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AUTOMATIC CAPACITANCE BRIDGE

Model ESP 300A

ESP

1pF To 2000 μ F Autoranging Accuracy $\pm 0.5\%$



ESP

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ESP 300A

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Electronic Services & Products Ltd.

Digital Capacitance Meter Mod.300A

General Specifications.

Measuring Range	1pF to 1999uF
Range Selection	Automatic
Refresh Rate	1.5 second intervals
Decimal Point	Automatic Positioning
Display	3½ digit plus pF nF and uF
User Controls	Preset Zero
Accuracy	+ 0.5% or 1 digit.
Power Supply	200-250 Volts, or 100-120 Volts 50-60Hz.
Instrument Case	Low Profile, black, with tilt bar.
Dimensions	Width 283mm, depth 235mm height 60mm.

Electronic Specifications

Operating Mode	Count-Hold-Discharge, repetitive.
Test Voltage	5 Volts D.C. Max.
Counting Source	5MHz. high stability crystal.
Count Gating	Utilise temperature stabilised precision TTL comparator.
Display	0.6 & 0.3in. Red seven segment L.E.D.S.
Circuit Blocks	Reliable TTL 74 series, 14 & 16 pin DIL.
Other Active Components	All silicon devices.
Resistors	Metal oxide or carbon film 5% or better. Multi-turn cermet presets.
Capacitors	Mixed types, selected to suit circuit configuration.
Stabilised Supply	D.C.5 volts nominal, stability of voltage better than 0.01%, ripple less than 10mV. Thermal and over current protection.
Circuit Protection.	Fused at 1 amp.
Mains Indicator.	Long Life Neon.

General Information

The E.S.P. Digital Capacitance Meter Mod.300A is designed to enable quick measurement of Capacitance. This bridge type of instrument covers over nine decades of measurement from 1pF to 1,999uF; ranging is fully automatic, with decimal point positioning and pF/nF or uF display. No buttons to press a new reading every one and a half seconds.

The unit operates by charging and discharging the external capacitance Cx; the charging current to Cx is progressively increased during the 'ranging' to allow for the increases of leakage currents encountered with the larger values of capacitance. No provision has been made to allow for excessive Cx leakage currents, an excessively high leakage current will give a high reading on the meter and so indicate an 'out of spec' device.

Modern electronic technology has been used in the design and construction of the instrument, integrated circuits are extensively used in the interests of reliability, and a highly stable crystal oscillator is used to ensure accuracy of display.

Access to the preset potentiometers is obtained by removing the top two inside screws at the rear of the unit, then slide the top of the unit forward and lift off. Removal of the four front panel screws and the two screws on the printed circuit board enables the whole of the electronic assembly to be lifted away from the base, the front panel complete with the display printed circuit board can be unplugged from the main board if required. The electronic assembly can be operated in a dismantled condition if required; great care should be exercised to ensure that the high potential parts of the circuit - the switch and neon plus associated P.C. conductors do not come into contact with the case etc. Reassembly is the reverse of the removal procedure; ensure that the main circuit board is correctly mated with the front panel connector, prior to re-tightening the front panel screws. Check the accuracy of calibration before fitting the top cover.

To convert the 300A to 100-120 volt operation, proceed as follows:- Cut links between 2 and 3 on both transformers, reconnect pin 2 to pin 4, and pins 3 to pin 1 on both transformers; label rear of unit to show new mains voltage.

Circuit Operation

An oscillator with a mark space ratio of approx. 10:1 and a period of approx. 1.5 seconds controls the display and reset sequence, one half of P11 produces this waveform, the other half of this package squares up same; a complimentary output is obtained by using one gate of P12 as an inverter. Initially with OSC high the following occurs - T10 is on, causing the capacitor across Cx to discharge via R73, pin 5 of P9 holds Ra at OV and the counter is inhibited due to the positive voltage on the reset line. The NOT OSC line clears the shift register, and resets the bistable P13 via C13.

When the oscillator switches T10 is turned off, OV on pin 5 of P9 places a '1' into the input of the shift register P10, the counter is enabled; the NOT OSC output is now high so the shift register is enabled.

The Ra output is applied to pin 11 of P16, causing the output of the inverter to fall and a P to be displayed on I5 Ra is also fed to pin 6 P13, the output of this NOR gate is inverted and used to enable the 5MHz count gate, pins 8, 9 and 10 of P14; the high output from pin 8 P15 is also used to drive the outputs of the divider package P7 to a '1001' state, this inhibits the divider; the 500KHz count gate, pins 4, 5 and 6 of P14, is inhibited due to the '0' and '1' on it's inputs.

Cx commences to charge via R81; during the initial charging period of Cx the voltage at the comparator input will be below the reference voltage as set by VR8, so the output of P8 will be high and is used to enable the common count gate, pins 11, 12 and 13 of P12. When the voltage across Cx is equal to the reference voltage, the voltage at pin 9 P8 will return to 0, this shuts the common count gate, and the display will be frozen until a reset pulse occurs.

For larger values of capacitance the auto-ranging circuitry comes into operation, assuming a value of capacitance in excess of 1000uF the following sequence occurs - Ra is high so Cx commences to charge; the 5MHz count pulses are routed through pins 9 and 8 of P14 then pins 13 and 11 of P12, the common count gate, to the counter input pin 14 of P6. The output of P6 is applied to the input of the second decade counter P5, the output of P5 is again inverted to bring the count train to the correct phase to operate P4, a presettable decade counter. When the count changes from 999pF to 1,000pF a carry output is produced at pin 7 of P4, this pulse is fed via pins 12 and 11 of P14, into pin 8 of P10 and clocks the shift register from Ra to Rb, the carry pulse also loads a '1' into P4 via C2, a NOR gate, and inverter. The leading edge of the Rb shift register pulse is differentiated by C1 and sets P13 bistable; the high output of this bistable at pin 13 holds the count frequency at 5MHz, and holds T9 off; the low output at pin 10 places a decimal point into 13 and inhibits the carry pulse NAND gate pin 12 of P14. The Rb output is also used to hold the shift register's input to '0' via pin 12 of P9.

The inverted Rb output is used to place an 'n' into I5, and to switch on T2 to bring in a lower value of charging resistance R80 plus RV1. The count now at 1.00nF continues to increment to 9.99nF and a carry pulse is again generated; the NAND gate output, pin 11 of P14 is inhibited so the shift register remains at Rb. The carry pulse is also fed through C2 and pins 2 and 1 of P13 to reset the bistable; the high output at pin 10 of the bistable turns off the decimal point in I3 and enables the carry pulse NAND gate, pin 12 of P14. The low output on pin 13 allows T9 to turn on and place a decimal point into I4, this low output is also used to reduce the count frequency to 500KHz. The count now continues to 99.9nF, a clock pulse is again generated which causes the '1' in the shift register to move to Rc; an inverted output of Rc is used to energise the decimal point on 12, and to bring in the appropriate Cx charge circuit T3, VR2 and R79.

At the beginning of the ranges, Rb, Rc, Rd, Re and Rf a '1' is required at I2; the falling edge of the pulse which occurs when P4 returns to 0 volts is differentiated by C1 and fed into a NOR gate pin 2 P13, the pulse then passes through pins 13 and 12 of P15 to the 'load 1' input of P4 the presettable counter, the Rg shift register pulse is fed into a NOR gate, pin 3 of P13, to inhibit the loading of a '1' on this range.

On range Rb2 and subsequent ranges no input is applied to either pin 4 or 5 of P13, so the output of this gate goes high and enables the 500KHz count gate, pins 4, 5 and 6 of P14; an inverted NOR output from pin 8 P15 is used to disable the 5MHz count gate and bring the divide by ten package P7 into operation. The count gate pulses at 5MHz are fed into pin 14 of P7, are divided by ten, and appear as a 500KHz pulse train at pin 11; the pulses are now routed through pins 4 and 6 of P14 then pins 13 and 11 of P12 the common count gate, and counting continues. The shift register is clocked at the end of each range, inverted outputs are used to reposition the decimal point and select the correct Cx discharge paths are required. On the last range Rg a '1' is placed into I1; counting continues until the common count gate is inhibited by comparator switching action which occurs when V Cx is equal to V Ref.

Across the Cx terminals a certain amount of stray capacity exists, compensation for this is carried out by inhibiting a number of count pulses at the beginning of the count period. P17 provides the delay required which is presettable by VR6, VR7 is a preset rear panel control.

An integrated circuit voltage regulator provides a highly stable power supply, the 5 volt line is also decoupled against high and low frequency rippled and transients by C9 and C7; the two low current discharge paths for Cx and the comparator supply are further decoupled by R72 and C10.

Auto-range Selection

<u>Range</u>	<u>Count</u>	<u>Count Freq.</u>	<u>Discharge R.</u>
Ra	10-999pF	5MHz	1 Mohm
Rb1	1.00-9.99nF	5MHz	150K ohm plus pot
Rb2	10.00-99.99nF		
Rc	.100-.999uF	500KHz	15 Kohm plus pot
Rd	1.00-9.99uF	500KHz	1.5Kohm plus pot
Re	10.0-99.9uF	500KHz	150 ohm plus pot
Rf	100-999uF	500KHz	15 ohm plus pot
Rg	1000-1,999uF	500KHz	As range Rf

Setting Up Procedure

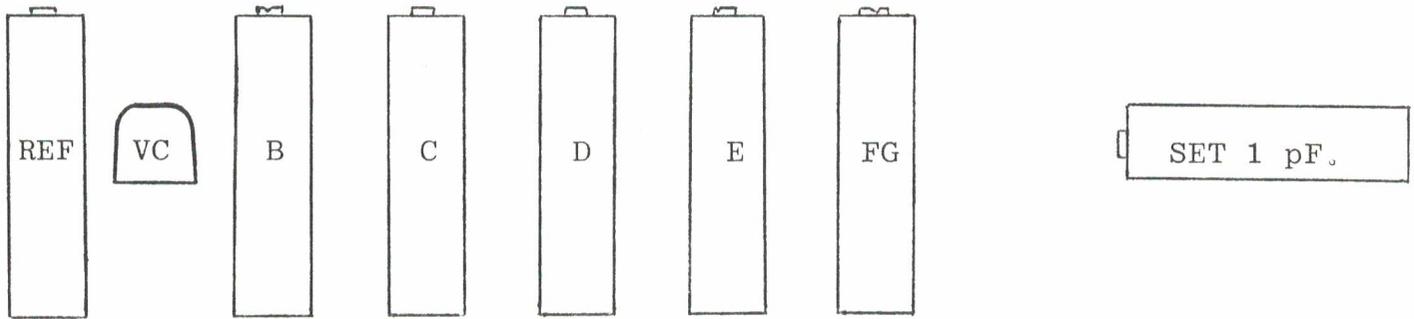
To accurately calibrate the instrument, a selection of close tolerance capacitors are required, or alternatively, a selection of good capacitors and an accurate bridge to determine their true value.

Switch on the unit and allow at least fifteen minutes for stabilisation, remove the top covers; set VR7 to centre of its rotation.

Calibrate instrument using the following procedure:-

1. Insert capacitor of 500pF, set to this value on display using preset 'ref', remove capacitor and then set residual capacity to 2pF using preset 'set 1pF' at rear of unit; repeat until correct reading and 2pF residual is obtained, now reduce residual carefully a fraction of a turn at a time until 1pF just appears. Check centre scale reading, then check different scale reading to ascertain linearity.
2. Insert capacitor of 50nF and adjust preset 'b' to read 50.0nF on display.
3. Insert capacitor of 5nF and adjust VC1 to read 5.00nF on display repeat 2 then 3 to obtain accurate 50nF and 5nF readings.
4. Insert capacitor of 0.5uF and adjust preset 'c' to read 500uF on display.
5. Insert capacitor of 5uF and adjust preset 'd' to read 5.00uF on display.
6. Insert capacitor of 50uF and adjust preset 'e' to read 50.0uF on display.
7. Insert capacitor of 500uF and adjust preset 'fg' to read 500uF on display.
8. Repeat 1 to obtain correct scale reading and residual reading of 1pF.

Pre-set Potentiometer layout:-



Components List

R1-R39	Resistor	270 ohm.	$\frac{1}{2}$ Watt.	5%	Carbon Film.
R50-R71	Resistor	1Kohm.	$\frac{1}{2}$ Watt.	5%	Carbon Film.
R40-R42	"	"	"	"	"
R81	"	1 Mohm.	$\frac{1}{2}$ Watt.	1%	Metal Oxide.
R79	"	150 Kohm	$\frac{1}{2}$ Watt	1%	Metal Oxide.
R80	"	15Kohm.	$\frac{1}{2}$ Watt.	1%	Metal Oxide.
R78	"	1.5Kohm.	$\frac{1}{2}$ Watt	1%	Metal Oxide.
R76	"	4.7 ohm.	$\frac{1}{2}$ Watt	1%	" "
R75	"	150 ohm.	$\frac{1}{2}$ Watt	"	" "
R73-R74	"	15 ohm.	$\frac{1}{2}$ Watt	"	" "
R77	"	680 ohm.	$\frac{1}{2}$ Watt	5%	Carbon Film.
R72	"	470 ohm	1 Watt	5%	Metal Oxide.
R46-R49	"	470 ohm	$\frac{1}{2}$ Watt	5%	Carbon Film.
R82	"	10 K ohm	$\frac{1}{2}$ Watt	1%	Metal Oxide.
VR2	Preset Resistor	10Kohm	1 Watt		Cermet.
VR3	"	1 Kohm	1 Watt		Cermet.
VR4	"	100 ohm	1 Watt		Cermet.
VR5	"	10 ohm	1 Watt		Cermet.
VR8	"	200ohm	1 Watt		Cermet.
VR6	"	5Kohm	1 Watt		Cermet.
VR7	Potentiometer	470ohm			Carbon Lin.
TH	Thermistor	ITT KR221CW.			
C2,C8,C13	Capacitor	0.005uF	160 Volts	Min.	Pol.
C6	"	0.47uF	160 Volts		Pol.
C3	"	4,700uF	10 Volts.		Elect.
C7	"	1 uF.	50 Volts.		Tantalum.
C4	"	10,000pF.	160 Volts.		Pol.
C1	"	0.22uF	160 Volts.		Pol.
C5	"	220uF	15 volts.		Elect.
C9	"	0.47uF	160 Volts.		Pol.
C10	"	4,700uF	10 Volts.		Elect.
C11	"	10,000uF	25 Volts.		Elect.
C12	"	0.01uF	1000 Volts		Met. Paper.
C14	"	18 - 100pF			AOT.
VC	"	Preset	5 - 65 pF.		
TI-T7	Transistor	BC479.			
T8,T9	"	BC107.			
D1-D10	Diode	IN4001			
D11,D12,	"	IN914			
B1	Diode Bridge	REC 70			
Reg.		LM309K			
I1-14	Indicator	0.6"	Seven Segment		HP7750
15-16	"	0.3"	"	"	DL707
P1-P3	Integrated Circuit	SN7447			
P4	"	SN74192			
P5-P7	"	SN7490			
P8	"	LM311N			
P9	"	SN7433			
P10	"	SN74164			
P11	"	SN7413			
P12	"	SN7400			
P13	"	SN7402			
P14	"	SN7403			
P15	"	SN7404			
P16	"	SN7416			
P17	"	SN74121			
MT1-MT2	Transformer	0-110.	250 Volts	4.5 Volts x 2 @	1 Amp.
Ne.	Neon Indicator	200-250	Volts		R.S.
F1	1 Amp Fuse.				
Sw.	Mains Switch	S.P.D.T.	H/Well.		8N1011.
VR1	Preset Resistor	100Kohm	1 Watt		Cermet.
X1	Crystal	5MHz	20 p.p.m.		Type 'J'

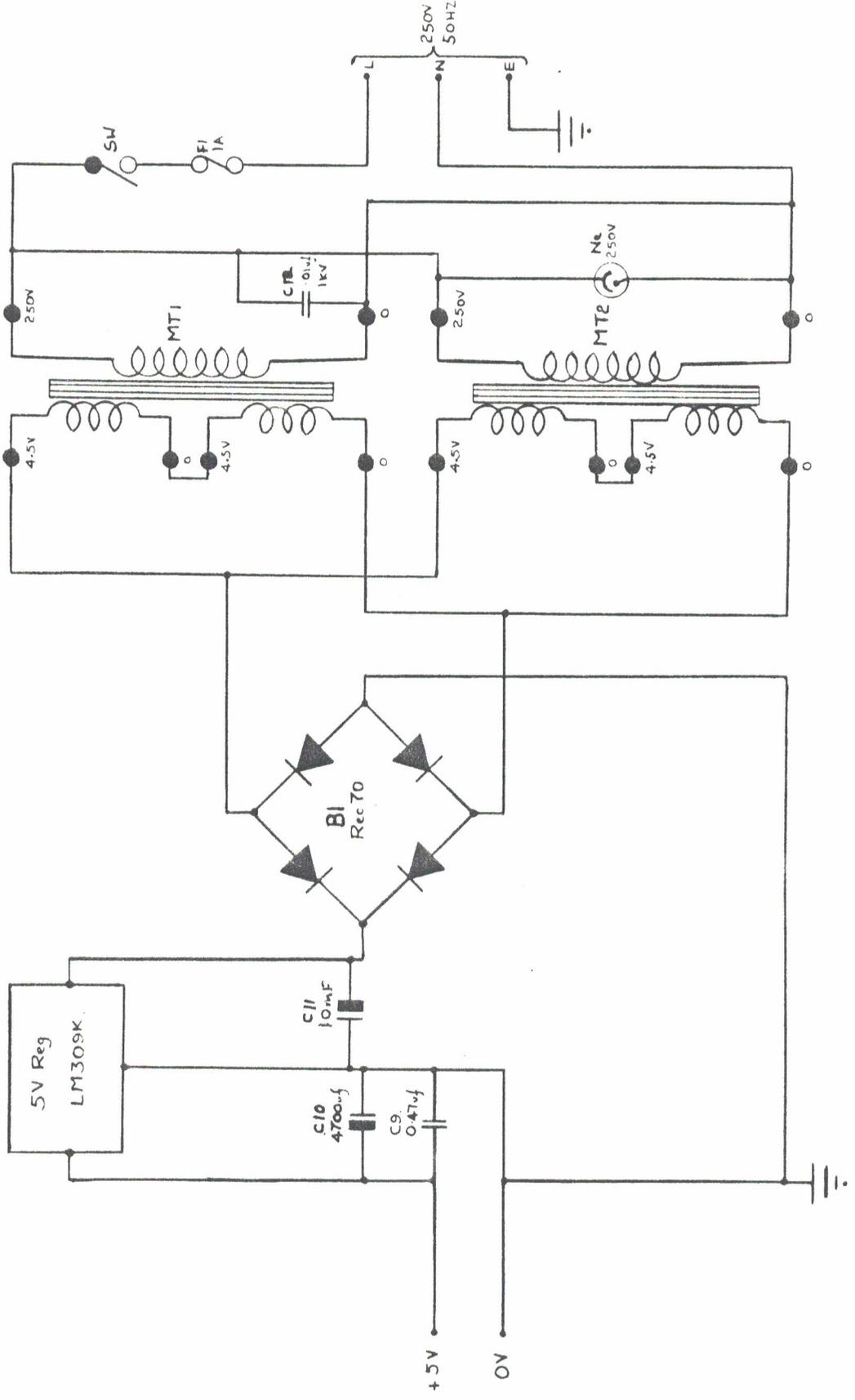
Component List Cont'd.....

Miscellaneous:-

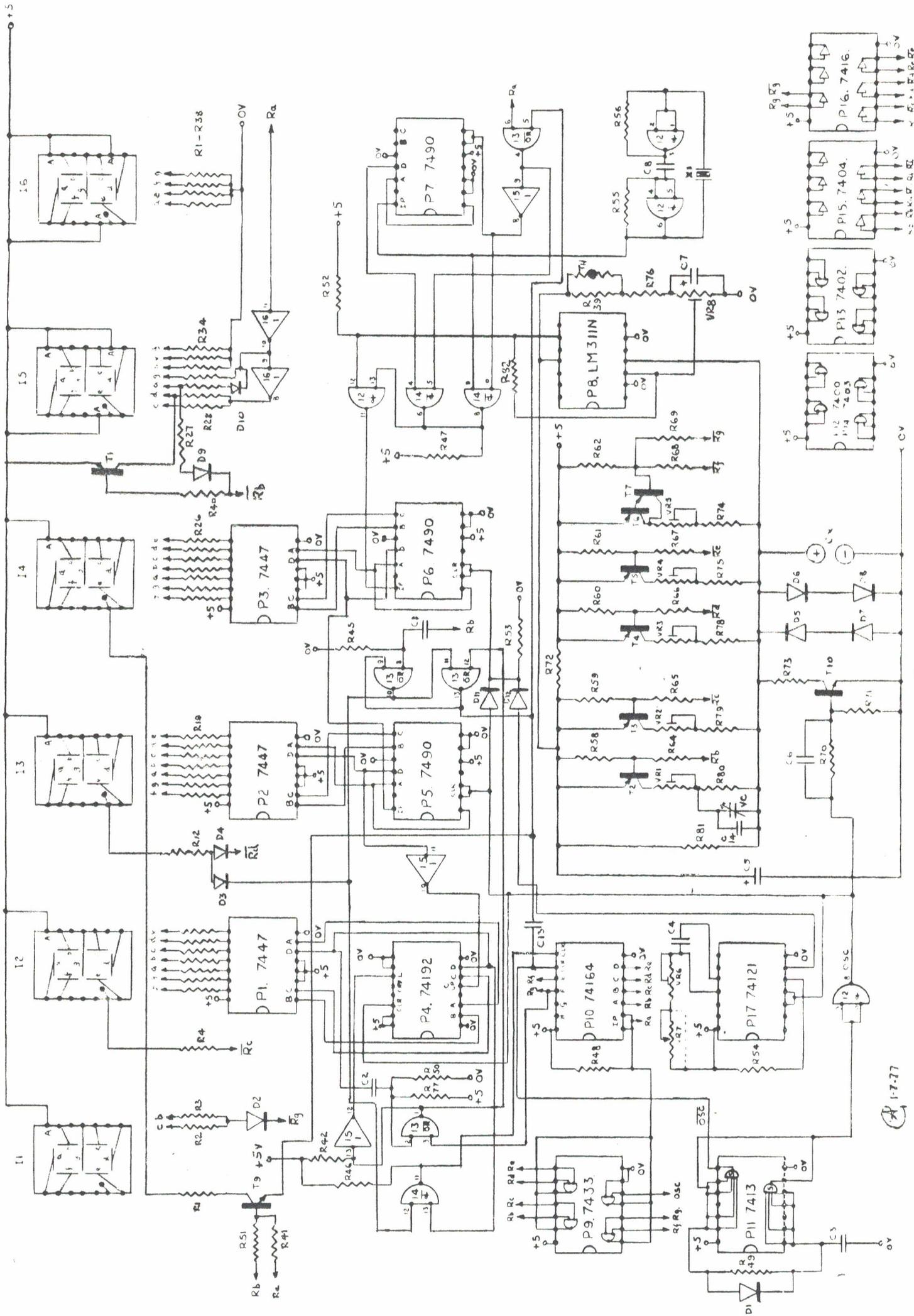
Control Knob $\frac{1}{2}$ " Black
Fuse Holder
Terminal Blocks 4 Way 3 off WECO 954
Socket 4mm Red.
Socket 4mm Black
14 Way D.I.L. Holders 19 off
16 Way D.I.L. Holders 4 off
Instrument Case
Instrument Case Tilt Bar
Front Panel
Cable Bush
Mains Lead. Black 3 core 23/0076 2 Meters
Printed Circuit Board P11T
Printed Circuit Board P1F
Edge Connector 24 + 24 Way

E.S.P. CAPACITANCE METER MODEL 300A.

POWER SUPPLY

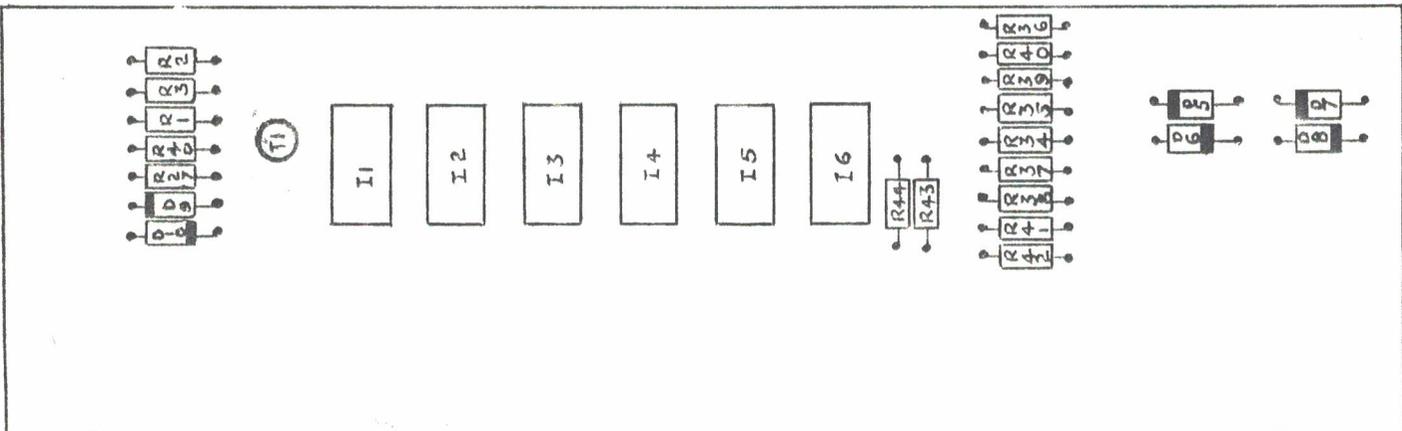
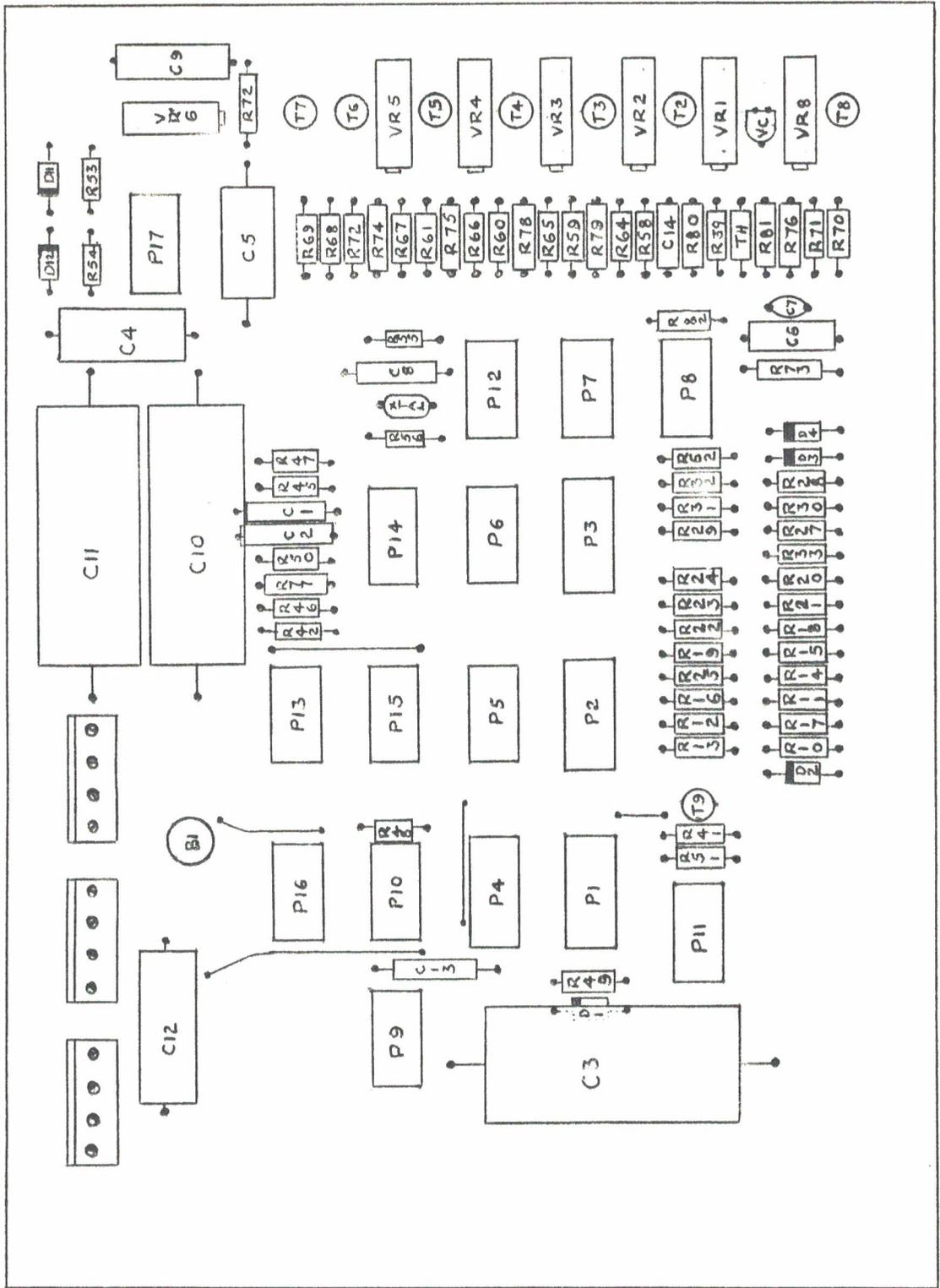


E. S. P. CAPACITANCE METER MODEL 300A



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E.S.P. 300A. PANEL LAYOUTS.





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