

INSTRUCTION MANUAL

DC - RESISTANCE BRIDGE
TYPE MB5

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Introduction

The MB5 Resistance Bridge has been designed mainly for production applications like the control of trimming machines, sorting machines, final tests, etc.

The bridge has a built-in standard using high precision metal-film resistors with very low temperature coefficient. Readout is provided on a panel meter and an analog output is available as well for the control of auxiliary equipment.

Realizing that for the various applications different control signals are required the limit or classifying circuits have been separated from the basic bridge. Space is available for a plug-in unit containing the functions required, and further to standard modules readily available special limit, timing, and interface modules can be used.

Danbridge offers to design modules to customers' specifications. Even the more complicated circuits can be built into the main frame so the need of using the well-known 'black boxes' does not exist.

Specifications

Bridge Circuit:

4-terminal Kelvin contacts.

Resistance Range:

0.1 Ω to 1111.1 M Ω in 10 decade ranges.
Decade values are set by 5 decade dials

Measuring Voltages:

Decade Ranges

Test Voltage

0.1 - 1 Ω	8 mV
1 - 10 Ω	80 mV
10 - 100 Ω	240 mV
100 Ω - 1 k Ω	800 mV
1 k - 10 k Ω	2.4 V
100 k - 1 M Ω	8 V
1 M - 10 M Ω	80 V
10 M - 100 M Ω	80 V
100 M - 1111 M Ω	80 V

The measuring voltage varies linearly with deviation around the above values.
Max. dissipation in unknown 10 mW.

Long-term Accuracy: $\pm 0.02\%$ from $10\ \Omega$ to $10\ \text{M}\Omega$.
 $\pm 0.1\%$ $1\ \Omega$ to $10\ \Omega$ and $10\ \text{M}\Omega$ to $100\ \text{M}\Omega$.
 $\pm 0.5\%$ $0.1\ \Omega$ to $1\ \Omega$, and $100\ \text{M}\Omega$ to $1000\ \text{M}\Omega$.
Temperature range for above accuracy
 15 to 35 degrees C.
 $\pm 0.01\%$ from $100\ \Omega$ to $10\ \text{M}\Omega$ at 25
 ± 2 degrees C.

Meter Ranges: ± 0.1 , ± 0.2 , ± 0.5 , ± 1 , ± 2 , ± 5 , ± 10 ,
 $\pm 20\%$ deviation with 20% overrange.

Meter Accuracy: $\pm (2\%$ of full scale $+1\%$ of reading).
On 0.1 to $1\ \Omega$ range additional inaccuracy up to -10% of reading.

Meter Switch: An internal meter switch is provided.
This is connected in parallel to two contacts on the output connector to provide remote switching, if required.

Terminals: 2 twin coax connectors for 4-terminal measurement, 2 screw terminals for 2-terminal measurement, ground terminal

Filter: An internally switched 2-section filter is provided. The filter timeconstant may be varied as required by installing the appropriate capacitor values.

Settling Time: With filter switched off the maximum settling time for the deviation output is 5 milliseconds from $10\ \text{M}\Omega$ to $100\ \Omega$. 10 milliseconds 10 to $100\ \Omega$, 50 milliseconds 1 to $10\ \Omega$, and 200 milliseconds 0.1 to $1\ \Omega$.
Settling time is reckoned from open circuit condition to within 0.05% deviation from final value.

Meter Output: $\pm 10\ \text{V}$ full scale (including overrange),
max. $\pm 10\ \text{mA}$. Accuracy $\pm 2\%$ of output.

Deviation Output: $0.5\ \text{V}/\%$ deviation, max $\pm 12\ \text{V}$, $\pm 10\ \text{mA}$.
Accuracy $\pm 0.5\%$ of output. Stability $\pm 0.1\%$ of output $\pm 2\ \text{mV}$.

DC Supply Outputs:	+15 V, max. 0.1 A. -15 V, max. 0.1 A. +12 V, max. 0.2 A.
Limit Module Facilities:	The instrument is prewired for mounting limit module in the right-hand free space of the cabinet.
Power:	90 to 130 V and 180 to 260 V, 50 to 60 Hz. Max. consumption 25 W.
Dimensions:	19 inch rack cabinet, 360 (deep) x 195 (high) mm overall dimensions.
Total Net Weight:	8.3 kg.
Accessories supplied:	3-core power cable, 13 pole output cable connector, 2 twin coax connectors

Limit Modules

A basic module has been designed which by small alterations can cover the most common requirements, for example

- 1 Channel System with adjustable low and high limits. Yellow, green, and red lamps to indicate LOW, PASS, HIGH conditions. Outputs are available as options.
- 2 Channel System (for example $\pm 5\%$ and $\pm 10\%$) with light indication for PASS 1, PASS 2, and REJECT. Outputs are available as options.

2. OPERATING INSTRUCTIONS

2.1. SETTING-UP

Check that the mains voltage selector on the rear panel is set to the actual supply voltage. To change the setting, pull the switch knob, turn to the correct position and push back. Check that a 0.5 A slow-blow fuse is fitted.

2.1.1. Earth Connection

For measurements on high-value resistors the instrument must be grounded either to the power supply ground via the green/yellow supply lead or to a local ground using the front panel ground terminal.

2.1.2. Measuring Cables

The measuring cables should be twin-lead types. A shielded cable should be used for the detector input with the shield connected to the connector ground.

For best accuracy on low ranges, the resistance per lead should be about 25 m Ω corresponding to a 1 meter length of 0.75 mm² wire.

2.1.3. Zero Check

Before making any measurements, a zero check must be made. Switch to check zero, set range switch to 1 to 10 Ω , highest value decade to 10 and meter switch to 1%. Short circuit the X terminals on front panel. Adjust zero pot. for meter zero. This adjustment is only important on the lowest ranges and has practically no influence above 1 k Ω .

2.2. MEASUREMENTS

Set nominal resistor value on the 5-decade resistor. The highest value (left-hand) dial should normally be set between 1 and 10, but measurements are possible at settings of zero on this dial and down to 8 on the next dial. Set range switch to the required range. The range markings on either side of the index indicate the resistance values corresponding to the setting 1 and 10 on the highest value decade dial. Set meter switch to the required range and mode switch to MEASURE.

Connect the unknown resistor using the cables for four-terminal measurements or the screw terminals for two-terminal measurement.

Read deviation on meter using the scale corresponding to the meter range switch setting.

2.2.1. Low Value Resistors

On the two lowest ranges the instrument is calibrated for measuring cables of 1 meter length. If longer cables are used, small errors will appear. An additional lead resistance of 50 milliohms for each lead results in a 0.06% low reading on the 1 to 10 Ω range and 0.02% on the 10 to 100 Ω range. This lead resistance corresponds to a 2 meter increase in length of each lead (cross section 0.75 mm²).

On the low ranges, due to the low value of measuring voltage, drift and noise in the amplifiers A3 and A4 become progressively more evident. The normal noise fluctuations observed on the meter on the 1 to 10 Ω range are about 0.005% deviation peak to peak, while drift is of the order of 0.02% over an 8 hour period at reasonably constant temperatures.

On the 0.1 to 1 Ω range, 10 times the above values will appear, so that on this range meter ranges below 1% are of limited use.

2.2.2. High Value Resistors

When accurate measurements of high value resistors are made it may be necessary to shield the measuring circuit to reduce errors due to hum. Excessive hum causes errors on the lower deviation ranges, or, if a limit detector is used, limit errors appear.

2.2.3. Filter Circuit

A 2-section filter is mounted internally on the main amplifier board. A switch on the board activates the filter when moved towards the front panel. Access to the board is obtained by removing the top panel.

The filter constants may be altered as required by changing the capacitors mounted above and below the filter switch. Capacitors of 0.5 μ F value give a hum reduction at 50 Hz of about 45 dB and settling time of less than 0.3 seconds.

2.2.4. Outputs

Two deviation outputs are provided at the rear output connector. One is an output directly proportional to deviation giving 0.5 V per % deviation and may be employed to drive a limit selector.

The second output is proportional to meter deflection, giving ± 10 volt for full scale meter reading ($\pm 1.2\%$ to $\pm 24\%$ according to range). This may be employed e.g. for driving a remote meter or to drive a limit selector when high output at small deviations is required.

A switch at the rear end of the circuit board in its upper position switches the meter out of circuit and to contact 5 on the output connector. The meter may then be switched remotely by connecting contacts 3 and 5, or the meter may be connected e.g. to a sample-hold circuit to display the sampled values.

3. CIRCUIT DESCRIPTION

The circuit functions as a 4-terminal bridge and employs operational amplifiers to determine the bridge ratios.

The main bridge circuit comprises the unknown resistor in series with the standard which is switched in steps of 1 - 3.3 - 10 between 100 Ω and 1 M Ω by the range switch.

The junction point between the standard and the unknown is connected to the detector amplifier input and constitutes a virtual earth at zero potential. The voltage across the unknown resistor is determined by the measuring voltage amplifier obtaining its reference from the negative 15 volt supply and setting the voltage by feedback resistors changed in steps of 1 - 3 - 10 by the range switch.

A second feedback loop from the detector output balances the bridge for deviations from the nominal value by varying the measuring voltage accordingly.

The voltage across the standard is controlled by a +8 volt reference voltage obtained through an inverter from the -15 volt supply.

This is applied through the decade resistor standard

to the standard voltage amplifier. The amplifier output varies inversely with the decade setting from -8 volt at 1 to -0.8 volt at 10 on the highest decade.

The output from the detector is strictly proportional to the deviation from the indicated value due to the balancing feedback. This output is fed into an inverter to obtain correct output polarity and low source impedance. The inverter output supplies 0.5 V per % deviation for limit detection. It also feeds the meter amplifier via a range switch.

3.1. DETAILS OF CIRCUIT

3.1.1. Bridge Circuit Board

The measuring voltage amplifier consists of a monolithic operational amplifier A5 driving an emitter follower T4 to supply the current required for low value resistors (up to 80 mA). The output voltage is insufficient for the 3 highest ranges, and these are fed from a 170 volt supply via a constant-current circuit and controlled by a shunt regulator. The current through the shunt transistor T2 is controlled by the low voltage regulator, thus closing the regulating loop. The constant-current circuit improves regulation and limits the output current to a safe value - about 2 mA.

The standard voltage amplifier A4, T5 is similar to the measuring amplifier except that the output is of opposite polarity and no high voltage supply is required.

The output of the detector amplifier A6 is of the same polarity as the input error signal to obtain correct feedback to the measuring voltage amplifier. Internal feedback in A6 is dimensioned to obtain a cut-off frequency low enough to ensure stable operation for all measuring voltages and for capacitive generator loads up to 400 pF.

A compensating circuit feeds a current set by P7 into the detector amplifier (A6) input to compensate the input current, in order to eliminate errors at high value resistor measurement.

For low value resistor measurement, a compensating voltage proportional to the measuring current is fed

to the inverting input of A6. This compensating voltage is adjusted to the correct voltage by adjusting P5.

This compensates the small error due to the finite transconductance of amplifier A5, T4.

The amplifiers A5 and A6 are selected for low offset voltage and temperature drift and the offsets are nulled by pre-set pots P3 and P8. "ADJ.ZERO" on the front panel allows correction of temperature drift and long-term drift.

Amplifiers A1, A2 and A4 are nulled by pre-set pots P4, P6 and P2 respectively.

To facilitate zero checks and adjustment the inputs to A4 and A5 may be switched to zero by a 2-pole switch ("CHECK-MEASURE"). The reference inverter A3 is nulled by P1 which also serves as a ratio adjuster to compensate small overall ratio errors in the complete circuit by varying A3 output.

An internally switchable filter switches capacitors across the feedback resistors of A6 and A2 to reduce hum and noise if required.

The decade resistor is a 5-dial decade with values $10 \times 10 \text{ k}\Omega$, $10 \times 1 \text{ k}\Omega$, $10 \times 100 \Omega$, $10 \times 10 \Omega$ and $10 \times 1 \Omega$.

3.1.2. Range Switching

The 5 middle ranges (from 100Ω to $10 \text{ M}\Omega$) employ switching of the measuring voltage feedback resistors in steps of $1 \text{ k} - 3 \text{ k} - 10 \text{ k} - 30 \text{ k} - 100 \text{ k}\Omega$ concurrent with standard resistor values in steps of $1 \text{ k} - 3.333 - 10 \text{ k} - 33.33 - 100 \text{ k}\Omega$.

On the 3 lowest ranges a current divider reduces the reference current to the measuring voltage amplifier to $1/10$. The feedback resistors for these ranges are $100 \Omega - 1 \text{ k}\Omega - 3 \text{ k}\Omega$ and the standard resistors $100 \Omega - 100 \Omega - 333.3 \Omega$.

On the two highest ranges the feedback resistor is $100 \text{ k}\Omega$ and the standard resistor $1 \text{ M}\Omega$. On the highest range the standard resistor is fed from a voltage divider, which reduces the standard voltage to $1/10$.

3.1.3. Power Supply

The power supply is mounted on the rear panel. Regulated outputs of $+15 \text{ V}$ and -15 V are provided. These are adjustable by pre-set pots.

An unregulated +170 V output feeds the high-voltage stabilizer, and an additional 12 volt unstabilized supply is provided for driving a plug-in limit module which may be mounted beside the bridge module.

4. MAINTENANCE INSTRUCTIONS

To maintain the high accuracy of this instrument, we recommend that the most critical adjustments are checked periodically. This refers mainly to the adjustments detailed in 4.2. and 4.3.

The other adjustments described will normally only be necessary if the corresponding amplifier or associated components have been replaced.

Using the check zero switch, most of the adjustments may be checked and readjusted if required, as described below.

To gain access to the pre-set pots., remove the top panel. The number of the pots. are marked on the print side of the circuit board and their location is also shown on the component layout drawing.

4.1. METER ZERO

Check mechanical zero with instrument switched off and readjust if necessary.
Switch on instrument and set meter switch to OFF.
Adjust P4 for zero reading.

4.2. STANDARD VOLTAGE ZERO

Set check switch to CHECK ZERO, meter switch to 0.1%, decade to 11,000 and range switch to 100 to 1 k.
Connect a resistor about 1 k to X-terminals.

Note deflection on meter. Switch highest decade repeatedly between 1 and 0 and adjust P2 for zero change.

4.3. DETECTOR ZERO AND MEASURING VOLTAGE ZERO

These two adjustments are interdependent so they must be repeated alternately for correct final setting.

Set check switch to CHECK ZERO, meter switch to 1%, decade to 1000 and range switch to 1 to 10 Ω . Connect a decade resistor adjustable to 1 k to X (or connect a 1 k resistor across X-terminals).

Set X to 1 k and adjust P8 for meter zero.
Set X to zero (or short X-terminals) and adjust P3 for meter zero. Repeat adjustments until zero is obtained for both settings.

Note: If the pots. are grossly misadjusted, set resistance range switch to a higher setting and switch to the lower range for final adjustment. This will normally only be necessary if the respective amplifier has been replaced. The ranges of P8 and P3 have been deliberately limited to allow precise adjustment. Some selected amplifiers may have offsets outside the adjustment range. A resistor 562k mounted alongside the amplifier on the pcb may be connected by a wire strap to either the +15 or -15 V line as required to shift the range.

4.4. DEVIATION OUTPUT ZERO

P6 adjusts the offset of A2 to obtain zero output with zero input.

To adjust P6, connect a DVM to A6 output, short X-terminals, set range to 1 to 10 k Ω , decade to 100.000 and meter switch to 0.1%. Set to check zero and adjust zero on front panel for DVM zero (within ± 0.5 mV). Connect DVM to A2 output and adjust P6 for DVM zero. Check that meter reads zero within $\pm 0.001\%$.

Readjust "ADJ. ZERO" on front panel on a low range.

4.5. RATIO ADJUSTMENT

P1 sets the overall bridge ratio by slightly altering the standard reference voltage. It is factory-set to achieve the best possible mean accuracy on all ranges and decade settings. Re-adjustment of this pot. should only be attempted if accurate standards are available e.g. standards of 1 k Ω , 10 k Ω , and 100 k Ω $\pm 0.005\%$ or better and a decade resistor or transfer standard with 10 steps equal within less than $\pm 0.005\%$.

Using these standards the four middle ranges may be checked and P1 adjusted for a mean accuracy better than 0.01

4.6. HIGH VALUE INPUT CURRENT ADJUSTMENT

P7 sets the input current compensation. Connect a high value resistor (about 100 M Ω or higher) to the X-terminals. Set to CHECK ZERO, decade to 100,000, range to 10 M to 100 M, meter switch to 1%.

Adjust P7 for meter zero.

4.7. LOW VALUE CORRECTION

If the amplifier A5 or emitter follower MPS U2 have been changed it may be necessary to adjust P5. This corrects the error at low values due to the finite transconductance of the amplifier circuit causing a too high reading at low resistance values. The correction is normally about 0.05% at 1 Ω and is thus not very critical. For checking the correction an accurate 1 Ω four-terminal standard is required.

Connect the standard by the four-terminal cables, set range to 1 - 10 Ω , decade to 10,000, check the zero adjustment and then switch to measure. Adjust P5 to obtain correct meter reading.

4.8. SUPPLY VOLTAGE ADJUSTMENT

The +15 and -15 volt supplies are stabilized by a dual integrated circuit.

The bridge balance is nearly independent of supply voltage variations.

The deviation output and meter deflection are both proportional to the negative voltage, so this should vary less than $\frac{1}{2}\%$ for accurate readings.

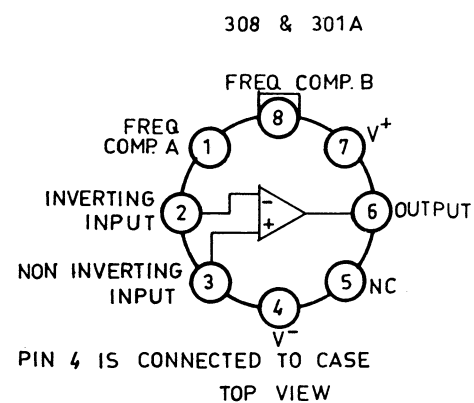
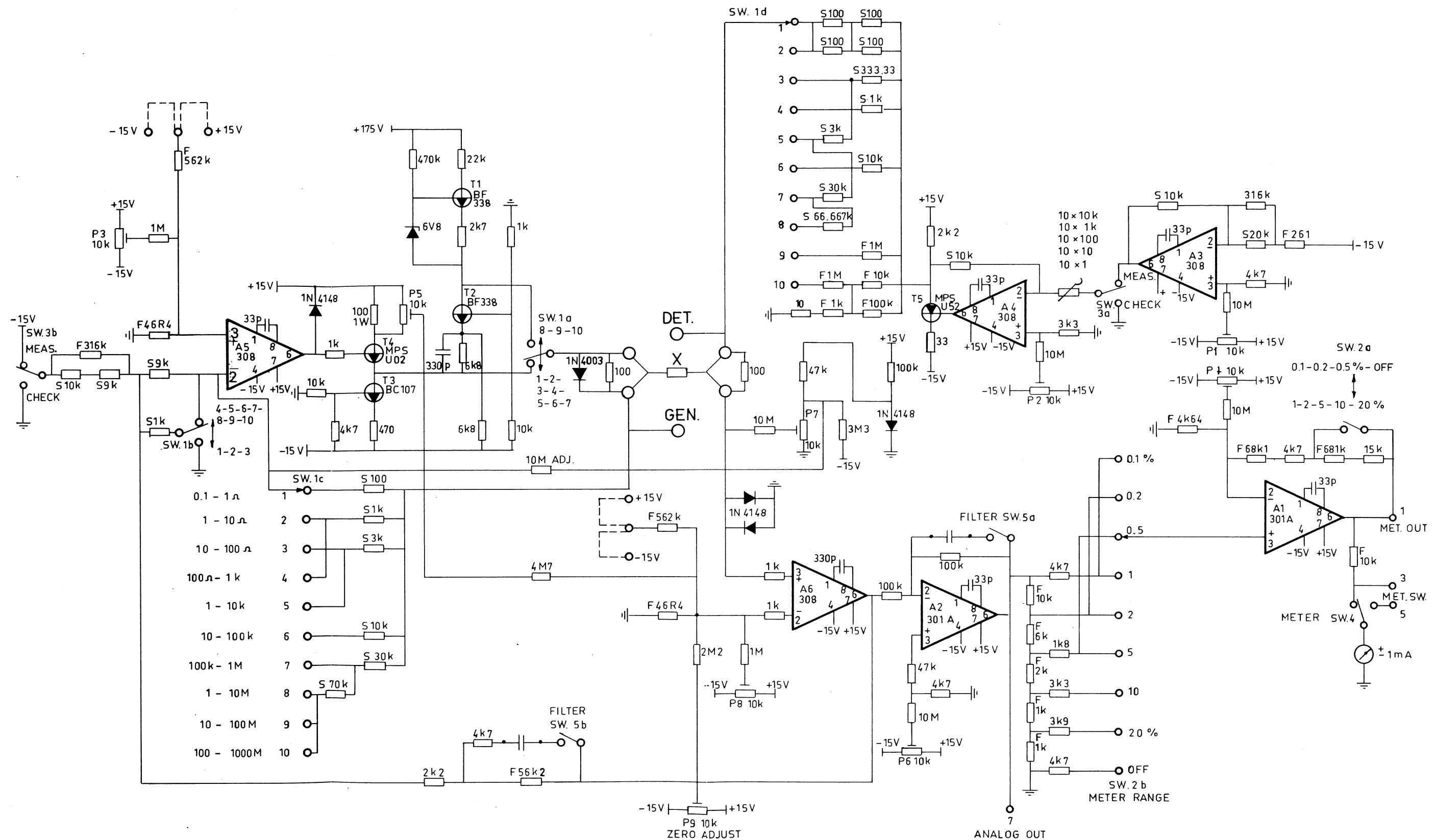
If a limit selector with calibrated dial is employed, the tracking of the two supplies becomes important, because this determines the accuracy of limit setting.

The outputs may be checked using a DVM and adjusted by the two 1-turn pots. on the power supply board.

4.9. CRITICAL COMPONENTS

The amplifiers A5 and A6 are selected and matched units and replacement pairs should be ordered from Danbridge.

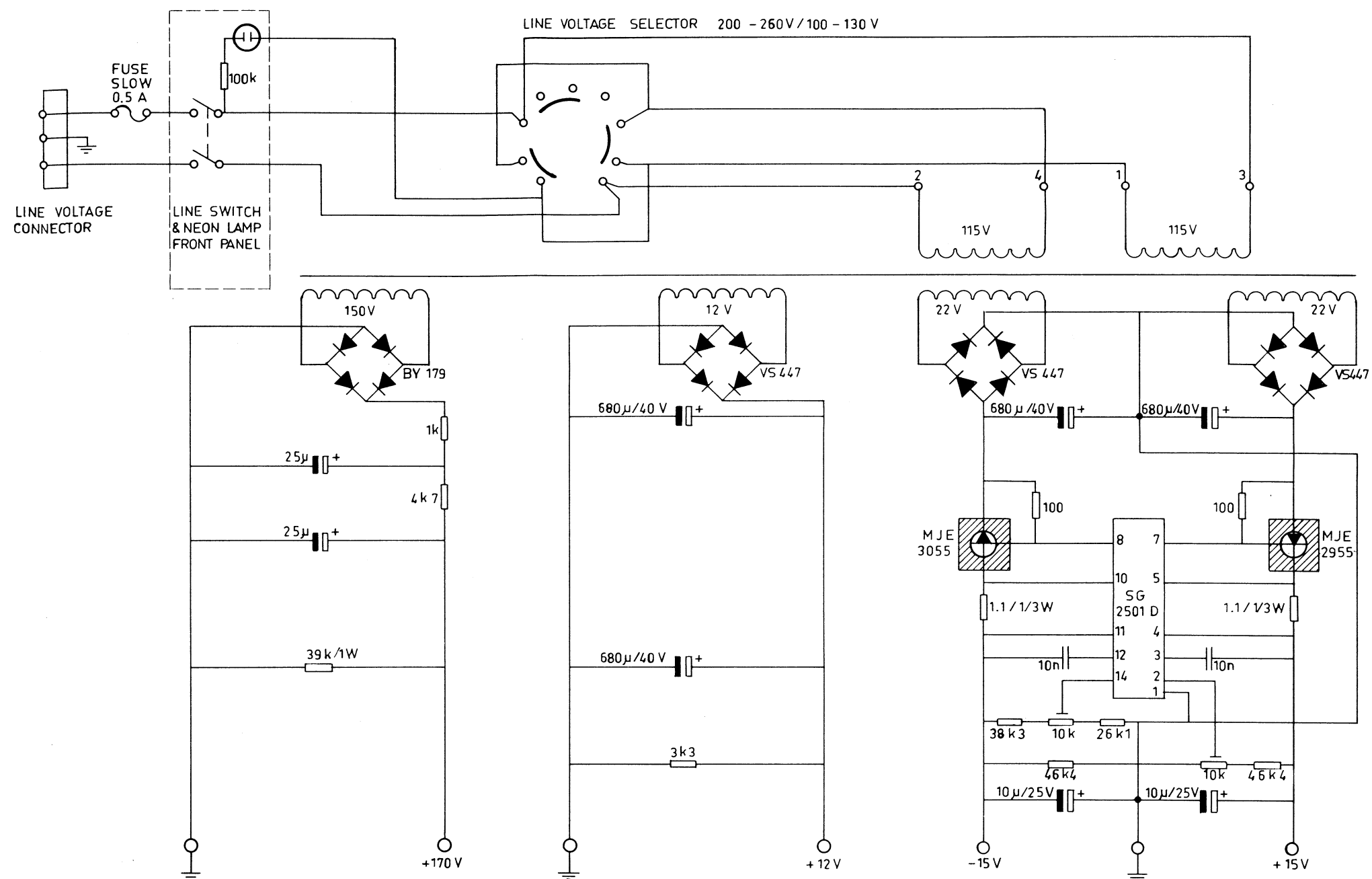
All ratio resistors on the range switch as well as the decade resistors are matched in value to better than 0.003% and if any of these resistors are faulty the instrument should be returned to Danbridge for repair and re-adjustment.





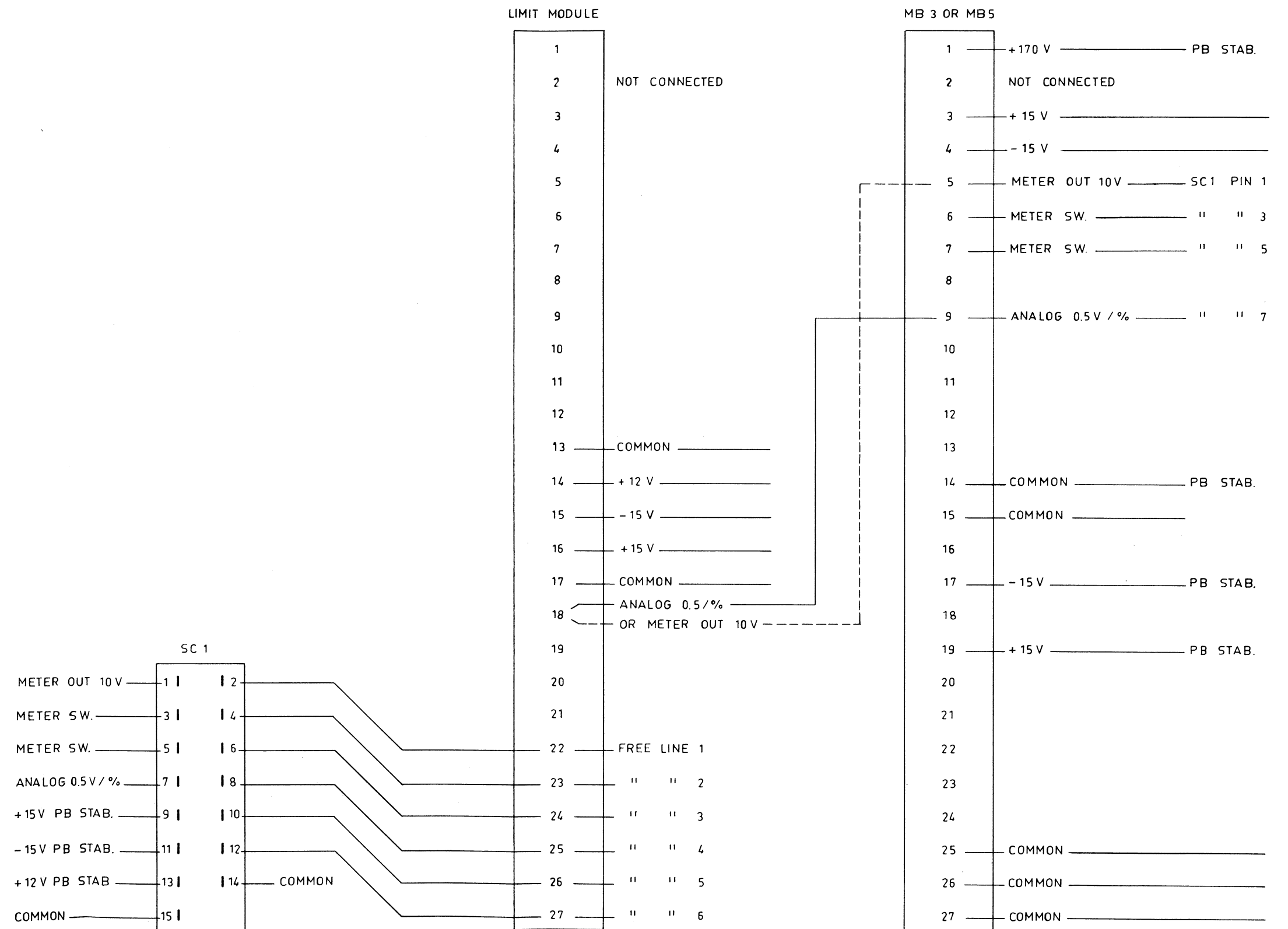
RESISTORS MARKED S : PRECISION TYPE 0.02 %
ON RANGE SWITCH MATCHED
WITHIN 0.003 %

RESISTORS MARKED F : METALFILM 1 %

85042-1	MB 5 BRIDGE CIRCUIT				
RETTET		GODK.	RETTET	GODK.	
TEGNET		130674 B. Ras.			
KONSTR.		VAGN JENSEN			
GODK.					
A/s DANBRIDGE.					



85040 - 2 85042	MB 3 & MB 5 POWER SUPPLY				
		130675 BR			
RETTET		GODK.	RETTET	GODK.	
TEGNET		210574 B. Ras.			
KONSTR.		VAGN JENSEN			
GODK.					
A/s DANBRIDGE.					



85040-3 85042-3 A/s DANBRIDGE.	MB 3 & MB5						
	INTERCONNECTION WIRING BETWEEN CONNECTORS			RETTET	GODK.	RETTET	GODK.
	(SEEN FROM REAR OF CABINET)			TEGNET		220574 B. Ras.	
				KONSTR.		VAGN JENSEN	
				GODK.		J	

