon Film	¼	5	20-2330
R24	1.5 k	Carbon Film	¼	5	20-2152
R25	470	Carbon Film	¼	5	20-2471
R26	562	Metal Film	¼	1	20-4971
R27	1 k	Variable			20-7070
R28	820	Carbon Film	¼	5	20-2821
R29	825	Metal Film	¼	1	20-4972
R30	121	Metal Film	¼	1	20-4967
R31	4.7 k	Carbon Film	¼	5	20-2472
R32	1.82 k	Metal Film	¼	1	20-4975
R33	10 k	Carbon Film	¼	5	20-2103
R34	221	Metal Film	¼	1	20-4968
R35	1 k	Carbon Film	¼	5	20-2102

Cct. Ref.	Value	Description	Rat	Tol %	Racal-Dana Part Number
R36	1.82 k	Metal Film	¼	1	20-4975
R37	2.7 k	Carbon Film			20-2272
R38	10 k	Variable			20-7071
R39	1 k	Metal Film	¼	½	20-4882
R40	121	Metal Film	¼	1	20-4967
R41	2.26 k	Metal Film	¼	¼	20-4931
R42	10 k	Carbon Film	¼	5	20-2103
R43	221	Metal Film	¼	1	20-4968
R44	1.76 k	Metal Film	¼	1	20-7516
R45	Selected on test from range 120 to 270	Carbon Film	¼	5	
R46	1 k	Metal Film	¼	½	20-4882
R47	118	Metal Film	¼	0.1	20-4966
R48	5.9 k	Metal Film	¼	1	20-4875
R49	3.3 k	Carbon Film	¼	5	20-2332
R50	3.3 k	Carbon Film	¼	5	20-2332
R51	121	Metal Film	¼	1	20-4967
R52	1 k	Metal Film	¼	½	20-4882
R53	39 k	Carbon Film	¼	5	20-2393
R54	379	Metal Film	¼	1	20-4969
R55	4.7 k	Carbon Film	¼	5	20-2472
R56	562	Metal Film	¼	1	20-4971
R57	2.7 k	Carbon Film	¼	5	20-2272
R58	10 k	Variable			20-7071
R59	1.76 k	Metal Film	¼	1	20-7516
R60	330	Carbon Film	¼	5	20-2331
R61	1.5 k	Carbon Film	¼	5	20-2152
R62	820	Carbon Film	¼	5	20-2821
R63	820	Carbon Film	¼	5	20-2821
R64	33 k	Carbon Film	¼	5	20-2333
R65	820	Carbon Film	¼	5	20-2821
R66	50 k	Variable			20-7072
R67	1.5 M	Carbon Film	¼	5	20-2155
R68	1 k	Metal Film	¼	0.1	20-4883
R69	10	Carbon Film	¼	5	20-2100
R70	100 k	Metal Film	¼	0.1	20-7504
R71	1 k	Metal Film	¼	0.1	20-4883
R72	10	Carbon Film	¼	5	20-2100
R73	9 k	Metal Film	¼	0.1	20-7500
R74	1 k	Metal Film	¼	0.1	20-4883
R75	330	Metal Film	¼	1	20-4063

Cct. Ref.	Value	Description	Rat	Tol %	Racal-Dana Part Number
R76	3.32 k	Metal Film	¼	0.1	20-4949
R77	2.4 k	Metal Film	¼	0.1	20-4999
R78	7.5 k	Metal Film	¼	0.1	20-4902
R79	2.2 M	Carbon Film	¼	5	20-2225
R80	50 k	Variable			20-7072
R81	220 k	Carbon Film	¼	5	20-2224
R82	22 k	Carbon Film	¼	5	20-2223
R83	10 M	Carbon Film	¼	5	20-2106
R84	24 k	Metal Film	¼	0.1	20-7501
R85	22 k	Carbon Film	¼	5	20-2223
R86	30.1 k	Metal Film	¼	0.1	20-7503
R87	120 k	Metal Film	¼	0.1	20-7505
R88	500	Variable			20-7065
R89	6.8 k	Carbon Film	¼	5	20-2682
R90	13x10 k	DIL Array			20-5503
R91	390	Carbon Film	¼	5	20-2391
R92	27	Carbon Film	0.1	5	20-1540
R93	39	Carbon Film	¼	5	20-2390

Capacitors

	F		V		
C1	150 n	Polyester	630	10	21-4567
C2	115 p	Silver Mica	350	1	21-2806
C3	1 n	Ceramic	500	20	21-1532
C4	1 n	Ceramic	500	20	21-1532
C5	0.8p to 8.5p	Variable	500		21-6042
C6	4.5p to 36p	Variable			21-6040
C7	4.7 n	Chip	100	10	21-1736
C8	2.7 n	Ceramic	500	20	21-1537
C9	12 p	Ceramic	500	10	21-1509
C10	150 p	Silver Mica	750	5	21-2660
C11	10p to 60p	Variable			21-6039
C12	22 p	Ceramic	500	10	21-1512
C13	100 n	Ceramic	50	20	21-1708
C14	100 n	Ceramic	50	20	21-1708
C15	470 n	Polyester	63	10	21-4568
C16	470 µ	Electrolytic		20	21-0771
C17	470 µ	Electrolytic		20	21-0771
C18	2.2 p	Ceramic	500	½p	21-1500
C19	10 n	Ceramic	25	-20+80	21-1545
C20	10 n	Ceramic	25	-20+80	21-1545

Cct. Ref.	Value	Description	Rat	Tol %	Racal-Dana Part Number
C21	10 n	Ceramic	25	-20+80	21-1545
C22	330 µ	Electrolytic	16	20	21-0770
C23	2.7 p	Ceramic	500	½p	21-1501
C24	100 µ	Electrolytic	25	20	21-0790
C25	10 n	Ceramic	25	-20+80	21-1545
C26	220 µ	Electrolytic	10		21-0792
C27	100 n	Ceramic	25	-20+80	21-1551
C28	1 p	Ceramic	500	¼p	21-1618
C29	10 n	Ceramic	25	-20+80	21-1545
C30	100 n	Ceramic	25	-20+80	21-1551
C31	10 n	Ceramic	25	-20+80	21-1545
C32	100 µ	Electrolytic	25	20	21-0790
C33	Op to 115p	Variable			21-6033
C34	2.7 p	Ceramic	500	½p	21-1501
C35	220 µ	Electrolytic	10		21-0792
C36	6.8 µ	Tantalum	35	20	21-1040
C37	1 p	Ceramic	500	¼p	21-1618
C38	47 µ	Electrolytic	25	20	21-0789
C39	100 n	Ceramic	25	-20+80	21-1551
C40	10 n	Ceramic	25	-20+80	21-1545
C41	8.2 p	Ceramic	500	10	21-1507
C42	100 µ	Electrolytic	25	20	21-0790
C43	470 p	Ceramic	100	5	21-1720
C44	100 n	Ceramic	25	-20+80	21-1551
C45	10 n	Ceramic	25	-20+80	21-1545
C46	47 µ	Electrolytic	25	20	21-0789
C47	10 n	Ceramic	25	-20+80	21-1545
C48	47 µ	Electrolytic	25	20	21-0789
C49	10 n	Ceramic	25	-20+80	21-1545
C50	10 n	Ceramic	25	-20+80	21-1545
C51	10 n	Ceramic	25	-20+80	21-1545
C52	100 n	Polyester	100	20	21-4506
C53	100 n	Ceramic	25	-20+80	21-1551
C54	100 n	Polyester	100	20	21-4506
C55	100 n	Polyester	100	20	21-4506
C56	100 n	Ceramic	25	-20+80	21-1551
C57	100 n	Ceramic	25	-20+80	21-1551
C58	47 µ	Electrolytic	25	20	21-0789
C59	18 p	Ceramic	500	10	21-1511
C60	10 n	Ceramic	25	-20+80	21-1545
C61	2.2 µ	Tantalum	35	20	21-1048
C62	10 n	Ceramic	25	-20+80	21-1545

Cct. Ref.	Value	Description	Rat	Tol %	Racal-Dana Part Number
Diodes					
D1		Silicon (1N4149)			22-1029
D2		Voltage Regulator (BZX79C6V8)			22-1811
D3		Voltage Regulator (BZX79C6V8)			22-1811
D4		Silicon (1N4149)			22-1029
Integrated Circuits					
IC1		H11F1) Matched Pair			22-7105
IC2		H11F1)			
IC3		MC14053B			22-4763
IC4		ICL 7650			22-4673
IC5		CA3046 / CA3146 - 22-4246			22-4213
IC6		CA3046			22-4213
IC7		CA3046			22-4213
IC8		TL082			22-4240
IC9		MC14053B			22-4763
Transistors					
Q1		2N2369			22-6017
Q2		2N2369			22-6017
Q3		E201			22-6120
Q4		2N4126			22-6010
Q5		BC109			22-6041
Q6		ZTX450			22-6112
Q7		BC109			22-6041
Q8		2N2369			22-6017
Q9		2N2369			22-6017
Q10		2N2369			22-6017
Q11		2N2369			22-6017
Q12		J271			22-6150
Q13		J271			22-6150
Q14		E108			22-6111
Q15		2N2369			22-6017
Inductors					
FX1		Ferrite Bead			23-8000
Relays					
RLA		Double Pole, NO			23-7523
RLB		Single Pole, NO			23-7520
RLC		Double Pole, NO			23-7523
RLD		Single Pole, CO			23-7522
RLE		Single Pole, CO			23-7522

Cct. Ref.	Value	Description	Rat	Tol %	Racal-Dana Part Number
RLF		Single Pole, CO			23-7522
RLG		Single Pole, CO			23-7522
RLH		Single Pole, CO			23-7522
RLJ		Single Pole, CO			23-7522
RLK		Single Pole, CO			23-7522
RLL		Single Pole, CO			23-7522

Connectors

SK11		Cable Assembly			10-2701
PL7		Coaxial Assembly			10-2806

PARTS LIST

DETECTOR ASSEMBLY 19-1022

Fig. 11

Cct. Ref.	Value	Description	Rat	Tol %	Racal-Dana Part Number
Resistors					
	Ω		W		
R1	10 k	Carbon Film	¼	5	20-2103
R2	100 k	Carbon Film	¼	5	20-2104
R3	1.47 k	Metal Film	¼	½	20-4981
R4	562	Metal Film	¼	1	20-4971
R5	1 k	Carbon Film	¼	5	20-2102
R6	20.3 k	Metal Film	¼	¼	20-4934
R7	1.21 k	Metal Film	¼	¼	20-4936
R8	3.3 k	Carbon Film	¼	5	20-2332
R9	47 k	Carbon Film	¼	5	20-2473
R10	1.21 k	Metal Film	¼	¼	20-4936
R11	12 k	Carbon Film	¼	5	20-2123
R12	20.3 k	Metal Film	¼	¼	20-4934
R13	18 k	Carbon Film	¼	5	20-2183
R14	68 k	Carbon Film	¼	5	20-2683
R15	1.21 k	Metal Film	¼	¼	20-4936
R16	68 k	Carbon Film	¼	5	20-2683
R17	1.21 k	Metal Film	¼	¼	20-4936
R18	18 k	Carbon Film	¼	5	20-2183
R19	1 k	Metal Film	¼	1	20-4973
R20	10 k	Carbon Film	¼	5	20-2103
R21	1 k	Carbon Film	¼	5	20-2102
R22	1 k	Carbon Film	¼	5	20-2102
R23	220 k	Carbon Film	¼	5	20-2224
R24	13.3 k	Metal Film	¼	¼	20-4096
R25	39 k	Carbon Film	¼	5	20-2393
R26	220 k	Carbon Film	¼	5	20-2224
R27	50 k	Variable			20-7072
R28	13.3 k	Metal Film	¼	¼	20-4096
R29	220 k	Carbon Film	¼	5	20-2224
R30	1 k	Metal Film	¼	1	20-4973
R31	220 k	Carbon Film	¼	5	20-2224
R32	220 k	Carbon Film	¼	5	20-2224
R33	39 k	Carbon Film	¼	5	20-2393
R34	121 k	Metal Film	¼	1	20-4979
R35	150 k	Carbon Film	¼	5	20-2154

Cct. Ref.	Value	Description	Rat	Tol %	Racal-Dana Part Number
R36	182 k	Metal Film	¼	¼	20-4896
R37	220	Carbon Film	¼	5	20-2221
R38	470 k	Carbon Film	¼	5	20-2474
R39	27 k	Carbon Film	¼	5	20-2273
R40	27 k	Carbon Film	¼	5	20-2273
R41	330 k	Carbon Film	¼	5	20-2334
R42	27 k	Carbon Film	¼	5	20-2273
R43	220 k	Carbon Film	½	5	20-2224
R44	4.7 k	Carbon Film	¼	5	20-2472
R45	1 k	Variable			20-7070
R46	4.7 k	Carbon Film	¼	5	20-2472
R47	39 k	Carbon Film	¼	5	20-2393
R48	33 k	Carbon Film	¼	5	20-2333
R49	1 k	Variable			20-7070
R50	3.32 k	Metal Film	¼	½	20-4953
R51	1.43 k	Metal Film	¼	½	20-4952
R52	100	Carbon Film	¼	5	20-2101
R53	2.26 k	Metal Film	¼	¼	20-4931
R54	12 k	Carbon Film	¼	5	20-2123
R55	1 M	Carbon Film	¼	5	20-2105
R56	100 k	Variable			20-7068
R57	220	Carbon Film	¼	5	20-2221
R58	120	Carbon Film	¼	5	20-2121
R59	1.8 k	Carbon Film	¼	5	20-2182
R60	50 k	Variable			20-7072
R61	33 k	Carbon Film	¼	5	20-2333
R62	27 k	Carbon Film	¼	5	20-2273
R63	15 k	Carbon Film	¼	5	20-2153
R64	6.19 k	Metal Film	¼	¼	20-4904
R65	50	Variable			20-7064
R66	6.19 k	Metal Film	¼	¼	20-4904
R67	15 k	Carbon Film	¼	5	20-2153
R68	27 k	Carbon Film	¼	5	20-2273
R69	1.8 k	Carbon Film	¼	5	20-2182
R70	24.3 k	Metal Film	¼	¼	20-4876
R71	24.3 k	Metal Film	¼	¼	20-4876
R72		Not used			
R73	15 k	Carbon Film	¼	5	20-2153
R74	100 k	Metal Film	¼	½	20-4963
R75	2.7 k	Metal Film	¼	¼	20-4868

Cct. Ref.	Value	Description	Rat	Tol %	Racal-Dana Part Number
R76	1.5 M	Carbon Film	¼	5	20-2155
R77	100 k	Metal Film	¼	½	20-4963
R78	50 k	Variable			20-7072
R79	10 k	Carbon Film	¼	5	20-2103
R80		Not used			
R81	1.3 k	Metal Film	¼	¼	20-4928
R82	1.3 k	Metal Film	¼	¼	20-4928
R83	200	Variable			20-7069
R84	100	Carbon Film	¼	5	20-2101
R85	100	Carbon Film	¼	5	20-2101
R86	8.87 k	Metal Film	¼	½	20-4887
R87	390 k	Carbon Film	¼	5	20-2394
R88	1 k	Carbon Film	¼	5	20-2102
R89	1 k	Carbon Film	¼	5	20-2102
R90	4.7 k	Carbon Film	¼	5	20-2472
R91	4.7 k	Carbon Film	¼	5	20-2472
R92	10 k	Carbon Film	¼	5	20-2103
R93	10 k	Carbon Film	¼	5	20-2103
R94	4.7 k	Carbon Film	¼	5	20-2472
R95	15 k	Carbon Film	¼	5	20-2153
R96	10 k	Carbon Film	¼	5	20-2103
R97	10 k	Carbon Film	¼	5	20-2103
R98	10 k	Metal Film	¼	½	20-4961
R99	10 k	Metal Film	¼	½	20-4961
R100	10 k	Metal Film	¼	½	20-4961
R101	100 k	Carbon Film	¼	5	20-2104
R102	10 k	Metal Film	¼	½	20-4961
R103	10 k	Carbon Film	¼	5	20-2103
R104	560	Carbon Film	¼	5	20-2561
R105	68 k	Carbon Film	¼	5	20-2683
R106	10 k	Carbon Film	¼	5	20-2103
R107	50 k	Variable			20-7072
R108	33 k	Carbon Film	¼	5	20-2333
R109	220 k	Carbon Film	¼	5	20-2224
R110	1.3 k	Metal Film	¼	¼	20-4928
R111	200	Variable			20-7069
R112	390 k	Carbon Film	¼	5	20-2394
R113	100	Carbon Film	¼	5	20-2101
R114	100	Carbon Film	¼	5	20-2101
R115	8.87 k	Metal Film	¼	½	20-4887

Cct. Ref.	Value	Description	Rat	Tol %	Racal-Dana Part Number
R116	1 k	Carbon Film	¼	5	20-2102
R117	1 k	Carbon Film	¼	5	20-2102
R118	4.7 k	Carbon Film	¼	5	20-2472
R119	4.7 k	Carbon Film	¼	5	20-2472
R120	10 k	Carbon Film	¼	5	20-2103
R121	10 k	Carbon Film	¼	5	20-2103
R122	4.7 k	Carbon Film	¼	5	20-2472
R123	15 k	Carbon Film	¼	5	20-2153
R124	10 k	Metal Film	¼	½	20-4961
R125	10 k	Metal Film	¼	½	20-4961
R126	10 k	Metal Film	¼	½	20-4961
R127	10 k	Metal Film	¼	½	20-4961
R128	10 k	Metal Film	¼	½	20-4961
R129	10 k	Metal Film	¼	½	20-4961
R130	10 k	Carbon Film	¼	5	20-2103
R131	560	Carbon Film	¼	5	20-2561
R132	68 k	Carbon Film	¼	5	20-2683
R133	50 k	Variable			20-7072
R134	220 k	Carbon Film	¼	5	20-2224
R135	270	Metal Oxide	¼	1	20-4019
R136	2.7 k	Carbon Film	¼	5	20-2272
R137	220	Metal Oxide	½	5	20-3221
R138	1.8 k	Carbon Film	¼	5	20-2182
R139	22 k	Carbon Film	¼	5	20-2223
R140	390	Metal Oxide	½	5	20-3391

Capacitors

	F		V		
C1	47 n	Ceramic	40	-20+80	21-1549
C2	47 µ	Electrolytic	25	20	21-0789
C3	100 µ	Electrolytic	25	20	21-0790
C4	8.2 p	Ceramic	500	10	21-1507
C5	47 µ	Electrolytic	25	20	21-0789
C6	1 n	Ceramic	500	20	21-1532
C7	10 n	Ceramic	25	-20+80	21-1545
C8	1 n	Ceramic	500	20	21-1532
C9	1 µ	Polyester	100	20	21-4512
C10	1 n	Ceramic	500	20	21-1532
C11	10 p	Ceramic	500	10	21-1508
C12	220 n	Polyester	100	20	21-4508
C13	10 n	Ceramic	25	-20+80	21-1545
C14	560 p	Ceramic	500	10	21-1529
C15	1 µ	Electrolytic	40		21-0731

Cct. Ref.	Value	Description	Rat	Tol %	Racal-Dana Part Number
C16	220 n	Polyester	100	20	21-4508
C17	100 µ	Electrolytic	25	20	21-0790
C18	100 n	Ceramic	12	-20+80	21-1616
C19	2.2 p	Ceramic	500	½p	21-1500
C20	22 µ	Electrolytic	16	20	21-1039
C21	100 n	Ceramic	25	-20+80	21-1551
C22	22 µ	Electrolytic	16	20	21-1039
C23	10 n	Ceramic	25	-20+80	21-1545
C24	100 n	Ceramic	12	-20+80	21-1616
C25	100 n	Ceramic	12	-20+80	21-1616
C26	100 n	Ceramic	25	-20+80	21-1551
C27		Not used			
C28	10 n	Ceramic	25	-20+80	21-1545
C29	1 µ	Electrolytic	40		21-0731
C30	1 µ	Electrolytic	40		21-0731
C31		Not used			
C32	100 µ	Electrolytic	25	20	21-0790
C33	100 n	Ceramic	12	-20+80	21-1616
C34	100 n	Ceramic	12	-20+80	21-1616
C35	10 n	Polyester	400	20	21-4500
C36	100 n	Ceramic	25	-20+80	21-1551
C37	100 n	Ceramic	25	-20+80	21-1551
C38	100 n	Polyester	100	20	21-4506
C39	100 n	Ceramic	12	-20+80	21-1616
C40	100 n	Ceramic	12	-20+80	21-1616
C41	10 n	Polyester	400	20	21-4500
C42	100 n	Polyester	100	20	21-4506
C43	560 p	Ceramic	500	10	21-1529
C44	2.7 n	Ceramic	500	20	21-1537
C45	27 p	Ceramic	500	10	21-1513
C46	4.7 n	Ceramic	50	10	21-1587

Diodes

D1		Hot Carrier (5082.2811)			22-1033
D2		Hot Carrier (5082.2811)			22-1033
D3		Voltage Regulator (BZX79C4V7)			22-1807
D4		Silicon (1N4149)			22-1029
D5		Silicon (1N4149)			22-1029
D6		Voltage Regulator (BZX79C6V8)			22-1811
D7		Silicon (1N4149)			22-1029
D8		Silicon (1N4149)			22-1029
D9		Voltage Regulator (BZX79C6V8)			22-1811
D10		Voltage Regulator (BZX79C6V8)			22-1811

Cct. Ref.	Value	Description	Rat	Tol %	Racal-Dana Part Number
D11		Voltage Regulator (BZX83C2V7)			22-1801
D12		Silicon (1N4149)			22-1029
D13		Voltage Regulator (BZX83C2V7)			22-1801
D14		Voltage Regulator (BZX83C2V7)			22-1801
Integrated Circuits					
IC1		CA 3046 (specially selected)			22-4246
IC2		CA 3046 (specially selected)			22-4246
IC3		CA 3046 (specially selected)			22-4246
IC4		TL084			22-4243
IC5		TL084			22-4243
IC6		SP9680			22-4674
IC7		LM320T-5.2			22-4223
IC8		LM340T-5.0			22-4263
IC9		MC1496			22-4091
IC10		TL081			22-4229
IC11		SP9680			22-4674
IC12		SP9680			22-4674
IC13		CA 3240			22-4242
IC14		CA 3240			22-4242
IC15		CA 3240			22-4242
IC16		CA 3240			22-4242
Transistors					
Q1		J105			22-6154
Q2		J271			22-6150
Q3		BC109			22-6041
Q4		BC109			22-6041
Q5		J271			22-6150
Q6		E108			22-6111
Q7		2N4416			22-6092
Q8		2N4416			22-6092
Q9		2N4416			22-6092
Q10		2N4416			22-6092
Q11		2N4416			22-6092
Q12		BFY90			22-6039
Q13		BFY90			22-6039
Q14		2N4416			22-6092
Q15		J176			22-6140
Q16		2N2369			22-6017
Q17		J271			22-6150
Q18		BFY90			22-6039
Q19		BFY90			22-6039
Q20		2N4416			22-6092

Cct. Ref.	Value	Description	Rat	Tol %	Racal-Dana Part Number
Q21		J176			22-6140
Q22		J271			22-6150

<u>Connectors</u>

Cct. Ref.	Value	Description	Rat	Tol %	Racal-Dana Part Number
SK15		Cable Assembly			10-2702
SK7		Coaxial Receptacle			23-3126
PL11		Header, 20-way			23-3306

PARTS LIST

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Fig. 13

Cct. Ref.	Value	Description	Rat	Tol %	Racal-Dana Part Number
Resistors					
	Ω		W		
R1	3.3k	DIL Array	¼	5	20-2332
R2	10 k	Carbon Film	¼	5	20-2103
R3	56 k	Carbon Film	¼	5	20-2563
R4	1M	Carbon Film	¼	5	20-2105
R5	8.2 k	Carbon Film	¼	5	20-2822
R6	10 k	Carbon Film	¼	5	20-2103
R7	56 k	Carbon Film	¼	5	20-2563
R8	100 k	Carbon Film	¼	5	20-2104
R9	47 k	Carbon Film	¼	5	20-2473
R10	8.2 k	Carbon Film	¼	5	20-2822
R11	150 k	Carbon Film	¼	5	20-2154
R12	1M	Carbon Film	¼	5	20-2105
R13	22 k	Carbon Film	¼	5	20-2223
R14	2.2 k	Carbon Film	¼	5	20-2222
R15	1 k	Variable			20-7070
R16	5.9 k	Metal Film	¼	¼	20-4875
R17	2.2 k	Carbon Film	¼	5	20-2222
R18	113 k	Metal Film	¼	½	20-7518
R19	1 M	Metal Film	¼	1	20-4995
R20	4x22k	DIL Array			20-5527
R21	3.3 k	Carbon Film	¼	5	20-2332
R22	2.2 k	Carbon Film	¼	5	20-2222
R23	100 k	Carbon Film	¼	5	20-2104
R24	100 k	Carbon Film	¼	5	20-2104
R25	2.2M	Carbon Film	¼	5	20-2225
R26	1.2 k	Carbon Film	¼	5	20-2122
R27	100	Carbon Film	¼	5	20-2101
R28	3.9 k	Carbon Film	¼	5	20-2392
R29	1.5 k	Carbon Film	¼	5	20-2152
R30	8x3.3 k	DIL Array			20-5525

Cct. Ref.	Value	Description	Rat	Tol %	Racal-Dana Part Number
R31	2.2 k	Carbon Film	¼	5	20-2222
R32	4.7 k	Carbon Film	¼	5	20-2472
R33	8x3.3 k	DIL Array			20-5525
R34	8x3.3 k	DIL Array			20-5525
R35	8x3.3 k	DIL Array			20-5525
R36	3.3M	Carbon Film	¼	5	20-2335
R37	2.2 k	Carbon Film	¼	5	20-2222
R38	10 k	Carbon Film	¼	5	20-2103
R39	820	Carbon Film	¼	5	20-2821
R40	10	Carbon Film	¼	5	20-2100
R41	1 k	Carbon Film	¼	5	20-2102
R42	10 k	Carbon Film	¼	5	20-2103
R43	10 k	Carbon Film	¼	5	20-2103
R44	1 k	Variable, 25-turn			20-7040
R45	3.9 k	Metal Film	¼	1	20-7515
R46	2.2 k	Metal Film	¼	1	20-7514
R47	820	Metal Film	¼	1	20-7513
R48	4.3 k	Metal Film	¼	1	20-4990
R49	1 k	Variable, 25-turn			20-7040
R50	2.2 k	Carbon Film	¼	5	20-2222
R51	9x10 k	DIL Array			20-5521
R52	9x10 k	DIL Array			20-5521
R53	3.3 k	Carbon Film	¼	5	20-2332
R54	3.3 k	Carbon Film	¼	5	20-2332
R55	3.3 k	Carbon Film	¼	5	20-2332

Capacitors

	F		V		
C1	22000 µ	Electrolytic	16		21-0595
C2	3300 µ	Electrolytic	35		21-0663
C3	3300 µ	Electrolytic	35		21-0663
C4	3300 µ	Electrolytic	16		21-0597
C5	47 n	Ceramic	12	-20 +80	21-1548
C6	47 n	Ceramic	12	-20 +80	21-1548
C7	100 n	Ceramic	25	-20 +80	21-1551
C8	100 µ	Ceramic	25	-20 +80	21-1551
C9	47 n	Ceramic	25	20	21-0789
C10	47 n	Ceramic	25	20	21-0789
C11	47 n	Ceramic	25	20	21-0789
C12	47 n	Ceramic	25	20	21-0789
C13	47 n	Ceramic	25	20	21-0789
C14	47 n	Ceramic	12	-20 +80	21-1548
C15	47 n	Ceramic	12	-20 +80	21-1548

Cct. Ref.	Value	Description	Rat	Tol %	Racal-Dana Part Number
C16	10 n	Ceramic	25	-20 +80	21-1545
C17	22 µ	Electrolytic	10		21-0710
C18	100 n	Ceramic	25	-20 +80	21-1551
C19	47 n	Ceramic	12	-20 +80	21-1548
C20	100 n	Ceramic	25	-20 +80	21-1551
C21	10 n	Ceramic	25	-20 +80	21-1545
C22	100 n	Ceramic	25	-20 +80	21-1551
C23	100 n	Ceramic	25	-20 +80	21-1551
C24	10 n	Ceramic	25	-20 +80	21-1545
C25	10 n	Ceramic	25	-20 +80	21-1545
C26	68 p	Silver Mica	350	2	21-2643
C27	270 p	Ceramic	500	10	21-1525
C28	47 n	Ceramic	12	-20 +80	21-1548
C29	47 n	Ceramic	12	-20 +80	21-1548
C30	330 p	Ceramic	500	10	21-1526
C31	47 n	Ceramic	12	-20 +80	21-1548
C32	47 n	Ceramic	12	-20 +80	21-1548
C33	47 n	Ceramic	12	-20 +80	21-1548
C34	47 n	Ceramic	12	-20 +80	21-1548
C35	47 n	Ceramic	12	-20 +80	21-1548
C36	47 n	Ceramic	12	-20 +80	21-1548
C37	47 n	Ceramic	12	-20 +80	21-1548
C38	100 n	Ceramic	25	-20 +80	21-1551
C39	47 n	Ceramic	12	-20 +80	21-1548
C40	47 n	Ceramic	12	-20 +80	21-1548
C41	47 n	Ceramic	12	-20 +80	21-1548
C42	47 µ	Electrolytic	25	20	21-0789
C43	47 n	Ceramic	12	-20 +80	21-1548
C44	47 n	Ceramic	12	-20 +80	21-1548
C45	47 n	Ceramic	12	-20 +80	21-1548
C46	27 p	Ceramic	500	10	21-1513
C47	27 p	Ceramic	500	10	21-1513
C48	47 n	Ceramic	12	-20 +80	21-1548
C49	100 n	Ceramic	25	-20 +80	21-1551
C50		Not Used			
C51	10 n	Ceramic	25	-20 +80	21-1545
C52	4.7 n	Paper	250		21-0004
C53	4.7 n	Paper	250		21-0004
C54	100 n	Ceramic	25	-20 +80	21-1551

Cct. Ref.	Value	Description	Rat	Tol %	Racal-Dana Part Number
Diodes					
D1		Bridge Rectifier (VH 248)			22-1662
D2		Silicon (1N4003)			22-1603
D3		Silicon (1N4003)			22-1603
D4		Silicon (1N4003)			22-1603
D5		Silicon (1N4003)			22-1603
D6		Silicon (1N4003)			22-1603
D7		Silicon (1N4003)			22-1603
D8		Silicon (1N4003)			22-1603
D9		Silicon (1N4003)			22-1603
D10		Silicon (1N4003)			22-1603
D11		Silicon (1N4003)			22-1603
D12		Voltage Regulator (BZY88C5V6)			22-1809
D13		Hot Carrier (5082.2811)			22-1033
D14		Voltage Regulator (BZX79C5V6)			22-1809
D15		Voltage Regulator (BZX79C5V6)			22-1809
D16		Voltage Regulator (BZX79C10)			22-1815
D17		Hot Carrier (5082.2800)			22-1068
D18		Not Used			
D19		Silicon (1N4149)			22-1029
D20		Silicon (1N4149)			22-1029
Integrated Circuits					
IC1		Not Used			
IC2		Not Used			
IC3		LM339			22-4249
IC4		Header Assembly			17-1026
IC5		LM339			22-4249
IC6		LM339			22-4249
IC7		LM339			22-4249
IC8		4066			22-4761
IC9		8750J			22-4594
IC10		Not Used			
IC11		6821			22-8303
IC12		6821			22-8303
IC13		74LS14			22-4570
IC14		74LS123			22-4547
IC15		74HC00			22-4775

Cct. Ref.	Value	Description	Rat	Tol %	Racal-Dana Part Number
IC16		2732 (programmed)		22-8566	22-8519
IC17		2732 (programmed)		22-8565	22-8518
IC18		2732 (programmed)		22-8564	22-8517
IC19		2732 (programmed)		22-8563	22-8516
IC20		6514-9			22-8204

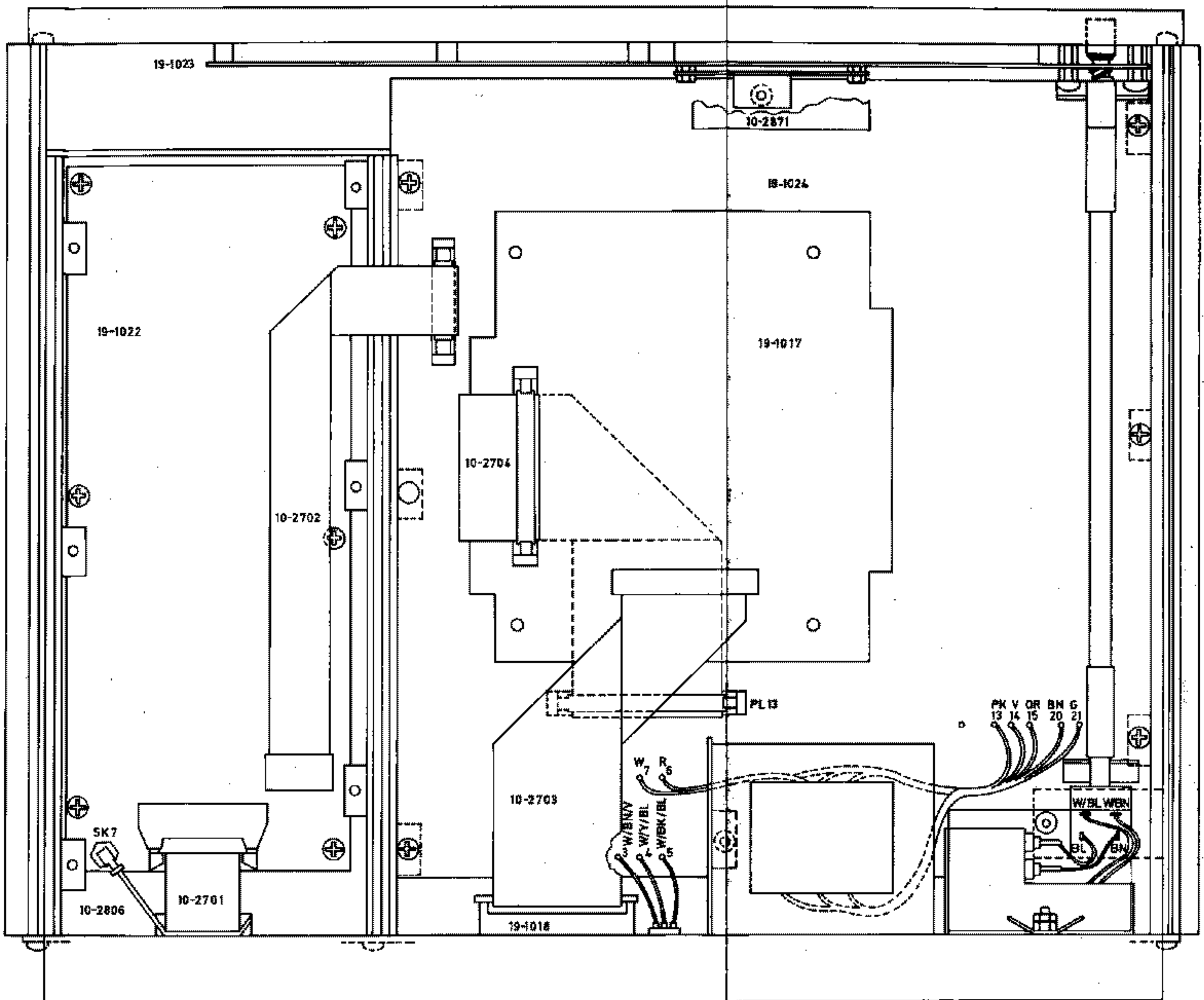
Note: When ordering replacements for IC's 16, 17, 18 and 19 the software issue number and the instrument serial number must be quoted in addition to the part number. The software issue number is marked on the component. Each column of part numbers forms a hardware compatible set. The ROMs fitted must all be from the same set, and be of the same software issue.

IC21		6514-9			22-8204
IC22		74LS245			22-4584
IC23		74LS244			22-4583
IC24		74LS244			22-4583
IC25		74LS138			22-4587
IC26		74LS139			22-4678
IC27		74LS30			22-4597
IC28		74LS240			22-4588
IC29		74LS240			22-4588
IC30		6802			22-8302
IC31		74LS74			22-4534
IC32		74LS138			22-4587
IC33		7407			22-4063
IC34		74LS138			22-4587
IC35		74LS00			22-4531
IC36		74LS04			22-4533
IC37		74LS09			22-4596
IC38		79MGU1C			22-4261
IC39		78MGU1C			22-4260
IC40		ZN458B			22-4250
IC41		Not used			
IC42		74HC00			22-4775
IC43		74HC4075			22-4776
IC44		7705			22-4267
IC45		3078E			22-4268

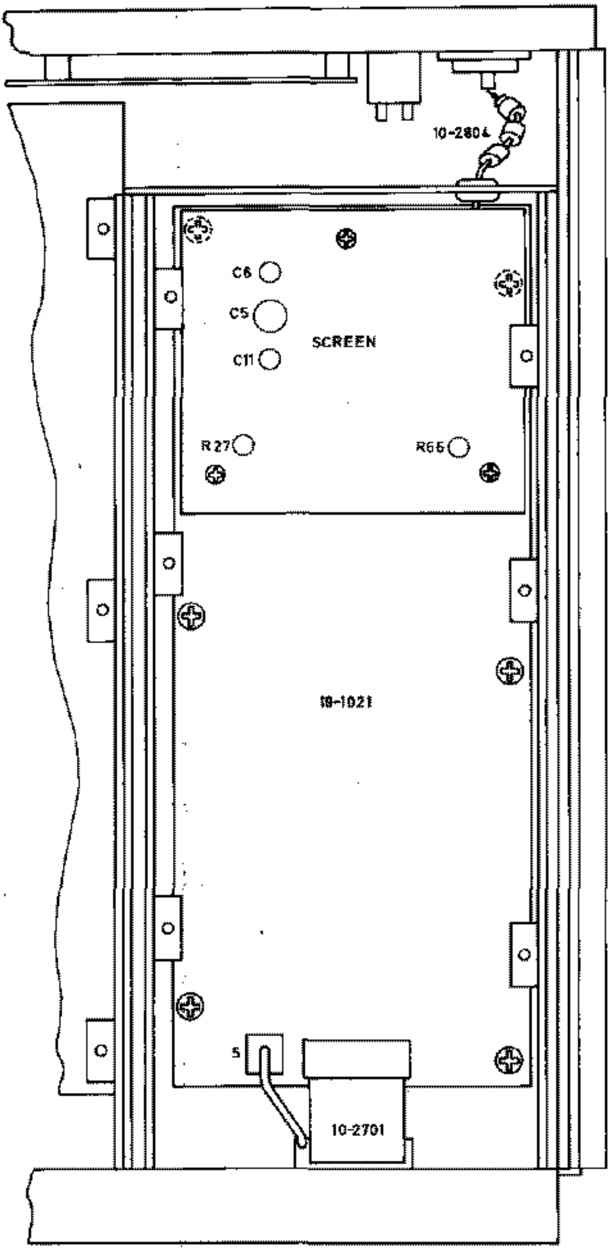
Transistors

Q1		BC109			22-6041
Q2		ZTX450			22-6112

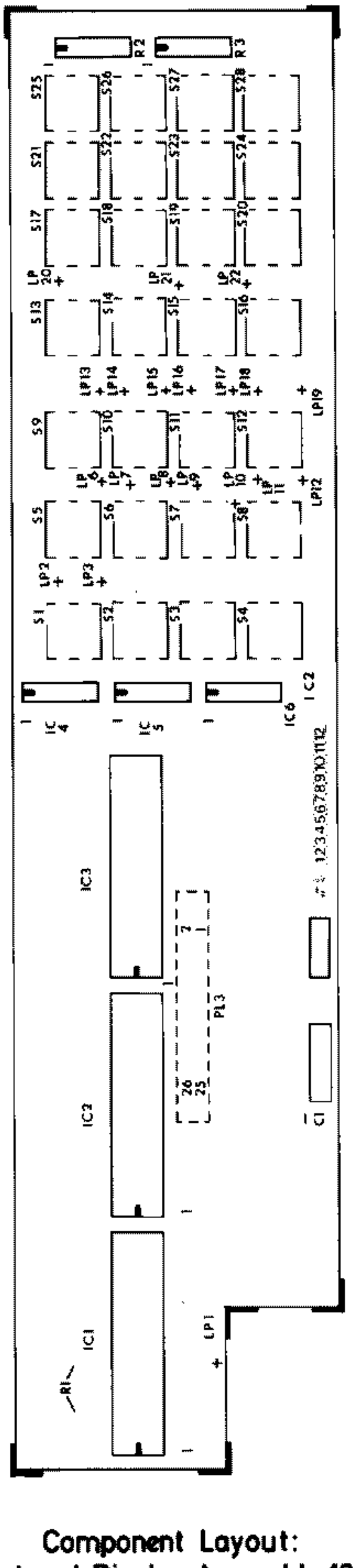
Cct. Ref.	Value	Description	Rat	Tol %	Racal-Part Number
Inductors					
	H				
L1	100 μ	Choke, RF			23-7056
Connectors					
SK3		Cable Assembly			10-2871
PL15		PCB header, 20-way			23-3319
PL13		PCB header, 34-way			23-3325
Miscellaneous					
FS1		Fuse link, 1.6 A			23-0055
		Holder for FS1			23-0054
		Lithium Battery			23-2513
S30		Switch, DIL			23-4089
S29		Switch, with flexible extension			23-4104
		Knob for S29			23-9098
LK1 LK3		Shorting jack			23-9143



Internal Layout

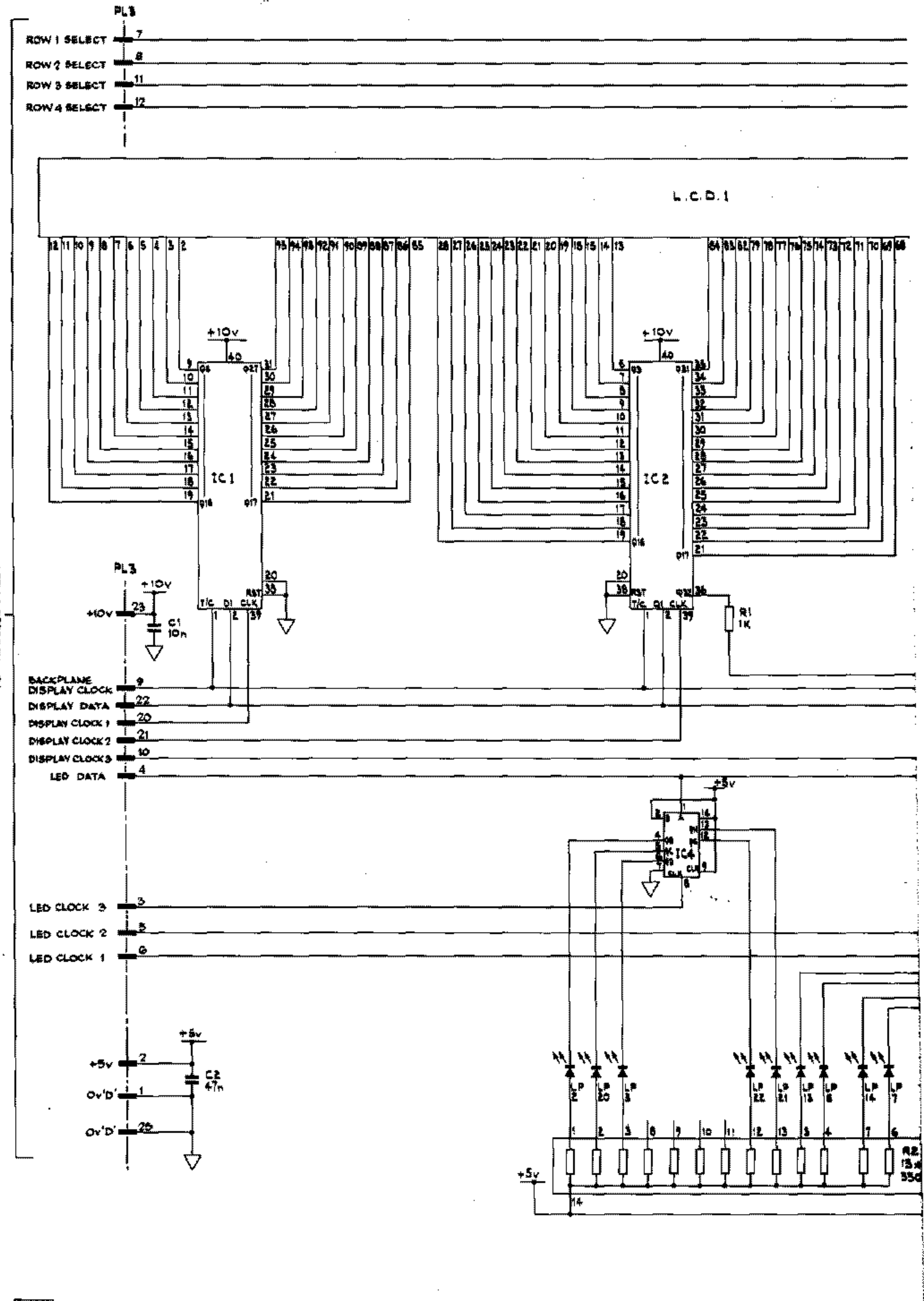


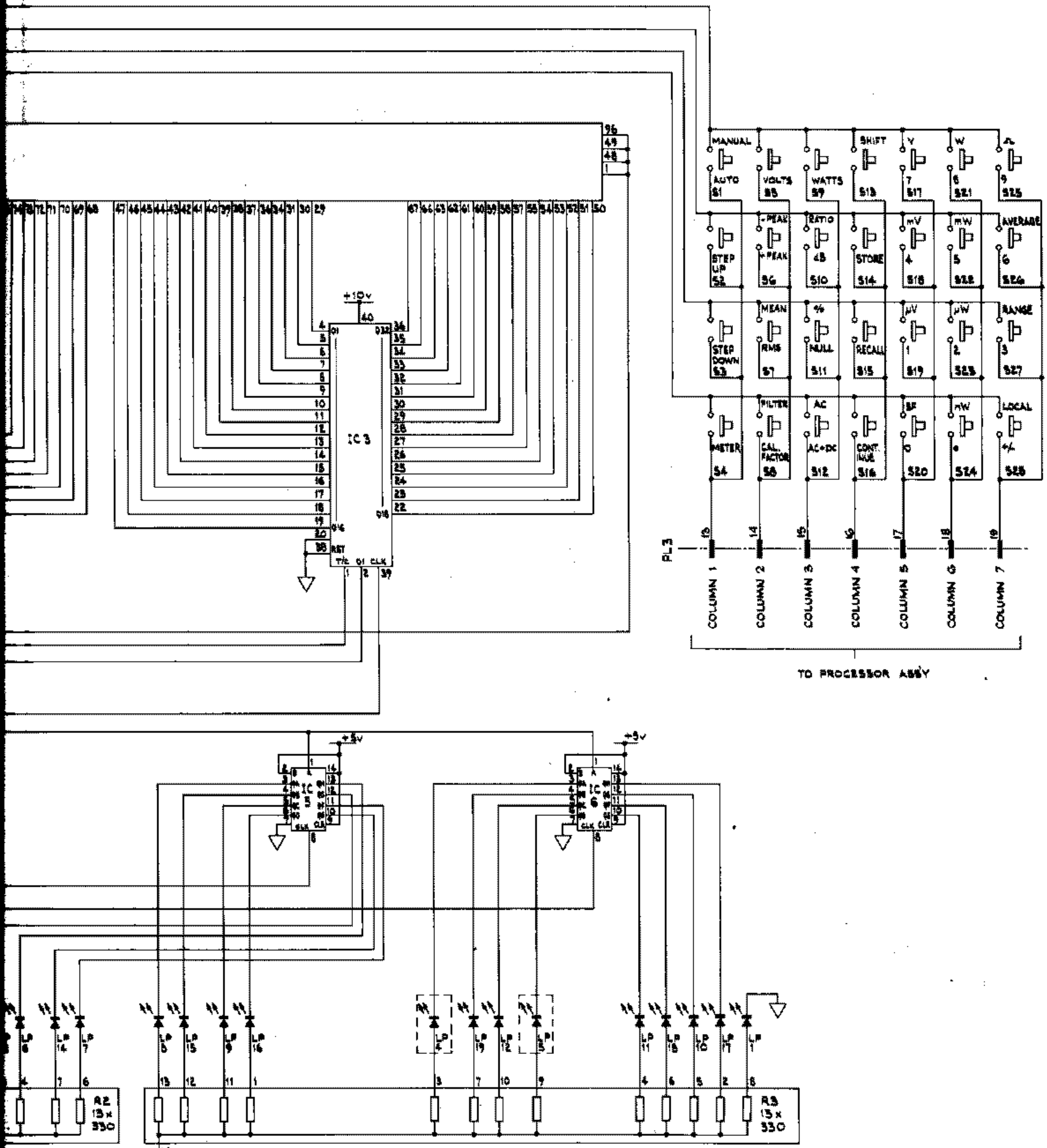
VIEW OF UNDERSIDE OF MODULE ASSEMBLY



Component Layout:
Keyboard and Display Assembly 19-1023

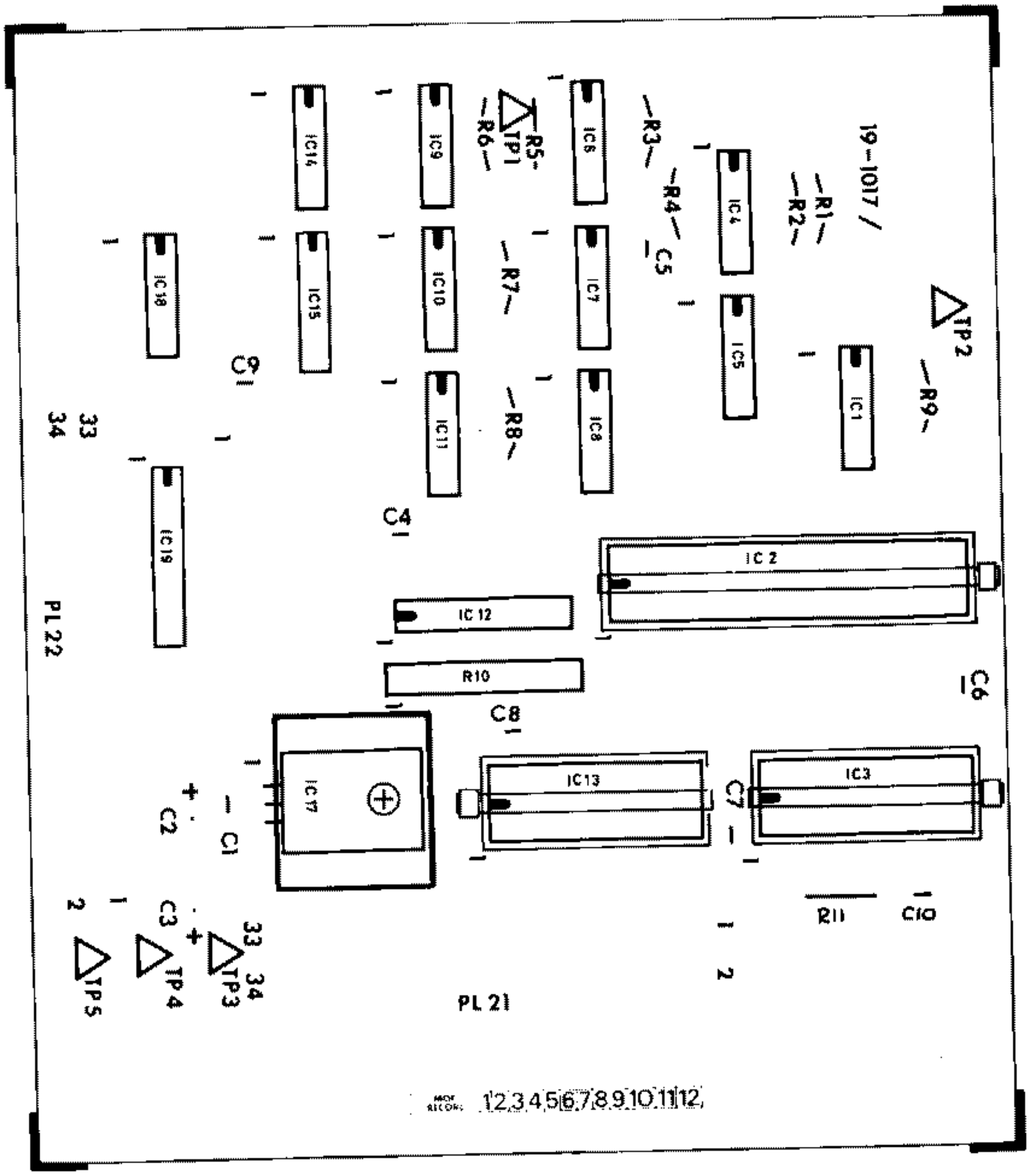
Fig. 2


PL3
ROW 1 SELECT
ROW 2 SELECT
ROW 3 SELECT
ROW 4 SELECT
L.C.D. 1
+10v
IC 1
IC 2
IC4
R1
1K
C1
10n
C2
47n
TO PROCESSOR ASS'Y
+10v
BACKPLANE DISPLAY CLOCK
DISPLAY DATA
DISPLAY CLOCK 1
DISPLAY CLOCK 2
DISPLAY CLOCK 3
LED DATA
LED CLOCK 3
LED CLOCK 2
LED CLOCK 1
+5v
0v'D'
0v'D'
TH4026



Circuit Diagram: Keyboard and Display Assembly 19-1023

Fig. 3



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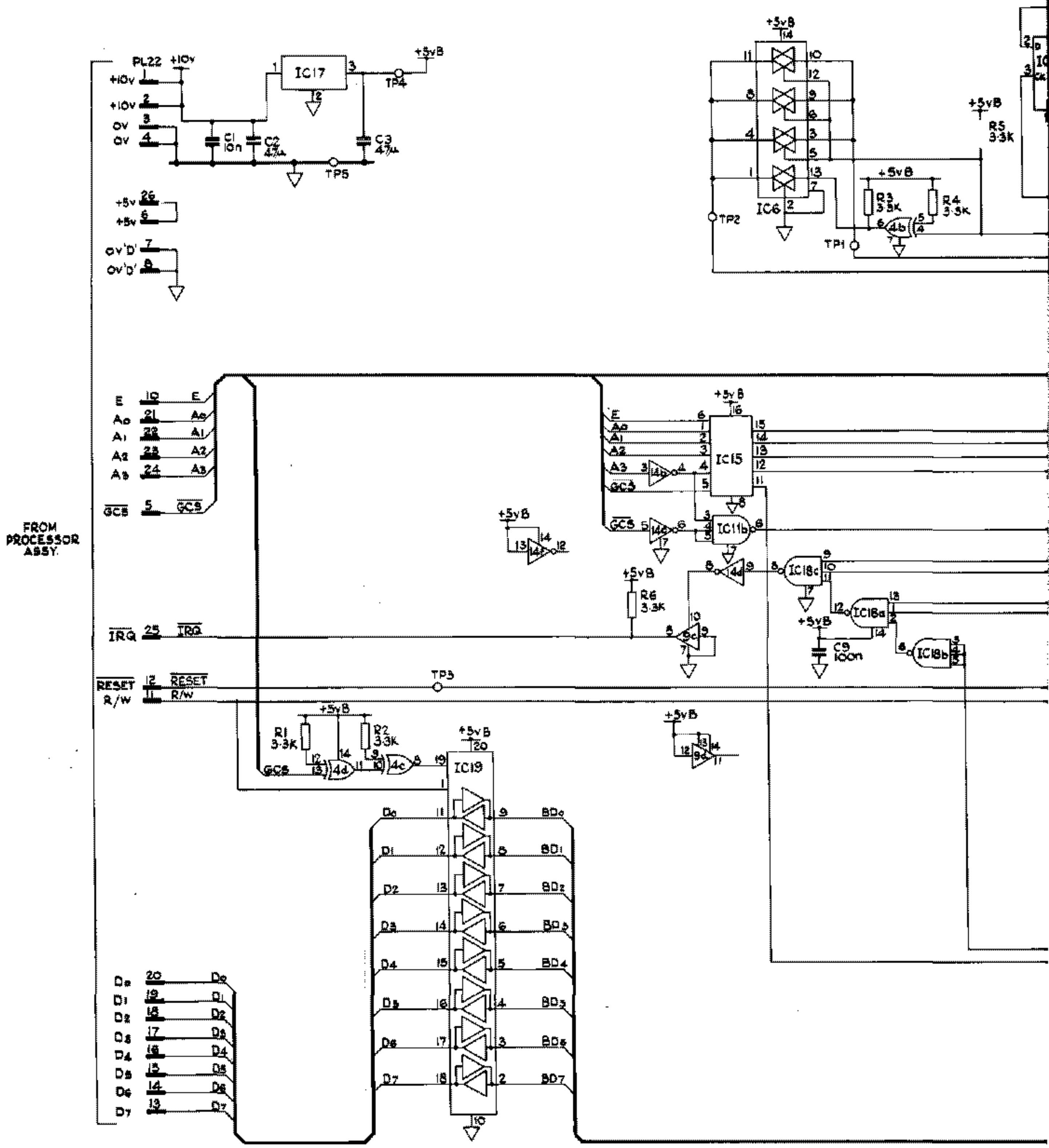
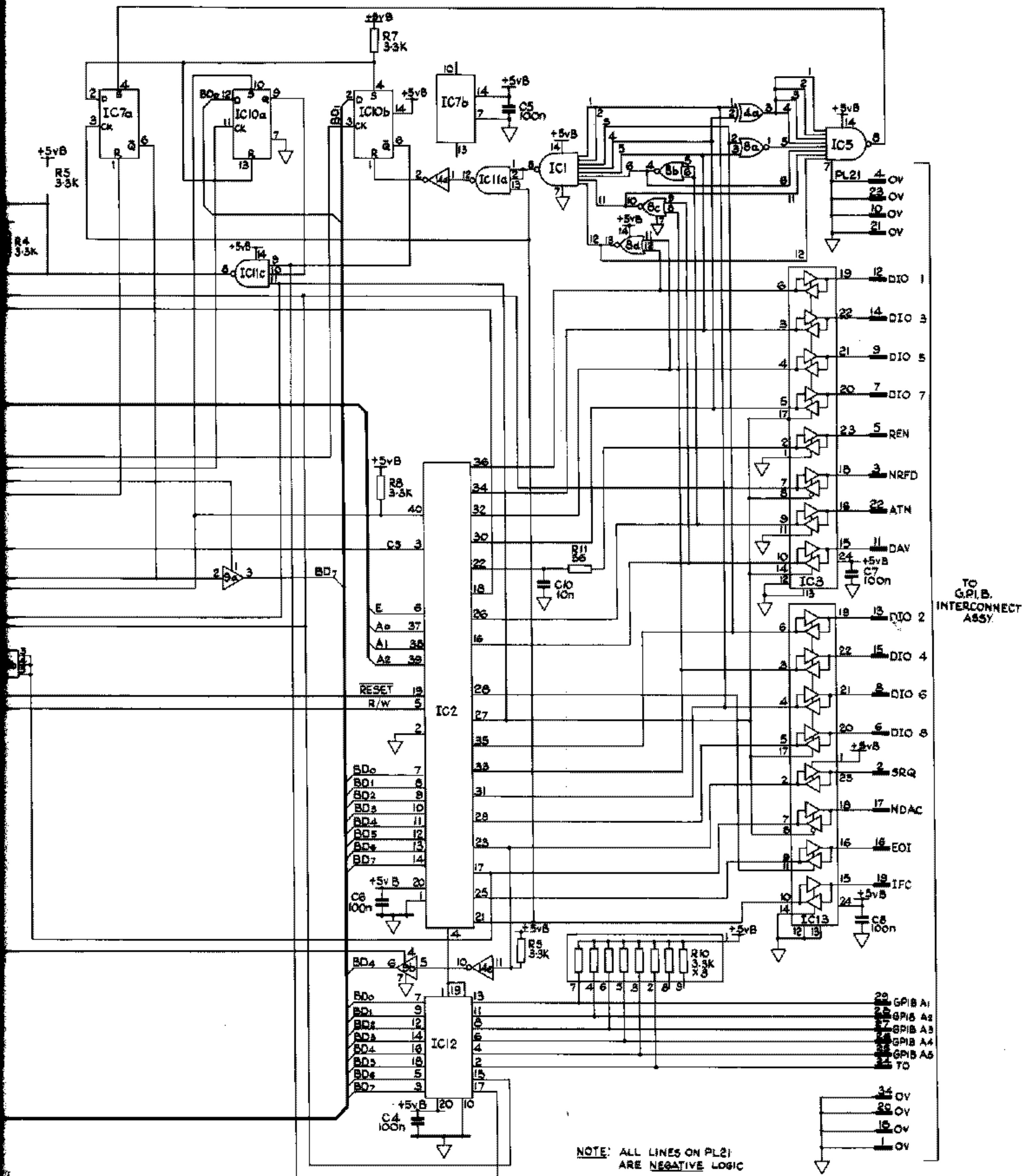
Component Layout:
GPIB Assembly 19-1017

Fig. 4

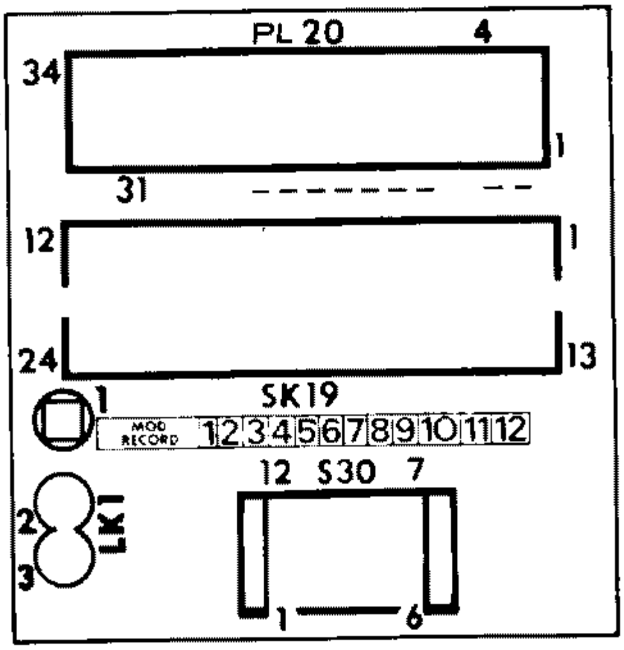


RACAL
TH4028
1



Circuit Diagram:
GPIB Assembly 19-1017

Fig.5



Component Layout:
GPIB Connector Assembly 19-1018

Fig.6

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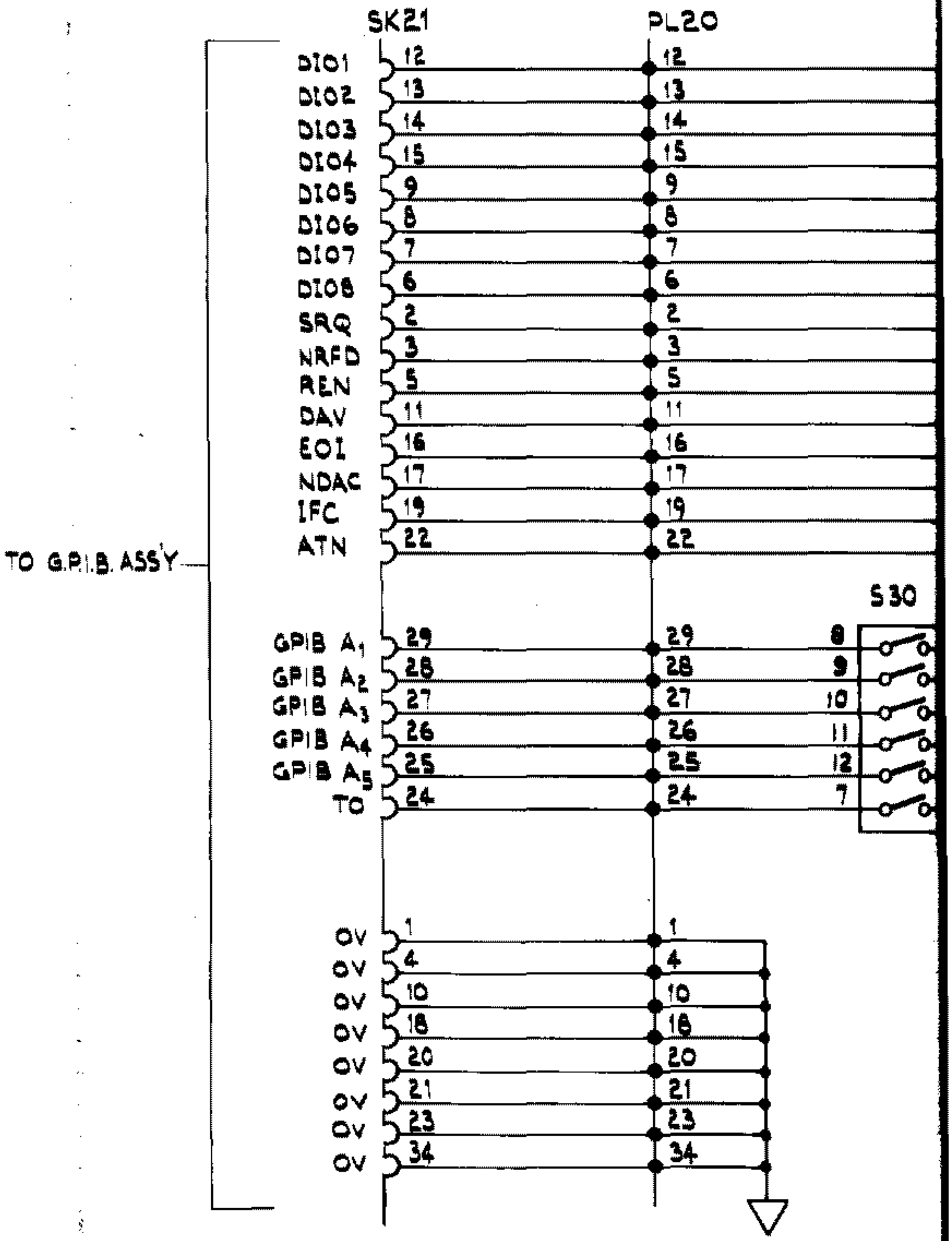
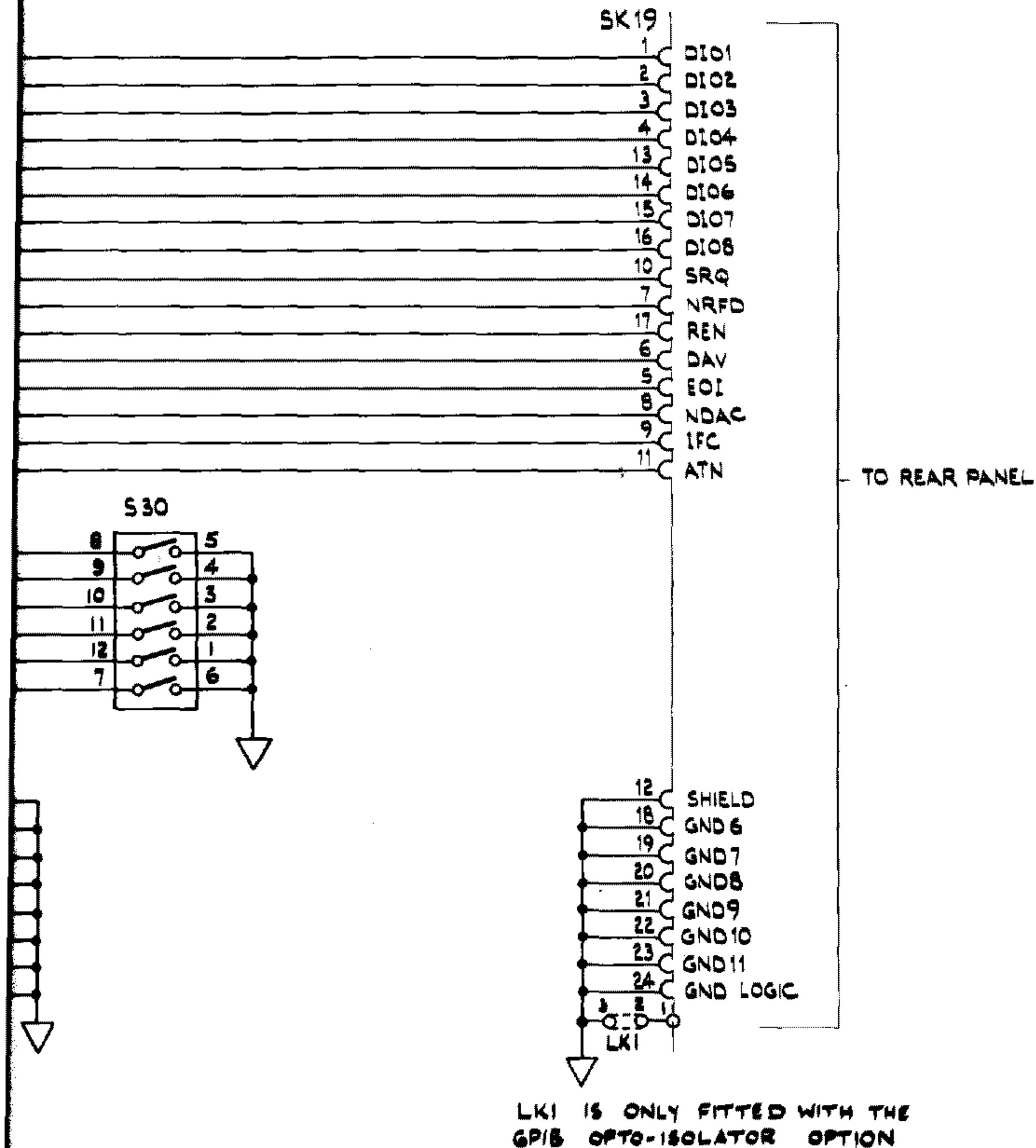
1 2



SK21
PL20
DIO1
DIO2
DIO3
DIO4
DIO5
DIO6
DIO7
DIO8
SRQ
NRFD
REN
DAV
EOI
NDAC
IFC
ATN
TO G.P.I.B. ASS'Y
S30
GPIB A1
GPIB A2
GPIB A3
GPIB A4
GPIB A5
TO
OV

TH4026
1 2 3



Circuit Diagram: GPIB
Connector Assembly 19-1018 Fig.7

TEST VOLTAGES

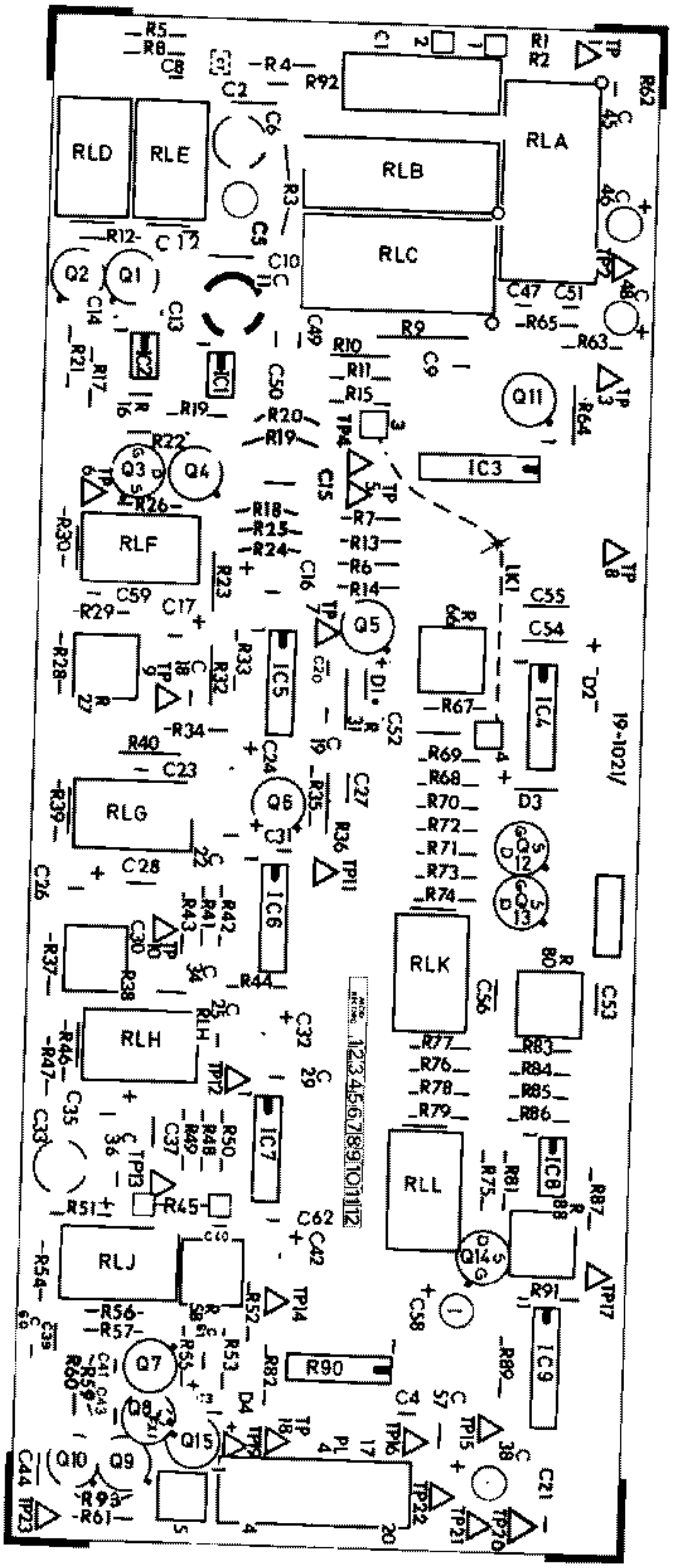
AMPLIFIER ASSEMBLY 19-1021

TEST CONDITIONS

5002 Settings: MANUAL ranging mode.
300 mV range.
VOLTS primary measurement function
RMS secondary measurement function
AC coupling

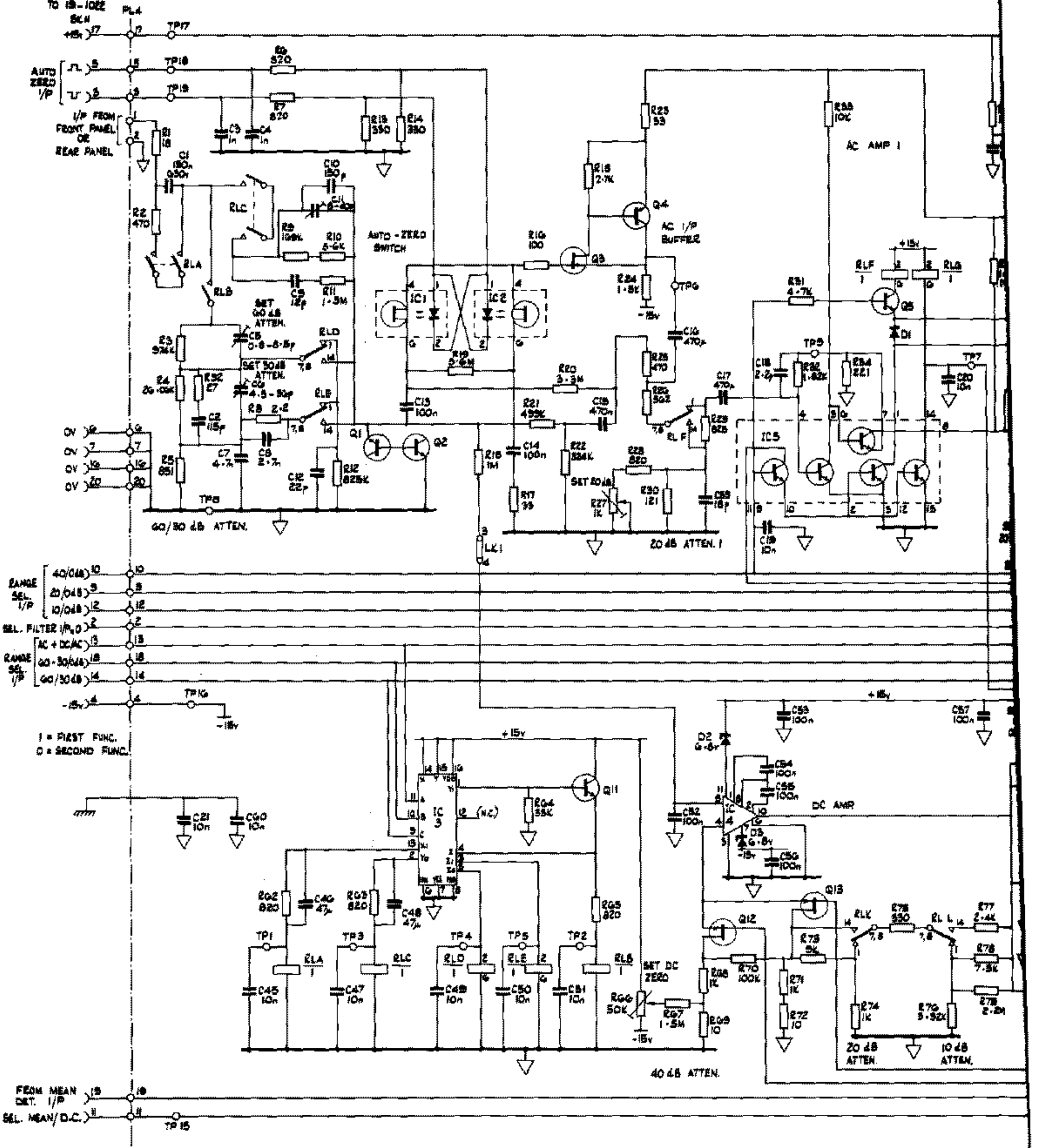
5002 Input: Sinusoidal, 316.2 mV r.m.s. at 1 kHz.

Test Point	AC Peak-to-Peak	Mean Level
IC1/6	0.66 V	0 V
TP6	0.66 V	0 V
TP9	0.24 V	+0.74 V
IC5/8	0.12 V	+8.2 V
TP10	0.27 V	+0.75 V
IC6/8	0.14 V	+8.5 V
TP13	0.27 V	+0.83 V
IC7/8	0.41 V	+8.2 V
TP23	1.25 V	+2.1 V



Component Layout :
Amplifier Assembly 19-1021

Fig. 8



RACAL
TM4026
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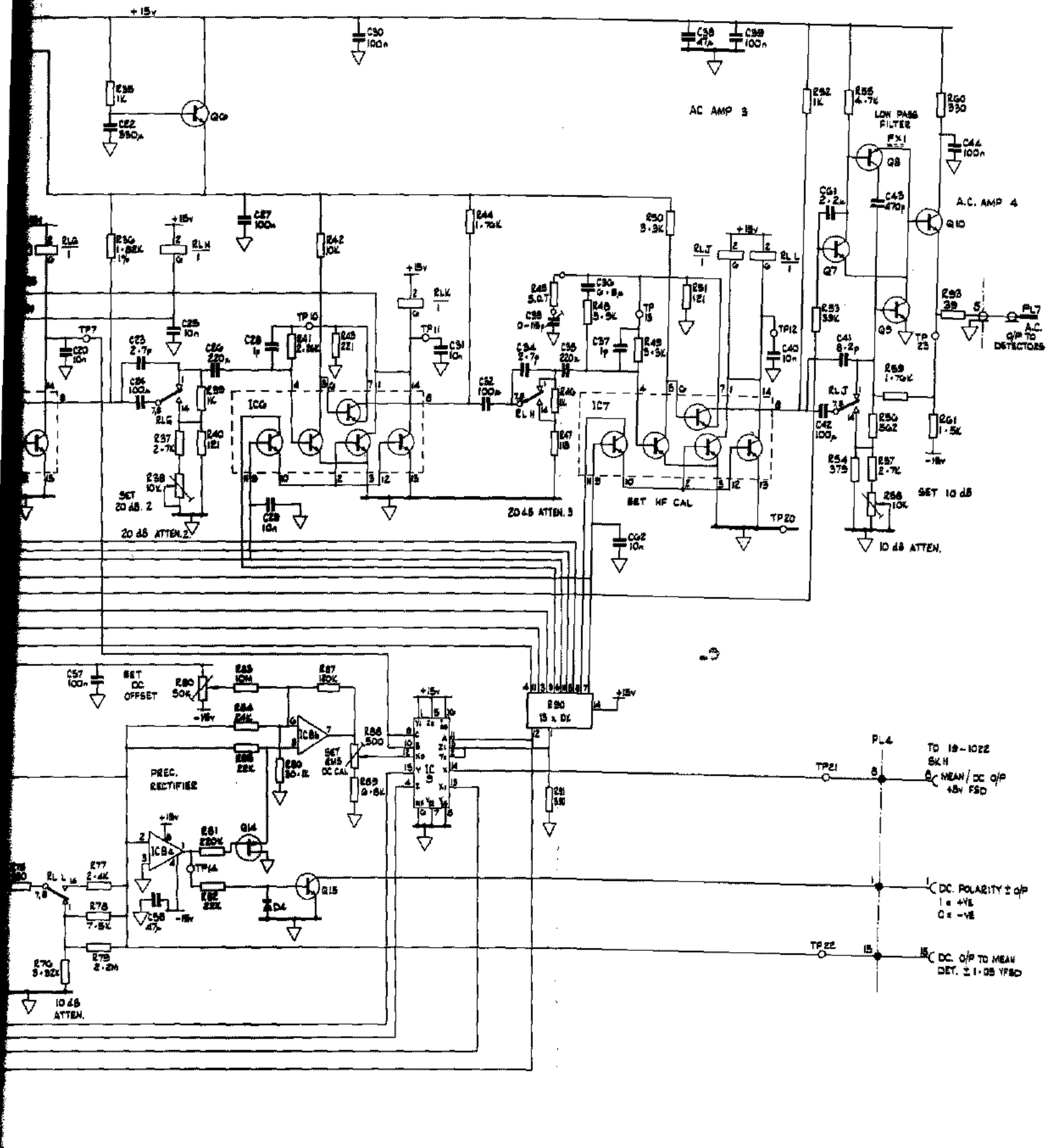


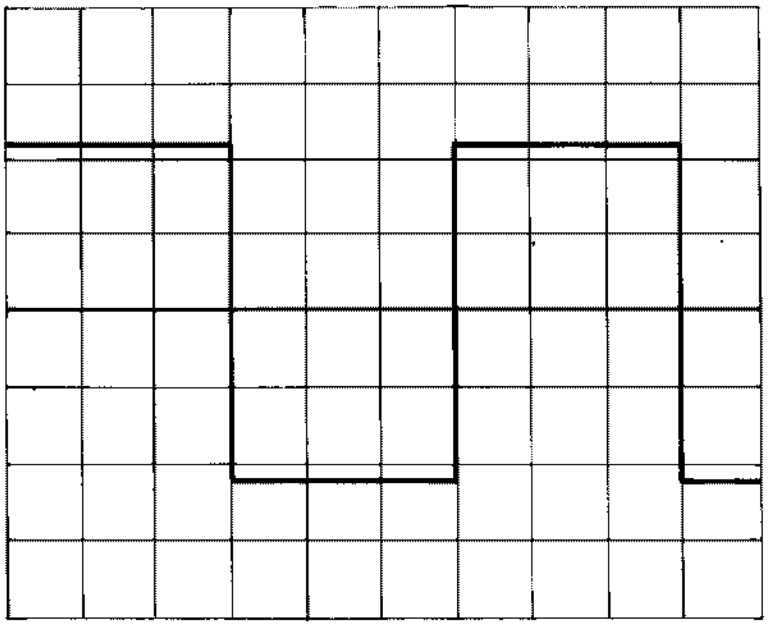
Circuit Diagram:
Amplifier Assembly 19-1021

Fig. 9

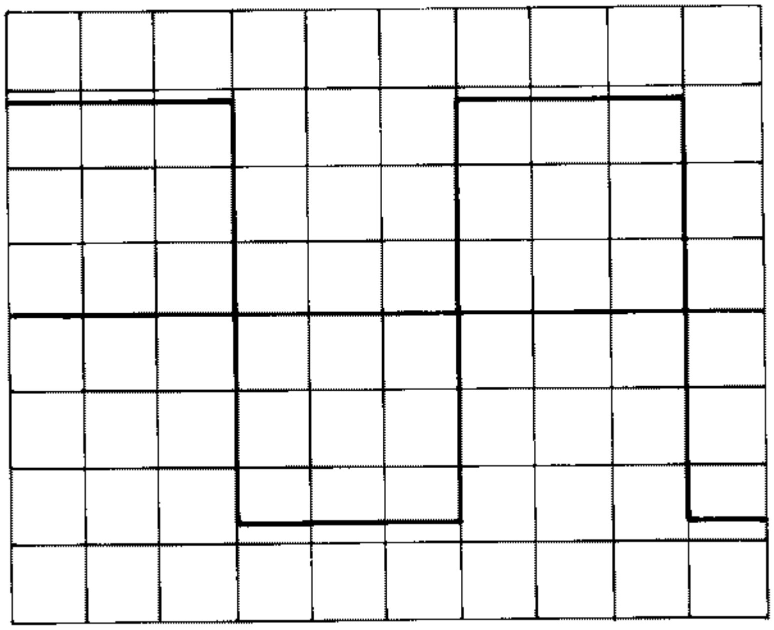
DETECTOR ASSEMBLY 19-1022

TEST CONDITIONS

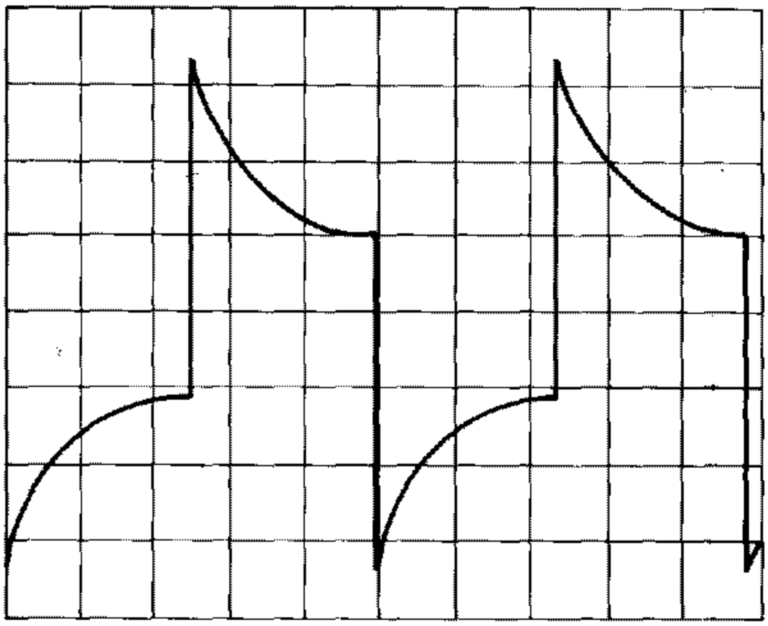
5002 Settings:	MANUAL ranging mode. 300 mV range. AC coupling	VOLTS primary measurement function. RMS secondary measurement function
5002 Input:	Sinusoidal, 316.2 mV r.m.s. at 1 kHz	
Oscilloscope:	Waveforms taken via X10 probe. DC coupling, except where stated. Internal trigger.	



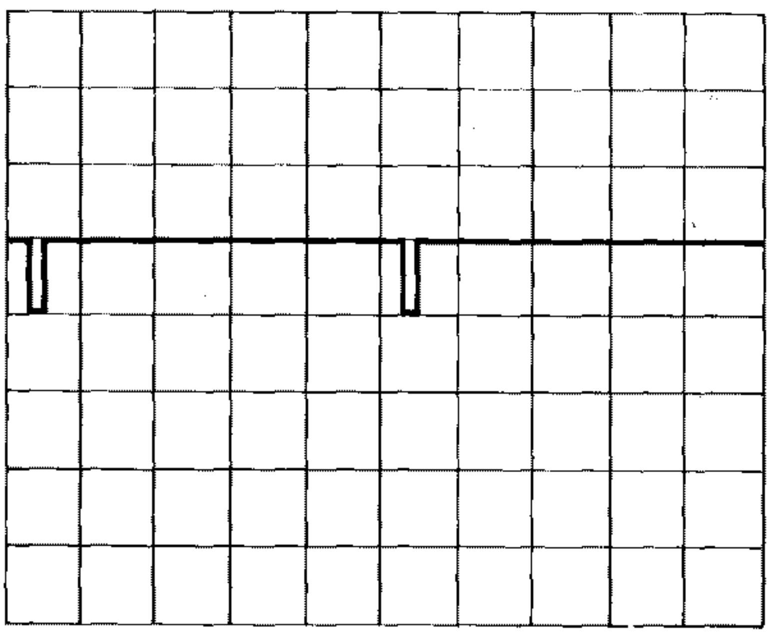
Monitor Point TP 6
Vertical scale 50 mV/division
Horizontal scale 10 ms/division



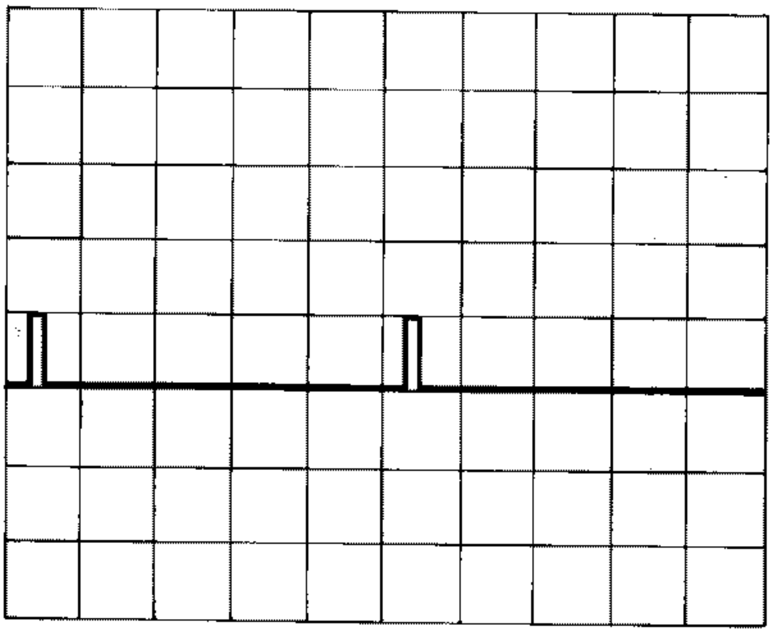
Monitor Point TP 13
Vertical scale 5 V/division
Horizontal scale 10 ms/division



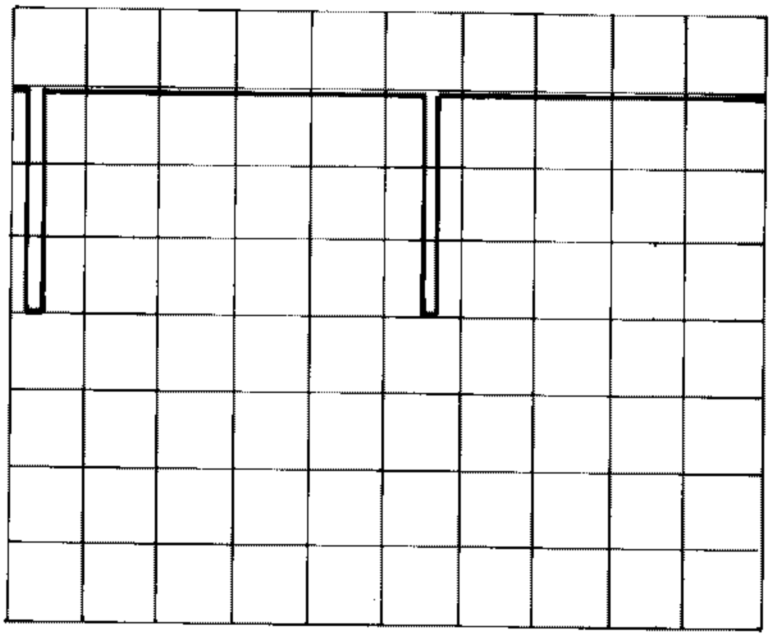
Monitor Point	TP 20 and TP 23
Vertical scale	200 mV/division
Horizontal scale	200 µs/division
AC coupling	
Mean DC level	4.5 V



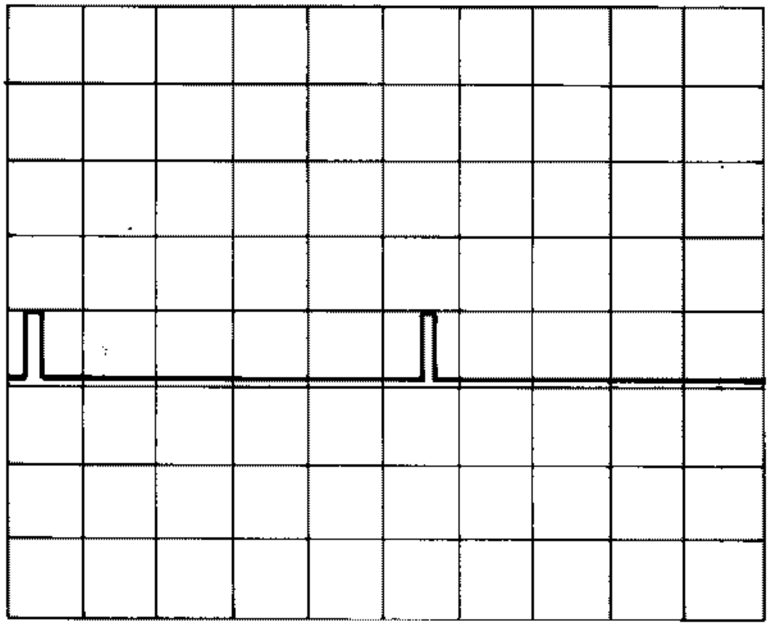
Monitor Point	TP 26
Vertical scale	0.5 V/division
Horizontal scale	20 ms/division



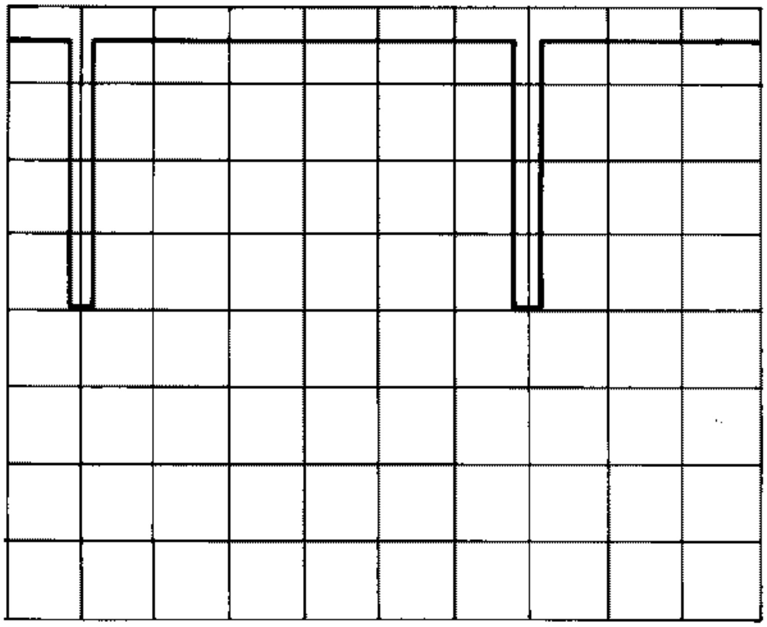
Monitor point TP27
Vertical scale 0.5 V/division
Horizontal scale 20 ms/division



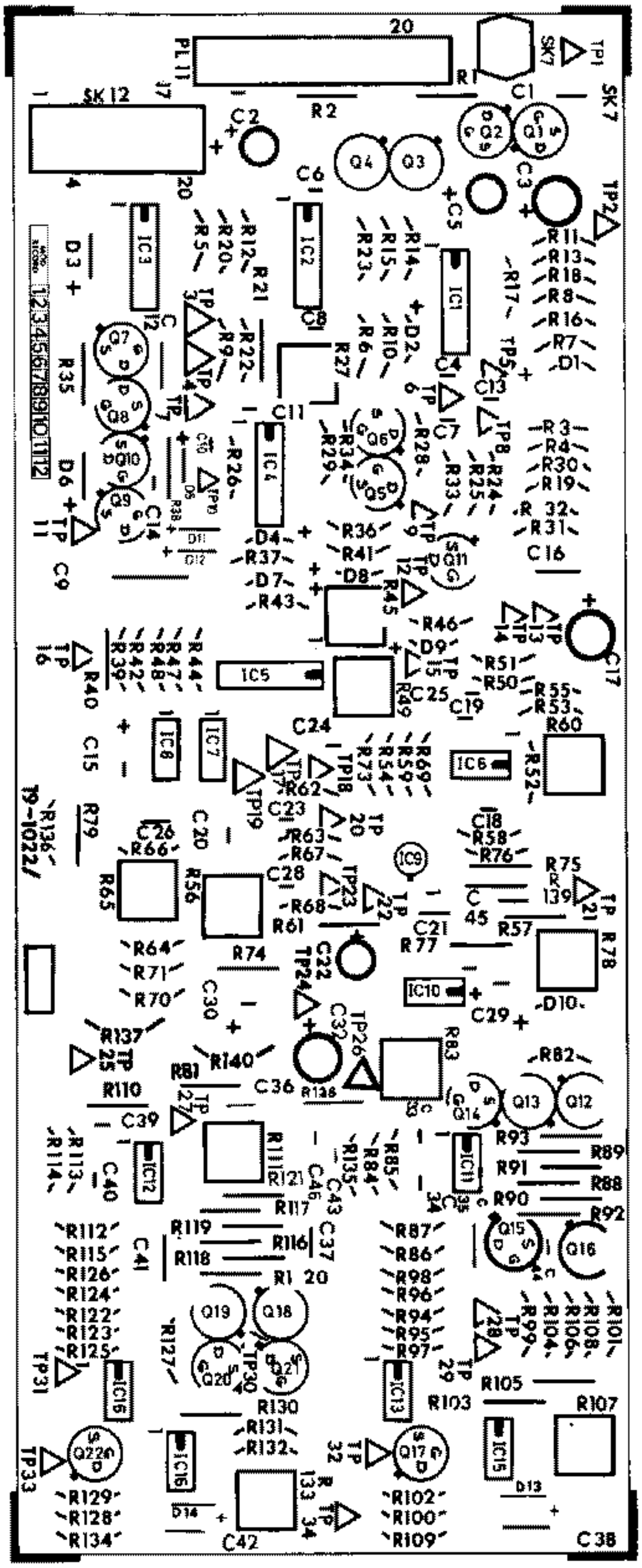
Monitor point TP30
Vertical scale 5 V/division
Horizontal scale 20 ms/division



Monitor Point TP 28 and TP 31
Vertical scale 1 V/division
Horizontal scale 20 ms/division



Monitor Point TP 32 and TP 33
Vertical scale 1 V/division
Horizontal scale 20 ms/division



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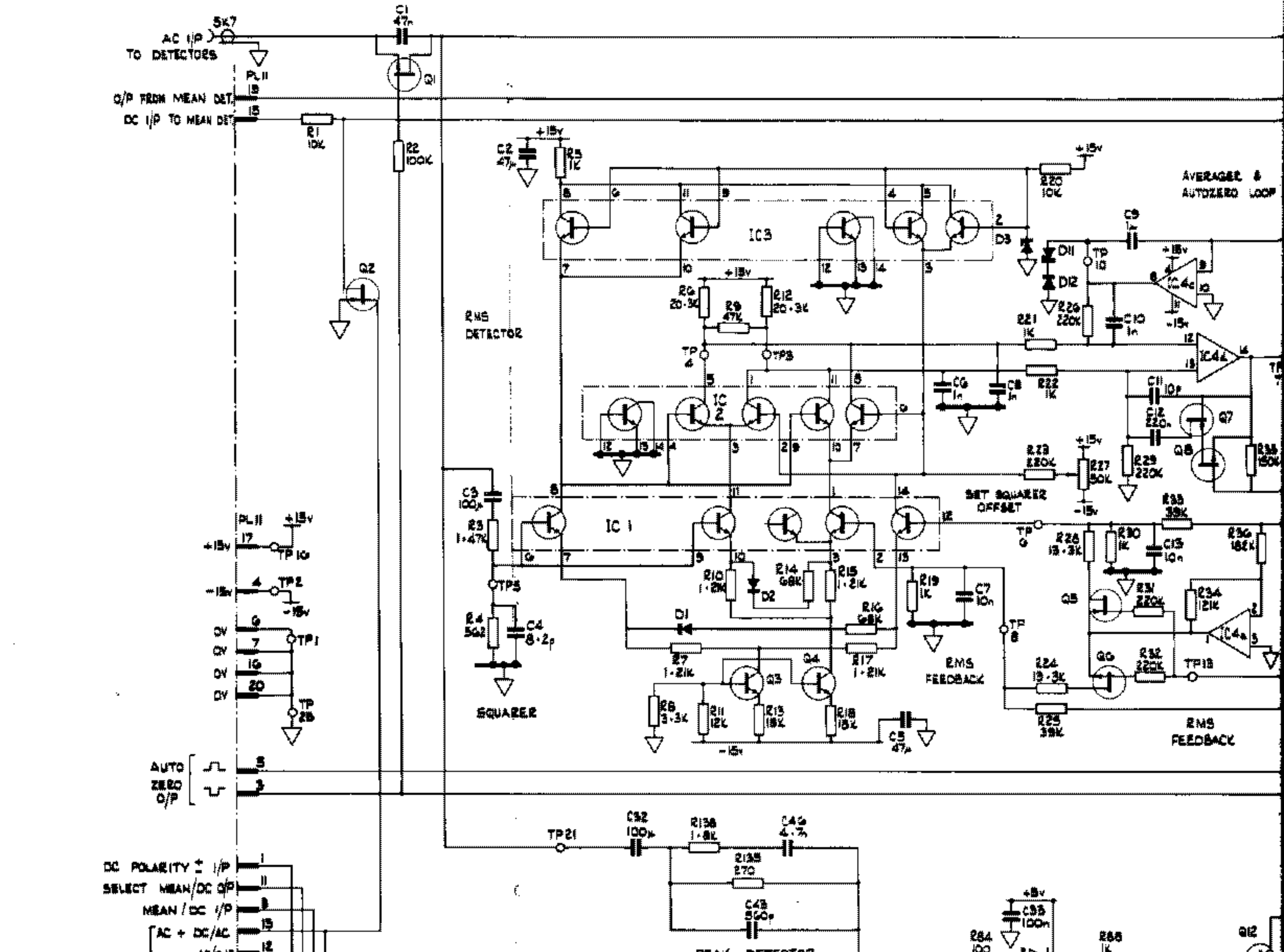
Component Layout:
Detector Assembly 19-1022

Fig. 10



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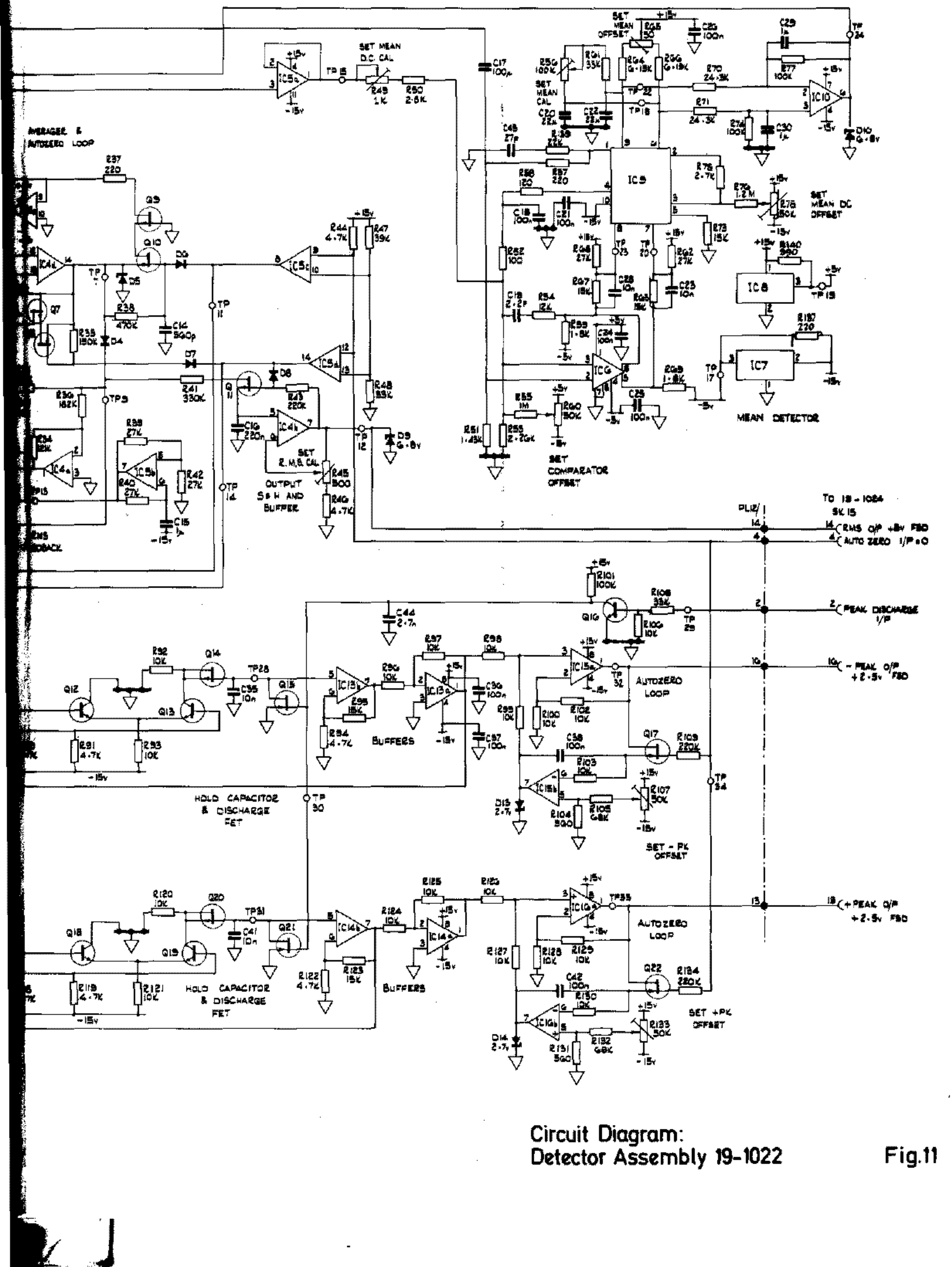
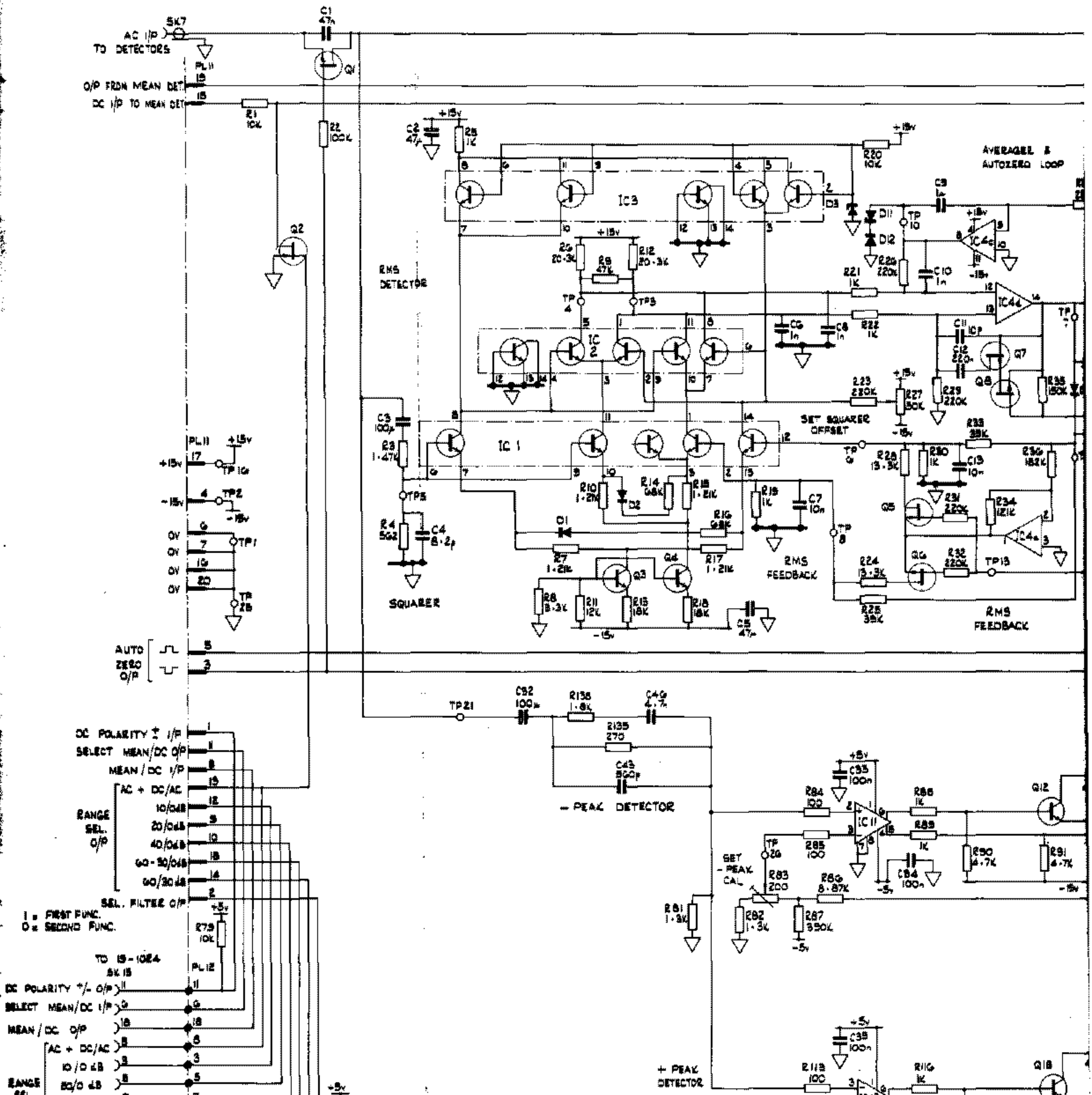


Circuit Diagram:
Detector Assembly 19-1022

Fig.11



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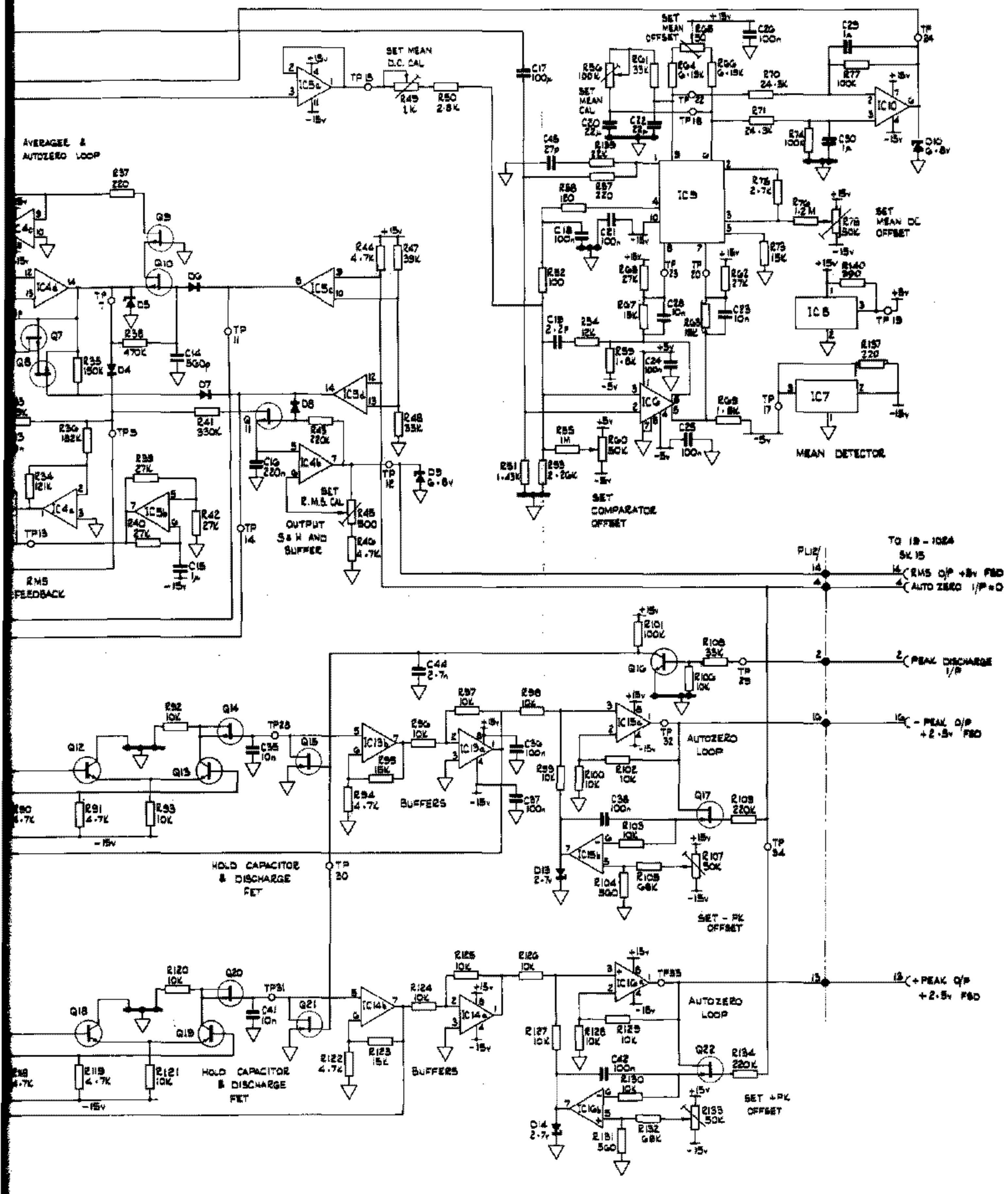
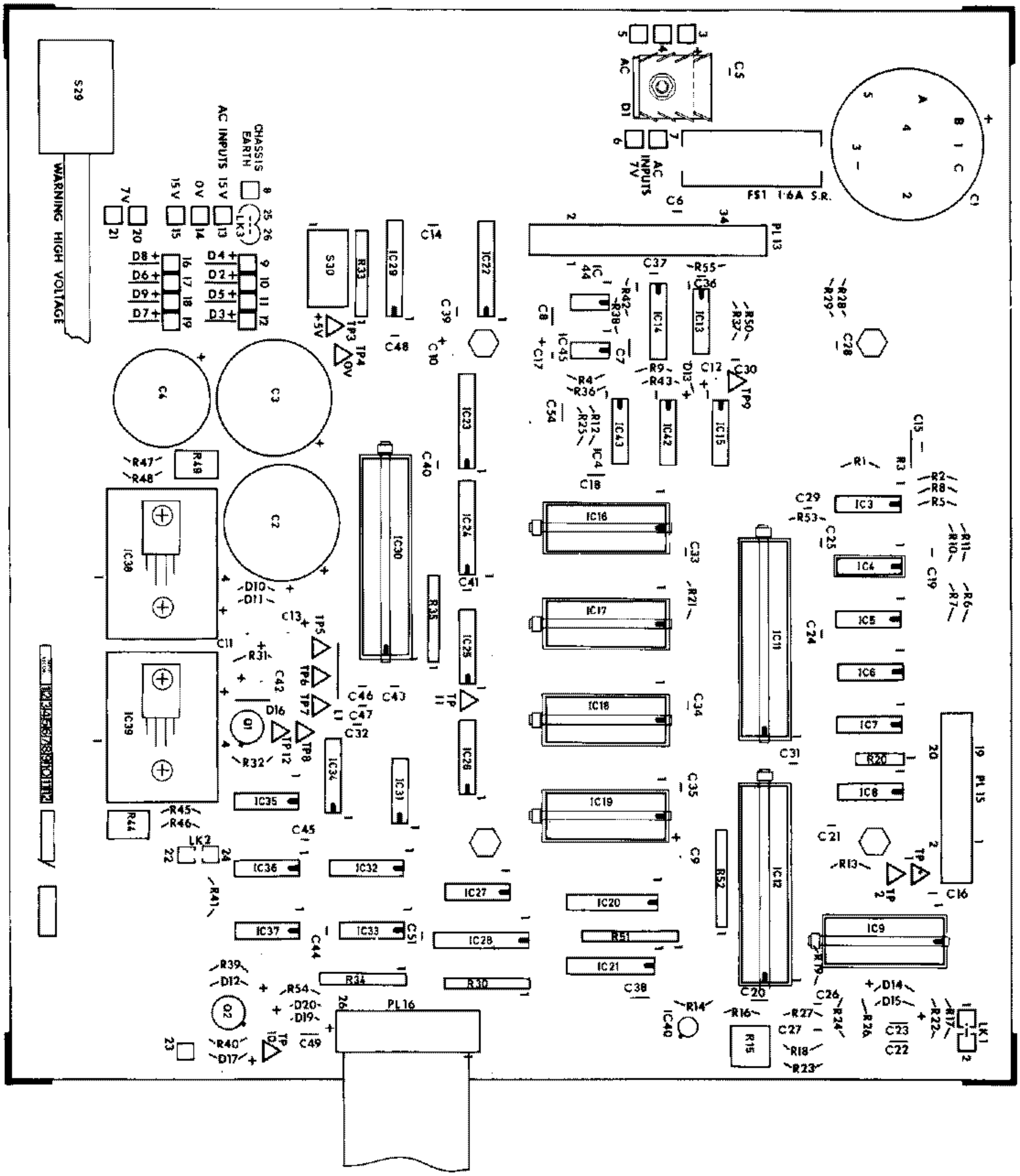


Circuit Diagram:
Detector Assembly 19-1022

Fig.11



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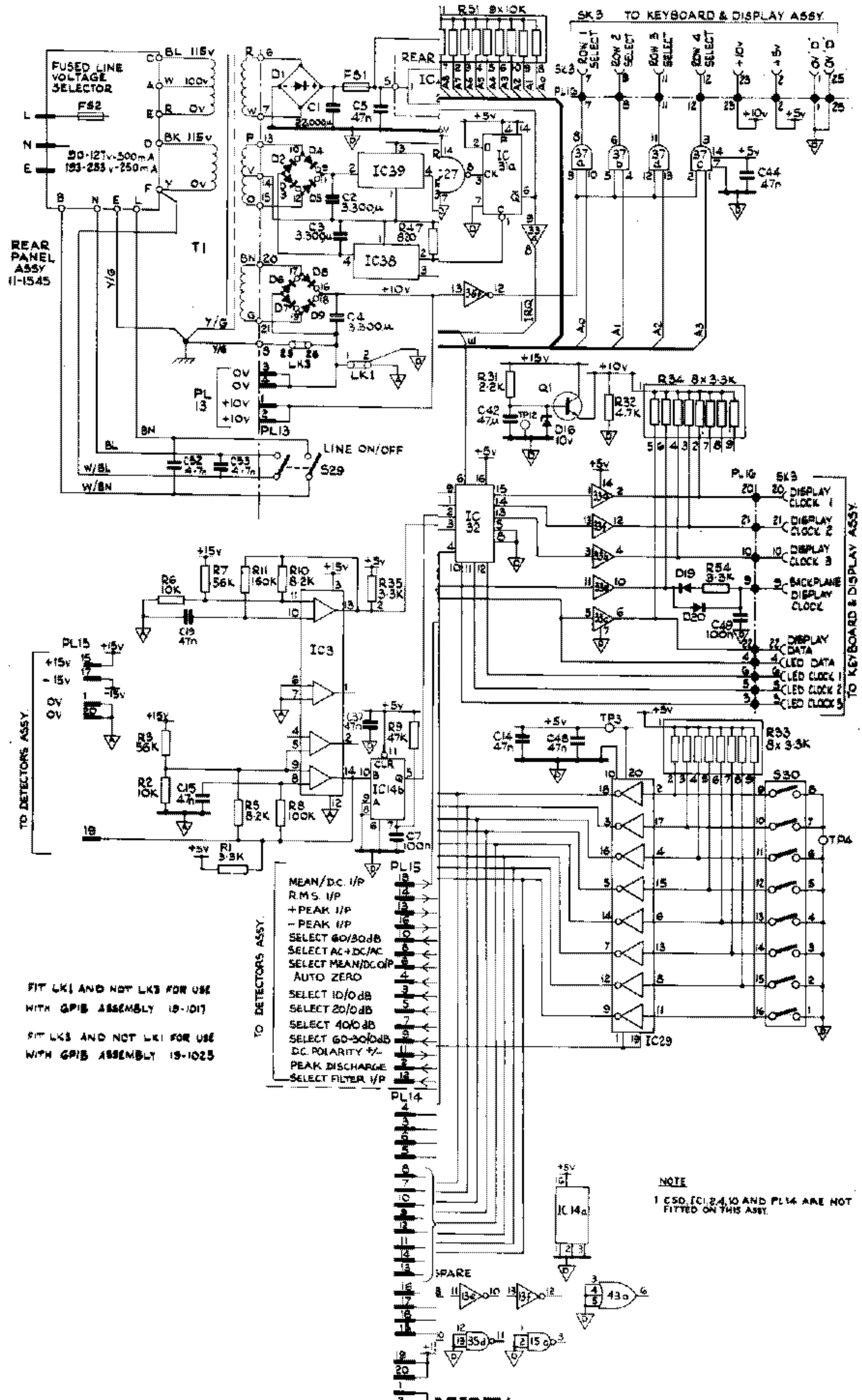
2 34

Component Layout: Processor Assembly 19-1024

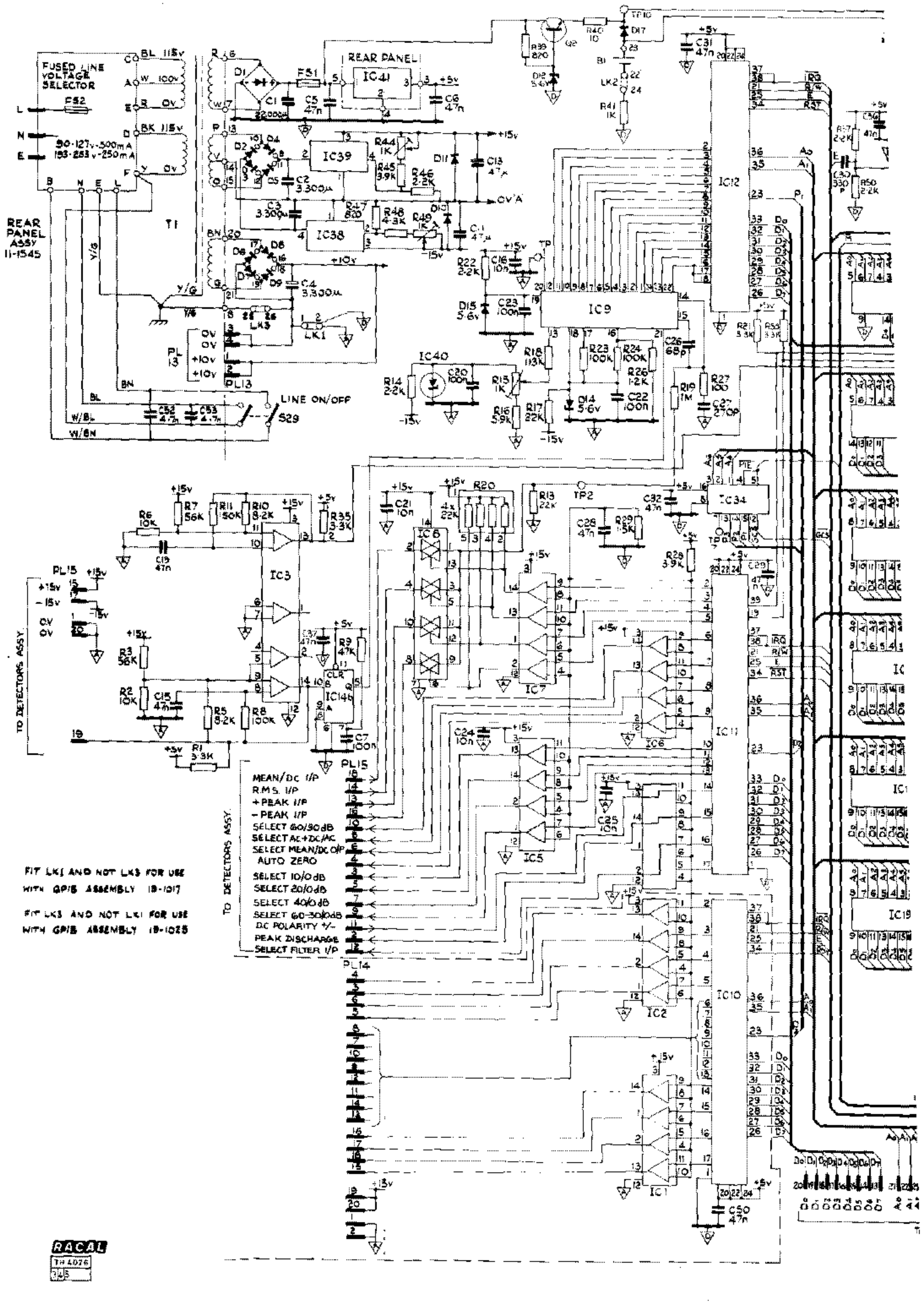
Fig.12

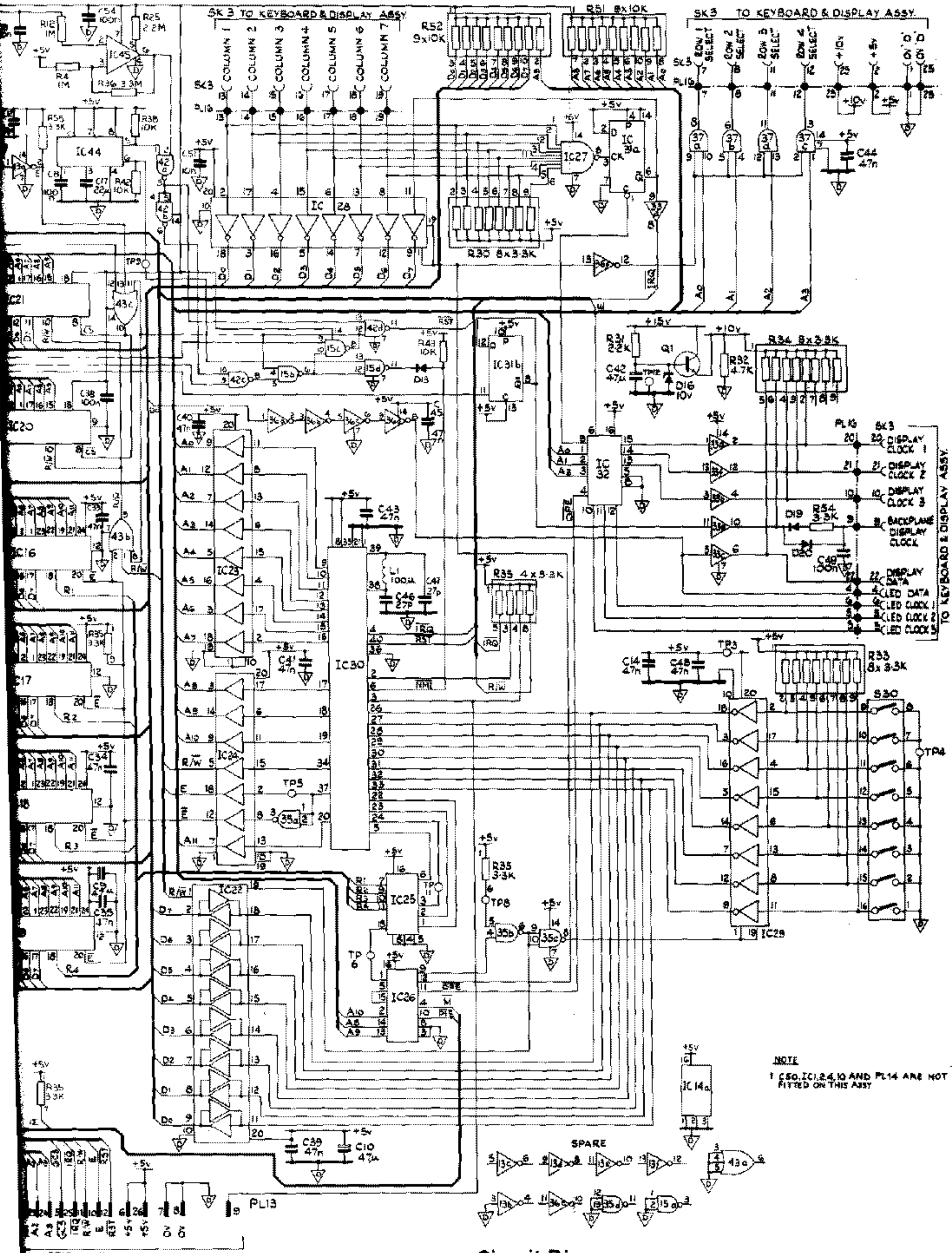


RACAL TH 4026 345

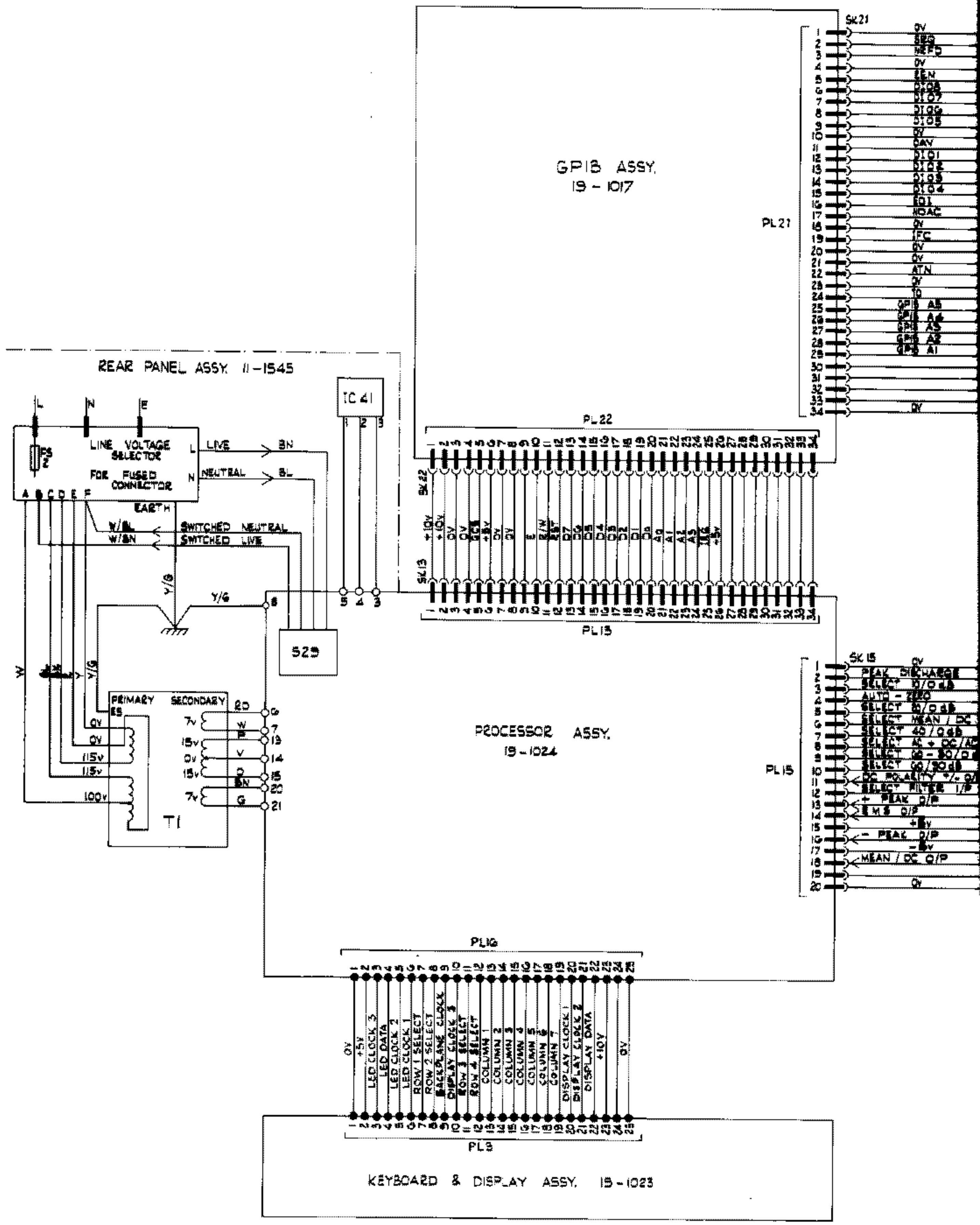
...iagram: Assembly 19-1024

Fig. 13

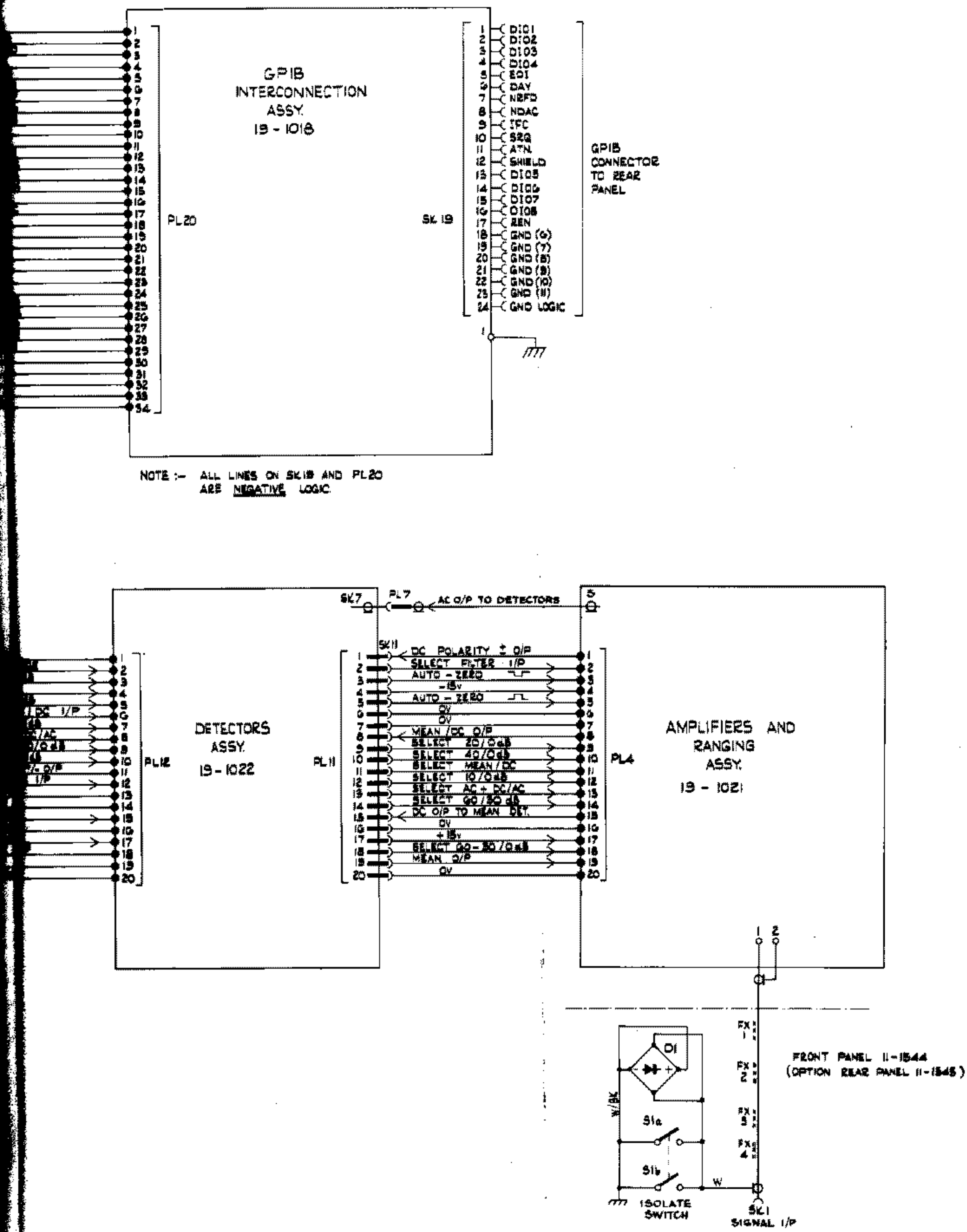

FUSED LINE VOLTAGE SELECTOR
FS2
90-127v-500mA
193-253v-250mA
REAR PANEL ASSY 11-1545
T1
REAR PANEL
IC41
IC39
IC38
IC9
IC40
+15v
-15v
+10v
OV'A'
LINE ON/OFF
S29
PL 13
LK1
LK3
IC12
IC34
IC3
IC146
IC8
IC7
IC6
IC5
IC11
IC2
IC10
IC1
IC19
PL15
PL14
TO DETECTORS ASSY.
MEAN/DC I/P
R.M.S. I/P
+PEAK I/P
-PEAK I/P
SELECT 60/30dB
SELECT AC+DC/AC
SELECT MEAN/DC O/P
AUTO ZERO
SELECT 10/0dB
SELECT 20/0dB
SELECT 40/0dB
SELECT 60-30/0dB
DC POLARITY +/-
PEAK DISCHARGE
SELECT FILTER I/P
FIT LK1 AND NOT LK3 FOR USE WITH GPIB ASSEMBLY 19-1017
FIT LK3 AND NOT LK1 FOR USE WITH GPIB ASSEMBLY 19-1025
RACAL
TH 4026



Circuit Diagram:
Processor Assembly 19-1024 **Fig. 13**



GPIB ASSY.
19 - 1017
PL21
SK21
PL22
SK22
SK13
PL13
REAR PANEL ASSY. 11-1545
LINE VOLTAGE SELECTOR
FOR FUSED CONNECTOR
EARTH
LIVE
NEUTRAL
SWITCHED NEUTRAL
SWITCHED LIVE
IC41
529
PRIMARY
SECONDARY
T1
PROCESSOR ASSY.
19 - 1024
PL15
SK15
PEAK DISCHARGE
AUTO - ZERO
MEAN / DC O/P
PL16
PL3
KEYBOARD & DISPLAY ASSY. 19 - 1023
RACAL
TH 4026



Interconnections Fig.14