215-5

DC VACUUM TUBE VOLTMETER

HP

MODEL → 412A/AR

NUMAC
REF.: 4

OPERATING AND SERVICE MANUAL

MODEL 412A/AR

SERIALS PREFIXED: 316-

DC VACUUM TUBE VOLTMETER

00129-3

Printed: OCT 1963

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 1 of 2)

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 handbooks.

CODE NO.	MANUFACTURER	ADDRESS
00136	McCoy Electronics	Mount Holly Springs, Pa.
00334	Humidial Co.	Colton, Calif.
00335	Westrex Corp.	New York, N.Y.
00373	Garlock Packing Co., Electronic Products Div.	Camden, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp, Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00815	Northern Engineering Laboratories, Inc.	Burlington, Wis.
00853	Sangamo Electric Company, Ordill Division (Capacitors)	Marion, Ill.
00866	Goe Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	Pacific Semiconductors, Inc.	Culver City, Calif.
01295	Texas Instruments, Inc. Transistor Products Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01561	Chassi-Trak Corp.	Indianapolis, Ind.
01589	Pacific Relays, Inc.	Van Nuys, Calif.
01930	Amerock Corp.	Rockford, Ill.
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02286	Cole Mfg. Co.	Palo Alto, Calif.
02660	Amphenol-Borg Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America Semiconductor and Materials Div.	Somerville, N.J.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	El Monte, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co.	Morristown, N.J.
03954	Air Marine Motors, Inc.	Los Angeles, Calif.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04062	Elmenco Products Co.	New York, N.Y.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04298	Elgin National Watch Co., Electronics Division	Burbank, Calif.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Sylvania Electric Prods., Inc. Electronic Tube Div.	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04732	Filtron Co., Inc. Western Division	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Ill.
04796	Sequoia Wire & Cable Company	Redwood City, Calif.
04870	P. M. Motor Co.	Chicago 44, Ill.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05277	Westinghouse Electric Corp., Semi-Conductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	San Mateo, Calif.
05593	Illumitronic Engineering Co.	Sunnyvale, Calif.
05624	Barber Colman Co.	Rockford, Ill.
05729	Metropolitan Telecommunications Corp., Metro Cap. Div.	Brooklyn, N.Y.
05783	Stewart Engineering Co.	Santa Cruz, Calif.
06004	The Bassick Co.	Bridgeport, Conn.
06136	Ward Leonard Electric	Los Angeles, Calif.
06175	Bausch and Lomb Optical Co.	Rochester, N.Y.
06402	E.T.A. Products Co. of America	Chicago, Ill.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06751	U.S. Semcor Div. of Nuclear Corp. of Am.	Phoenix, Ariz.
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
07115	Corning Glass Works Electronic Components Dept.	Bradford, Pa.
07126	Digitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Semiconductor Corp.	Mountain View, Calif.
07700	Technical Wire Products	Springfield, N.J.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Rheem Semiconductor Corp.	Mountain View, Calif.
07966	Shockley Semi-Conductor Laboratories	Palo Alto, Calif.
07980	Boonton Radio Corp.	Boonton, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada
08717	Sloan Company	Burbank, Calif.
08718	Cannon Electric Co. Phoenix Div.	Phoenix, Ariz.
08792	CBS Electronics Semiconductor Operations, Div. of C.B.S. Inc.	Lowell, Mass.
08984	Mel-Rain	Indianapolis, Ind.
09026	Babcock Relays, Inc.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09250	Electro Assemblies, Inc.	Chicago, Ill.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
10214	General Transistor Western Corp.	Los Angeles, Calif.
10411	Ti-Tal, Inc.	Berkeley, Calif.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11312	Microwave Electronics Corp.	Palo Alto, Calif.
11534	Duncan Electronics, Inc.	Santa Ana, Calif.
11711	General Instrument Corporation Semiconductor Division	Newark, N.J.
11717	Imperial Electronics, Inc.	Buena Park, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12697	Clarostat Mfg. Co.	Dover, N.H.
12859	Nippon Electric Co., Ltd.	Tokyo, Japan
12930	Delta Semiconductor Inc.	Newport Beach, Calif.
13396	Telefunken (G.M.B.H.)	Hannover, Germany
14099	Sem-Tech	Newbury Park, Calif.
14193	Calif. Resistor Corp.	Santa Monica, Calif.
14298	American Components, Inc.	Conshohocken, Pa.
14655	Cornell Dubilier Elec. Corp.	So. Plainfield, N.J.
15909	The Daven Co.	Livingston, N.J.
16688	De Jur-Amsco Corporation	Long Island City 1, N.Y.
16758	Delco Radio Div. of G. M. Corp.	Kokomo, Ind.
18873	E. I. DuPont and Co., Inc.	Wilmington, Del.
19315	Eclipse Pioneer, Div. of Bendix Aviation Corp.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19701	Electra Manufacturing Co.	Kansas City, Mo.
20183	Electronic Tube Corp.	Philadelphia, Pa.
21226	Executive, Inc.	New York, N.Y.
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
21335	The Fafnir Bearing Co.	New Britain, Conn.
21964	Fed. Telephone and Radio Corp.	Clifton, N.J.
24446	General Electric Co.	Schenectady, N.Y.
24455	G.E., Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26365	Gries Reproducer Corp.	New Rochelle, N.Y.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
37942	P. R. Mallory & Co., Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C. A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer and Inst. Co.	Philadelphia, Pa.
49956	Raytheon Company	Lexington, Mass.
52090	Rowan Controller Co.	Baltimore, Md.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Sorenson & Co., Inc.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex, Inc.	St. Paul, Minn.
60741	Tripplett Electrical Inc.	Bluffton, Ohio
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Swissvale, Pa.
62119	Universal Electric Co.	Owosso, Mich.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Div. of Daystrom, Inc.	Newark, N.J.
66295	Wittek Manufacturing Co.	Chicago 23, Ill.
66346	Wollensak Optical Co.	Rochester, N.Y.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control Co., Inc.	New York, N.Y.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	New York, N.Y.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
71218	Bud Radio Inc.	Cleveland, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Allen D. Cardwell Electronic Prod. Corp.	Plainville, Conn.
71400	Bussmann Fuse Div. of McGraw-Edison Co.	St. Louis, Mo.
71450	CTS Corp.	Elkhart, Ind.
71468	Cannon Electric Co.	Los Angeles, Calif.
71471	Cinema Engineering Co.	Burbank, Calif.
71482	C. P. Clare & Co.	Chicago, Ill.
71528	Standard-Thomson Corp., Clifford Mfg. Co. Div.	Waltham, Mass.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71700	The Cornish Wire Co.	New York, N.Y.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A. O. Smith Corp., Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Corp.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72092	Eitel-McCullough, Inc.	San Bruno, Calif.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
71707	Coto Coil Co., Inc.	Providence, R.I.
72354	John E. Fast & Co.	Chicago, Ill.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	General Ceramics Corp.	Keasbey, N.J.
72758	Girard-Hopkins	Oakland, Calif.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72964	Robert M. Hadley Co.	Los Angeles, Calif.
72982	Erie Resistor Corp.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73138	Helipot Div. of Beckman Instruments, Inc.	Fullerton, Calif.
73293	Hughes Products Division of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co., Inc.	Hicksville, N.Y.
73506	Bradley Semiconductor Corp.	Hamden, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Inc.	Philadelphia, Pa.

From: F.S.C. Handbook Supplements
H4-1 Dated Supplement 22
H4-2 Dated April 1962

00015-32
Revised: July 26, 1963

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 2 of 2)

CODE NO.	MANUFACTURER	ADDRESS
73734	Federal Screw Products Co.	Chicago, Ill.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio
73905	Jennings Radio Mfg. Co.	San Jose, Calif.
74455	J. H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	R.F. Products Division of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E. F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75173	Jones, Howard B., Division of Cinch Mfg. Corp.	Chicago, Ill.
75378	James Knights Co.	Sandwich, Ill.
75382	Kulka Electric Corporation	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littelfuse Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C. W. Marwedel	San Francisco, Calif.
76433	Micamold Electronic Mfg. Corp.	Brooklyn, N.Y.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J. W. Miller Co.	Los Angeles, Calif.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio
76854	Oak Manufacturing Co.	Crystal Lake, Ill.
77068	Bendix Pacific Division of Bendix Corp.	No. Hollywood, Calif.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	Potter and Brumfield, Div. of American Machine and Foundry	Princeton, Ind.
77630	Radio Condenser Co.	Camden, N.J.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
78189	Shakeproof Division of Illinois Tool Works	Elgin, Ill.
78283	Signal Indicator Corp.	New York, N.Y.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	Pasadena, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.
80120	Schnitzer Alloy Products	Elizabeth, N.J.
80130	Times Facsimile Corp.	New York, N.Y.
80131	Electronic Industries Association Any brand tube meeting EIA standards	Washington, D.C.
80207	Unimax Switch, Div. of W. L. Maxson Corp.	Wallingford, Conn.
80248	Oxford Electric Corp.	Chicago, Ill.
80294	Bourns Laboratories, Inc.	Riverside, Calif.
80411	Acro Div. of Robertshaw Fulton Controls Co.	Columbus 16, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80583	Hammerlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments, Inc.	New Haven, Conn.
81073	Grayhill Co.	LaGrange, Ill.
81312	Winchester Electronics Co., Inc.	Norwalk, Conn.
81349	Military Specification	
81415	Wilkor Products, Inc.	Cleveland, Ohio
81453	Raytheon Mfg. Co., Industrial Components Div., Industr. Tube Operations	Newton, Mass.
81483	International Rectifier Corp.	El Segundo, Calif.
81860	Barry Controls, Inc.	Watertown, Mass.
82042	Carter Parts Co.	Skokie, Ill.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Allen B. DuMont Labs., Inc.	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc., Electronic Tube Div.	Emporium, Pa.
82376	Astron Co.	East Newark, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals and Controls, Inc., Div. of Texas Instruments, Inc., Spencer Prods.	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Manufacturing Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83053	Western Washer Mfr. Co.	Los Angeles, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N.H.
83125	Pyramid Electric Co.	Darlington, S.C.
83148	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Union, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83501	Gavitt Wire and Cable Co., Div. of Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronics, Inc.	New York, N.Y.
84396	A. J. Glesener Co., Inc.	San Francisco, Calif.
84411	Good All Electric Mfg. Co.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N.J.
85471	A. B. Boyd Co.	San Francisco, Calif.
85474	R. M. Bracamonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	New Haven, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86197	Clifton Precision Products	Clifton Heights, Pa.
86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.
87216	Philco Corp. (Lansdale Division)	Lansdale, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.
87664	Van Waters & Rogers Inc.	Seattle, Wash.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
88220	Gould-National Batteries, Inc.	St. Paul, Minn.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
89636	Carter Parts Div. of Economy Baler Co.	Chicago, Ill.
89665	United Transformer Co.	Chicago, Ill.
90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91260	Connor Spring Mfg. Co.	San Francisco, Calif.
91345	Miller Dial & Nameplate Co.	El Monte, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Brothers, Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Philadelphia, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91929	Minneapolis-Honeywell Regulator Co., Microswitch Div.	Freeport, Ill.
92196	Universal Metal Products, Inc.	Bassett Puente, Calif.
93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N.Y.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93983	Insuline-Van Norman Ind., Inc. Electronic Division	Manchester, N.H.
94144	Raytheon Mfg. Co., Industrial Components Div., Receiving Tube Operation	Quincy, Mass.
94145	Raytheon Mfg. Co., Semiconductor Div., California Street Plant	Newton, Mass.
94148	Scientific Radio Products, Inc.	Loveland, Colo.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	East Paterson, N.J.
94310	Tru Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	New York, N.Y.
95264	Lerco Electronics, Inc.	Burbank, Calif.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95348	Gordas Corp.	Bloomfield, N.J.
95354	Methode Mfg. Co.	Chicago, Ill.
95987	Weckesser Co.	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Division of Aerovox	Olean, N.Y.
96256	Thordarson-Meissner Div. of Maguire Industries, Inc.	Mt. Carmel, Ill.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97539	Automatic and Precision Mfg. Co.	Yonkers, N.Y.
97966	CBS Electronics, Div. of C.B.S., Inc.	Danvers, Mass.
97979	Reon Resistor Corp.	Yonkers, N.Y.
98141	Axel Brothers Inc.	Jamaica, N.Y.
98220	Francis L. Mosley	Pasadena, Calif.
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98405	Carad Corp.	Redwood City, Calif.
98734	Palo Alto Engineering Co., Inc.	Palo Alto, Calif.
98821	North Hills Electric Co.	Mineola, N.Y.
98925	Clevite Transistor Prod. Div. of Clevite Corp.	Waltham, Mass.
98978	International Electronic Research Corp.	Burbank, Calif.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99515	Marshall Industries, Electron Products Division	Pasadena, Calif.
99707	Control Switch Division, Controls Co. of America	El Segundo, Calif.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Semiconductor Div. of Hoffman Electronics Corp.	Evanston, Ill.
99957	Technology Instrument Corp. of Calif.	Newbury Park, Calif.

THE FOLLOWING H-P VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

0000F	Malco Tool and Die	Los Angeles, Calif.
0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000N	Nahm-Bros. Spring Co.	San Leandro, Calif.
0000P	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
0000T	Texas Instruments, Inc. Metals and Controls Div.	Versailles, Ky.
0000U	Tower Mfg. Corp.	Providence, R.I.
0000W	Webster Electronics Co. Inc.	New York, N.Y.
0000X	Spruce Pine Mica Co.	Spruce Pine, N.C.
0000Y	Midland Mfg. Co. Inc.	Kansas City, Kans.
0000Z	Willow Leather Products Corp.	Newark, N.J.
000AA	British Radio Electronics Ltd.	Washington, D.C.
000AB	ETA	England
000AC	Indiana General Corp., Elect. Div.	Indiana
000BB	Precision Instrument Components Co.	Van Nuys, Calif.
000CC	Computer Diode Corp.	Lodi, N.J.
000EE	A. Williams Manufacturing Co.	San Jose, Calif.
000GG	Goshen Die Cutting Service	Goshen, Ind.
000HH	Rubbercraft Corp.	Torrance, Calif.
000II	Birtcher Corporation, Industrial Division	Monterey Park, Calif.
000KK	Amatom	New Rochelle, N.Y.
000LL	Avery Label	Monrovia, Calif.
000MM	Rubber Eng. & Development	Hayward, Calif.
000NNA	"N" D Manufacturing Co.	San Jose 27, Calif.
000PP	Atohm Electronics,	Sun Valley, Calif.
000QQ	Cooltron	Oakland, Calif.
000RR	Radio Industries	Des Plaines, Ill.
000SS	Control of Elgin Watch Co.	Burbank, Calif.
000TT	Thomas & Betts Co., The	Elizabeth 1, N.J.
000WW	California Eastern Lab.	Burlingame, Calif.
000XX	Methode Electronics, Inc.	Chicago 31, Ill.
000YY	S. K. Smith Co.	Los Angeles 46, Calif.

From: F.S.C. Handbook Supplements
H4-1 Dated Supplement 22
H4-2 Dated April 1962

00015-32
Revised: July 26, 1963

MANUAL CHANGES

MODEL 412A

VACUUM TUBE VOLTMETER

Manual Serial Prefixed: 316-
Manual Printed: 10/63

To adapt this manual to instruments with other serial prefixes check for errata below, and make changes shown in tables.

NOTE

This backdating manual change sheet (green sheet) is similar to the updating (yellow sheet) and makes this manual applicable to the earlier instrument. Instrument-component values that differ from those in the manual, yet are not listed in the backdating sheet, should be replaced using the stock number given in the manual.

Instrument Serial Prefix	Make Manual Changes	Instrument Serial Prefix	Make Manual Changes
301-	1		
134-	1, 2		

CHANGE #1

Table 5-1

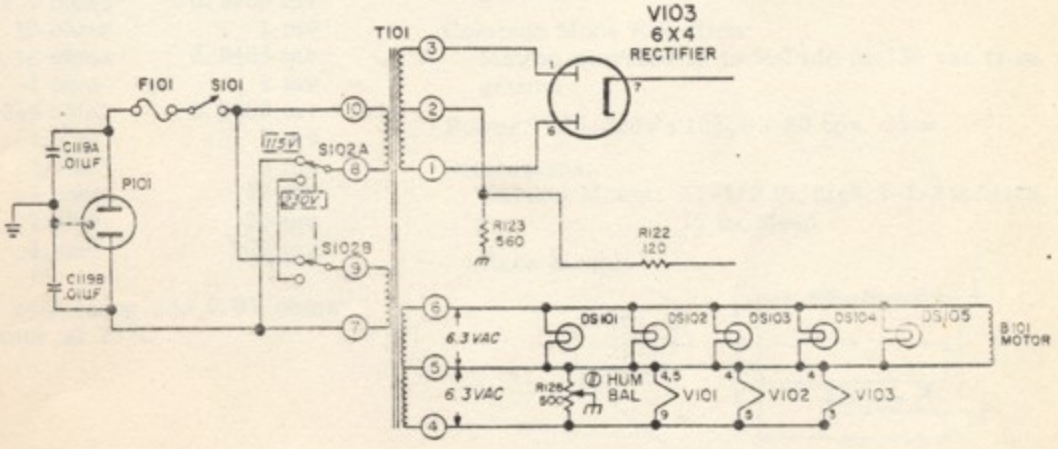
Change: T101 to Ⓢ Stock No. 9100-0021

Table 5-2.

Delete: Ⓢ Stock No. 9100-0238, Transformer, power
Add: Ⓢ Stock No. 9100-0021, Transformer, power; Mfr. 98734, Mfr. Part No. 4076, TQ, 1; RS, 1

Figure 4-15

Change schematic diagram as shown:



CHANGE #2

Table 5-1 and Table 5-2

Change: Ⓢ Stock No. & Mfr. Part No. 412A-21D to 412A-21A
Ⓢ Stock No. & Mfr. Part No. 412A-21E to 412A-21B
Ⓢ Stock No. & Mfr. Part No. 412A-21F to 412A-21C

Table 1-1. Specifications

VOLTMETER

Voltage Range:
Positive and negative voltages from 1 millivolt full scale to 1000 volts full scale in 13 ranges

Accuracy:
±1% of full scale on any range

Input Resistance:
10 megohms ±1% on 1mv, 3mv, and 10mv ranges
30 megohms ±1% on 30 mv range
100 megohms ±1% on 100mv range
200 megohms ±1% on 300mv range and above

AC Rejection:
A voltage at power line or twice power line frequency 40 db greater than full scale affects reading less than 1%. Peak voltage must not exceed 1500 volts.

AMMETER

Current Range:
Positive and negative currents from 1 microampere full scale to 1 ampere full scale in thirteen ranges

Accuracy:
±2% of full scale on any range

Input Resistance:

Range	Internal Shunt Resistance*	Full Scale Voltage Drop
.001 ma	1000 ohms	1 mv
.003 ma	316 ohms	0.9486 mv
.01 ma	100 ohms	1 mv
.03 ma	31.6 ohms	0.9486 mv
.1 ma	10 ohms	1 mv
.3 ma	3.16 ohms	0.9486 mv
1 ma	1 ohm	1 mv
3 ma	.316 ohm	0.9486 mv
10 ma	.1 ohm	1 mv
30 ma	.1 ohm	3 mv
100 ma	.1 ohm	10 mv
300 ma	.1 ohm	30 mv
1000 ma	.1 ohm	100 mv

*For total insertion resistance add 0.07 ohms copper lead resistance at 25°C

OHMMETER

Resistance Range:
Resistance from 1 ohm center-scale to 100-megohms center-scale in nine decade ranges

Accuracy:
±5% of reading from 0.2 ohm to 500 megohms
±10% of reading from 0.1 to 0.2 ohm and from 500 megohms to 5000 megohms.

Voltages and Currents:

Range	Open Circuit Volts	Short Circuit Current
x1	10 mv	10 ma
x10	100 mv	10 ma
x100	1 v	10 ma
x1000	1 v	1 ma
x10K	1 v	100 μa
x100K	1 v	10 μa
x1M	1 v	1 μa
x10M	1 v	.1 μa
x100M	1 v	.01 μa

AMPLIFIER

Voltage Gain: 1000 maximum

AC Rejection:
3 db at 1 cps, approximately 80 db at 50 and 60 cps

Output:
Proportional to meter indication; 1 volt at full scale; maximum current, 1 ma. (Full scale corresponds to 1.0 on upper scale.)

Output Impedance:
Less than 2 ohms at dc

Noise:
Less than 0.1% of full scale on any range

Drift: negligible

GENERAL

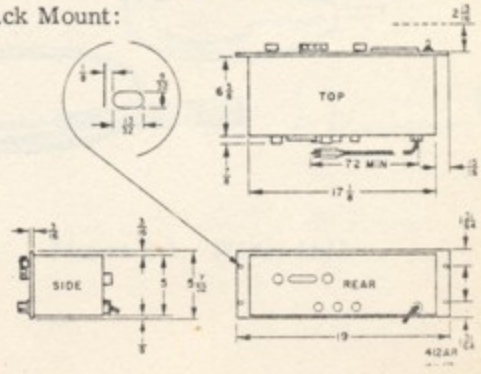
Isolation Resistance:
At least 100 megohms shunted by 0.1 uf between common terminal and case (power line) ground

Common Mode Rejection:
May be operated up to 500 vdc or 130 vac from ground

Power: 115/230v ± 10%, 50-60 cps, 35 w

Dimensions:
Cabinet Mount: 11-1/2 in. high, 7-1/2 in. wide, 10 in. deep

Rack Mount:



Weight: Cabinet Mount: Net 12 lbs, shipping 17 lbs
Rack Mount: Net 12 lbs, shipping 20 lbs

SECTION I
GENERAL DESCRIPTION

1-1. GENERAL.

1-2. The Model 412A/AR DC Vacuum Tube Voltmeter is a precision, wide range, multipurpose instrument which covers the entire range of dc voltage, current, and resistance measurements normally encountered in electronic equipment.

1-3. It measures dc voltages over the wide range of 0.02 millivolts to 1000 volts on thirteen ranges arranged in a 1, 3, 10 sequence from 1 mv full scale to 1000 v full scale. Overall accuracy on all thirteen ranges is within ±1% of full scale. Voltage differences can be measured easily since the input circuit is isolated from the case and from the power line ground.

1-4. DAMAGE IN SHIPMENT.

1-5. Inspect and operate this instrument upon receipt. Section IV includes a performance check which is a good test as part of incoming quality control inspection. The check can be made with the instrument in its cabinet. If there is any damage, see the "Claim for Damage in Shipment" paragraph at the back of this manual.

1-6. POWER CABLE.

1-7. The three-conductor power cable supplied with this instrument terminates in a polarized three-prong male connector recommended by the National Electrical Manufacturers' Association. The third contact is an offset round pin added to a standard two-blade connector. This contact grounds the instrument when used with an appropriate receptacle. An adapter should be used to connect the NEMA plug to a standard two-contact output. When the adapter is used, the ground connection becomes a short lead from the adapter. This lead should be connected to a suitable ground for the protection of operating personnel.

1-8. 115-230 VOLT OPERATION.

1-9. A switch located on the instrument rear converts the Model 412A/AR for use from either a 115-volt or 230-volt, 50-60 cps power source. The switch changes the connection of the dual 115-volt primary windings of the power transformer from a parallel combination to a series combination, or vice versa. Switch positions are marked 115 and 230.

1-10. To convert the instrument from 115-volt operation to 230-volt operation, or vice versa, insert a screwdriver blade into the switch slot and slide the slot until the marking indicates the line voltage. At the time of the change, replace the line fuse. A 0.6 ampere slow-blow fuse should be used for 115-volt operation; a 0.4 ampere slow-blow fuse should be used for 230-volt operation.

CAUTION

Be sure the 115/230 V switch is set at the proper position before applying power to the instrument. Incorrect setting of the switch can result in damage to the instrument.

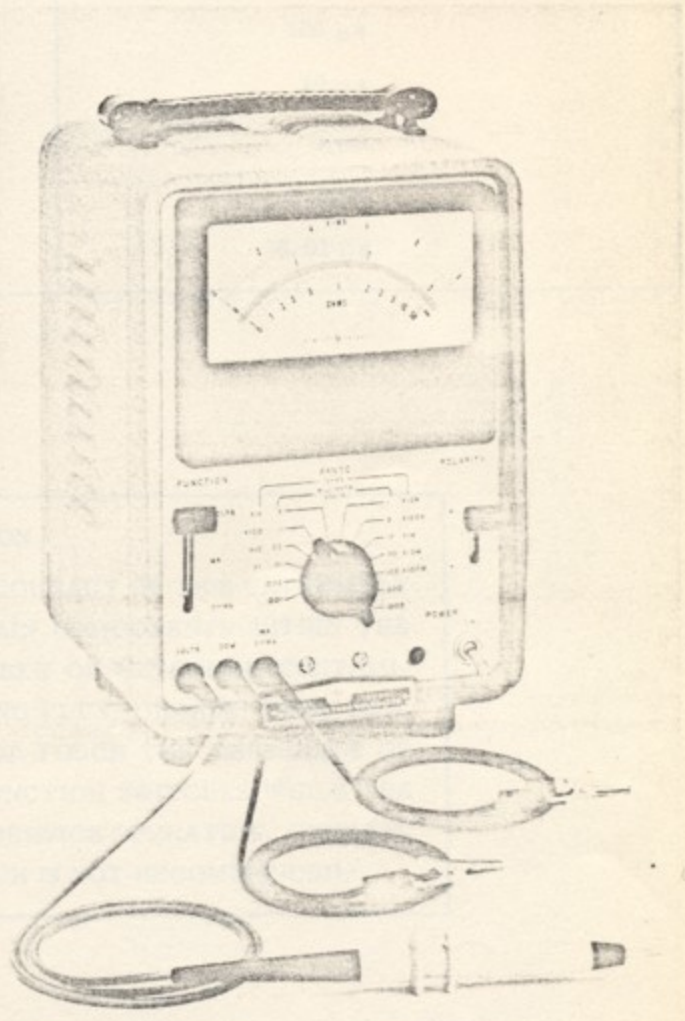


Figure 1-1. Model 412A

Table 2-1. Resistance Range vs Open-Circuit Volts/Short-Circuit Current

Range	Open Circuit Volts (1.0 on upper voltage scale)	Short Circuit Current (0 on upper voltage scale)
X1	10 mv	10 ma
X10	100 mv	10 ma
X100	1 v	10 ma
X1000	1 v	1 ma
X10K	1 v	100 μa
X100K	1 v	10 μa
X1M	1 v	1 μa
X10M	1 v	0.1 μa
X100M	1 v	0.01 μa

CAUTION

TO MAINTAIN THE SPECIFIED ACCURACY OF THIS EXTREMELY SENSITIVE INSTRUMENT, CERTAIN COMPONENTS WITHIN THE INSTRUMENT MUST BE KEPT FREE OF EXTERNAL CONTAMINANTS SUCH AS ROSIN SOLDERING FLUX, GREASE, BODY OILS, ETC. IN PARTICULAR, DO NOT TOUCH THE TERMINALS OR WAFERS OF THE RANGE OR FUNCTION SWITCHES WHILE THE CABINET IS REMOVED FOR ANY SERVICE OPERATION. GENERAL CLEANING OF THE RANGE SWITCH IS NOT RECOMMENDED.

SECTION II
OPERATING INSTRUCTIONS

2-1. LOW-LEVEL ELECTRICAL PHENOMENA.

2-2. Stray low-level electrical phenomena are present in one form or another, in nearly all electrical circuits. The 412A does not distinguish between stray and signal voltages; it measures net voltage. Thus, when using the lower voltage ranges, consider the possibility of low-level electrical phenomena. Thermocouples (thermoelectric effect), flexing of coaxial cables (triboelectric effect), apparent residual charges on capacitors (dielectric absorption), battery action of two terminals mounted on an imperfect insulator (galvanic action) all can produce voltages within the range of the 412A.

2-3. The 412A voltage probe, current/resistance lead and common lead are designed to have a very low thermoelectric effect with copper, the most complete electrical conductor. However, you may encounter other materials. For example, the leads of many transistors are made of a mixture of iron, nickel and cobalt known commercially as Kovar, Fernico, etc. This material makes a very good thermocouple with copper: about 40 uv/^{0}C with respect to a reference junction.

2-4. Whenever possible, connect the 412A leads to copper and maintain the points of connection at the same temperature, preferably ambient temperature. With the leads so connected, any voltage indicated by the 412A is developed within the circuit under test.

2-5. OPERATING INSTRUCTIONS.

CAUTION

Do not overload the instrument. Amplifier input, current shunts, and internal resistance standards are not protected from extreme overload. Momentary overloads ten times full scale will not damage the instrument.

2-6. Turn the Model 412A on and allow a few minutes warmup.

2-7. VOLTAGE MEASUREMENT.

a. Set FUNCTION selector to VOLTS.

b. Set POLARITY switch to desired polarity.

c. Set RANGE switch to desired range.

d. Use VOLTS and COM leads to connect instrument across circuit or component, and read voltage.

2-8. CURRENT MEASUREMENT.

a. Set FUNCTION selector to MA.

b. Set RANGE switch to desired range.

c. De-energize circuit to be tested.

d. Use MA/OHMS and COM leads to connect instrument into circuit.

e. Energize circuit, set POLARITY switch for upscale reading, and read current.

Note

When measuring current, be sure there is no connection between the chassis-ground and cabinet-ground terminals of the DC AMPLIFIER OUTPUT connector.

2-9. RESISTANCE MEASUREMENT.

a. Set FUNCTION selector to OHMS.

b. De-energize circuit to be measured.

c. Use MA/OHMS and COM leads to connect instrument across circuit or component.

d. Select range which brings meter pointer as close as possible to midscale, and read resistance.

2-10. When measuring the resistance of non-linear devices such as crystal diodes or transistors, you may want to know the voltage applied to the device and/or the current through it at the time of measurement. By using table 2-1 and the upper voltage scale on the meter face, you can determine both. The meter reading is directly proportional to the voltage across the device being measured, and the meter reading subtracted from full scale is directly proportional to the current. For example, on the X10 range the upper voltage scale is a 0-100 mv scale and a 10-0 ma scale. If the meter indicates .25 on the resistance scale, the device being measured has an equivalent resistance of 2.5 ohms. But the meter also indicates .2 on the upper voltage scale; thus, from table 2-1, the device has 2.5-ohms equivalent resistance with 20 mv across it and 8 ma flowing through it.

2-11. OPERATION WITH A RECORDER.

2-12. To obtain permanent records of 412A readings, connect a recorder to the DC AMPLIFIER OUTPUT connector and operate the 412A as directed above. The output of the 412A is 1 volt at full scale; if necessary, externally attenuate the 412A output to match it with recorder sensitivity. Maximum rated load current from the 412A is 1 ma. A load resistance of less than 1000 ohms may cause the load current to exceed 1 ma and thus cause errors in meter indication and amplifier gain.

SECTION III
CIRCUIT OPERATION

3-1. GENERAL

3-2. The Model 412A is basically a 0 to 0.9 millivolt dc voltmeter. Precision voltage dividers, shunts, and reference resistors extend the range of the basic voltmeter and permit current and resistance measurements as well.

3-3. CIRCUIT OPERATION.

3-4. With the FUNCTION selector and RANGE switch properly set, voltage is applied to a photoconductive modulator through a low-pass filter. See figure 3-1. The filter attenuates ac components present on any input signal, and the modulator converts the remaining dc component to a square wave. A synchronous-motor-driven, light-beam chopper sets modulator frequency at 5/6 power-line frequency. An ac-coupled amplifier amplifies modulator output about 500,000 times. A demodulator synchronized with the modulator by the light-beam chopper, converts amplifier output to dc. The output of the demodulator is filtered and applied through a cathode follower to 1) a feedback network, 2) the DC AMPLIFIER OUTPUT terminals and 3) an output indicator. The feedback network stabilizes the dc gain of the modulator-amplifier-demodulator system to a value of 1111, thereby providing an output of 1 volt for an input of 0.9 millivolt. The output indicator is a 0-1 voltmeter. The POLARITY switch permits reversal of indicator connections, if required, to obtain up-scale readings. The POLARITY switch is disabled when the FUNCTION selector is set to OHMS.

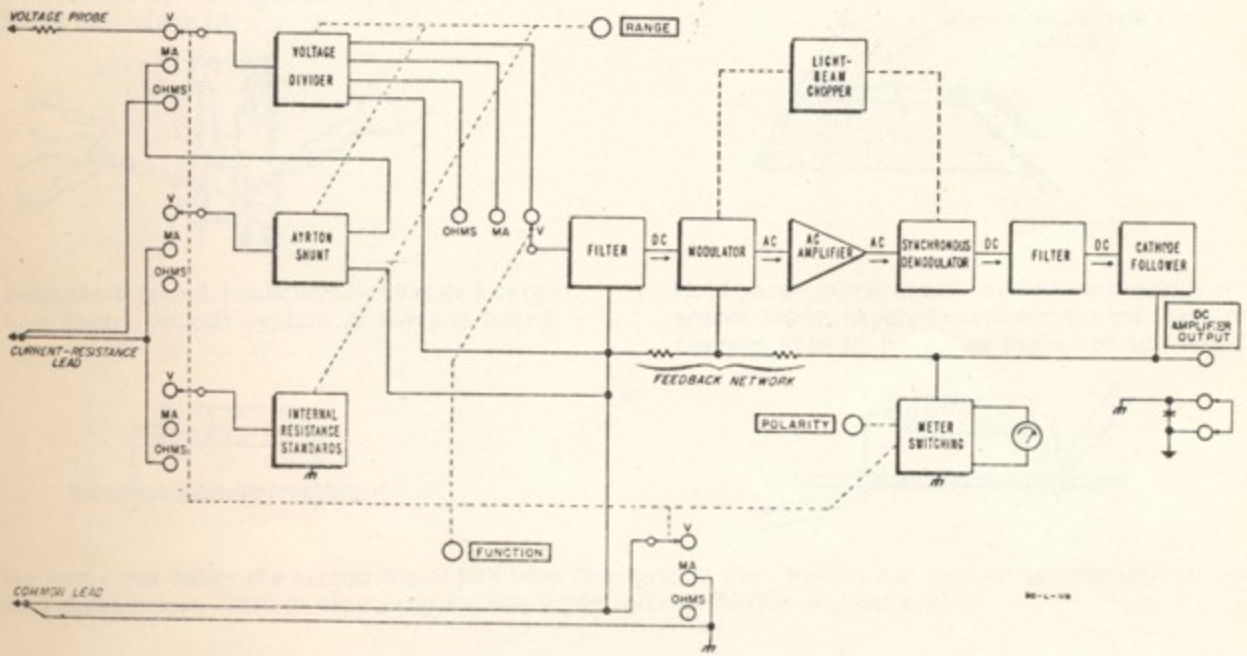


Figure 3-1. Model 412A Block Diagram

SERVICING ETCHED CIRCUIT BOARDS

Excessive heat or pressure can lift the copper strip from the board. Avoid damage by using a low power soldering iron (50 watts maximum) and following these instructions. Copper that lifts off the board should be cemented in place with a quick drying acetate base cement having good electrical insulating properties.

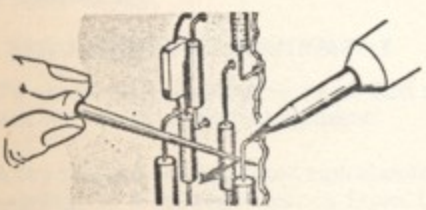
A break in the copper should be repaired by soldering a short length of tinned copper wire across the break.

Use only high quality rosin core solder when repairing etched circuit boards. NEVER USE PASTE FLUX. After soldering, clean off any excess flux and coat the repaired area with a high quality electrical varnish or lacquer.

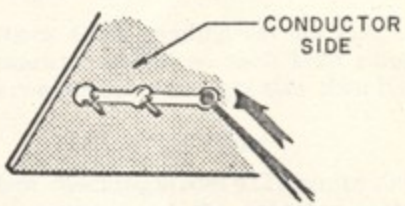
When replacing components with multiple mounting pins such as tube sockets, electrolytic capacitors, and potentiometers, it will be necessary to lift each pin slightly, working around the components several times until it is free.

WARNING: If the specific instructions outlined in the steps below regarding etched circuit boards without eyelets are not followed, extensive damage to the etched circuit board will result.

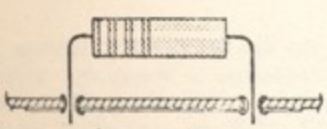
1. Apply heat sparingly to lead of component to be replaced. If lead of component passes through an eyelet in the circuit board, apply heat on component side of board. If lead of component does not pass through an eyelet, apply heat to conductor side of board.



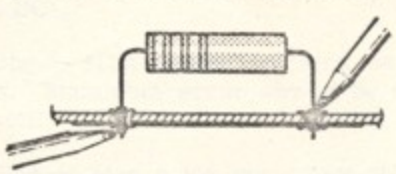
2. Reheat solder in vacant eyelet and quickly insert a small awl to clean inside of hole. If hole does not have an eyelet, insert awl or a #57 drill from conductor side of board.



3. Bend clean tinned leads on new part and carefully insert through eyelets or holes in board.

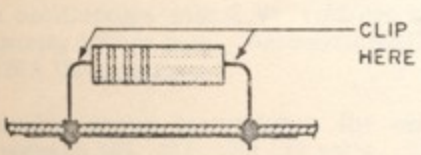


4. Hold part against board (avoid overheating) and solder leads. Apply heat to component leads on correct side of board as explained in step 1.

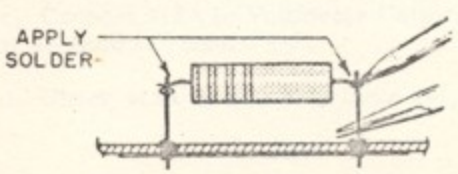


In the event that either the circuit board has been damaged or the conventional method is impractical, use method shown below. This is especially applicable for circuit boards without eyelets.

1. Clip lead as shown below.



2. Bend protruding leads upward. Bend lead of new component around protruding lead. Apply solder using a pair of long nose pliers as a heat sink.



This procedure is used in the field only as an alternate means of repair. It is not used within the factory.

Figure 4-1. Servicing Etched Circuit Boards

SECTION IV
MAINTENANCE

4-1. INTRODUCTION.

4-2. This section contains testing and servicing information. Included is a performance check to verify proper instrument operation. The check can be made with the instrument in its cabinet and is a good test as part of routine maintenance or incoming quality control inspection.

4-3. Standard, readily available components are used for manufacture of ℘ instruments whenever possible. Special components are available through your local ℘ sales office where a parts stock is maintained for your convenience.

4-4. When ordering parts, specify instrument model and serial number plus the component description and stock number appearing in the Table of Replaceable Parts.

4-5. Your local ℘ sales office maintains complete facilities and specially trained personnel to assist you with ℘ instruments.

4-6. REQUIRED TEST EQUIPMENT

4-7. To carry out the instructions in this section, you will need the following test equipment:

a. A dc voltmeter with an input resistance of at least 100 megohms to measure voltages from 1 volt to 350 volts. You can use a voltmeter with 20,000 ohms/volt sensitivity, but circuit loading will cause errors in some readings. Recommended ℘ equipment: 410B Vacuum Tube Voltmeter or 412A DC Vacuum Voltmeter.

b. A dc metering device which can resolve 10 mv. A plain meter movement is satisfactory if it can resolve 10 mv. Recommended ℘ equipment: 410B Vacuum Tube Voltmeter or 412A DC Vacuum Tube Voltmeter.

c. A dc voltage source to supply voltages from .001 volt to 300 volts in steps of 1, 3, 10, etc., and voltages from 0 to 1 volt in 0.1-volt steps. All voltages should be accurate within 0.1%. Recommended ℘ equipment: Model 738A Voltmeter Calibrator.

d. An oscilloscope with 0.01 volt/cm sensitivity for measuring 10-cps hum. Recommended ℘ equipment: 120A Oscilloscope.

e. Variable power transformer for varying line voltage between 103, 115, and 127 volts. The transformer should have a monitor voltmeter accurate within 1 volt and should have a capacity of at least 1 amp.

f. An ohmmeter. Recommended ℘ equipment: 410B Vacuum Tube Voltmeter or 412A DC Vacuum Tube Voltmeter.

4-8. PERFORMANCE CHECK.

4-9. You can check instrument performance without moving the cabinet. Before starting, check the mechanical zero of the meter; if the meter requires adjustment, see paragraph 4-15.

4-10. VOLTMETER CHECK.

a. Turn Voltmeter Calibration Generator on and allow 5-minute warmup.

b. Connect 412A to variable power source, set line voltage to rated value (115/230v) and turn Model 412A on. Allow Model 412A a few minutes to warm up.

c. Set FUNCTION selector to VOLTS and POLARITY switch to +.

d. Connect VOLTS and COM leads to OUTPUT connector of Voltmeter Calibration Generator.

e. Check 412A reading versus Voltmeter Calibration Generator output on each 412A range. Maximum 412A error should be no greater than 1% of full scale.

Note

When checking Model 412A on its .003 and .001 volt ranges, set the selector switch of Voltmeter Calibration Generator to OFF and note any 412A zero offset due to thermoelectric voltage. Add or subtract, as appropriate, any offset from the 412A reading when Voltmeter Calibration Generator selector switch is set to DC+.

f. Check 412A meter tracking on + and -1 volt ranges. Maximum error should be no greater than 0.01 volt.

g. Repeat step e (on one range only) at line voltage of 103 and 127 volts.

4-11. MILLIAMMETER CHECK.

a. Set line voltage to 115 volts.

b. Set FUNCTION selector to MA and POLARITY switch to +.

c. Connect 412A to Voltmeter Calibration Generator as shown in figure 4-2.

d. Check 412A as shown in table 4-1.

Note

Switching through the current ranges from 10 to 1000 does not change the current shunt. Only the voltage attenuator, checked in paragraph 4-10 above, changes. (See figures 4-6, 4-7, and 4-8 for simplified switching details.)

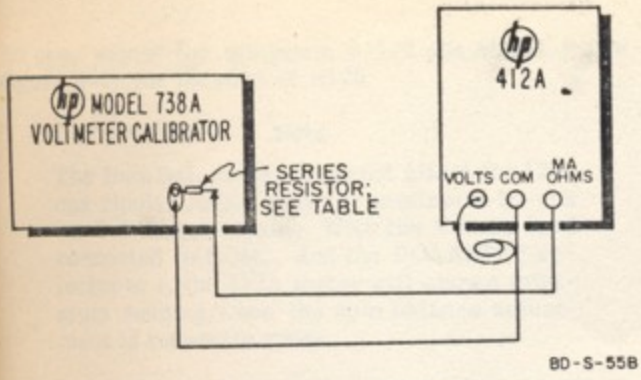


Figure 4-2. Equipment Setup for Current Check

4-12. OHMMETER CHECK.

a. Set FUNCTION selector to OHMS.

b. Connect 1% resistor of 1,10, 100, 1000, 10K, 100K, 1M, 10M and 100M ohms between MA/OHMS and COM leads. With appropriate range selected, meter should indicate between 0.95 and 1.05 in each case.

4-13. CABINET REMOVAL.

a. Unplug power cord from power source.

b. Remove two retaining screws from instrument rear.

c. Slide instrument chassis forward out of cabinet. Bezel ring remains attached to front panel.

CAUTION

The wafers in the range switch are made of a plastic material which provides an extremely high insulation resistance. Dirt from hand tools, flux from soldering, body oils from your finger, or residue from conventional "switch contact cleaners" may permanently damage the range switch or seriously affect instrument performance. Routine cleaning of the range and function switches is not recommended.

If cleaning of these switches is absolutely necessary, only type PC FREON solvent made by the Dupont Company (Wilmington 98, Delaware) should be used. Other cleaners (particularly those with alcohol) will cause the plastic wafers to disintegrate. Use the above solvent to clean the terminals of all components within the input circuit including the input cable terminal board.

4-14. ADJUSTMENTS.

4-15. MECHANICAL ADJUSTMENT OF METER ZERO.

4-16. When meter is properly zero-set, pointer rests over the zero calibration mark on the meter scale when instrument is 1) at normal operating temperature, 2) in its normal operating position, and 3) turned off. Zero-set as follows to obtain best accuracy and mechanical ability.

a. Allow the instrument to operate for at least 20 minutes; this allows meter movement to reach normal operating temperature.

b. Turn instrument off and allow 30 seconds for all capacitors to discharge.

c. Rotate mechanical zero-adjustment screw clockwise until meter pointer is to left of zero and moving upscale toward zero.

d. Continue to rotate adjustment screw clockwise; stop when pointer is right on zero. If pointer overshoots zero, repeat steps c and d.

e. When pointer is exactly on zero, rotate adjustment screw approximately 15 degrees counterclockwise. This is enough to free adjustment screw from the meter suspension. If pointer moves during this step you must repeat steps c through e.

4-17. HUM BALANCE ADJUSTMENT.

a. Turn instrument on and allow a few minutes warmup.

b. Set FUNCTION selector to VOLTS.

c. Connect oscilloscope to DC AMPLIFIER OUTPUT connector.

d. Adjust Hum Bal. (R126), for minimum 10-cps signal on oscilloscope. (If power-line frequency is

Table 4-1. Ammeter Check

Output of Voltmeter Calibration Generator	Series Resistance	Model 412A Range	Model 412A Reading (± 2% of full scale)
1 volt	1.00M ± 0.1%	.001	1.0
3 volts	1.00M ± 0.1%	.003	3.0
10 volts	1.00M ± 0.1%	.01	1.0
30 volts	1.00M ± 0.1%	.03	3.0
100 volts	1.00M ± 0.1%	.1	1.0
300 volts	1.00M ± 0.1%	.3	3.0
300 volts	300K ± 0.1%	1.0	1.0
300 volts	100K ± 0.1%	3.0	3.0
300 volts	30K ± 0.1% (5 watts)	10.0	1.0
300 volts	30K ± 0.1% (5 watts)	30.0	1.0 (on 0-3 scale)

50 cps, adjust for minimum 8-1/3 cps signal.) See figure 4-11 for location of R126.

Note

The Hum Bal. control does not affect the 120-cps ripple. Adjust only for minimum 10-cps (or 8-1/3 cps) ripple. With the VOLTS lead connected to COM., and the POLARITY selector to +, the 412A meter will show a minimum reading when the hum balance adjustment is correctly made.

4-18. CATHODE FOLLOWER BIAS ADJUSTMENT.

a. Set RANGE switch full clockwise - one step beyond 1000.

b. Adjust BIAS ADJ. (R116), to set meter pointer approximately on zero. R116 is located on instrument rear. This adjustment is not critical, since any deviation from zero is reduced more than 100 times when the RANGE switch is on any operating position.

4-19. AMPLIFIER GAIN CALIBRATION AND METER CALIBRATION.

a. Connect equipment as shown in figure 4-3. You may replace the test voltmeter with any high resistance meter device which can resolve 10 mv.

b. Set Voltmeter Calibration Generator output to +1 volt.

c. On 412A under test, set FUNCTION selector to VOLTS, POLARITY switch to +, RANGE switch to 1.

d. Adjsut Gain Cal (R119) for zero on test voltmeter. For location of R119 see figure 4-11. A 10-mv reading on test voltmeter indicates 1% error in gain calibration.

e. Adjust Meter Cal (R46) to set meter pointer on 1.0.

f. Disconnect test voltmeter.

g. Check 412A reading versus Voltmeter Calibration Generator output on each range. See note in step e of paragraph 4-10. If any reading is in error more than 1% of full scale, readjust Gain Cal. (R119) to bring all readings within 1%.

4-20. OHMMETER ADJUSTMENT.

a. Set FUNCTION selector to OHMS and RANGE switch to X1K. Be sure MA/OHMS and COM leads are not connected through some external resistance.

b. Adjust OHMS ADJ. (R36) to set meter pointer on ∞, which corresponds to 1.0 on upper voltage scale. R36 is located on instrument rear.

4-21. TUBE REPLACEMENT.

4-22. Tubes will sometimes cause trouble; check them by substitution and replace only those which are defective. Following the replacement of a particular tube, make the adjustment indicated in table 4-2.

Table 4-2. Tube Replacement

Tube Replaced	Adjustment
V101 (12AX7) Amplifier	Hum balance; check gain calibration
V102 (6AU8) Amplifier/ Cathode Follower	Cathode follower bias; check gain calibration
V103 (6X4) Rectifier	None
V104 (OA2) Regulator	Ohmmeter
V105 (OB2) Regulator	None

4-23. TROUBLESHOOTING.

4-24. When isolating trouble, consider the Model 412A as having two sections: switching and amplifier/power supply sections. Front-panel indications should indicate the section in which a trouble is located and, in the case of switching-section trouble, should isolate the trouble to a few components. For example, if the instrument operates properly on all voltage ranges but .003, only R1, R9, or associated switch contacts and wiring can be faulty. For a simplified breakdown of

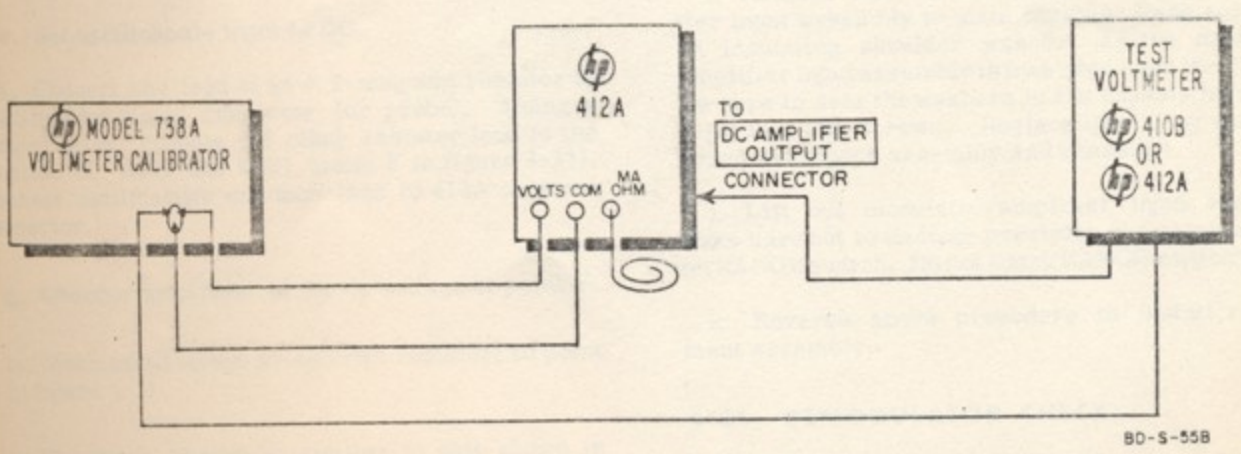


Figure 4-3. Equipment Setup for Amplifier Gain Calibration

the switching sequence, see figures 4-6, 4-7 and 4-8. Figure 4-13 identifies parts mounted on the RANGE, FUNCTION, and POLARITY switches.

Note

BE CAREFUL when working with the RANGE switch. Avoid touching the switch wafers. A dirty switch wafer can degrade instrument performance. When soldering to the switch, use a minimum of heat. Excessive heat will melt the wafer material. Use a low-flux (2%) solder, and remove any traces of flux after soldering connections on the RANGE switch, modulator/amplifier assembly, or cable terminal board. A cotton swab soaked in type PC Freon is recommended for this purpose.

4-25. Should trouble occur in the amplifier/power supply section, it will be common to all ranges and all functions. Voltages are indicated at various points on the schematic diagram; these are typical voltages and may vary somewhat from instrument to instrument.

4-26. The 412A is a sensitive instrument. If it has an offset from zero or gives unexpected readings on its lowest voltage ranges, it may be measuring thermoelectric voltages, etc., in addition to the expected voltage (see paragraph 2-1). When in doubt, check instrument performance (paragraph 4-9) before troubleshooting.

4-27. If the instrument fails to operate at all, be sure power is supplied to it, the POWER switch is on, and fuse F101 is good before checking inside.

4-28. MODULATOR CHECK

a. Unplug the 412A from the power source, and remove the cabinet.

b. Remove V101 and reconnect the 412A to the power source.

c. Connect a clip lead from the 412A input terminals to the center arm of R116, Bias Adjust Potentiometer.

d. Set RANGE (VOLTS) to .001.

e. Set oscilloscope input to DC.

f. Connect one lead of an 8.2-megohm resistor to oscilloscope signal connector (or probe). Using a jumper wire, connect the other resistor lead to the junction of R101 and C101 (point F in figure 4-11). Connect oscilloscope common lead to 412A common connector.

g. Observe amplitude of the dc voltage at point F.

h. Move oscilloscope probe (with resistor) to point A in figure 4-11.

i. Waveform should be similar to that shown in figure 4-4, and should have a peak-to-peak amplitude approximately equal to the deflection found in step g. Signal frequency should be 5/6 line frequency.

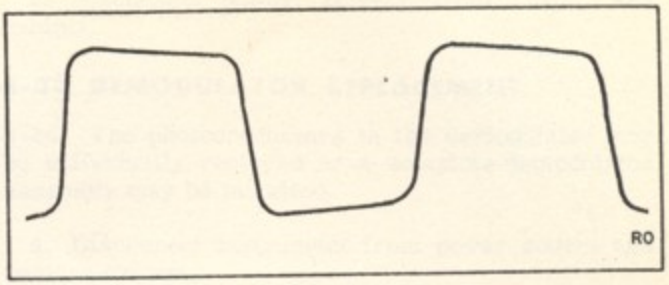


Figure 4-4. Modulator Waveform

4-29. MODULATOR REPLACEMENT.

4-30. Should it become necessary to replace the modulator, we recommend that you send your instrument to your local ℗ repair facility. If you repair the instrument, check with your Hewlett-Packard sales office about a replacement modulator. The procedure for replacement is as follows:

a. Unplug 412A from power source and remove cabinet. Remove shield from left side of chassis to expose modulator assembly.

b. Disconnect black and black-white leads from modulator assembly (point A in figure 4-10).

c. Disconnect white-orange lead (point B in figure 4-10).

d. Disconnect white lead at Gain Cal potentiometer R119 (point C in figure 4-10).

e. Disconnect green lead (point F in figure 4-11).

f. Disconnect cable to amplifier at amplifier (point D in figure 4-10).

g. Remove four machine screws and nuts holding light beam chopper (figure 4-9) and let it hang by its leads.

h. Spread collars on modulator light rods (figure 4-10) and slide rods out of modulator assembly.

i. Remove four screws holding modulator/amplifier input assembly to main chassis. Each screw has an insulating shoulder washer, as the modulator/amplifier input assembly is insulated from the chassis. Be sure to seat the washers in the chassis holes when replacing the screws. Replace insulating wafer between modulator assembly and chassis.

j. Lift out modulator/amplifier input assembly. Take care not to damage precision resistors mounted on RANGE switch. Do not touch RANGE switch wafers.

k. Reverse above procedure to install replacement assembly.

4-31. DEMODULATOR CHECK.

4-32. The demodulator assembly is located between the main chassis and power transformer. See figure 4-11. Proceed as follows:

a. Unplug instrument from power source and remove cabinet.

b. Remove V102.

c. On light-beam chopper assembly, remove upper lamp nearest front of instrument. This lamp illuminates the forward section of demodulator.

d. Connect 1 uf capacitor across input terminals of ohmmeter.

e. Connect ohmmeter common lead to demodulator center terminal to which pink-orange lead (brown-orange lead in a rack model) is connected.

f. Connect other ohmmeter lead to terminal to which white-orange lead is connected.

g. Plug instrument into power source and turn it ON.

h. Note resistance indicated by ohmmeter. Typical resistance is between 1 meg and 2 meg.

i. Turn instrument off and unplug it from power source.

j. Replace lamp in light-beam chopper and remove upper lamp nearest rear of instrument. This lamp illuminates rear section of demodulator.

k. Connect common ohmmeter lead to demodulator terminal to which brown-orange lead (pink-orange lead in rack model) is connected.

m. Connect other ohmmeter lead to terminal to which white-orange lead is connected.

n. Plug instrument into power source, turn it ON, and note resistance indicated on ohmmeter. Typical resistance is between 1 meg and 2 megs.

o. Disconnect power; replace lamp, V102, and cabinet.

4-33. DEMODULATOR REPLACEMENT.

4-34. The photoconductors in the demodulator may be individually replaced or a complete demodulator assembly may be installed.

a. Disconnect instrument from power source and remove cabinet.

b. Note and record wire color codes before disconnecting three wires to demodulator.

c. Remove nuts from mounting screws and remove demodulator from instrument. To gain access to screw heads, remove four mounting screws from light-beam chopper assembly (figure 4-9) and let assembly hang on leads.

4-35. Reverse above procedure to reinstall demodulator. Reconnect three wires to correct terminals as noted during removal of assembly.

4-36. CABLE REPLACEMENT.

4-37. Figure 4-5 is a connection diagram for the VOLTS, MA/OHMS, and COM cables. Replacement of the VOLTS and MA/OHMS cables is straightforward: connect the new ones as indicated in the figure. However, be careful when replacing the COM cable. The position and length of the leads on terminal post #3 affects the accuracy of the instrument. Connect the leads as shown in detail (figure 4-5).

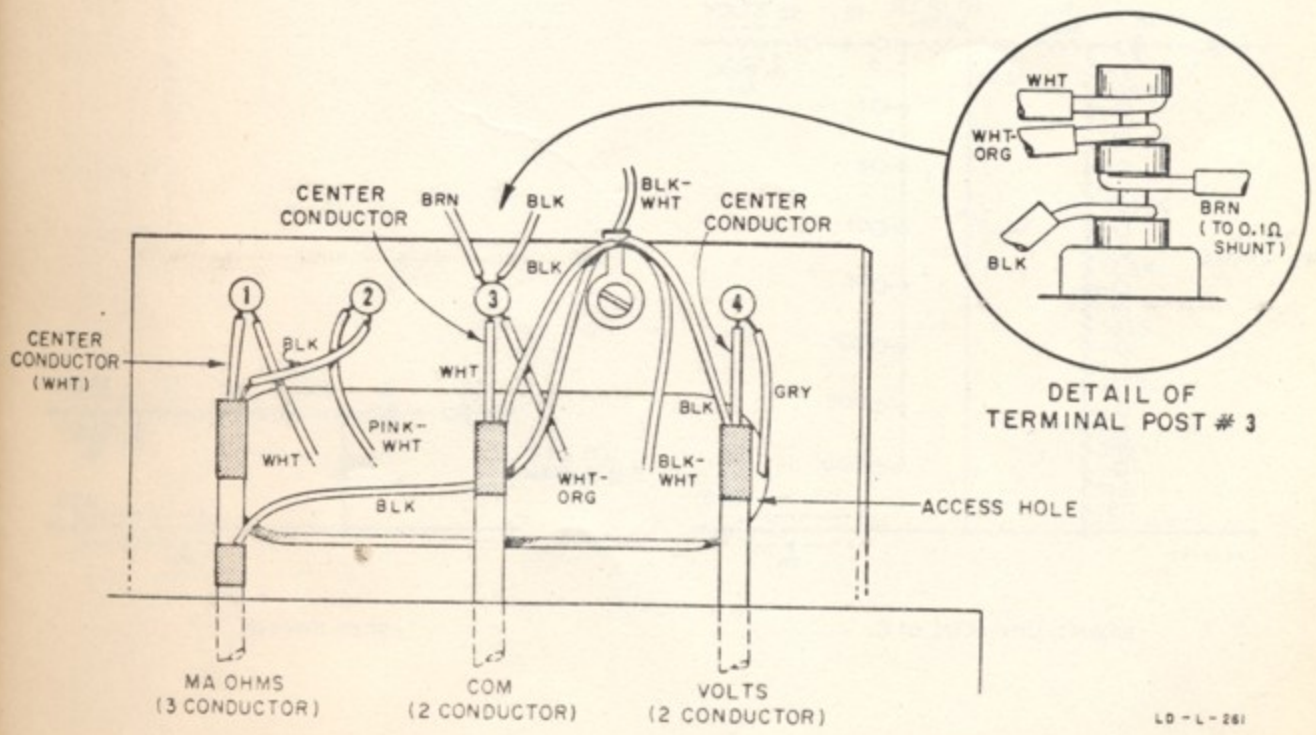
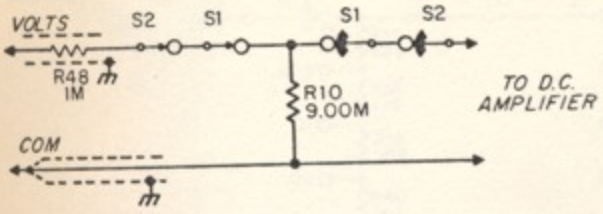
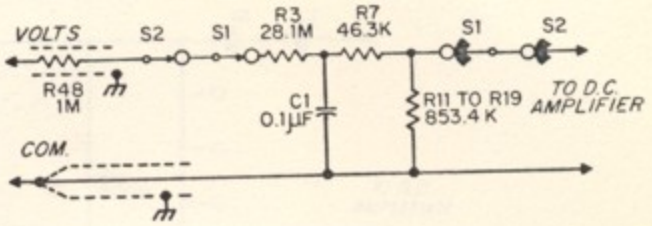


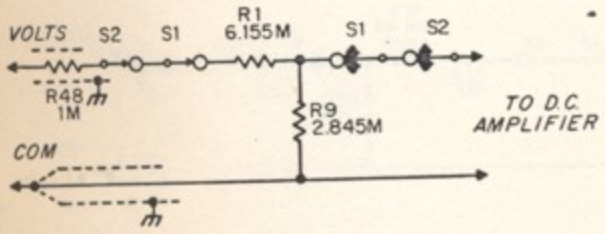
Figure 4-5. Connection Diagram for Volts, MA/OHMS and COM Cables



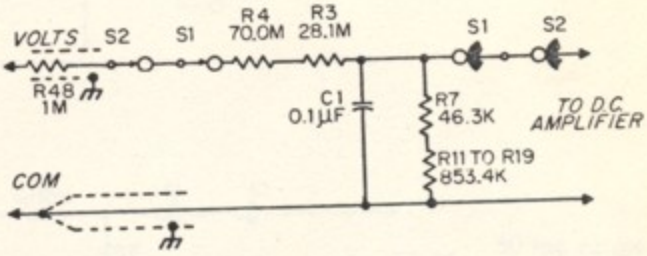
.001-volt range



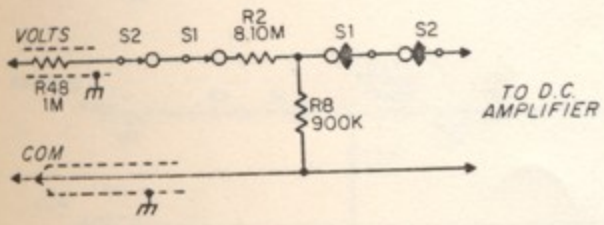
.03-volt range



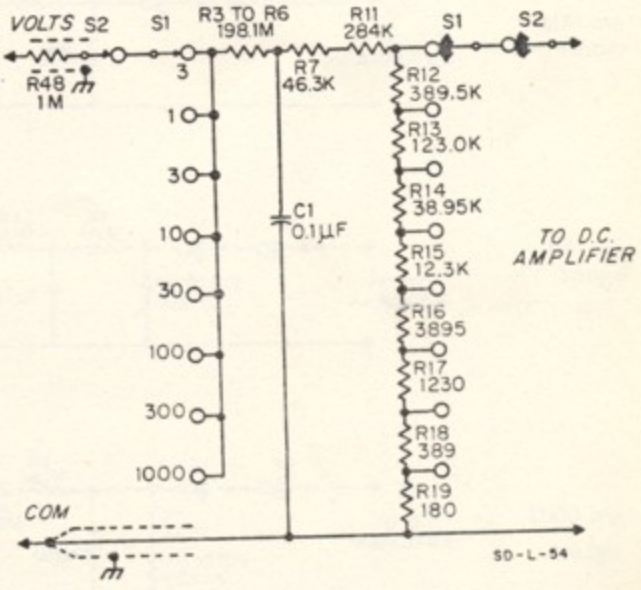
.003-volt range



.1-volt range



.01-volt range



.3 to 1000-volt ranges

Figure 4-6. Simplified Diagram of Voltmeter Switching

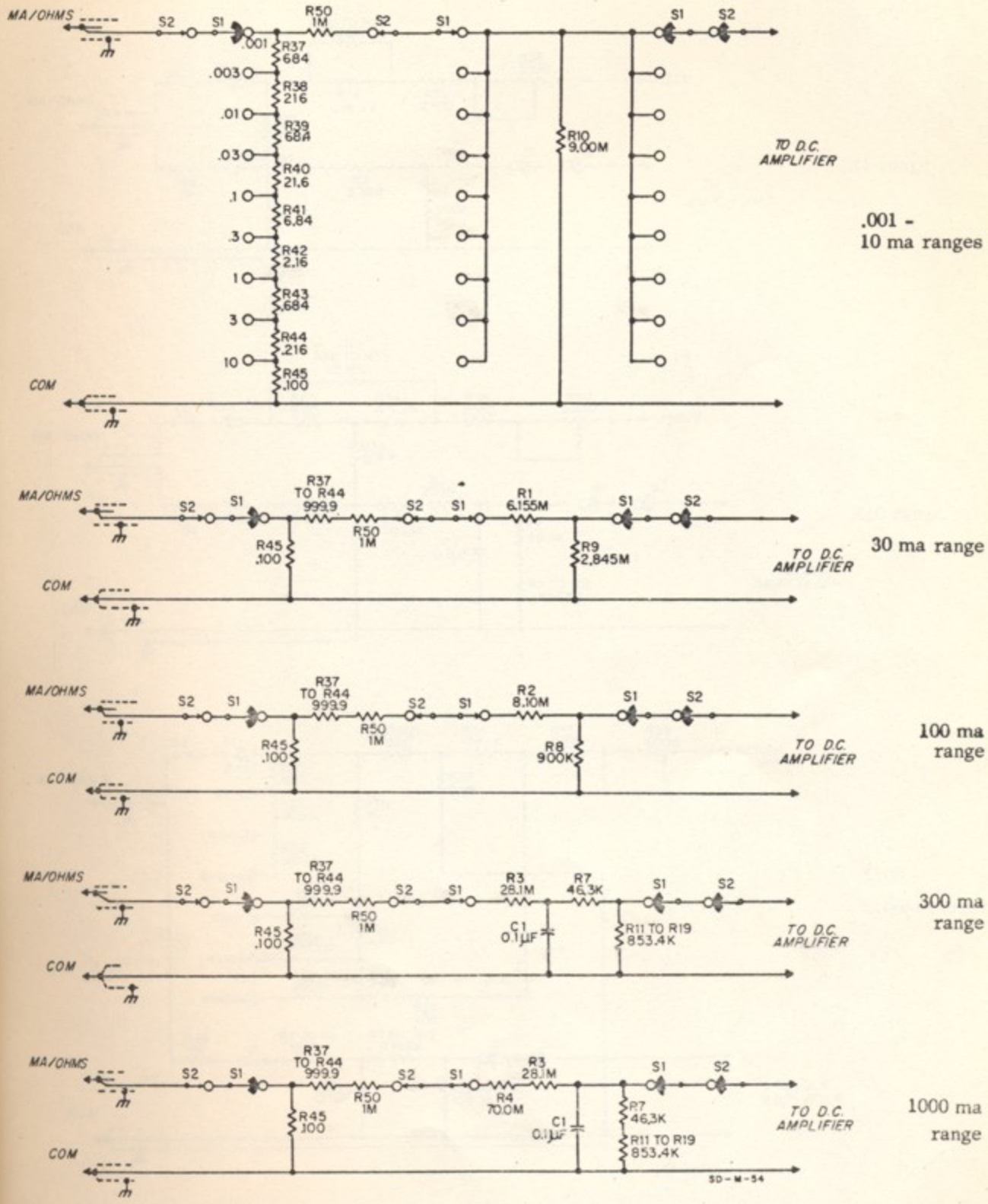


Figure 4-7. Simplified Diagram of of Ammeter Switching

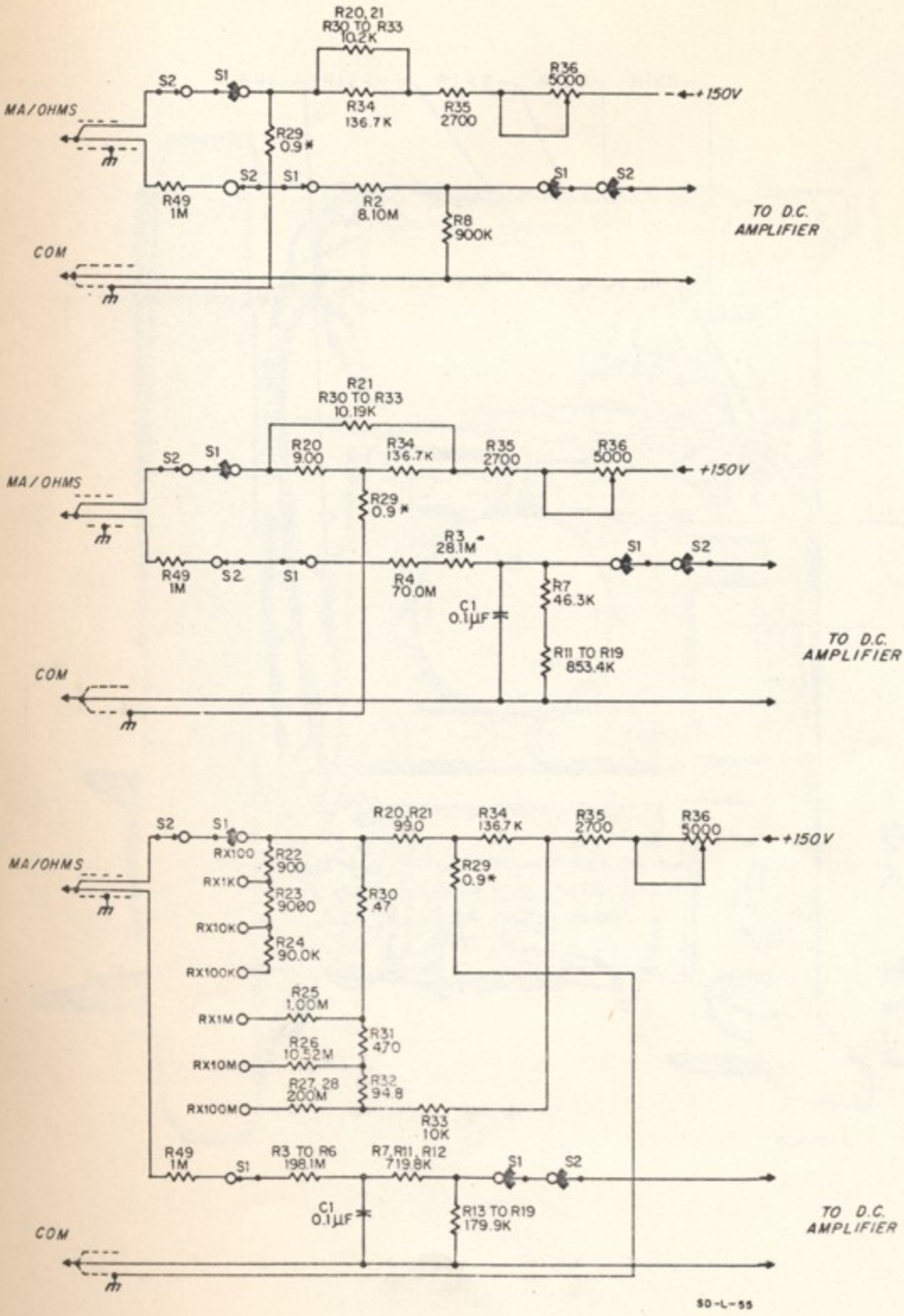


Figure 4-8. Simplified Diagram of Ohmmeter Switching

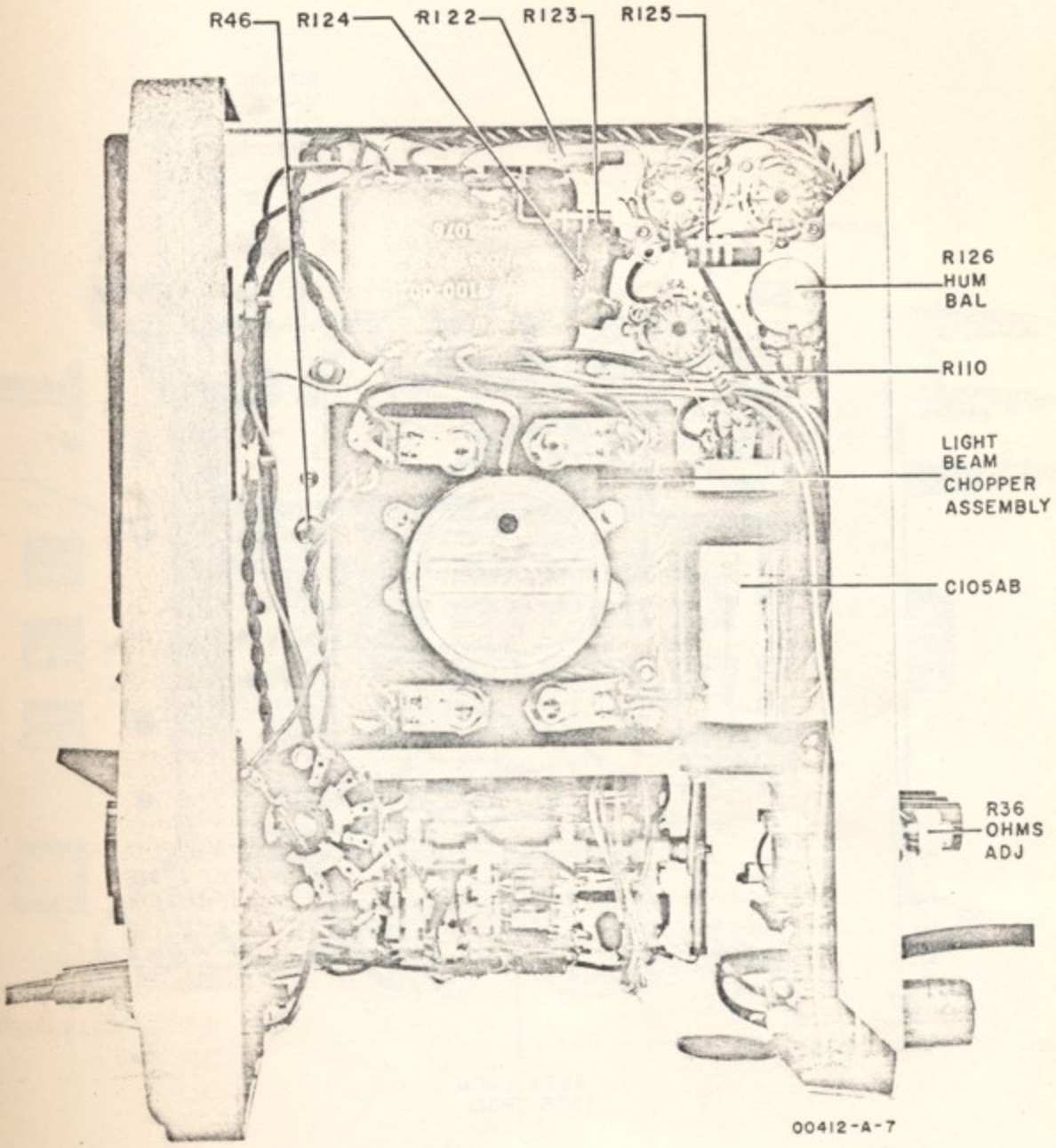


Figure 4-9. Typical Right Side View Model 412A

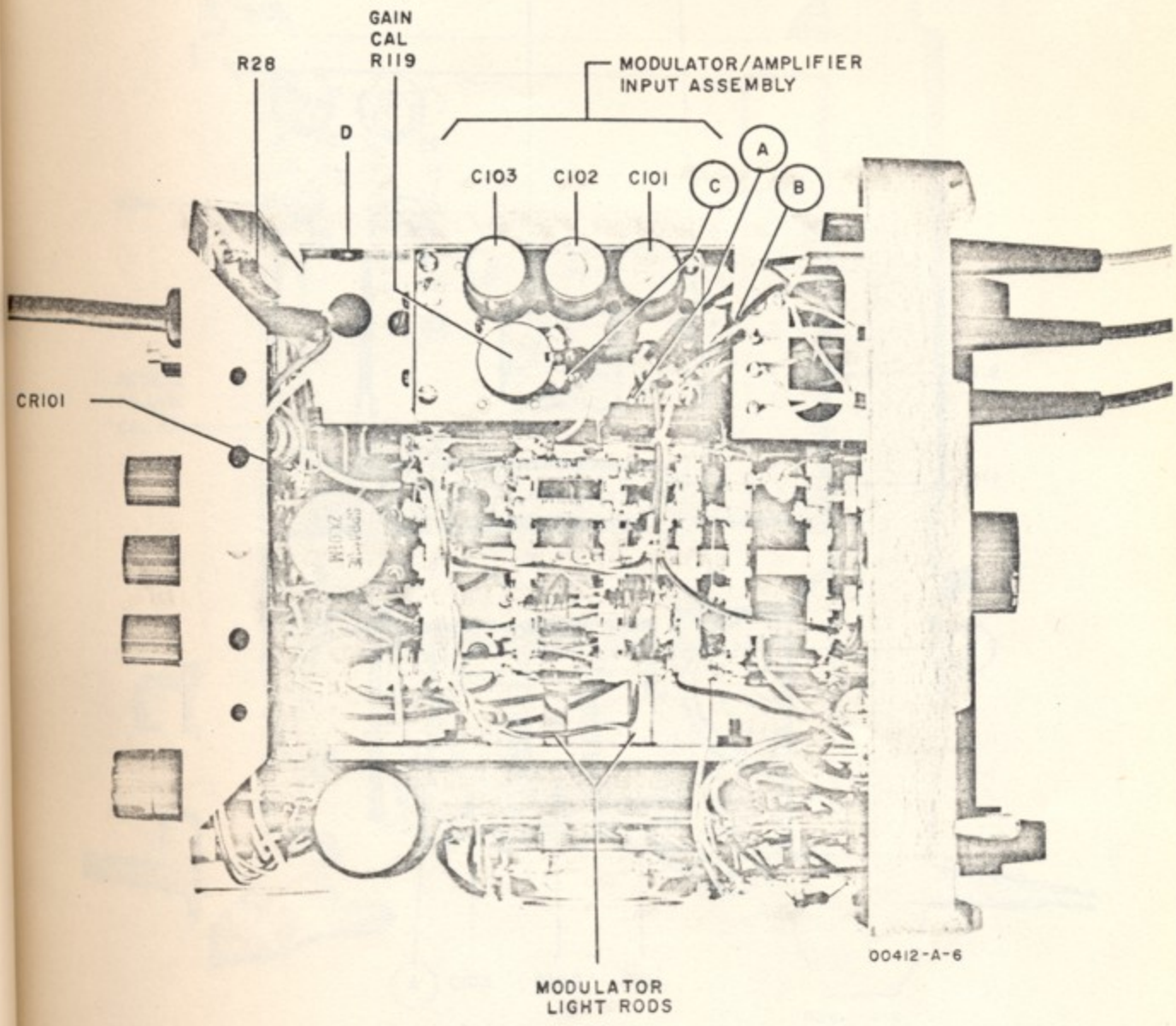


Figure 4-10. Typical Bottom View Model 412A

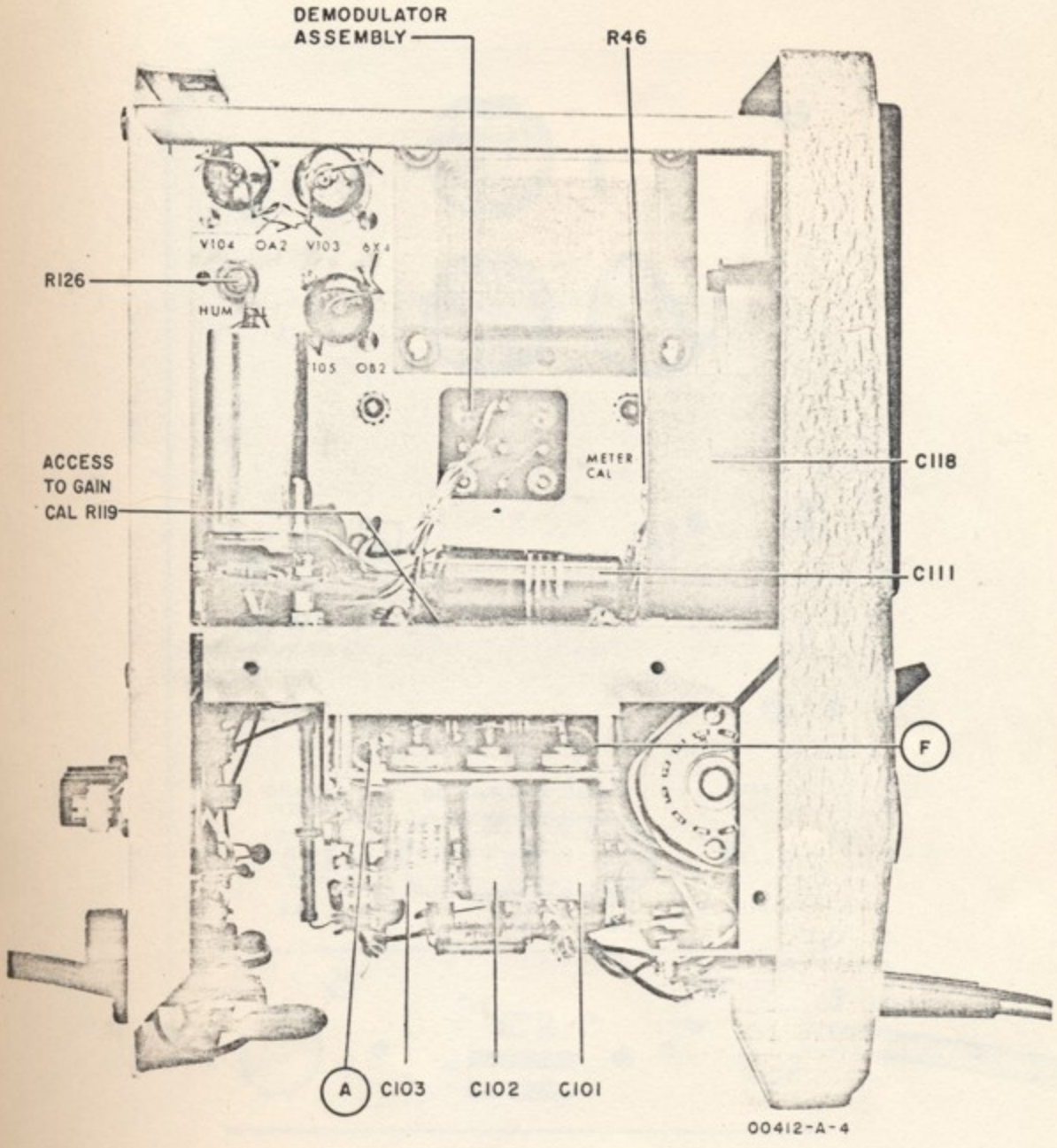


Figure 4-11. Typical Left Side View Model 412A

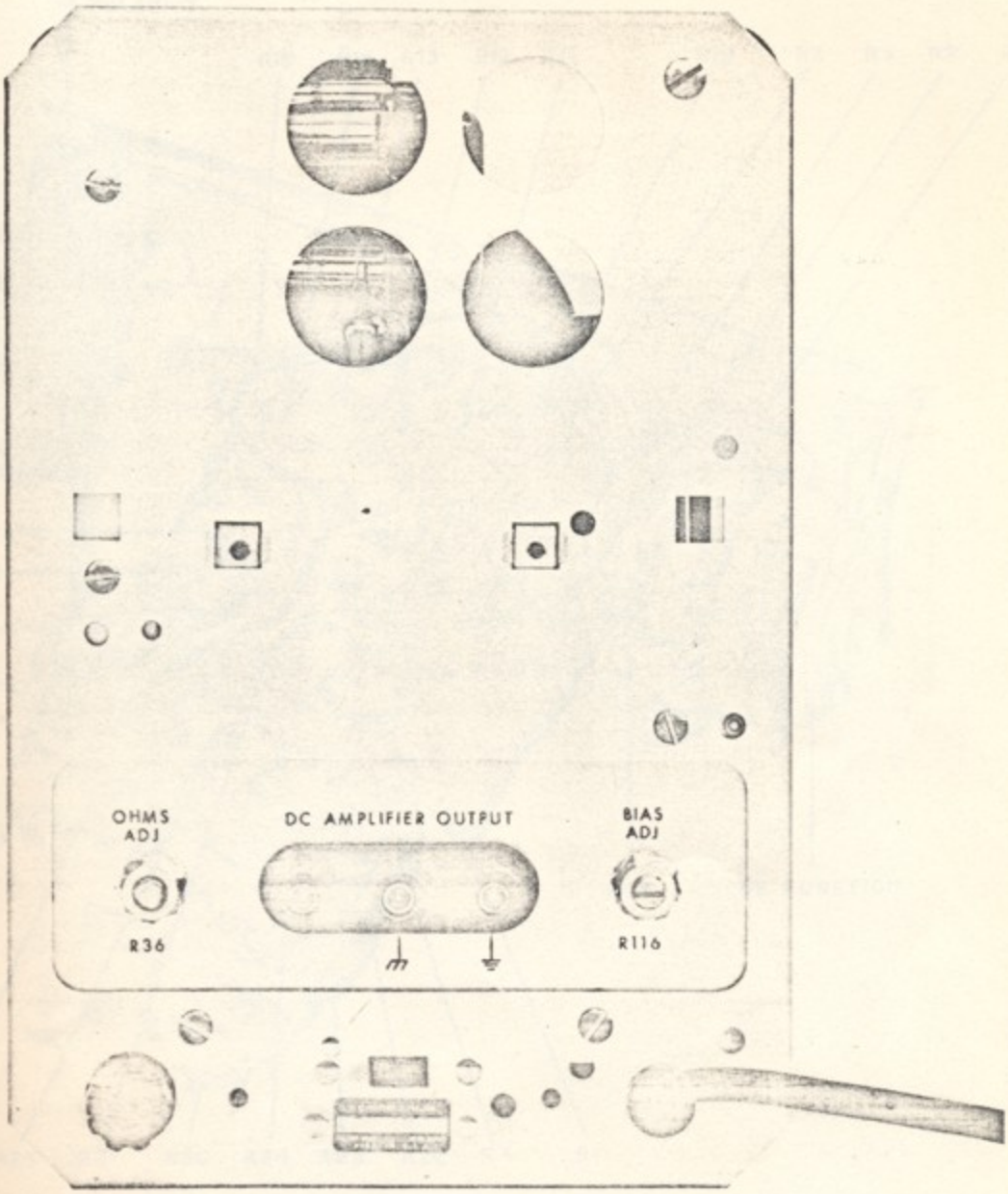


Figure 4-12. Typical Rear View Model 412A

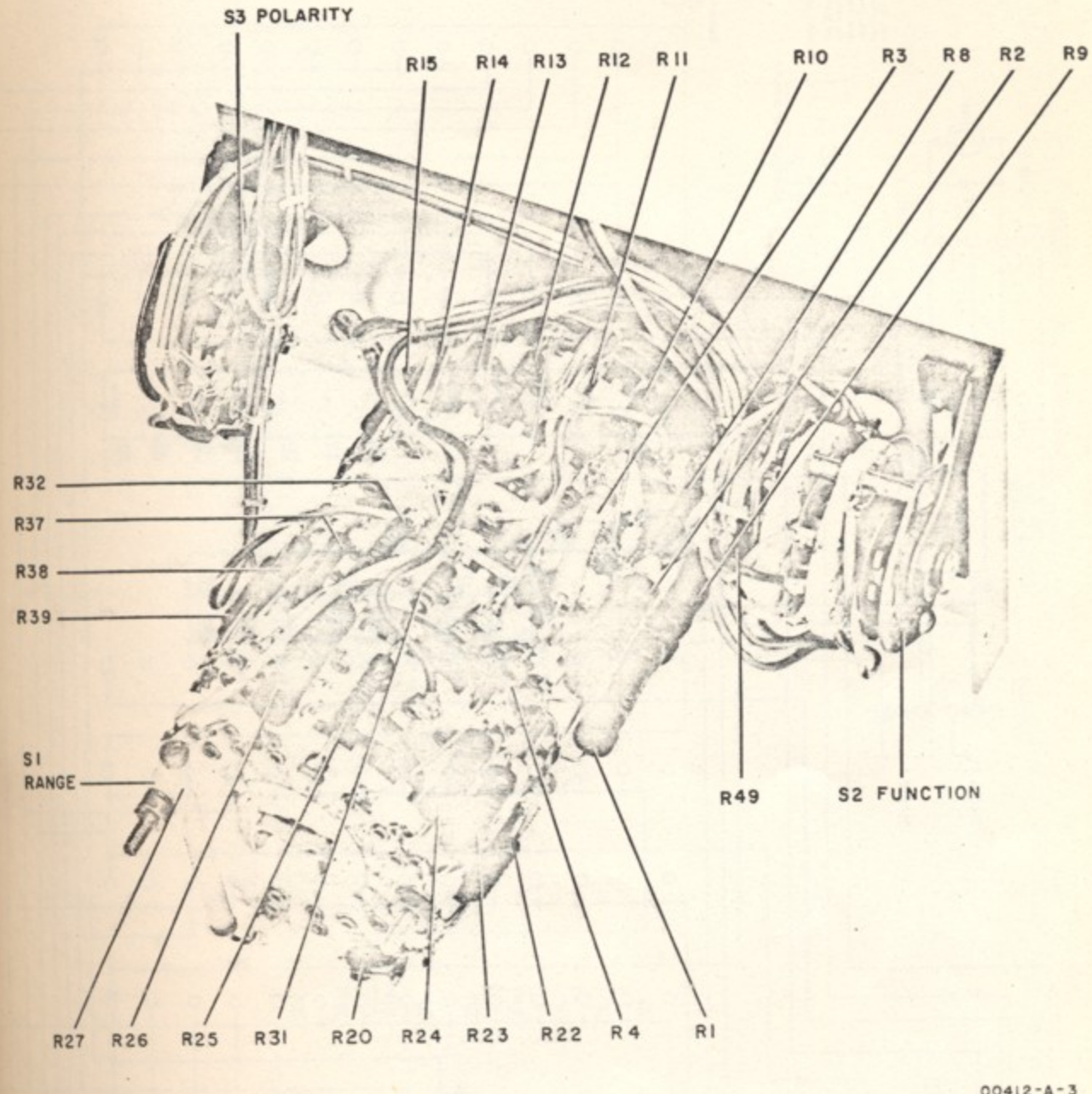


Figure 4-13. Location of Parts Mounted on Typical Range, Function, and Polarity Switches

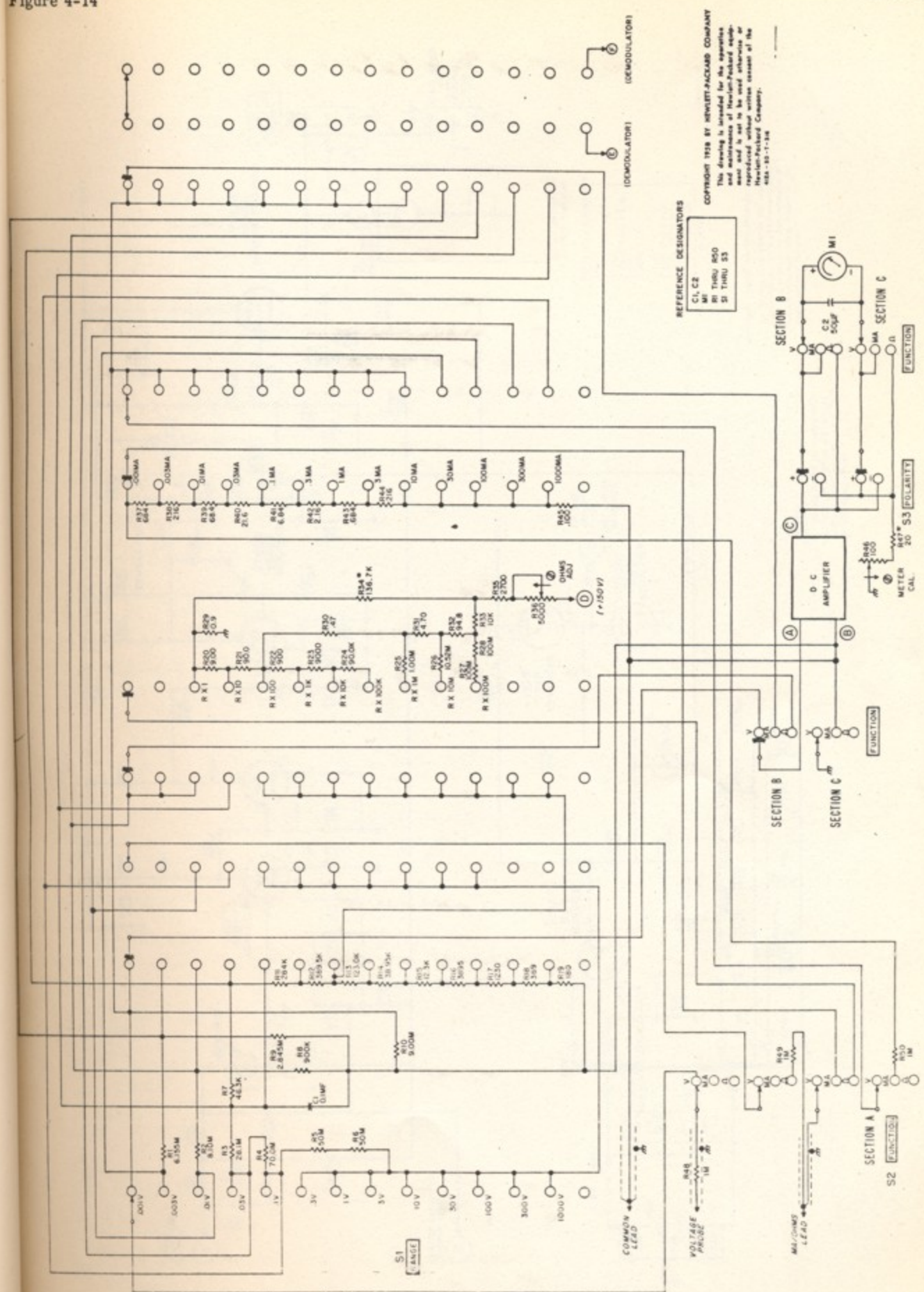


Figure 4-14. Range, Function and Polarity Switch Assembly

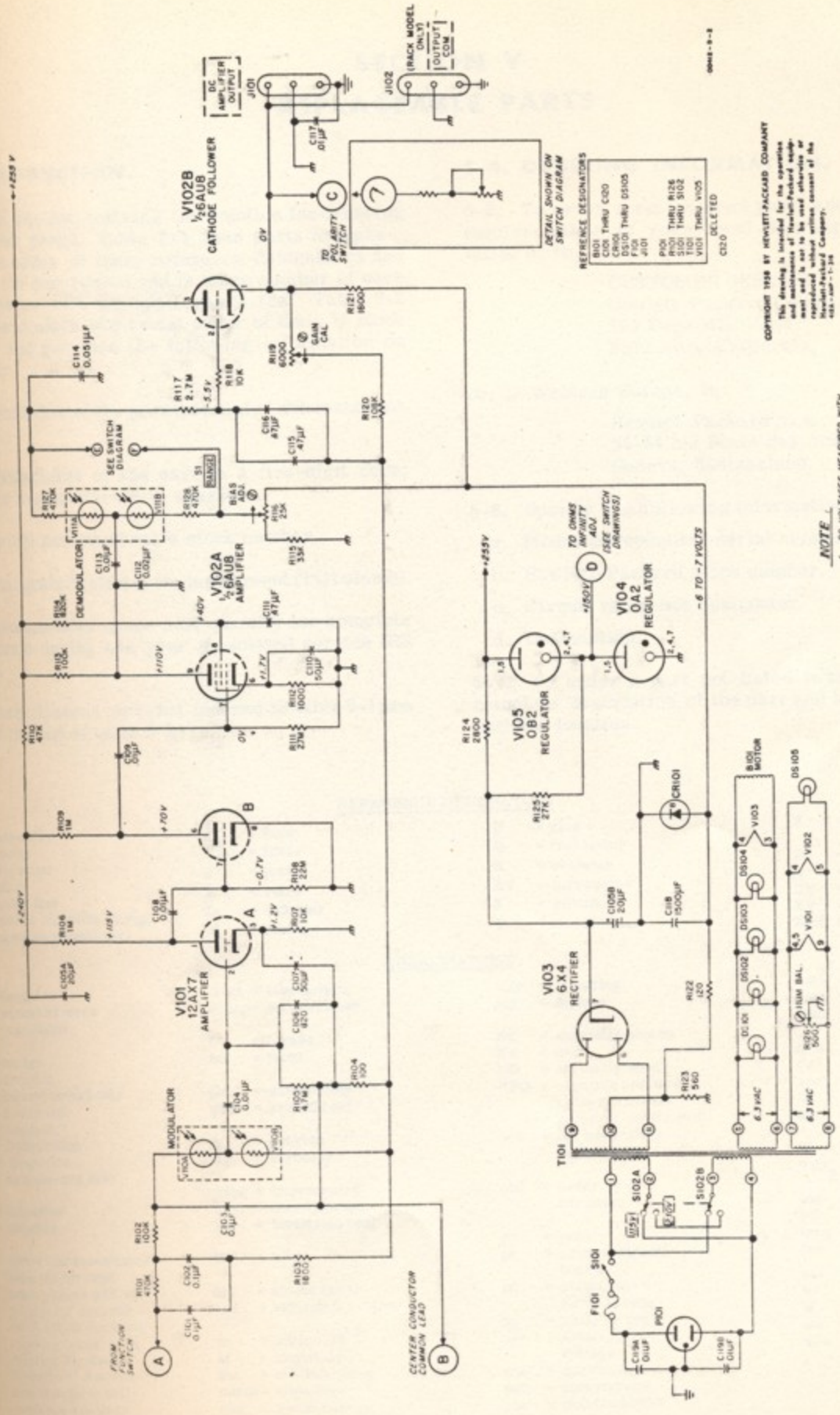


Figure 4-15. Amplifier and Power Supply

SECTION V
REPLACEABLE PARTS

-1. INTRODUCTION.

-2. This section contains information for ordering eplacement parts. Table 5-1 lists parts in alpha-umerical order of their reference designators and ndicates the description and ℗ stock number of each art, together with any applicable notes. Table 5-2 ists parts in alpha-numerical order of their ℗ stock umbers and provides the following information on ach part:

a. Description of the part (see list of abbreviations elow).

b. Manufacturer of the part in a five-digit code; ee list of manufacturers in appendix.

c. Typical manufacturer's stock number.

d. Total quantity used in the instrument (TQ column).

e. Recommended spare part quantity for complete maintenance during one year of isolated service (RS column).

5-3. Miscellaneous parts not indexed in table 5-1 are listed at the end of table 5-2.

5-4. ORDERING INFORMATION.

5-5. To order a replacement part, address order or inquiry either to your local Hewlett-Packard field office or to

CUSTOMER SERVICE
Hewlett-Packard Company
395 Page Mill Road
Palo Alto, California,

or, in Western Europe, to

Hewlett-Packard S. A.
54-54 bis Route des Acacias
Geneva, Switzerland.

5-6. Specify the following information for each part:

a. Model and complete serial number of instrument.

b. Hewlett-Packard stock number.

c. Circuit reference designator.

d. Description.

5-7. To order a part not listed in table 5-1, give a complete description of the part and include its function and location.

REFERENCE DESIGNATORS

A = assembly
B = motor
C = capacitor
CR = diode
DL = delay line
DS = device signaling (lamp)
E = misc electronic part

F = fuse
FL = filter
J = jack
K = relay
L = inductor
M = meter

P = plug
Q = transistor
R = resistor
RT = thermistor
S = switch
T = transformer

V = vacuum tube, neon bulb, photocell, etc.
W = cable
X = socket
XF = fuseholder
XV = tube socket
XDS = lampholder

ABBREVIATIONS

bp = bandpass
bwo = backward wave oscillator

c = carbon
cer = ceramic
cmo = cabinet mount only
coef = coefficient
com = common
comp = composition
conn = connection
crt = cathode-ray tube

dep = deposited
det = detector

EIA = Tubes and transistors selected for best performance will be supplied if ordered by ℗ stock numbers; tubes or transistors meeting Electronic Industries' Association standards will normally result in instrument operating within specifications

elect = electrolytic
encap = encapsulated

f = farads
fxd = fixed

Ge = germanium
grd = ground (ed)

h = henries
Hg = mercury

impg = impregnated
incd = incandescent
ins = insulation (ed)

K = kilo

lin = linear taper
log = logarithmic taper

m = milli = 10^{-3}
M = megohms
ma = milliamperes
minat = miniature
mfg = metal film on glass
mfr = manufacturer

mtg = mounting
my = mylar

NC = normally closed
Ne = neon
NO = normally open
NPO = negative positive zero-zero temperature coefficient
nsr = not separately replaceable

obd = order by description

p = peak
pc = printed circuit board
pf = picofarads = 10^{-12} farads
pp = peak-to-peak
piv = peak inverse voltage
pos = position(s)
poly = polystyrene
pot = potentiometer

rect = rectifier

rot = rotary
rms = root-mean-square
rmo = rack mount only

s-b = slow-blow
Se = selenium
sect = section(s)
Si = silicon
sl = slide

td = time delay
TiO_2 = titanium dioxide

tog = toggle
tol = tolerance
trim = trimmer
twt = traveling wave tube

var = variable
w/ = with
W = watts
ww = wirewound
w/o = without

* = optimum value selected at factory; average value shown (part may be omitted)

Table 5-1. Reference Designation Index

Circuit Reference	Stock No.	Description #	Note
B101	3140-0013	Motor, synchronous type: 6.3V, AC	
C1	0170-0019	C, fxd, my, 0.1 μf ±5%, 200 vdcw	
C2	0180-0105	C, fxd, semi-polarized, 50 μf, 25 vdcw	
C3 thru C100		Not assigned	
C101 thru C103	0170-0030	C, fxd, poly, 0.1 μf ±10%, 50 vdcw	
C104	0170-0029	C, fxd, poly, 0.01 μf ±10%, 50 vdcw	
C105A/B	0180-0086	C, fxd, elect, 2 sect, 20 μf/sect, 450 vdcw	
C106	0140-0010	C, fxd, mica, 820 pf ±10%, 500 vdcw	
C107	0180-0033	C, fxd, elect, 50 μf, 6 vdcw	
C108, 109	0150-0012	C, fxd, cer, 0.01 μf ±20%, 1000 vdcw	
C110	0180-0033	C, fxd, elect, 50 μf, 6 vdcw	
C111	0160-0015	C, fxd, paper, 0.47 μf ±10%, 200 vdcw	
C112	0150-0024	C, fxd, cer, 0.02 μf + 80% -20%, 600 vdcw	
C113	0150-0012	C, fxd, cer, 0.01 μf ±20%, 1000 vdcw	
C114	0170-0003	C, fxd, my, 0.051 μf ±10%, 200 vdcw	
C115, 116	0160-0015	C, fxd, paper, 0.47 μf ±10%, 200 vdcw	
C117	0160-0019	C, fxd, paper, 0.01 μf ±5%, 600 vdcw	
C118	0180-0054	C, fxd, elect, 1 sect, 1.5K μf, 10 vdcw	
C119A/B	0150-0119	C, fxd, cer, 2 sect, 0.01 μf/sect, 250 vdcw	
CR101	1902-0137	Diode, breakdown: 7V	
DS101 thru DS105	2140-0012	Lamp, minat: 2 pin	
F101	2110-0016	Fuse, cartridge: 0.6 amp, s-b (for 115V operation)	
	2110-0019	Fuse, cartridge: 0.4 amp, s-b (for 230V operation)	
J101	AC-10C AC-10D AC-54B	Binding post: black Binding post: red Insulator	
J102		Rack mount only	
	AC-10C AC-10D AC-54B	Binding post: black Binding post: red Insulator	
M1	G-81D	Meter	
P101	8120-0050	Power cord	
R1	0730-0128	R, fxd, dep c, 6.155M ±1/2%, 1 W	
R2	0730-0134	R, fxd, dep c, 8.1M ±1/2%, 1 W	
R3	0730-0149	R, fxd, dep c, 28.1M ±1/2%, 1 W	
R4	0733-0014	R, fxd, dep c, 70M ±1/2%, 2 W	
R5, 6	0730-0150	R, fxd, dep c, 50M ±1/2%, 1 W	
R7	0727-0192	R, fxd, dep c, 46.3K ohms ±1/2%, 1/2 W	
R8	0727-0262	R, fxd, dep c, 900K ohms ±1/2%, 1/2 W	
R9	0730-0117	R, fxd, dep c, 2.845M ±1/2%, 1 W	

See introduction to this section

Table 5-1. Reference Designation Index (Cont'd)

Circuit Reference	Ⓗ Stock No.	Description #	Note
R10	0730-0139	R, fxd, dep c, 9M ±1/2%, 1 W	
R11	0727-0231	R, fxd, dep c, 284K ohms ±1/2%, 1/2 W	
R12	0727-0239	R, fxd, dep c, 389.5K ohms ±1/2%, 1/2 W	
R13	0727-0215	R, fxd, dep c, 123K ohms ±1/2%, 1/2 W	
R14	0727-0188	R, fxd, dep c, 38.950 ohms ±1/2%, 1/2 W	
R15	0727-0164	R, fxd, dep c, 12.3K ohms ±1/2%, 1/2 W	
R16	0727-0130	R, fxd, dep c, 3895 ohms ±1/2%, 1/2 W	
R17	0727-0106	R, fxd, dep c, 1230 ohms ±1/2%, 1/2 W	
R18	0727-0070	R, fxd, dep c, 389 ohms ±1/2%, 1/2 W	
R19	0727-0051	R, fxd, dep c, 180 ohms ±1/2%, 1/2 W	
R20	412A-26G	R, fxd, ww, 9 ohms	
R21	0727-0039	R, fxd, dep c, 90 ohms ±1/2%, 1/2 W	
R22	0727-0095	R, fxd, dep c, 900 ohms ±1%, 1/2 W	
R23	0727-0152	R, fxd, dep c, 9K ohms ±1%, 1/2 W	
R24	0727-0203	R, fxd, dep c, 90K ohms ±1%, 1/2 W	
R25	0727-0274	R, fxd, dep c, 1M ±1%, 1/2 W	
R26	0730-0144	R, fxd, dep c, 10.52M ±1%, 1 W	
R27,28	0733-0017	R, fxd, dep c, 100M ±1%, 2 W	
R29	412A-26D	R, fxd, ww, 0.900 ohms	
R30	0813-0019	R, fxd, ww, 0.47 ohms ±1%, 1/2 W	
R31	0698-0001	R, fxd, comp, 4.7 ohms ±5%, 1/2 W	
R32	0727-0040	R, fxd, dep c, 94.8 ohms ±1%, 1/2 W	
R33	0811-0007	R, fxd, ww, 10K ohms ±1%, 5 W	
R34	0727-0216	R, fxd, dep c, 136.7K* ohms ±1%, 1/2 W	
R35	0690-2721	R, fxd, comp, 2.7K ohms ±10%, 1 W	
R36	2100-0011	R, var, comp, lin, 5K ohms ±20%, 1/2 W	
R37	0727-0086	R, fxd, dep c, 684 ohms ±1/2%, 1/2 W	
R38	0727-0056	R, fxd, dep c, 216 ohms ±1%, 1/2 W	
R39	0727-0035	R, fxd, dep c, 68.4 ohms ±1/2%, 1/2 W	
R40	412A-26H	R, fxd, ww, 21.6 ohms	
R41	412A-26F	R, fxd, ww, 6.84 ohms	
R42	412A-26E	R, fxd, ww, 2.16 ohms	
R43	412A-26C	R, fxd, ww, 0.684 ohms	
R44	412A-26B	R, fxd, ww, 0.216 ohms	
R45	412A-26A	R, fxd, ww, 0.1 ohms	
R46	2100-0021	R, var, ww, lin, 100 ohms ±20%, 2 W	
R47	0727-0012	R, fxd, dep c, 20*ohms ±1%, 1/2 W	
R48		nsr; part of voltage probe assy	
R49,50	0727-0274	R, fxd, dep c, 1M ±1%, 1/2 W	

See introduction to this section

Table 5-1. Reference Designation Index (Cont'd)

Circuit Reference	Stock No.	Description #	Note
R51 thru R100		Not assigned	
R101	0687-4741	R, fxd, comp, 470K ohms ±10%, 1/2 W	
R102	0687-1041	R, fxd, comp, 100K ohms ±10%, 1/2 W	
R103	0687-1821	R, fxd, comp, 1.8K ohms ±10%, 1/2 W	
R104	0727-0043	R, fxd, dep c, 100 ohms ±1%, 1/2 W	
R105	0687-4751	R, fxd, comp, 4.7M ±10%, 1/2 W	
R106	0687-1051	R, fxd, comp, 1M ±10%, 1/2 W	
R107	0687-1031	R, fxd, comp, 10K ohms ±10%, 1/2 W	
R108	0687-2261	R, fxd, comp, 22M ±10%, 1/2 W	
R109	0687-1051	R, fxd, comp, 1M ±10%, 1/2 W	
R110	0687-4731	R, fxd, comp, 47K ohms ±10%, 1/2 W	
R111	0687-2751	R, fxd, comp, 2.7M ±10%, 1/2 W	
R112	0687-1021	R, fxd, comp, 1K ohms ±10%, 1/2 W	
R113	0687-1041	R, fxd, comp, 100K ohms ±10%, 1/2 W	
R114	0687-8241	R, fxd, comp, 820K ohms ±10%, 1/2 W	
R115	0687-3331	R, fxd, comp, 33K ohms ±10%, 1/2 W	
R116	2100-0009	R, var, comp, 25K ohms ±20%, 1/3 W	
R117	0687-2751	R, fxd, comp, 2.7M ±10%, 1/2 W	
R118	0687-1031	R, fxd, comp, 10K ohms ±10%, 1/2 W	
R119	2100-0136	R, var, comp, lin, 6K ohms ±20%, 3/10 W	
R120	0727-0209	R, fxd, dep c, 108K ohms ±1%, 1/2 W	
R121	0687-1821	R, fxd, comp, 1.8K ohms ±10%, 1/2 W	
R122	0690-1211	R, fxd, comp, 120 ohms ±10%, 1 W	
R123	0690-5611	R, fxd, comp, 560 ohms ±10%, 1 W	
R124	0813-0018	R, fxd, ww, 2.8K ohms ±10%, 5 W	
R125	0693-2731	R, fxd, comp, 27K ohms ±10%, 2 W	
R126	2100-0078	R, var, comp, lin, 500 ohms ±30%, 3/10 W	
R127, 128	0684-4741	R, fxd, comp, 470K ohms ±10%, 1/4 W	
S1	412A-19W	Assy, range switch for cabinet model (incl. S2, S3)	
S1	412A-19W-1	Assy, range switch for rack model (incl. S2, S3)	
S2	3100-0183	Switch, lever: 2 sect, 3 pos	
S3	3100-0184	Switch, lever: 1 sect, 2 pos	
S4 thru S100		Not assigned	
S101	3101-0001	Switch, tog: SPST, 250V, 3 amp	
S102	3101-0033	Switch, sl: DPDT	
T1 thru T100		Not assigned	
T101	9100-0238	Transformer, power	

See introduction to this section

Table 5-1. Reference Designation Index (Cont'd)

Circuit Reference	Stock No.	Description #	Note
V1 thru V100		Not assigned	
V101	1932-0030	Tube, elect: 12AX7	
V102	1933-0007	Tube, elect: 6AU8	
V103	1930-0016	Tube, elect: 6X4	
V104	1940-0004	Tube, elect: OA2	
V105	1940-0007	Tube, elect: OB2	
V106 thru V109		Not assigned	
V110A/B		nsr; part of modulator assembly	
V111A/B	G-30E	Transducer, photoconductive	
		MISCELLANEOUS	
	AC-54F	Insulator: for J101 (bp side)	
	G-74N	Knob: range switch	
	G-74BX	Knob: function switch/polarity switch	
	412A-21D	Probe and cable assy, voltage (incl. R48)	
		SEPARATE PARTS FOR VOLTAGE PROBE AND CABLE ASSEMBLY	
	10010A	Jaw and outer sleeve assy	
	412A-21A-95A	Sleeve, inner (incl. R48)	
	5040-0407	Locknut, sleeve: plastic	
	AC-21A-95B	Inner body assy, shielded	
	5040-0405	Handle and boot assy	
	412A-21A-1	Cable assy, shielded	
	412A-83A	Boot, cable: panel mtd	
	2190-0027	Lockwasher: panel boot mtg	
	2950-0006	Nut, 1/4 - 20: panel boot mtg	
	412A-21E	Cable assy, Common	
	412A-21F	Cable assy, Ohm-Ma	
	412A-23B	Demodulator assy (incl V111A/B, R127, R128)	
	412A-37A	Light rod: modulator, for cabinet Model 412A	
	412A-37B	Light rod: modulator, for rack Model 412AR	
	412A-95A	Modulator assy (incl. V110A/B)	
	412A-58A	Input ckt assy (incl.C101-103, R101-103, V110A/B)	
	412A-65A	Amplifier assy	
	425A-97A	Chopper assy (incl. motor, lamps and leads)	
	1220-0009	Tube, shield	
	1400-0007	Fuseholder: extractor post type	
	1400-0084	Fuseholder: extractor post type	
	1450-0022	Lampholder: for 2 pin lamp	

See introduction to this section

Table 5-2. Replaceable Parts

Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
AC-10C	Binding post: black	28480	AC-10C	2	1		
AC-10D	Binding post: red	28480	AC-10D	1	1		
AC-54B	Insulator	28480	AC-54B	1	1		
G-81D	Meter	28480	G-81D	1	1		
G-30E	Transducer, photoconductive; part of 412A-23B	28480	G-29G-79	1	1		
412A-26A	R, fxd, ww, 0.1 ohms	28480	G-30E	2	0		
412A-26B	R, fxd, ww, 0.216 ohms	28480	412A-26A	1	1		
412A-26C	R, fxd, ww, 0.684 ohms	28480	412A-26B	1	1		
412A-26D	R, fxd, ww, 0.900 ohms	28480	412A-26C	1	1		
412A-26E	R, fxd, ww, 2.16 ohms	28480	412A-26D	1	1		
412A-26F	R, fxd, ww, 6.84 ohms	28480	412A-26E	1	1		
412A-26G	R, fxd, ww, 9 ohms	28480	412A-26F	1	1		
412A-26H	R, fxd, ww, 21.6 ohms	28480	412A-26G	1	1		
412A-19W	Assy, range switch: for 412A (incl. 3100-0183 and 3100-0184)	28480	412A-26H	1	1		
412A-19W-1	Assy, range switch: for 412AR (incl. 3100-0183 and 3100-0184)	28480	412A-19W	1	1		
0140-0010	C, fxd, mica, 820 pf ±10%, 500 vdcw	76433	412A-19W-1	(1)	(1)		
0150-0012	C, fxd, cer, 0.01 µf ±20%, 1000 vdcw	56289	RCM20B821K	1	1		
0150-0024	C, fxd, cer, 0.02 µf + 80% -20%, 600 vdcw	91418	29C214A3-H-1038	3	1		
0150-0119	C, fxd, cer, 2 sect, 0.01 µf/sect, 250 vdcw	71590	B-02GMV	1	1		
0160-0015	C, fxd, paper, 0.47 µf ±10%, 200 vdcw	56289	DA171CB	1	1		
0160-0019	C, fxd, paper, 0.01 µf ±5%, 600 vdcw	56289	109P47492	3	1		
0170-0003	C, fxd, my, 0.051 µf ±10%, 200 vdcw	00853	160P10356	1	1		
0170-0019	C, fxd, my, 0.1 µf ±5%, 200 vdcw	84411	33M02152	1	1		
0170-0029	C, fxd, poly, 0.01 µf ±10%, 50 vdcw	56289	620S	1	1		
0170-0030	C, fxd, poly, 0.1 µf ±10%, 50 vdcw	56289	114P1039R5S2	1	1		
0180-0033	C, fxd, elect, 50 µf, 6 vdcw	56289	type 114P, style T15	3	1		
0180-0054	C, fxd, elect, 1 sect, 1.5K µf, 10 vdcw	56289	30D133A1	2	1		
0180-0086	C, fxd, elect, 2 sect, 20 µf/sect, 450 vdcw	56289	D32495	1	1		
0180-0105	C, fxd, semi-polarized, 50 µf, 25 vdcw	56289	D32477	1	1		
0684-4741	R, fxd, comp, 470K ohms ±10%, 1/4 W	01121	S97441	1	1		
0687-1021	R, fxd, comp, 1K ohms ±10%, 1/2 W	01121	CB4741	2	2		
0687-1031	R, fxd, comp, 10K ohms ±10%, 1/2 W	01121	EB1021	1	1		
0687-1041	R, fxd, comp, 100K ohms ±10%, 1/2 W	01121	EB1031	2	1		
0687-1051	R, fxd, comp, 1M ±10%, 1/2 W	01121	EB1041	2	1		
0687-1821	R, fxd, comp, 1.8K ohms ±10%, 1/2 W	01121	EB1051	2	1		
0687-2261	R, fxd, comp, 22M ±10%, 1/2 W	01121	EB1821	2	1		
0687-2751	R, fxd, comp, 2.7M ±10%, 1/2 W	01121	EB2261	1	1		
0687-3331	R, fxd, comp, 33K ohms ±10%, 1/2 W	01121	EB2751	2	1		
0687-4731	R, fxd, comp, 47K ohms ±10%, 1/2 W	01121	EB3331	1	1		
0687-4741	R, fxd, comp, 470K ohms ±10%, 1/2 W	01121	EB4731	1	1		
			EB4741	1	1		

See introduction to this section

Table 5-2. Replaceable Parts (Cont'd)

Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
0687-4751	R, fxd, comp, 4.7M ±10%, 1/2 W	01121	EB4751	1	1		
0687-8241	R, fxd, comp, 820K ohms ±10%, 1/2 W	01121	EB8241	1	1		
0690-1211	R, fxd, comp, 120 ohms ±10%, 1 W	01121	GB1211	1	1		
0690-2721	R, fxd, comp, 2.7K ohms ±10%, 1 W	01121	GB2721	1	1		
0693-2731	R, fxd, comp, 27K ohms ±10%, 2 W	01121	HB2731	1	1		
0698-0001	R, fxd, comp, 4.7 ohms ±5%, 1/2 W	01121	EB47G5	1	1		
0727-0012	R, fxd, dep c, 20* ohms ±1%, 1/2 W	19701	DC1/2CR5 obd#	1	1		
0727-0035	R, fxd, dep c, 68.4 ohms ±1/2%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0039	R, fxd, dep c, 90 ohms ±1/2%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0040	R, fxd, dep c, 94.8 ohms ±1%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0043	R, fxd, dep c, 100 ohms ±1%, 1/2 W	19701	DC1/2BR5 obd#	1	1		
0727-0051	R, fxd, dep c, 180 ohms ±1/2%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0056	R, fxd, dep c, 216 ohms ±1/2%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0070	R, fxd, dep c, 389 ohms ±1/2%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0086	R, fxd, dep c, 684 ohms ±1/2%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0095	R, fxd, dep c, 900 ohms ±1%, 1/2 W	19701	DC1/2CR5 obd#	1	1		
0727-0106	R, fxd, dep c, 1230 ohms ±1/2%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0130	R, fxd, dep c, 3895 ohms ±1/2%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0152	R, fxd, dep c, 9K ohms ±1%, 1/2 W	19701	DC1/2BR5 obd#	1	1		
0727-0164	R, fxd, dep c, 12.3K ohms ±1/2%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0188	R, fxd, dep c, 38.95K ohms ±1/2%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0192	R, fxd, dep c, 46.3K ohms ±1/2%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0203	R, fxd, dep c, 90K ohms ±1%, 1/2 W	19701	DC1/2BR5 obd#	1	1		
0727-0209	R, fxd, dep c, 108K ohms ±1%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0215	R, fxd, dep c, 123K ohms ±1/2%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0216	R, fxd, dep c, 136.7* ohms ±1%, 1/2 W	19701	DC1/2CR5 obd#	1	1		
0727-0231	R, fxd, dep c, 284K ohms ±1/2%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0239	R, fxd, dep c, 389.5K ohms ±1/2%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0262	R, fxd, dep c, 900K ohms ±1/2%, 1/2 W	19701	DC1/2AR5 obd#	1	1		
0727-0274	R, fxd, dep c, 1M ±1%, 1/2 W	19701	DC1/2AR5 obd#	3	1		
0730-0117	R, fxd, dep c, 2.845M ±1/2%, 1 W	19701	DC1R5 obd#	1	1		
0730-0128	R, fxd, dep c, 6.155M ±1/2%, 1 W	19701	DC1R5 obd#	1	1		
0730-0134	R, fxd, dep c, 8.1M ±1/2%, 1 W	19701	DC1R5 obd#	1	1		
0730-0139	R, fxd, dep c, 9M ±1/2%, 1 W	19701	DC1R5 obd#	1	1		
0730-0144	R, fxd, dep c, 10.52M ±1%, 1 W	19701	DC1R5 obd#	1	1		
0730-0149	R, fxd, dep c, 28.1M ±1/2%, 1 W	03888	PT1000 obd#	1	1		
0730-0150	R, fxd, dep c, 50M ±1/2%, 1 W	19701	DC1R5 obd#	2	1		
0733-0014	R, fxd, dep c, 70M ±1/2%, 2 W	03888	PT2000 obd#	1	1		
0733-0017	R, fxd, dep c, 100M ±1%, 2 W	03888	PT2000 obd#	2	1		

See introduction to this section

Table 5-2. Replaceable Parts (Cont'd)

# Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
0811-0007	R, fxd, ww, 10K ohms ±1%, 5 W	91637	RS-5	1	1		
0813-0018	R, fxd, ww, 2.8K ohms ±10%, 5 W	35434	C-5-2800	1	1		
0813-0019	R, fxd, ww, 0.47 ohms ±1%, 1/2 W	75042	BW-1/2	1	1		
1902-0137	Diode, breakdown: 7V	28480	1902-0137	1	1		
1930-0016	Tube, elect: 6X4	80131	6X4	1	1		
1932-0030	Tube, elect: 12AX7	80131	12AX7	1	1		
1933-0007	Tube, elect: 6AU8	80131	6AU8	1	1		
1940-0004	Tube, elect: OA2	80131	OA2	1	1		
1940-0007	Tube, elect: OB2	80131	OB2	1	1		
2100-0009	R, var, comp, 25K ohms ±20%, 1/3 W	11237	type 45 obd#	1	1		
2100-0011	R, var, comp, lin, 5K ohms ±20%, 1/2 W	11237	type 45 obd#	1	1		
2100-0021	R, var, ww, lin, 100 ohms ±20%, 2 W	11236	type 112	1	1		
2100-0078	R, var, comp, lin, 500 ohms ±30%, 3/10 W	11237	Model 70	1	1		
2100-0136	R, var, comp, lin, 6K ohms ±20%, 3/10 W	11237	type 70	1	1		
2110-0016	Fuse, cartridge: 0.6 amp, s-b (for 115V operation)	71400	MDL6/10	1	10		
2110-0019	Fuse, cartridge: 0.4 amp, s-b (for 230V operation)	75915	313-400				
2140-0012	Lamp, minat: 2 pin base	24455	No. 12	5	5		
3100-0183	Switch, lever: 2 sect, 3 pos	76854	190503-187-N2C	1	1		
3100-0184	Switch, lever: 1 sect, 2 pos	76854	189777-187-K1	1	1		
3101-0001	Switch, tog: SPST, 250V, 3 amp	04009	80994-H	1	1		
3101-0033	Switch, sl: DPDT	42190	4633	1	1		
3140-0013	Motor, synchronous type: 6.3V, AC	73061	"synchron" model 610 (6.3V)	1	1		
8120-0050	Power cord	70903	CS-9941/PH-151/ 7.5 ft	1	1		
9100-0238	Transformer, power	28480	9100-0238	1	1		

See introduction to this section

Table 5-2. Replaceable Parts (Cont'd)

Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
	MISCELLANEOUS						
C-54F	Insulator: for J101 (bp side)	28480	AC-54F	1	1		
G-74N	Knob: range switch	28480	G-74N	1	1		
G-74BX	Knob: function switch/polarity switch	28480	G-74BX	2	1		
12A-21D	Probe and cable assy, voltage	28480	412A-21D	1	1		
	SEPARATE PARTS FOR VOLTAGE PROBE AND CABLE ASSEMBLY						
C-21A-95B	Inner body assy, shielded	28480	AC-21A-95B	1	0		
12A-21A-1	Cable assembly, shielded	28480	412A-21A-1	1	1		
12A-21A-95A	Sleeve, inner (incl. R48)	28480	412A-21A-95A	1	1		
12A-83A	Boot, cable: panel mtd.	28480	412A-83A	1	0		
190-0027	Lockwasher: panel boot mtg.	78189	1914	1	0		
950-0006	Nut, 1/4 - 32: panel boot mtg.	73734	9000	1	0		
040-0405	Handle and boot assy	28480	5040-0405	1	0		
040-0407	Locknut, sleeve: plastic	28480	5040-0407	1	1		
0010A	Jaw and outer sleeve assy	28480	10010A	1	1		
12A-21E	Cable assy, Common	28480	412A-21E	1	1		
12A-21F	Cable assy, Ohm-Ma	28480	412A-21F	1	1		
12A-23B	Demodulator assy	28480	412A-23B	1	1		
12A-37A	Light rod: modulator for Model 412A	28480	412A-37A	2	1		
12A-37B	Light rod: modulator for Model 412AR	28480	412A-37B	(2)	(1)		
12A-58A	Input ckt assy (incl.modulator assy 412A-95A)	28480	412A-58A	1	1		
12A-75A	Amplifier assy	28480	412A-65A	1	1		
12A-95A	Modulator assy (incl. V110A/B)	28480	412A-95A	1	0		
25A-97A	Chopper assy (incl. motor, lamps and leads)	28480	425A-97A	1	1		
220-0009	Tube, shield	71785	12627	1	1		
400-0007	Fuseholder: extractor post type	75915	342003	1	1		
400-0084	Fuseholder: extractor post type	75915	342014	1	1		
350-0022	Lampholder: for 2 pin lamp	72765	2020AE	5	1		

See introduction to this section