TRUE R.M.S. VOLTMETER VM 1484

SOLARTRON

SOLARTRON

TECHNICAL MANUAL

OPERATIONAL MANUAL

FOR

TRUE R.M.S. VOLTMETER

TYPE VM 1484

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

SECTION 1

INTRODUCTION

1. The VM 1484 is an r.m.s. responding voltmeter measuring a.c. signals of up to 300 volts r.m.s. over the frequency range 10 c/s - 10Mc/s. The instrument employs a patented thermocouple circuit* which eliminates the sluggish response and susceptibility to temperature changes, which characteristics normally limit the usefulness of thermocouple devices. An automatic power limiting circuit takes count of both peak and average values of signal input to provide protection against damage from overload. It also enables the instrument to be used for the accurate measurement of low duty-cycle pulse trains and noise. Facilities are provided to permit the accurate setting of the input capacitance of an RC passive probe, which can then be used in conjunction with the instrument without any degradation of specification. Square-wave signals of accurately defined amplitude are provided for the calibration of the two basic ranges.

* This circuit is the subject of letters patent granted to Weston Instruments Inc., an associate company of Solartron within the Schlumberger Group.

SECTION 2

SPECIFICATION

2. Voltage Range

12 ranges from 1mV f.s.d. to 300V f.s.d., in 1, 3, 10 sequence.

Total calibrated range -72dB to +52dB, referred to 1mW into 600 ohms.

Useful indications to ~~100μV~~. 1% ± 1% Fsd

Meter Ranges

Voltage 0-1, and 0-3.

Decibels -12 to +2dBm.

Frequency Range

10 c/s - 10Mc/s.

Accuracy

±1% of f.s.d. from 50 c/s - 1Mc/s.

±2% of f.s.d. from 1Mc/s - 2Mc/s.

±3% of f.s.d. from 2Mc/s - 3Mc/s.

±5% of f.s.d. from 3Mc/s - 10Mc/s.

±5% of f.s.d. from 10c/s - 50c/s.

Response Time

Typically 3 seconds to 1% of final reading.

Response

Responds to r.m.s. (heating) value of a.c. signal input.

Crest Factor Rating

(ratio of peak amplitude to r.m.s. value)

8: 1 at f.s.d.

Proportionally greater at fractions of f.s.d.,

viz; 16: 1 at half-scale, and 32: 1 at quarter-scale.

Input Impedance

10MΩ shunted by 25pF on the mV ranges.

10MΩ shunted by 15pF on the V ranges.

Overload Protection

Maximum d.c. input, 600V

Maximum input on mV ranges, 50V p-p

Maximum input on V ranges, 450V peak

Output

+1V at f.s.d., proportional to meter deflection. Nominal source impedance, 1000 ohms.

Access, rear panel sockets.

Noise Level

With input short-circuited approximately 40µV on 1mV and 1V ranges.

Calibrator

30mV and 1V r.m.s. square-waves. accurate to 0.5% over temperature range 0-50°C.

Temperature Rating

0 - 50°C.

Power Requirement

95-125V, or 190-250V, 50-60c/s. a.c. mains.

Consumption, 24VA approximately.

Overall Dimensions and Weight

Bench Mounting Unit

Height	8¼ in.	(20.9 cm)
Width	5.5/8 in.	(14.3 cm)
Depth	13 in.	(33 dm)
Weight	14 lb	(6.3kg)

Accessories Supplied

Signal lead type CX 1564, consisting of 4ft twin coaxial, screened cable terminated with 83 UHF connector at one end, and two 4mm plugs at the other to take the provided test probes, test prods, spade terminals, or crocodile clips.

Calibrator lead type CX 1565 to connect the internally generated calibration signal to the instrument input socket.

Accessories Available

RC probe type CX 1167 incorporating a 10 : 1 resistive attenuator, and trimming capacitor.

Probe adaptor type CX 1563, for matching the CX 1167 probe to the VM 1484.

SECTION 3.

INSTALLATION AND OPERATING INSTRUCTIONS

INSTALLATION

General

3. The instrument is supplied as a fully assembled and electrically set-up unit ready for installation.

   (1) Set mains voltage selector. mounted on the rear panel of the instrument, in accordance with the declared voltage of the mains supply. Arrowhead pointing to "230" for 190-250 volts mains input, or pointing to "115" for 95-125 volts mains input.

   (2) Check presence, continuity, and rating of mains fuse carried in holder on the back panel of the instrument, 500mA for 190-250 volts mains inputs, or one ampere for 95-125 volts mains inputs.

   (3) Check mechanical zero of meter, resetting by front panel adjustment screw if necessary.

   (4) Connect mains plug to mains lead, red to line (L), black to neutral (N) and green to earth (E).

OPERATION

General

4. The calibration procedure, as described in paragraph 5, need only be performed at the commencement of each period of operation, or before making a measurement that specifically requires the absolute accuracy of the instrument. In order to minimise error arising from chopper amplifier drift, whenever possible, the range selected should be such that the reading is taken between ⅓rd of f.s.d. and f.s.d. (Refer explanatory note given in paragraph 9). In circumstances which require that minimum loading is applied to the signal source, the RC probe type CX 1167 can be used. (Refer paragraph 6).

Normal Calibration Procedure

5. (1) Apply mains power to instrument, check that POWER ON indicator lamp lights, and allow a minimum warm-up period of one minute.

   NOTE

   If the measurement is to be made to the full accuracy of the instrument, the warm-up period must be extended to 15 minutes.

   (2) Set range selector to "30mV", and by means of the short lead supplied, connect the 30mV CAL. socket to the signal INPUT socket.

Normal Calibration Procedure (continued)

(3) Adjust preset potentiometer RV101 (F.S.D.) for a reading of "3" (30mV) on the lower voltage scale.

NOTE

RV101 is one of two, internal, preset controls mounted in the upper rear left-hand corner of the instrument. Screwdriver access is gained via the ventilation slots cut in the instrument cover. The positions and sign-written legends for these preset controls are shown in Fig.1.

(4) Set range selector to "300mV", and wait for three minutes before proceeding further.

(5) Adjust preset variable resistor RV103 ("10%") for a reading of "0.3" (30mV) on the lower voltage scale.

NOTE

Refer sub-paragraph (3) and Fig. 1 for location of RV103.

(6) The instrument is now calibrated ready for use on any of the 12 ranges.

Use of RC Probe

General

6. The input signal to the instrument can be applied via an RC probe type CX 1167, if it is necessary that the loading applied to the circuit under investigation is kept to the minimum. Provided that the probe is accurately set-up, and that the VM 1484 is subsequently calibrated at the f.s.d. and 10% f.s.d. point, in accordance with the directions given in paragraph 7, the performance of the instrument will not be affected. The RC probe type CX 1167 and the probe adaptor type CX 1563 are available as optional accessories to the VM 1484 voltmeter. The procedure necessitates the use of a high-sensitivity oscilloscope, capable of delivering externally a square-wave calibrating signal.

Method of Probe Adjustment and VM 1484 Calibration

7. (1) Insert the probe type CX 1167 into the probe adaptor type CX 1563, and connect the adaptor to the INPUT socket of the instrument.

(2) Set the instrument range selector to "100mV", and stand intrument upright on its rear panel.

(3) Remove plastic button from aperture in underside of instrument case, and connect the oscilloscope input leads to the PROBE CAL. test point thereby exposed.

<u>Method of Probe Adjustment and VM 1484 Calibration</u> (continued)

(4) Set oscilloscope square-wave calibration signal to 200mV, and apply this signal to the CX 1167 probe.

(5) Adjust oscilloscope controls to give a large-scale display of the top of the square-wave.

(6) By screwdriver adjustment of the slotted brass screw at the probe tip, set the probe capacitance for optimum square-wave response.

<u>NOTE</u>

It is important that this adjustment is performed with precision, if the specified accuracy of the VM 1484 is to be maintained.

(7) Disconnect oscilloscope input leads from PROBE CAL. test point, replace plastic button, and return instrument to operational position.

(8) With the instrument still switched to the "100mV" range, apply probe to the 1V CAL. output socket on the VM 1484, and adjust the F.S.D. preset potentiometer (RV101 - Fig.1) for full-scale deflection on the instrument meter.

<u>NOTE</u>

The probe type CX 1167 incorporates a 10 : 1 resistive attenuator.

(9) Set range selector to"30mV".

(10) Apply probe to the 30mV CAL. output socket on the VM 1484, and adjust the"10%" preset variable resistor (RV103 - Fig.1) to obtain a reading of "0.3" (3mV) on the lower voltage scale.

(11) The instrument and probe are now set-up for measurement within the specified accuracy on any of the six mV ranges. If the instrument is to be used on the volts (V) ranges, a further calibration procedure must be carried out in accordance with the following directions.

(12) Set instrument range selector to "1V", and stand instrument upright on its rear panel.

(13) Remove plastic button from aperture in underside of instrument case, and connect the oscilloscope input leads to the PROBE CAL. test point thereby exposed.

(14) Set oscilloscope square-wave calibration signal to a level of the order of 20 volts, and apply this signal to the CX 1167 probe.

(15) Adjust oscilloscope controls to give a large-scale display of the top of the square-wave.

Method of Probe Adjustment and VM 1484 Calibration (continued)

(16) By screwdriver adjustment of the slotted brass screw at the probe tip, set the probe capacitance for optimum square-wave response.

NOTE It is important that this adjustment is performed with precision, if the specified accuracy of the VM 1484 is to be maintained.

(17) Disconnect oscilloscope input leads from PROBE CAL. test point, replace plastic button, and return instrument to operational position.

(18) The instrument and probe are now set-up for measurement within the specified accuracy on any of the six volts (V) ranges.

Should it subsequently be required to return to operation on the mV ranges, the calibration procedures described in sub-paragraphs (2) to (11) must be carried out.

Input Attenuator H.F. Compensation

CAUTION

8. This procedure must only be performed if, following calibration of the "30mV" range as described in paragraph 5, a reading outside of 0.5% is obtained when the instrument is switched to the "1V" range, and the 1V calibration signal applied.

A sine-wave oscillator covering the frequency range 0-100Kc/s will be required. Though the adjustment can be made by reading direct from the VM 1484 meter scale, it is preferable that a digital voltmeter, connected at the rear panel DVM sockets, be used as the indicating device. It will be necessary to remove the upper section of the case after the withdrawal of six 4BA screws.

(1) Set oscillator to deliver a 500c/s signal, and adjust the level control for zero output.

(2) Set VM 1484 range selector to "300mV", and connect oscillator output lead to the VM 1484 INPUT socket.

(3) Gradually advance oscillator output control from zero position, until the VM 1484 registers f.s.d.

(4) Making no alteration to the oscillator frequency or output controls, set the VM 1484 range selector to "1V", and note the reading now displayed.

(5) Set oscillator to deliver a 100Kc/s signal, adjust the level control for zero output, and repeat the procedure detailed in sub-paragraphs (2) to (4) preceding.

(6) If the reading obtained on the 1V range in sub-paragraph (4) at 500c/s is the same as that obtained at 100Kc/s, apply 1V calibration signal to VM 1484 INPUT socket, and adjust variable resistor RV 209 for full-scale deflection on the meter. If the readings differ proceed as described in sub-paragraphs (7) to (9) following.

Input Attenuator H.F. Compensation (continued)

NOTE RV209 is the rearmost "flatpot" of a bank of seven, mounted on the edge of board No. 2.

(7) With the 100Kc/s signal still applied at the set amplitude, adjust trimming capacitor C7, with a non-metallic trimming tool, for a reading equal to that obtained in sub-paragraph (4).

NOTE The screw threaded and slotted adjustment shaft for C7 is located at the left-hand side of the instrument, directly behind the INPUT socket.

(8) Disconnect oscillator output from VM 1484 INPUT socket and connect INPUT socket instead to the 1V CAL. socket on the VM 1484.

(9) Adjust variable resistor RV209 for full-scale deflection on the meter.

Errors arising from Chopper Amplifier Drift

9. The d.c. output from a thermocouple is a measure of the power developed in the heater, and is therefore directly proportional to the square of the input voltage driving current through the heater. The full-load output from a thermocouple of the type employed in the VM 1484 is of the order of 7000μV, which output as a result of the square-law relationship between input and output voltages, will be 770 μV at one third of full-load, and 70 μV at one tenth of full-load. Therefore, full-scale meter deflection will occur with a thermocouple output of 7000 μV, and one third and one tenth full-scale deflections with thermocouple outputs of 770 μV and 70 μV respectively. Thus a drift of 7 μV in the chopper amplifier would represent an error of 5% of reading at one tenth f.s.d., and an error of less than 0.5% of reading at one third of f.s.d. It is therefore recommended that whenever possible, the range selected for any measurement is such that the reading is taken between the $\frac{1}{3}$ f.s.d. and f.s.d. points of the meter scale.

Measurement of High Crest-Factor Waveforms

10. The crest factor of a waveform is, by definition, the ratio of the peak value to the r.m.s. value. The crest factor rating of an r.m.s. voltmeter is a measure of its ability to read accurately the r.m.s. values of low duty-cycle pulse trains and waveforms of indeterminate shape. The crest factor of a low duty-cycle pulse train of the nature of those illustrated in Fig. 2, can be calculus be shown to be equal to $\frac{t_2}{t_1}$. The VM 1484, which has a specified crest factor at f.s.d. of at least 8 : 1, is therefore able to measure accurately at full-scale the r.m.s. value of any pulse train in which the ratio of t_2 to t_1, does not exceed 64. The pulse train measurement potential of the VM 1484 can best be appreciated by consideration of the waveforms shown in Fig. 2. That at (a) has a crest factor of 3, and that at (b) a crest factor of 8, both of which can therefore be measured at full-scale deflection to specified accuracy. When the crest factor of the waveform exceeds 8, the VM 1484 overload protection circuits come into operation to limit the power dissipated in the signal thermocouple, as a result of which, readings taken at full-scale deflection are outside the specified accuracy.

Measurement of High Crest-Factor Waveforms (continued)

However, pulse trains of crest factor greater than 8 can be measured to specification provided that the reading is taken within the confines of a reduced linear sector of the scale. The upper limit of this linear scale sector for a waveform of known crest factor can be established by dividing the rated f.s.d. crest factor of 8, by the crest factor of the waveform under investigation. Thus for a signal having a crest factor of 16, this upper limit will occur at half-scale($\frac{8}{16}$) deflection, and having regard to the drift considerations mentioned in paragraph 9, the specified accuracy of measurement will only be attained if the reading is taken between ⅓rd f.s.d. and half-scale. Generally, the crest factor of the signal waveform will be capable of determination by inspection on an oscilloscope, or if the signal originates from a pulse generator, by reference to the generator period and duration controls. In circumstances where these methods cannot be applied, the presence of overload due to excessive crest factor can be established by initially selecting a VM 1484 range which gives a deflection approaching full-scale, and then proceeding to the next range up, and checking that the same reading is obtained. Should the second reading be greater than the first, it can be assumed that the instrument was overloaded on the first selected range.

11. The mathematical derivation of the expressions for the r.m.s. value and crest factor of a typical pulse train (Fig.2a) follow.

V_p = peak voltage relative to average voltage.

V_a = average voltage.

The r.m.s. value of the waveform is:-

$$V_{r.m.s.} = \sqrt{\frac{1}{t_1 + t_2}\left(\int_0^{t_1} V_p^{\,2}\, dt + \int_0^{t_1} V_a^{\,2}\, dt\right)}$$

$$= \sqrt{\frac{V_p^{\,2}\, t_1}{t_1 + t_2} + \frac{V_a^{\,2}\, t_2}{t_1 + t_2}} \qquad 1$$

but $V_p t_1 = V_a t_2$ 2

$$\therefore V_a = \frac{V_p t_1}{t_2}$$

Substitute 2 in 1,

$$V_{r.m.s.} = \sqrt{V_p^{\,2}\frac{t_1}{t_2}} = V_p\sqrt{\frac{t_1}{t_2}}$$

$$\text{Crest factor} = \frac{V_p}{V_{r.m.s.}} = \sqrt{\frac{t_2}{t_1}}$$

Paragraph 11. (continued)

Note that had the d.c. term been included the crest factor would become

$$\sqrt{\frac{t_1 + t_2}{t_1}}$$

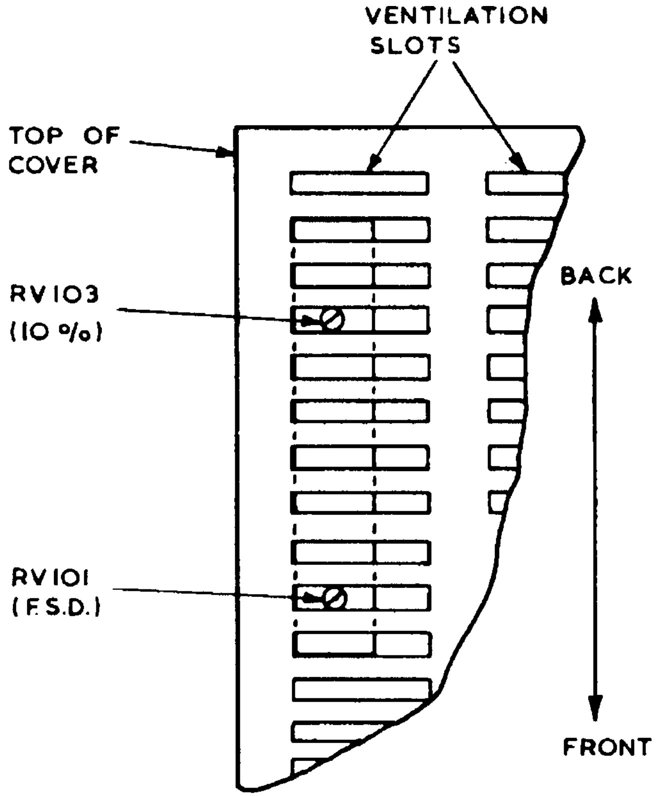
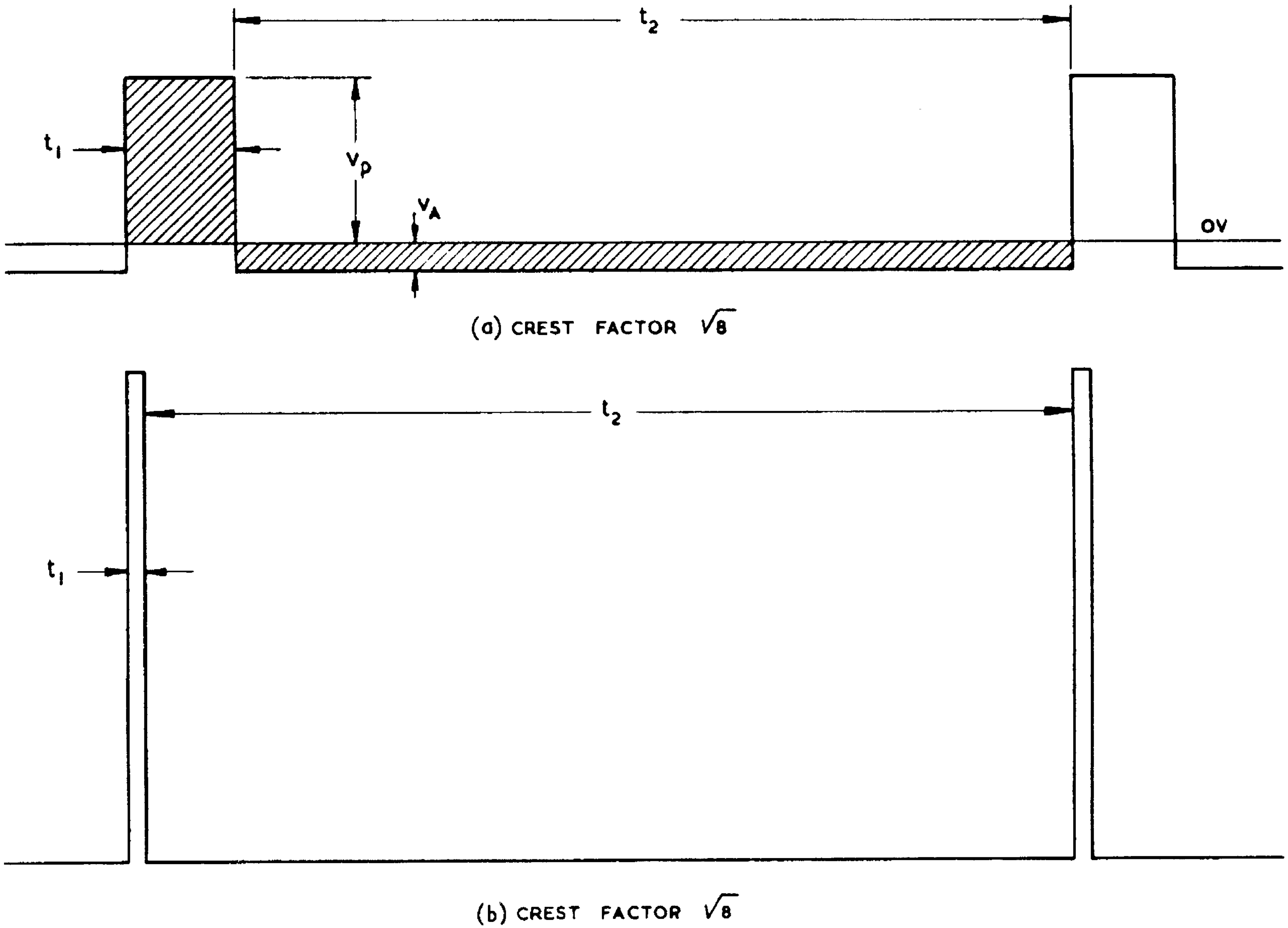
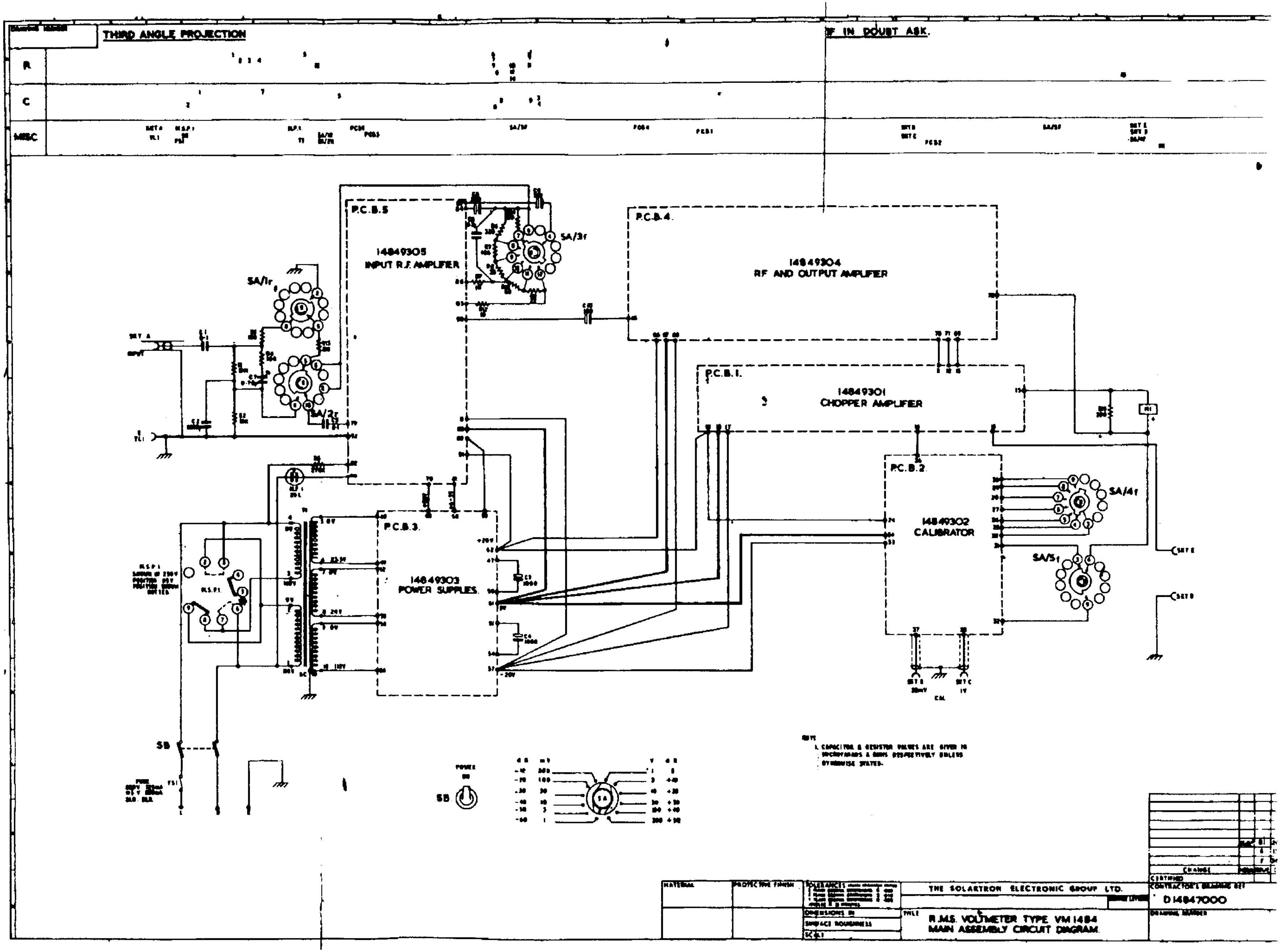


FIG. 1. LOCATION PRESET CONTROLS



(b) CREST FACTOR √8

FIG 2 TYPICAL PULSE TRAINS

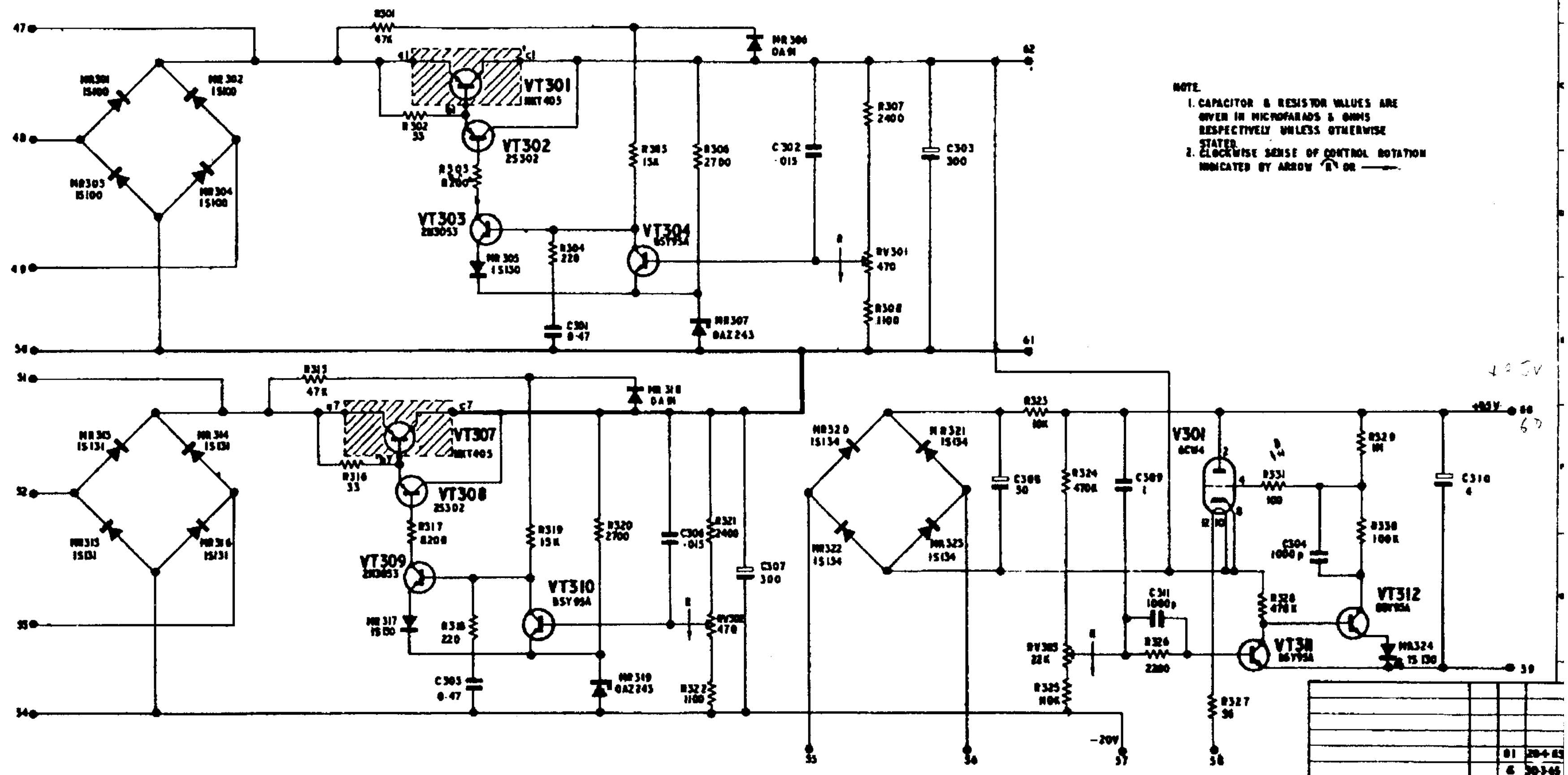


THIRD ANGLE PROJECTION
IF IN DOUBT ASK.
R
C
MISC
P.C.B.5
14849305
INPUT R.F. AMPLIFIER
SA/3r
P.C.B.4.
14849304
RF AND OUTPUT AMPLIFIER
SA/1r
SA/2r
P.C.B.1.
14849301
CHOPPER AMPLIFIER
P.C.B.2
14849302
CALIBRATOR
SA/4r
SA/5r
P.C.B.3.
14849303
POWER SUPPLIES.
+20V
-20V
SB
POWER
SB
NOTE
1. CAPACITOR & RESISTOR VALUES ARE GIVEN IN MICROFARADS & OHMS RESPECTIVELY UNLESS OTHERWISE STATED.
MATERIAL
PROTECTIVE FINISH
TOLERANCES
DIMENSIONS IN
SURFACE ROUGHNESS
SCALE
THE SOLARTRON ELECTRONIC GROUP LTD.
TITLE
R.M.S. VOLTMETER TYPE VM1484
MAIN ASSEMBLY CIRCUIT DIAGRAM.
CHANGE
CERTIFIED
CONTRACTOR'S DRAWING REF
D14847000
DRAWING NUMBER

DRAWING NUMBER

THIRD ANGLE PROJECTION — **IF IN DOUBT ASK.**

R	315 318 301 302 317 303 316 319 304 320 305 306 321 322 307 308 323 324 325 326 327 331 328 329 330
C	305 301 306 307 302 303 308 311 309 304 310
MISC.	MR301 MR303 MR313 MR315 MR302 MR304 MR314 MR316 VT307 VT308 VT309 MR317 VT301 VT302 VT303 MR305 VT310 VT304 MR318 MR319 MR307 RV302 MR306 RV301 MR320 MR322 MR321 MR323 RV303 V301 VT311 MR324 VT312



CHANGE		ISSUE	DATE
		01	20-4-65
		6	30-3-65

CERTIFIED

CONTRACTOR'S DRAWING REF.

C 14849303

DRAWING NUMBER

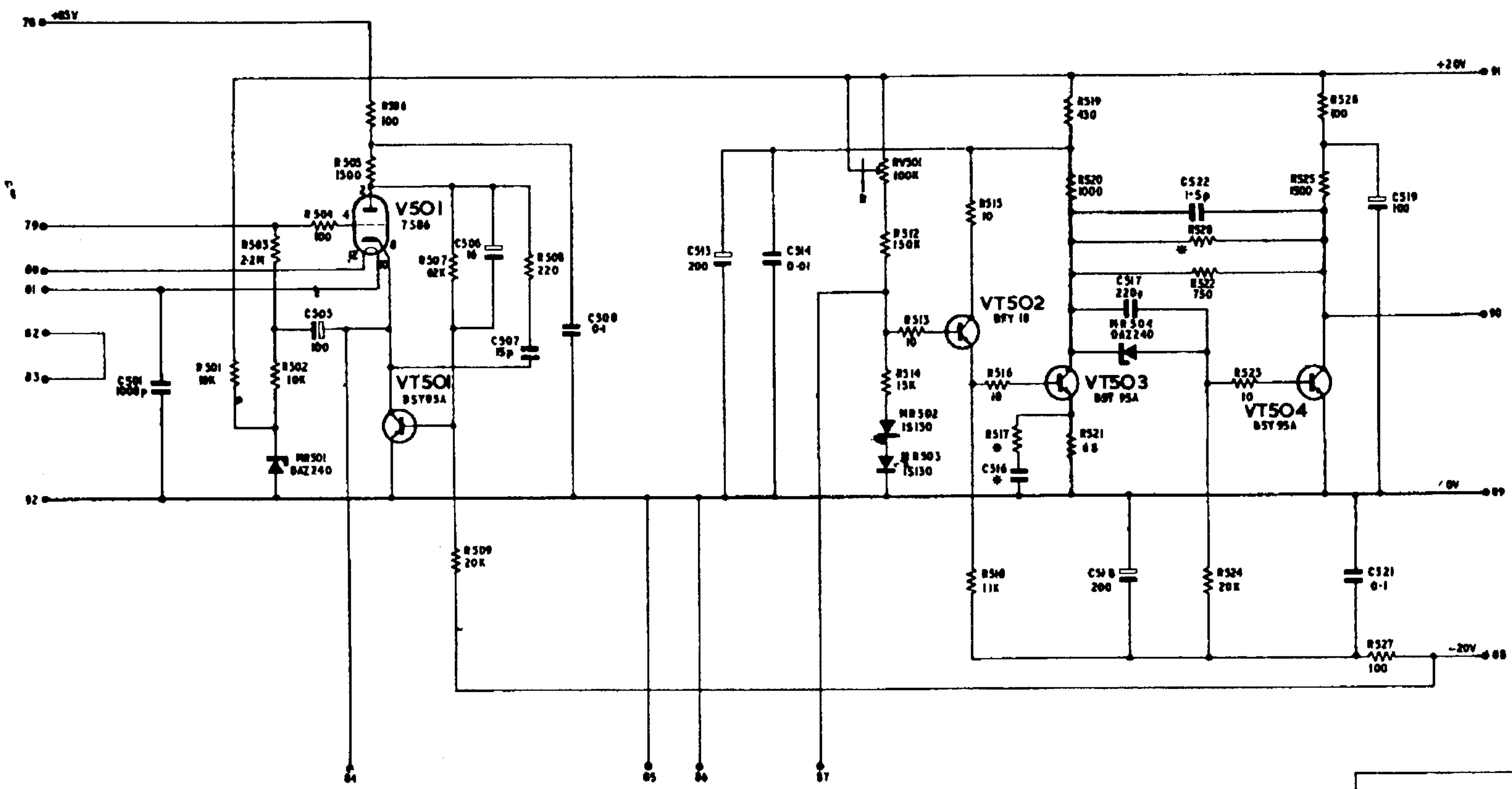
MATERIAL	PROTECTIVE FINISH	TOLERANCES	THE SOLARTRON ELECTRONIC GROUP LTD.
		DIMENSIONS IN	TITLE: POWER SUPPLIES.
		SURFACE ROUGHNESS	
		SCALE	

DRAWING NUMBER

THIRD ANGLE PROJECTION

IF IN DOUBT ASK.

R	501 503 502 504 506 505 507 509 508 512 513 514 515 516 518 517 519 520 521 522 524 523 528 525 526 527
C	501 503 506 507 508 513 514 516 517 518 522 519 521
MISC	MR501 V501 VT501 RV501 MR502 MR503 VT502 MR504 VT503 VT504



1. * TO BE SELECTED ON TEST.
2. CAPACITOR & RESISTOR VALUES ARE GIVEN IN MICROFARADS & OHMS RESPECTIVELY UNLESS OTHERWISE STATED.
3. CLOCKWISE SENSE OF CONTROL ROTATION INDICATED BY ARROW 'R' ON →

		01	20-4-65
		E	30-3-65
		D	21-10-64
COMPONENTS REMOVED		C	21-8-64
		B	18-6-64
CHANGE	MOD No.	ISSUE	DATE

MATERIAL

PROTECTIVE FINISH

TOLERANCES UNLESS OTHERWISE STATED
3 PLACE DECIMAL DIMENSIONS ± .005
2 PLACE DECIMAL DIMENSIONS ± .010
1 PLACE DECIMAL DIMENSIONS ± .020
ANGLES ± 15 MINUTES

DIMENSIONS IN

SURFACE ROUGHNESS

SCALE

THE SOLARTRON ELECTRONIC GROUP LTD.

SERVICE LETTERS

TITLE

INPUT R.F. AMPLIFIER

CERTIFIED

CONTRACTOR'S DRAWING REF.

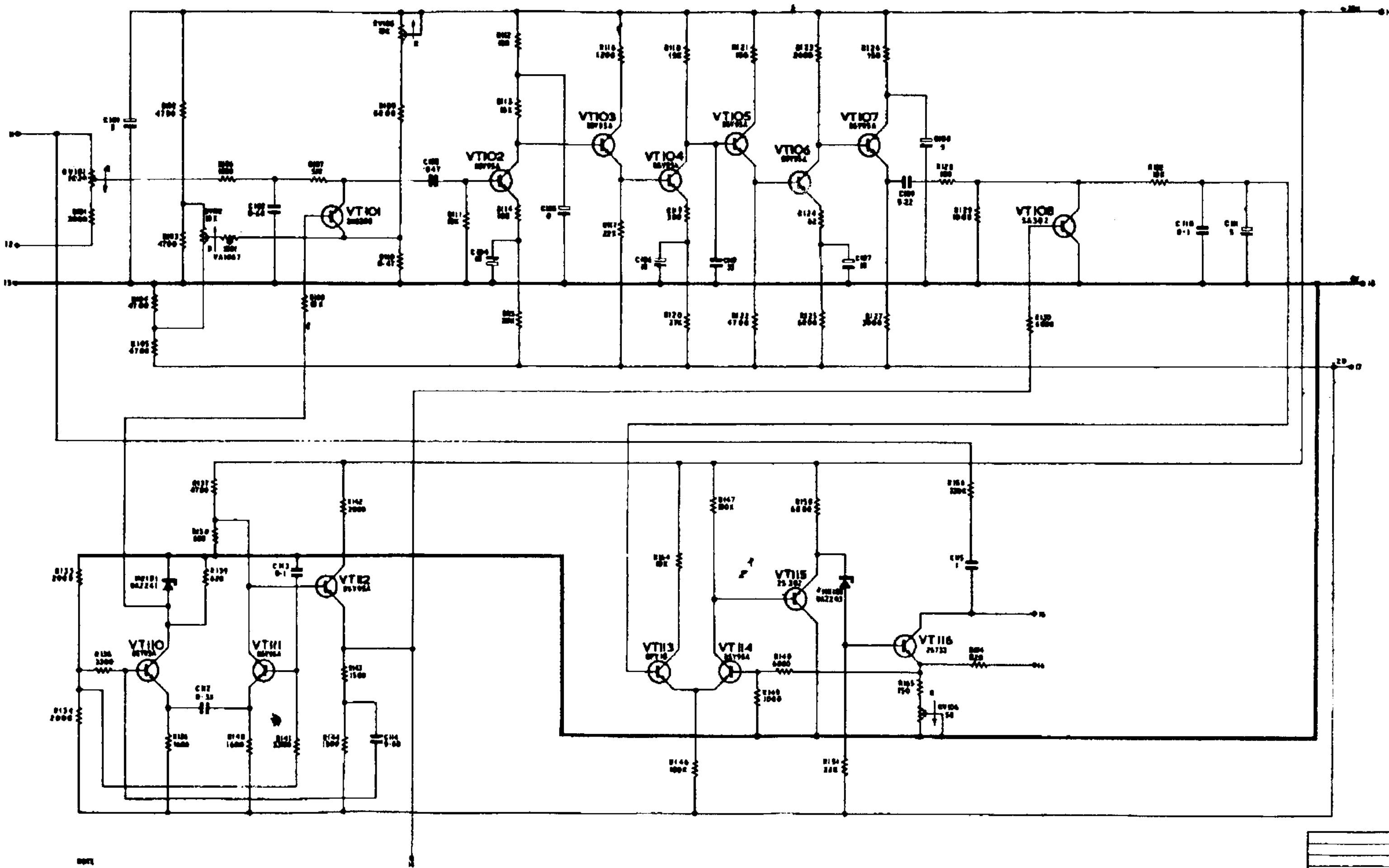
C14849305

DRAWING NUMBER

THIRD ANGLE PROJECTION

IF IN DOUBT ASK.

R
C
MISC



NOTE

1. CAPACITOR & RESISTOR VALUES ARE IN MICROFARADS & OHMS RESPECTIVELY UNLESS OTHERWISE STATED.
2. CLOCKWISE SENSE OF CONTROL ROTATION INDICATED BY ARROW OR ——.

MATERIAL	PROTECTIVE FINISH	TOLERANCES
		DIMENSIONS IN
		SURFACE ROUGHNESS
		SCALE

THE SOLARTRON ELECTRONIC GROUP LTD

TITLE: CHOPPER AMPLIFIER.

CHANGE | ISSUE | DATE

CERTIFIED

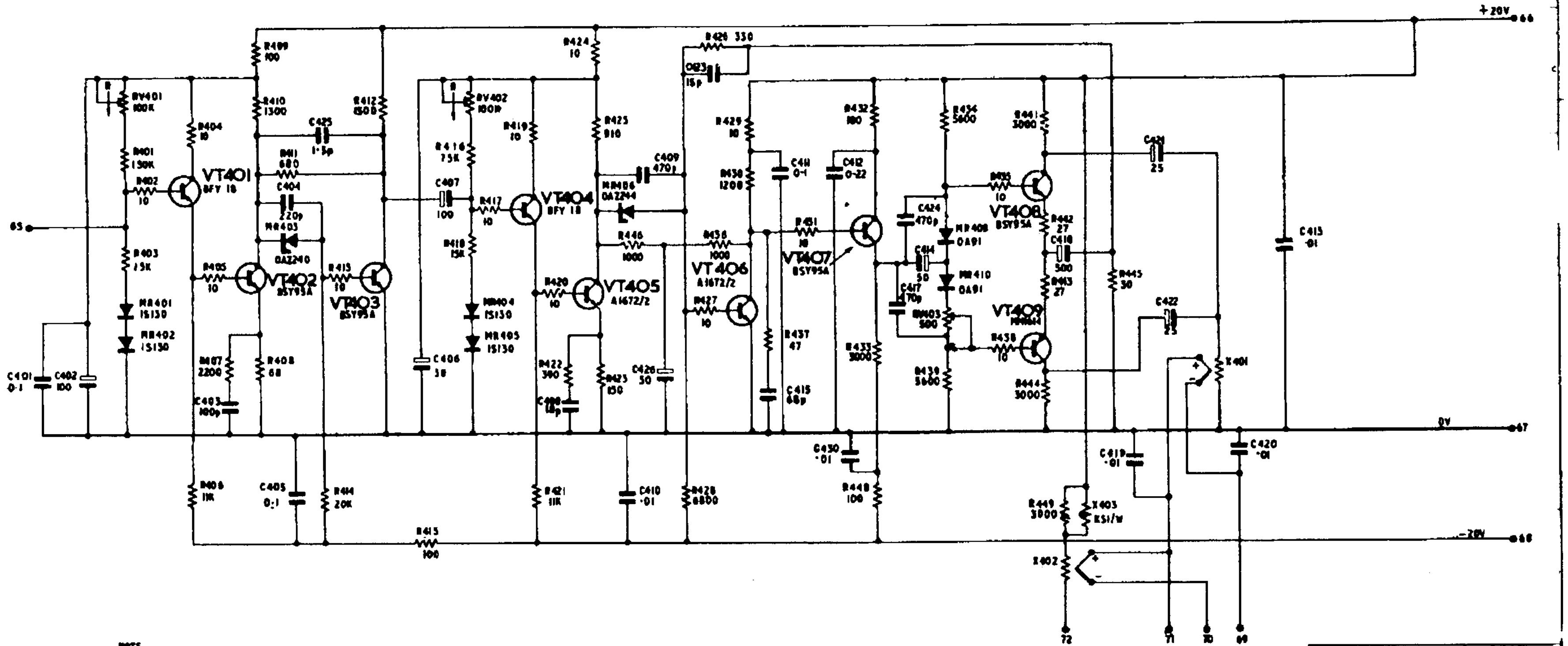
CONTRACTOR'S DRAWING REF: D14849301.

DRAWING NUMBER

DRAWING NUMBER

THIRD ANGLE PROJECTION

IF IN DOUBT ASK.



NOTE.
1. X401 & X402 TO BE INSERTED ON TEST
2. CAPACITOR & RESISTOR VALUES ARE GIVEN IN MICROFARADS & OHMS RESPECTIVELY UNLESS OTHERWISE STATED.
3. CLOCKWISE SENSE OF CONTROL ROTATION INDICATED BY ARROW OR ⟶.

CHANGE	MOD.	ISSUE	DATE
		01	20-4-65
		J	30-3-65
		H	3-12-64

CERTIFIED

MATERIAL	PROTECTIVE FINISH	TOLERANCES	THE SOLARTRON ELECTRONIC GROUP LTD.	CONTRACTOR'S DRAWING REF. C14849304
		DIMENSIONS IN	TITLE R. F. AND OUTPUT AMPLIFIERS	DRAWING NUMBER
		SURFACE ROUGHNESS		
		SCALE		

DRAWING NUMBER

THIRD ANGLE PROJECTION | **IF IN DOUBT ASK.**

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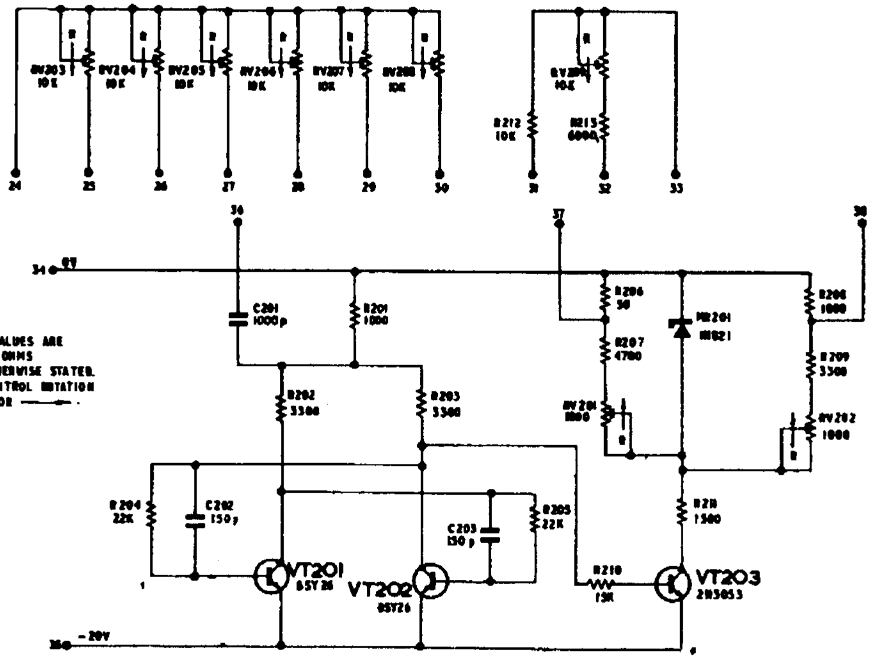
C	202 201 203
MISC.	RV203 RV204 RV205 RV206 RV207 RV208 RV209 RV201 MR201 VT201 VT202 VT203 RV202



TE.

1. CAPACITOR & RESISTOR VALUES ARE GIVEN IN MICROFARADS & OHMS RESPECTIVELY UNLESS OTHERWISE STATED.
2. CLOCKWISE SENSE OF CONTROL ROTATION INDICATED BY ARROW ↑ OR ——←—.

CHANGE		ISSUE	DATE
		H	20-4-65
		F	30-3-65
		E	26-0-64
CIRCUIT REVISED.		D	28.9.64
ADDITIONAL CIRCUITRY.		C	4.8.64
		B	10-6-64

CERTIFIED

MATERIAL | PROTECTIVE FINISH | TOLERANCES | DIMENSIONS IN | SURFACE ROUGHNESS | SCALE

THE SOLARTRON ELECTRONIC GROUP LTD.

TITLE **CALIBRATOR**

CONTRACTOR'S DRAWING REF.

C 14849302

DRAWING NUMBER