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SHALLTRONIX CORPORATION

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INSTRUCTION MANUAL

MODEL NO. 670-A

SERIAL NO. 1759



SHALLTRONIX

OPERATING INSTRUCTIONS

670-A

MILLIOHMMETER

OPERATING INSTRUCTIONS

670-A MILLIOHMMETER

1. CONNECT RESISTANCE TO BE MEASURED TO THE BINDING POSTS MARKED PROBE I AND PROBE II IN THE NORMAL FOUR TERMINAL METHOD OF LOW RESISTANCE MEASUREMENTS.
2. TURN SWITCH TO "ON" POSITION AND "OHMS FULL SCALE" SELECTOR TO THE PROPER RANGE.
3. IF THE "OHMS FULL SCALE" SELECTOR IS SET TO EITHER THE 0.1 OHM OR 0.5 OHM POSITION ADJUST THE METER TO THE RED LINE BY TURNING THE KNOB MARKED "ADJUST". FOR ALL OTHER SELECTOR POSITIONS ADJUST THE METER TO FULL SCALE.
4. THE VALUE OF THE RESISTANCE BEING TESTED IS OBTAINED BY DEPRESSING THE "TEST" SWITCH AND READING THE RESULT.
5. IF THE VALUE OF THE RESISTANCE BEING TESTED IS UNKNOWN PLACE THE SELECTOR SWITCH ON 0.5 OHM RANGE AND IN DESCENDING ORDER CHANGE THE RANGE UNTIL THE LARGEST DEFLECTION IS OBTAINED WHEN THE "TEST" SWITCH IS DEPRESSED.

BATTERY POWER:

NORMAL BATTERY SUPPLY IS 3V. THIS MAY BE OBTAINED FROM 2 DRY CELLS CONNECTED IN SERIES. STANDARD #6 BATTERIES WILL FIT IN THE COMPARTMENT PROVIDED. FOR PRODUCTION TESTING THIS INSTRUMENT SHOULD BE OPERATED FROM A 4 VOLT STORAGE BATTERY; TWO CELLS OF A REGULAR 6 VOLT STORAGE BATTERY MAY BE USED. RED LEAD GOES TO PLUS TERMINAL IN ALL CASES, BLACK LEAD TO MINUS.

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THEORY OF OPERATION - 670-A & 673-D MILLIOHMMETERS

The milliohmmeter measures the unknown resistance by the current/voltage method. The configuration is a true four-terminal measurement (see Figure I). The current is adjusted by a variable resistor in series with a DC power supply. The amount of current in the circuit is determined by measuring the voltage drop across a known standard. Once the current has been adjusted to a predetermined value, the meter is switched to measure the voltage drop across the unknown. THE UNKNOWN MUST BE IN THE CIRCUIT WHEN THE CURRENT IS ADJUSTED.

Further, if the current is adjusted to a multiple of the meter movement, the resistance can be read in ohms per volt. For example, if the current through the unknown is 1 amp, the voltage across the unknown equals 1 volt, the unknown would be 1 ohm, 10 volts equal 10 ohms, .1 volt equals .1 ohm, and so on. ($R = \frac{E}{I}$, Ohms Law). The currents used on each range are as follows:

RANGE OHMS F.S.	CURRENT THROUGH UNKNOWN IN AMPS	
	670-A	673-D
.001	5	-
.005	5	1
.01	5	1
.05	5	-
.1	3	-
.5	3	.3
1	-	.3
5	-	.3

The lead resistance of the current leads RL_1 and RL_4 introduce no errors in measurement. This resistance is not in the measurement circuit, only in the current circuit. This is compensated for in the initial current adjustment. The lead resistance of the potential leads will not normally introduce a significant error. The error introduced can be calculated by the amount of resistance that is added to the meter resistance (including the multiplier resistor). For example, if $RL_2 + RL_3 = 0.1$ ohm, the error introduced on the .001 range would be -1% (the meter movement is 10 ohms) See Table I

CALIBRATION OF SHALLTRONIX

NO. 670-A MILLIOHMMETER

ROUTINE CHECKS: Routine checks on the reliability of the indications are obtained by using test standard resistors. Check the 0.005 ohm range against a suitable standard of 2% accuracy or better. The reading should be accurate to within 5% of full scale or within $2\frac{1}{2}$ scale division at any point on the scale. If the reading is not accurate, the following calibration procedure should be used.

CALIBRATION PROCEDURE: (See Diagram BM-25450 & BM-25876)

- a. Unsolder one lead of the meter protecting resistor (9) and check its value on a Wheatstone Bridge. It should be 100 ohms $\pm 1\%$. Resolder the leads.
- b. If all ranges are in error in the same direction (all high or low) it may be possible to correct all ranges by changing the value of resistor R2 (0.15 ohm). For high readings (0.0025 standard readings 0.00258) decrease the value of the resistor R2. (See Diagram BM-25450 & BM-25876)
- c. Check the 0.001 ohm range against 0.001 ohm standard. If the full scale reading is out of tolerance substitute a resistance box for the R3 resistor. Adjust the resistance box to secure a value which will bring the 0.001 ohm range within tolerance.
- d. Repeat the test on the 0.005 ohm range and if it is out of tolerance change the value of resistor R4 to bring the range within tolerance.
- e. To correct the other ranges repeat the procedure outlined above and change the value of resistor R5 for the 0.01 ohm range; resistor R6 for the 0.05 ohm range; etc., until all ranges are corrected.

TABLE I

RANGE OHMS F.S.	METER RESISTANCE		MULTIPLIER RESISTANCE		ERROR $RL_2 + RL_3 = .1 \text{ OHM}$	
	670A	673D	670A	673D	670A	673D
.001	10 Ω	N/A	-	N/A	1%	N/A
.005	10 Ω	10 Ω	40 Ω	8.3 Ω	.2%	1%
.01	10 Ω	10 Ω	90 Ω	8.3 Ω	.1%	.5%
.05	10 Ω	N/A	490 Ω	N/A	.02%	N/A
.1	10 Ω	N/A	690 Ω	N/A	.014%	N/A
.5	10 Ω	10 Ω	3090 Ω	190 Ω	.003%	.05%
1	N/A	10 Ω	N/A	200 Ω	-	.047%
5	N/A	10 Ω	N/A	1600 Ω	-	.0062%

N/A - Not Applicable - No range on the instrument for the particular step.

NOTE: For value other than $RL_2 + RL_3 = .1 \text{ Ohm}$ % error =

$$100 \left(\frac{RL_2 + RL_3}{RM_1 + RM_2} \right)$$

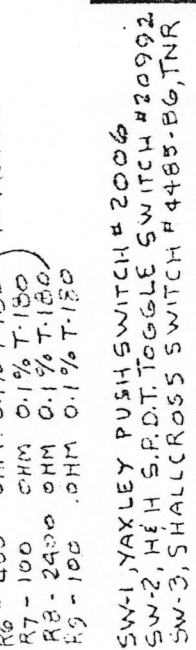
See Table II for RL_2 and RL_3 in ohms/1000 feet.

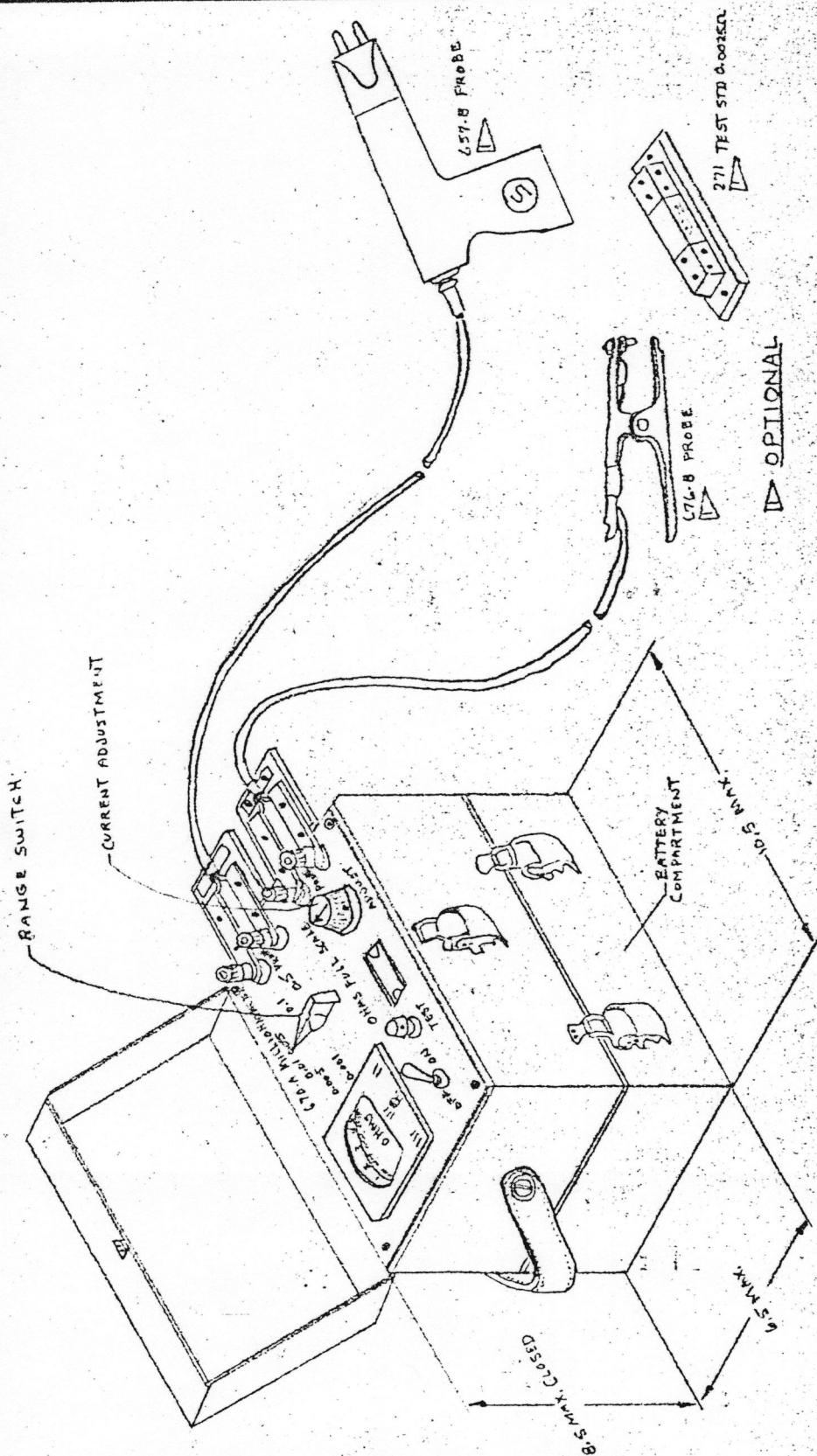
TABLE II WIRE BULF, STANDARD ANNEALED COPPER
AMERICAN WIRE GAGE. ENGLISH UNITS
OHMS PER 1,000 FEET, 0 TO 200°C

Gage	Diameter at 20°C Mils	Cross Section at 20°C		Ohms per 1,000 Feet 14 at the Temp. of						
		Circular Mils	Square Inch	0°C	20°C	25°C	50°C	75°C	100°C	200°C
				0.04516	0.04901	0.04998	0.05479	0.05961	0.06442	0.08369
0000	460.0	211 600	0.1662	0.04516	0.04901	0.04998	0.05479	0.05961	0.06442	0.08369
000	409.6	167 800	.1318	.05696	.06182	.06303	.06911	.07518	.08125	.1055
00	364.8	133 100	.1045	.07181	.07793	.07946	.08712	.09478	.1024	.1331
0	324.9	105 600	.0829 1	.090.53	.098.25	.1002	.1098	.1195	.1291	.1678
1	289.3	83 690	.065 73	.1142	.1239	.1264	.1385	.1507	.1629	.2116
2	257.6	66 360	.052 12	.1440	.1563	.1594	.1747	.1901	.2054	.2669
3	229.4	52 620	.041 33	.1816	.1971	.2010	.2203	.2397	.2590	.3365
4	204.3	41 740	.032 78	.2289	.2485	.2534	.2778	.3022	.3266	.4243
5	181.9	33 090	.025 99	.2888	.3134	.3196	.3504	.3812	.4120	.5352
6	162.0	26 240	.020 61	.3641	.3952	.4029	.4418	.4806	.5194	.6747
7	144.3	20 820	.016 35	.4589	.4981	.5079	.5568	.6057	.6547	.8504
8	128.5	16 510	.012 97	.5787	.6281	.6404	.7021	.7639	.8256	1.072
9	114.4	13 090	.010 28	.7302	.7925	.8080	.8859	.9637	1.042	1.353
10	101.9	10 380	.008 155	.9203	.9988	1.018	1.117	1.215	1.313	1.705
11	90.7	8230	.006 46	1.16	1.26	1.29	1.41	1.53	1.66	2.15
12	80.8	6530	.005 13	1.46	1.59	1.62	1.78	1.93	2.09	2.71
13	72.0	5180	.004 07	1.84	2.00	2.04	2.24	2.43	2.63	3.42
14	64.1	4110	.003 23	2.33	2.52	2.57	2.82	3.07	3.32	4.31
15	57.1	3260	.002 56	2.93	3.18	3.24	3.56	3.87	4.18	5.43
16	50.8	2580	.002 03	3.70	4.02	4.10	4.49	4.89	5.28	6.86
17	45.3	2050	.001 61	4.66	5.05	5.15	5.65	6.15	6.64	8.63
18	40.3	1620	.001 28	5.88	6.39	6.51	7.14	7.77	8.39	10.9
19	35.9	1290	.001 01	7.41	8.05	8.21	9.00	9.79	10.6	13.7
20	32.0	1020	.000 804	9.33	10.1	10.3	11.3	12.3	13.3	17.3
21	28.5	812	.000 638	11.8	12.8	13.0	14.3	15.5	16.8	21.8
22	25.3	640	.000 503	14.9	16.2	16.5	18.1	19.7	21.3	27.7
23	22.6	511	.000 401	18.7	20.3	20.7	22.7	24.7	26.7	34.7
24	20.1	404	.000 317	23.7	25.7	26.2	28.7	31.2	33.7	43.8
25	17.9	320	.000 252	29.8	32.4	33.0	36.2	39.4	42.5	55.3
26	15.9	253	.000 199	37.8	41.0	41.8	45.9	49.9	53.9	70.0
27	14.2	202	.000 158	47.4	51.4	52.4	57.5	62.6	67.6	87.8
28	12.6	159	.000 125	60.2	65.3	66.6	73.0	79.4	85.9	112
29	11.3	128	.000 100	74.8	81.2	82.8	90.8	98.8	107	139
30	10.0	100	.000 078 5	95.6	104	106	116	126	136	177

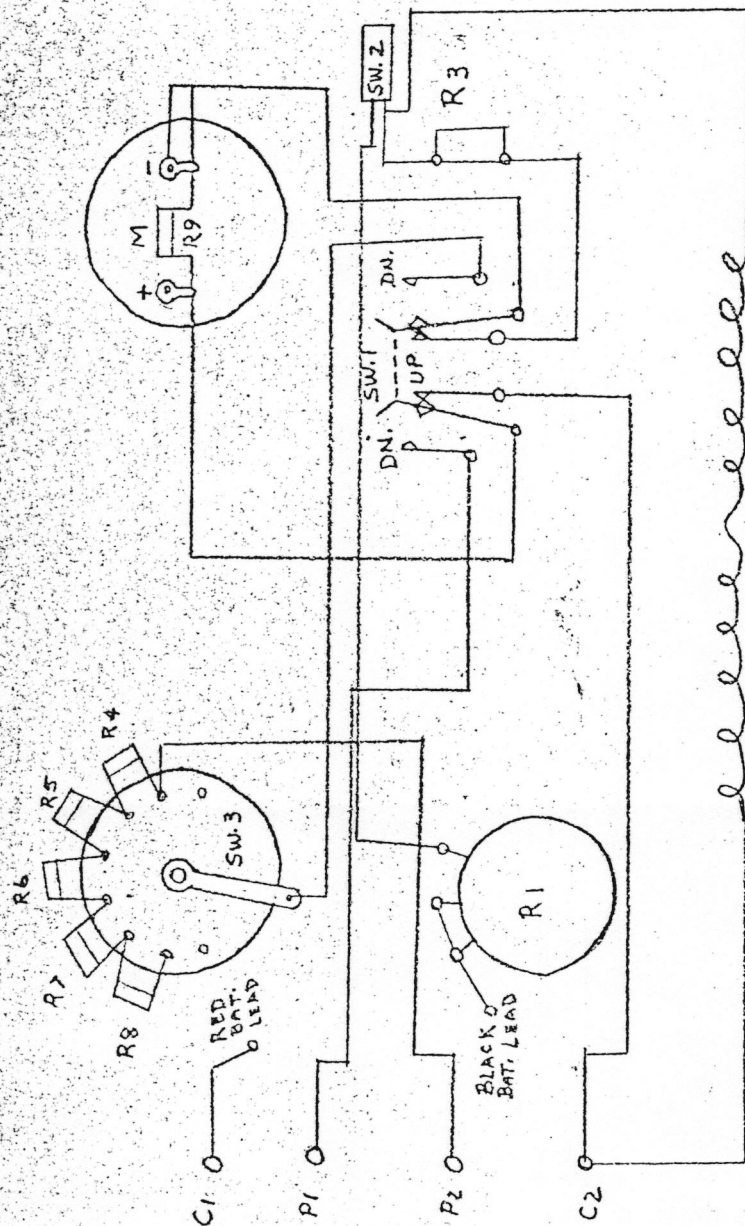
Gage	Diameter at 20°C Mils	Cross Section at 20°C		Ohms per 1,000 Feet ¹⁴ at the Temp. of						
		Circular Mils	Square Inch	0°C	20°C	25°C	50°C	75°C	100°C	200°C
31	8.9	79.2	.000 062 2	121	131	134	146	159	172	224
32	8.0	64.0	.000 050 3	149	162	165	181	197	213	277
33	7.1	50.4	.000 039 8	190	206	210	230	250	270	351
34	6.3	39.7	.000 031 2	241	261	266	292	318	343	446
35	5.6	31.4	.000 024 6	305	331	337	370	402	435	565
36	5.0	25.0	.000 019 6	382	415	423	464	505	545	708
37	4.5	20.2	.000 015 9	472	512	522	573	623	673	874
38	4.0	16.0	.000 012 6	597	648	661	725	788	852	1110
39	3.5	12.9	.000 009 62	780	847	863	946	1030	1110	1450
40	3.1	9.61	.000 007 55	994	1080	1100	1210	1310	1420	1840
41	2.8	7.84	.000 006 16	1220	1320	1350	1480	1610	1740	2260
42	2.5	6.25	.000 004 91	1530	1660	1690	1860	2020	2180	2830
43	2.2	4.84	.000 003 80	1970	2140	2180	2400	2610	2820	3660
44	2.0	4.00	.000 003 14	2390	2590	2640	2900	3150	3410	4430
45	1.76	3.10	.000 002 43	3080	3350	3410	3740	4070	4400	5720
46	1.57	2.46	.000 001 94	3880	4210	4290	4700	5120	5530	7180
47	1.40	1.96	.000 001 54	4880	5290	5400	5920	6440	6960	9030
48	1.24	1.54	.000 001 21	6210	6750	6880	7540	8200	8870	11500
49	1.11	1.23	.000 000 968	7760	8420	8580	9410	10200	11100	14400
50	0.99	0.980	.000 000 770	9750	10600	10800	11800	12900	13900	18100
51	0.88	0.774	.000 000 608	12300	13400	13700	15000	16300	17600	22900
52	0.78	0.608	.000 000 478	15700	17000	17400	19100	20700	22400	29100
53	0.70	0.490	.000 000 385	19500	21200	21600	23700	25700	27800	36100
54	0.62	0.384	.000 000 302	24900	27000	27500	30200	32800	35500	46100
55	0.55	0.302	.000 000 238	31600	34300	35000	38300	41700	45100	58500
56	0.49	0.240	.000 000 189	39800	43200	44000	48300	52500	56800	73800

¹⁴ Resistance at the stated temperature of a wire whose length is 1000 Ft. @ 20°C.

A-TELEDYNE POST 18AE-01E-8½X11



TOLERANCES		REVISIONS			SALES DWG. FOR N°670-A TEST SET			
(EXCEPT AS NOTED)		NO.	DATE	BY				
DECIMAL		1						
±		2						
FRACTIONAL		3						
±		4						
ANGULAR		5						
±								
					DRAWN BY	SCALE	MATERIAL	
					CHK'D	DATE		DRAWING NO.
					TRACED	APP'D		B-102386



NOTE:
SW. 1 IN "UP" POSITION. FOR VALUES
OF COMPONENTS SEE SCHEMATIC

TOLERANCES (EXCEPT AS NOTED)		REVISIONS		
DECIMAL	FRACTIONAL	NO.	DATE	BY
±	±	1		
±	±	2		
±	±	3		
±	±	4		
±	±	5		

DRAWN BY		SCALE		MATERIAL	

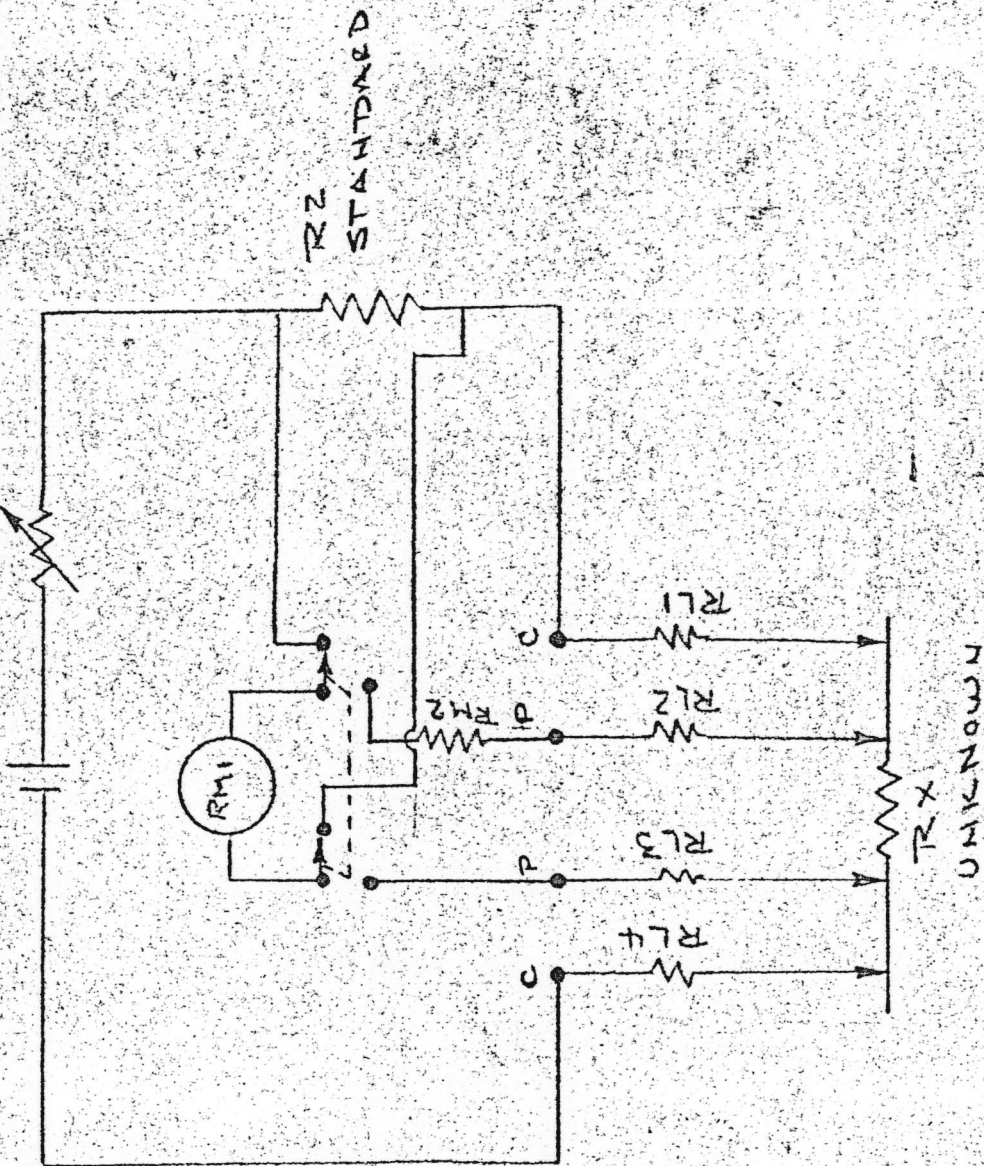
CHK'D		DATE		DRAWING NO.	

TRACED		APP'D	

WIRING DIAGRAM FOR 670-A &
670-B MILLIOHM METER

BM-25876

R1 - CURRENT ADJUSTMENT



MATERIAL

FIGURE I

DRAWN H0885 3/2/79

CHECKED

APPROVED 708 3/2/79

SCALE FIRST ASSEM. WHERE LISTED

FINISH

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

TOLERANCES ON

FRACTIONS

DECIMALS

ANGLES

.XX ±

.XXX ±

±



A- SHEET OF

ACCESSORIES

SEE PAGE 8, DWG NO. B-182386. The accessories, not supplied with the milliohmmeter but procurable as separate items, are the No. 676-B fixed clamp with terminal block and 15 foot cable, No. 271 0.0025 ohm test standard, and No. 657-B pistol grip exploring probe with terminal block and six foot Tirex type S.J. cord. In operation, the fixed clamp is attached to one end of the resistance path to be measured. Then by merely touching the other end of the resistance path with the hardened spikes fitted into the end of the pistol grip exploring probe, resistance measurements may be made. The test standard is used to check the milliohmmeter calibration. It is connected as shown in Dwg. B-182386, Page 8 and is used to check the center of the scale on the first range of 0.005 ohms full scale

ITEM NO.	DESCRIPTION	DRAWING NUMBER	REQ'D.		
1	CASE	CM-25395-1	1		
2	RESISTOR, 0.15 OHM $\pm$ 5% (MANGANIN)	25839	1		
3	RESISTOR, 40 OHMS $\pm$ 1% CALIBRATE	245-S	1		
	TO METER				
4	RESISTOR, 50 OHMS $\pm$ 1% CALIBRATE	245-S	1		
	TO METER				
5	RESISTOR, 100 OHM $\pm$ 1% CALIBRATE	245-S	1		
	TO METER				
6	RESISTOR, 400 OHMS $\pm$ 1% CALIBRATE	245-S	1		
	TO METER				
7	RESISTOR, 2400 OHMS $\pm$ 1% CAL.	BX-180	1		
	TO METER				
8	METER AND SCALE	AM-25500	1		
9	RHEOSTAT, OHMITE, 1 OHM, 50 WATT	900348	1		
10	SWITCH, ASM	905106	1		
11	SWITCH	AM-1848	1		
12	SWITCH	AM-1836	1		
13	KNOB	AM-1916	1		
	KNOB	AM-1928	1		
15	BINDING POST	B-179589-005	4		
16	NAME PLATE	AM-2539	1		
17	GASKET, RUBBER CHANNEL	900563	30"		
18	HOOK-UP WIRE		2'		
19	WIRE, RED BATTERY	900281	24"		
20	WIRE, BLACK BATTERY	900279	24"		
21	SHIELD, VARNISHED CAMBRIC	AM-25511	2		
22	STRAP	AM-4233	1		
23	SLEEVE	AM-25513	2		
24	LUG, SOLDER	3025	2		
25	LUG, SOLDER	3044	6		
26	WASHER, CUT #6	1761	4		
27	WASHER, COUNTERSUNK	AM-25512	2		
28	WASHER, 3/4 X 3/8 X 1/16 N.P.	1966	2		
29	LOCKWASHER, SHAKEPROOF 1/2"	900355	2		
30	SCREW, 6-32 X 1"	900324	4		
	SCREW, 8-32 X 1/2	900391	2		
32	SCREW, 1/4-20 X 3/4	900356	2		
PARTS LIST FOR		670-A MILLIOHMMETER		SHEET 1 OF 2	
		SHALLTRONIX CORP.		PL 670-A	

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