1932
Official
Radio Service
Manual
Vol. No. 1
Complete Directory
of all
1931-1933 Radio Receivers
Full Radio Service Guide
## TEXT INDEX

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>5</td>
</tr>
<tr>
<td>Elementary Radio Servicing</td>
<td>6</td>
</tr>
<tr>
<td>Servicing Radio Receivers</td>
<td>12</td>
</tr>
<tr>
<td>Analysis of Typical Receiver</td>
<td>25</td>
</tr>
<tr>
<td>Direct Current Receivers</td>
<td>42</td>
</tr>
<tr>
<td>Superheterodyne Service Notes</td>
<td>44</td>
</tr>
<tr>
<td>Remote Control Devices</td>
<td>47</td>
</tr>
<tr>
<td>Vacuum Tubes and Their Operation</td>
<td>49</td>
</tr>
<tr>
<td>Operating Data on Commercial Vacuum Tubes</td>
<td>54</td>
</tr>
<tr>
<td>Servicing the Automotive Receiver</td>
<td>90</td>
</tr>
<tr>
<td>Sound Pictures and the Service Man</td>
<td>101</td>
</tr>
<tr>
<td>Erecting Aerial and Installing Set</td>
<td>109</td>
</tr>
<tr>
<td>Electrolytic Condensers</td>
<td>112</td>
</tr>
<tr>
<td>A Modulated Test Oscillator</td>
<td>113</td>
</tr>
<tr>
<td>Potentiometers</td>
<td>114</td>
</tr>
<tr>
<td>R.M.A. Color Code</td>
<td>117</td>
</tr>
<tr>
<td>Ballast Resistor Calculation</td>
<td>118</td>
</tr>
<tr>
<td>Replacement Condenser Notes</td>
<td>119</td>
</tr>
<tr>
<td>Short Wave Receivers and Converters</td>
<td>122</td>
</tr>
<tr>
<td>Public Address and Centralized Radio Systems</td>
<td>125</td>
</tr>
<tr>
<td>Commercial Receiver Index</td>
<td>End of Book</td>
</tr>
<tr>
<td>Company</td>
<td>Models</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>AUDIOLA RADIO CO.</td>
<td></td>
</tr>
<tr>
<td>Model 6T Junior 101</td>
<td>. . . 170</td>
</tr>
<tr>
<td>AZTEC RADIO CO.</td>
<td></td>
</tr>
<tr>
<td>5 tube Pentode</td>
<td>. . . 177</td>
</tr>
<tr>
<td>BELMONT RADIO CORP.</td>
<td></td>
</tr>
<tr>
<td>Model 40</td>
<td>. . . 178</td>
</tr>
<tr>
<td>Models 45, 46</td>
<td>. . . 179</td>
</tr>
<tr>
<td>CROSLEY RADIO CORP.</td>
<td></td>
</tr>
<tr>
<td>Model 124</td>
<td>. . . 215</td>
</tr>
<tr>
<td>ECHOPHONE RADIO MFG. CO.</td>
<td></td>
</tr>
<tr>
<td>Model 48</td>
<td>. . . 226</td>
</tr>
<tr>
<td>Model 60</td>
<td>. . . 227</td>
</tr>
<tr>
<td>Model 80</td>
<td>. . . 223</td>
</tr>
<tr>
<td>Model 90</td>
<td>. . . 228</td>
</tr>
<tr>
<td>FEDERATED PURCHASER INC.</td>
<td></td>
</tr>
<tr>
<td>Models 35-40</td>
<td>. . . 233</td>
</tr>
<tr>
<td>Model 2</td>
<td>. . . 234</td>
</tr>
<tr>
<td>JESSE FRENCH &amp; SONS PIANO CO.</td>
<td></td>
</tr>
<tr>
<td>Model H-1</td>
<td>. . . 232</td>
</tr>
<tr>
<td>GRAYBAR ELECTRIC CO.</td>
<td></td>
</tr>
<tr>
<td>Model 8</td>
<td>. . . 247</td>
</tr>
<tr>
<td>GRIGSBY-GRUNOW COMPANY</td>
<td></td>
</tr>
<tr>
<td>Model 15</td>
<td>. . . 250</td>
</tr>
<tr>
<td>HORN RADIO CO.</td>
<td></td>
</tr>
<tr>
<td>Model 59</td>
<td>. . . 265</td>
</tr>
<tr>
<td>INSULINE CORPORATION OF AMERICA</td>
<td></td>
</tr>
<tr>
<td>AC Broadcast and Long Wave Combination</td>
<td>. . . 269</td>
</tr>
<tr>
<td>110 volt DC Midget</td>
<td>. . . 270</td>
</tr>
<tr>
<td>DC Broadcast and Long Wave</td>
<td>. . . 270</td>
</tr>
<tr>
<td>220 volt DC Midget</td>
<td>. . . 271</td>
</tr>
<tr>
<td>Insullette and Mascot</td>
<td></td>
</tr>
<tr>
<td>Broadcast and Long Wave</td>
<td>. . . 272</td>
</tr>
<tr>
<td>Insullette and Mascot AC</td>
<td>. . . 272</td>
</tr>
<tr>
<td>JACKSON BELL COMPANY</td>
<td></td>
</tr>
<tr>
<td>Model 84</td>
<td>. . . 275</td>
</tr>
<tr>
<td>Model 88</td>
<td>. . . 277</td>
</tr>
<tr>
<td>Model 87</td>
<td>. . . 276</td>
</tr>
<tr>
<td>Model 89A</td>
<td>. . . 278</td>
</tr>
<tr>
<td>COLIN B. KENNEDY CORP.</td>
<td></td>
</tr>
<tr>
<td>Model 42</td>
<td>. . . 285</td>
</tr>
<tr>
<td>KOLSTER RADIO Inc.</td>
<td></td>
</tr>
<tr>
<td>Models K-60, K-62</td>
<td>. . . 288</td>
</tr>
<tr>
<td>PHILADELPHIA STORAGE BATTERY CO.</td>
<td></td>
</tr>
<tr>
<td>Models 50, 50A</td>
<td>. . . 306</td>
</tr>
<tr>
<td>Model 35</td>
<td>. . . 310</td>
</tr>
<tr>
<td>PIERCE AIRO, Inc.</td>
<td></td>
</tr>
<tr>
<td>Model 746-7M</td>
<td>. . . 320</td>
</tr>
<tr>
<td>Model 546</td>
<td>. . . 315</td>
</tr>
<tr>
<td>Model 547</td>
<td>. . . 314</td>
</tr>
<tr>
<td>Model 554</td>
<td>. . . 312</td>
</tr>
<tr>
<td>PILOT RADIO &amp; TUBE CORP.</td>
<td></td>
</tr>
<tr>
<td>5 tube TRF Midget</td>
<td>. . . 321</td>
</tr>
<tr>
<td>RCA VICTOR, Inc.</td>
<td></td>
</tr>
<tr>
<td>Model R-5 Radiette</td>
<td>. . . 334</td>
</tr>
<tr>
<td>Model R-5 DC</td>
<td>. . . 336</td>
</tr>
<tr>
<td>REMLER COMPANY, Ltd.</td>
<td></td>
</tr>
<tr>
<td>Model 21</td>
<td>. . . 365</td>
</tr>
<tr>
<td>Model 15</td>
<td>. . . 366</td>
</tr>
<tr>
<td>ROLA COMPANY</td>
<td></td>
</tr>
<tr>
<td>Models 80, 90</td>
<td>. . . 367</td>
</tr>
<tr>
<td>SIMPLEX RADIO COMPANY</td>
<td></td>
</tr>
<tr>
<td>Model K</td>
<td>. . . 368</td>
</tr>
<tr>
<td>SILVER MARSHALL, Inc.</td>
<td></td>
</tr>
<tr>
<td>Model 782-16</td>
<td>. . . 377</td>
</tr>
<tr>
<td>Model F</td>
<td>. . . 388</td>
</tr>
<tr>
<td>SPARKS WITHINGTON, Inc.</td>
<td></td>
</tr>
<tr>
<td>Model 5</td>
<td>. . . 397</td>
</tr>
<tr>
<td>Model 410-420 DC</td>
<td>. . . 400</td>
</tr>
<tr>
<td>Model 10</td>
<td>. . . 403</td>
</tr>
<tr>
<td>Model 9</td>
<td>. . . 397</td>
</tr>
<tr>
<td>STERLING MFG. CO.</td>
<td></td>
</tr>
<tr>
<td>Miniature Receiver</td>
<td>. . . 420</td>
</tr>
<tr>
<td>Model 5-D-3A</td>
<td>. . . 449D</td>
</tr>
<tr>
<td>TRANSFORMER CORPORATION OF AMERICA</td>
<td></td>
</tr>
<tr>
<td>Model 40</td>
<td>. . . 456 &amp; 457</td>
</tr>
<tr>
<td>TRAV-LER MFG. CO.</td>
<td></td>
</tr>
<tr>
<td>Model AC SG DX</td>
<td>. . . 451</td>
</tr>
<tr>
<td>Travlette</td>
<td>. . . 454</td>
</tr>
<tr>
<td>Model DC SG</td>
<td>. . . 455</td>
</tr>
<tr>
<td>U. S. RADIO &amp; TELEVISION CO.</td>
<td></td>
</tr>
<tr>
<td>Model 26P</td>
<td>. . . 480</td>
</tr>
<tr>
<td>Model 8</td>
<td>. . . 483 &amp; 484</td>
</tr>
<tr>
<td>WESTINGHOUSE ELECTRIC &amp; MFG. CO.</td>
<td></td>
</tr>
<tr>
<td>Model WR-15</td>
<td>. . . 524</td>
</tr>
<tr>
<td>Model WR-14</td>
<td>. . . 525</td>
</tr>
<tr>
<td>WHOLESALE RADIO SERVICE COMPANY, Inc.</td>
<td></td>
</tr>
<tr>
<td>Mighty Atom</td>
<td>. . . 535</td>
</tr>
<tr>
<td>ZENITH RADIO CORP.</td>
<td></td>
</tr>
<tr>
<td>Model 6 tube Zenette</td>
<td>. . . 574</td>
</tr>
<tr>
<td>Model 5 tube Zenette</td>
<td>. . . 574</td>
</tr>
<tr>
<td>ZANEY GILL CORPORATION</td>
<td></td>
</tr>
<tr>
<td>Midget Receiver</td>
<td>. . . 496B</td>
</tr>
<tr>
<td>PUBLIC ADDRESS SYSTEMS</td>
<td></td>
</tr>
<tr>
<td>(See heading for &quot;AMPLIFIERS&quot;)</td>
<td></td>
</tr>
<tr>
<td>SHORT WAVE RECEIVERS AND CONVERTERS</td>
<td></td>
</tr>
<tr>
<td>CHAS. HOODWIN COMPANY</td>
<td></td>
</tr>
<tr>
<td>World Wide 1 tube</td>
<td>. . . 267</td>
</tr>
<tr>
<td>COLIN B. KENNEDY CORPORATION</td>
<td></td>
</tr>
<tr>
<td>Model 54 Super-het SW Converter</td>
<td>. . . 286</td>
</tr>
<tr>
<td>PILOT RADIO &amp; TUBE CORP.</td>
<td></td>
</tr>
<tr>
<td>Model SW Converter</td>
<td>. . . 321</td>
</tr>
<tr>
<td>RCA VICTOR, Inc.</td>
<td></td>
</tr>
<tr>
<td>Model AR-1145 SW</td>
<td>. . . 232</td>
</tr>
<tr>
<td>Model F</td>
<td>. . . 388</td>
</tr>
<tr>
<td>SILVER MARSHALL, Inc.</td>
<td></td>
</tr>
<tr>
<td>Model 737 AC SW</td>
<td>. . . 393</td>
</tr>
<tr>
<td>Model 739 SW</td>
<td></td>
</tr>
<tr>
<td>Adapter</td>
<td>. . . 386</td>
</tr>
<tr>
<td>STEWART WARNER CORPORATION</td>
<td></td>
</tr>
<tr>
<td>Short Wave Converter, 424</td>
<td></td>
</tr>
<tr>
<td>SOUND PICTURES (See Pacent and RCA Photophone)</td>
<td></td>
</tr>
<tr>
<td>TELEVISION SECTION</td>
<td></td>
</tr>
<tr>
<td>ALLIED ENGINEERING INSTITUTE</td>
<td></td>
</tr>
<tr>
<td>Find-All Receiver</td>
<td>. . . 455A</td>
</tr>
<tr>
<td>Model 90, Revised</td>
<td>. . . 447</td>
</tr>
<tr>
<td>Model AAA1 Tester</td>
<td>. . . 447</td>
</tr>
<tr>
<td>Model 560 Oscillator</td>
<td>. . . 445</td>
</tr>
<tr>
<td>Model 400 Tube Tester</td>
<td>. . . 445</td>
</tr>
<tr>
<td>Model 600-700 Tester</td>
<td>. . . 446</td>
</tr>
<tr>
<td>STERLING MFG. CO.</td>
<td></td>
</tr>
<tr>
<td>Model R-517 Mutual Conductance Tester</td>
<td>. . . 446</td>
</tr>
<tr>
<td>SUPREME INSTRUMENT CORPORATION</td>
<td></td>
</tr>
<tr>
<td>Model AAA1 Testers</td>
<td>. . . 447</td>
</tr>
<tr>
<td>Model 560 Type 8</td>
<td>. . . 449A</td>
</tr>
<tr>
<td>Analyzer</td>
<td>. . . 449C</td>
</tr>
<tr>
<td>Radio Test Panel</td>
<td>. . . 449B</td>
</tr>
</tbody>
</table>
Trade Name Index

Aero—Chas. Hoodwin Co.
Aerophone—Peerless
Allied Radio Co.—Columbia Radio
Acme—Acme Electric Co.
Acratone—Federated Purchaser
Airline—Montgomery, Ward & Co.
Amertran—American Transformer Co.
Amrad—Amrad Corp.
Apex—United States Radio & Television Co.
Arcadia—Wells-Gardner Co.
Argus—Graus Radio Corp.
Atwater Kent—Atwater Kent Mfg. Co.
Audion—Audion Radio Co.
Autoverter—Radiette
Aztec—Stein, Fred W.
Baldwin—Nathaniel Baldwin Co.
Balkite—National Transformer Mfg. Co.
(Balkite Sales Division)
Bosch—American Bosch Magneto Corp.
Brandeis—Kolster Radio Corp.
Bremer Tully—Bremer Tully Mfg. Co.
(Brown Brunswick Radio Co.)
Browning Drake—Browning Drake Corp.
Brunswick—Brunswick Balke Collender Co.
(Brunswick Radio Co.)
Buckingham-Buckingham Radio Co.
Bush & Lane—Bush & Lane Piano Co.
Capehart Orchestrope—Capehart Corp.
Webster Elec. Co.
Cardinal—Long Radio Co.
Cardon—Cardon-Cardon-Cardon Phone Craft Corp.
Clarion—Clarion Transformer Corp. of America
Clartone—Clartone Radio Corp.
Div. of Cincinnati Time Recorder
Colonial—Colonial Radio Corp.
Columbia—Columbia Phonograph Co.
(Columbia Radio Co.)
Counterphase—Bremer Tully Mfg. Co.
(Brown Brunswick Radio Co.)
Crosley—Crosley Radio Corp.
Daven—Daven Radio Co.
Day Fan—General Motors Radio Corp.
Dayrad—The Radio Products Co.
DeForest—DeForest Radio Corp.
Delco—Delco Appliance Corp.
Dewald—Pierce Airo, Inc.
Earl—Freef Radio Corp.
Edison—Edison, Thomas, A., Inc.
Electrad—Electrad, Inc.
Emerson—Emerson Radio & Phonograph Corp.
Envoy—See I. C. A.
Erla—Electrical Research Laboratories
Eveready—National Carbon Co.
Fada—Andrea, P. A. D., Inc.
Federal—Federal Radio Corp.
Find-All—Find-All Radio Co.
Freed Eleckman—Freed Radio Co.
Freshman—Freed Radio Co.
Genemotor—U. S. Electrical Works
General Motors—General Motors Radio Corp.
Gilbert—Gilbert, R. W.
Giffilian—Giffilian Bros., Inc.
Graybar—Graybar Electric Co.
Grebe—Grebe Co., A. H.
Guilbransen—Guilbransen Co.
Hammarlund—Hammarlund Mfg. Co.
Howard—Howard Radio Co.
Hyatt—Hyatt Electrical Corp.
ICA—Insulin Corp. of America
Jesse French-Jesse French & Sons Piano Co.
Kellogg—Kellogg Swbd. & Supply Co.
Kennedy—Kennedy Corp., Colin B.
King—King Mfg. Corp.
Knight—Wextark Radio Stores, Inc.
Kolster—Kolster Radio Corp.
Kyrlectron—United Reproducers Corp.
(Now Gray Electric Co.)
Lafayette—Wholesale Radio Service
Leutz—Leutz, Inc., C. R.
Lincoln—Lincoln Radio Corp.
Loflin White—(See Electrad)
Lyric—All American Mohawk Corp.
Majestic—Griggsy Grunow Co.
Martini—Martini Radio Corp.
Melo Head—Robertson Davis Co.
Melorad Cathedral—Federated Purchasers
Minera—Minerva Radio Co.
Miraco—Midwest Radio Corp.
Multicoupler—Amy, Aceres & King, Inc.
National—The National Co., Inc.
Navigator—A. C. Dayton Co.
Orpheus—Roth-Downs Mfg. Co.
Patterson—Patterson Radio Corp.
Peerless—United Reproducers Corp.
(Print Gray Electric Co.)
Peter Pan—Jackson Bell Co., Ltd.
Ehrartstihl—Pfansteihl Products Co.
Philo—Philadelphia Storage Battery Co.
Pierce Airo—Pierce Airo, Inc.
Pilot—Pilot Radio & Tube Corp.
Pionec—Pioneer Radio Corp.
Prices—Press Radio Co.
Premier—Premier Electric Co.
Radiette—Keller Fuller Mfg. Co., Ltd.
Radiola—R. C. A. Victor Co.
Radiotrope—U. S. Radio & Television Co.
Ranger—Brown & Manhart
Republic—Republic Radio Co.
Sentinel—United Air Cleaner Co.
Seven Seas—Leutz, Inc., C. R.
Silver—Silver Marshall, Inc.
Silvertone—Sears, Roebuck & Co.
Simplex—Simplex Radio Co.
Sonora—Sonora Phonograph Co., Inc.
Speart—Sparks Withington Co.
Splitdorf—Edison, Thomas A., Inc.
Star Raider—Continental Radio Co.
Steinite—Steinite Radio Corp.
Sterling—Sterling Mfg. Co.
Stewart Warner—Stewart Warner Corp.
Story & Clark—Story & Clark Radio Corp.
Telmaco—Telephone Maintenance Co.
Tempest—Temple Corp.
Tiffany Tone—Tone Radio Co.
Transite—See Philco
Trav-Ler—Trav-Ler Mfg. Co.
Vagabond—Vaga Radio Corp.
Vicoff—Victor Co.
Victoreen—Victoreen Radio Co.
Webster—Webster Electric Co.
Wilcox Labs, Inc.—Sterling Mfg. Co.
William—William Storage Battery Co.
Work-Rite—Work-Rite Radio Corp.
Wurritzer—(See All American Mohawk Corp.)
Zenith—Zenith Radio Corp.
+ INTRODUCTION +

IN compiling the new 1932 edition of the OFFICIAL RADIO SERVICE MANUAL, the editors have been inspired by the tremendous interest shown by Service Men all over the country.

Of the first edition, a total of 38,000 copies have been sold, and many more thousands will be sold in the future for the reason that there is no duplication between the information published in the first issue and the material published in the 1932 issue, or subsequent volumes.

The thousands of letters filled with helpful suggestions, criticisms, and praise, have been all carefully read, and the many ideas which, in the opinion of the editors, would enhance the value of the new volume, have been included in the present Manual.

The editors take this occasion to thank all of their many friends for the letters submitted during the year.

The electrical circuits of the most modern types of receivers naturally take up the major portion of the Manual. Radio Service Men will, no doubt, appreciate the increased information about the resistance, capacity and voltage values, which is so essential today, when time-saving and accurate knowledge are such important considerations to the Service Man.

The inclusion of the graphs on the characteristics of the various types of tubes now standard in the market, we are certain, will interest all radio men. The heart of the modern radio receiver is the vacuum tube, and no one can afford to ignore this information, which has never before been available in such compact and usable form.

For the radio Service Man just starting in the field, the section devoted to "Analysis of a Typical Receiver" will be of extreme helpfulness. No single receiver on the market contains every important feature of interest to the Service Man; for that reason, the presentation of a hypothetical radio receiver was considered necessary. This receiver embraces the outstanding variations, sectionalized into the radio-frequency, detector, and audio-frequency circuits. The various types of power supplies, automatic volume controls, and remote controls receive sufficient treatment so that the underlying theory covering the function of the various components employed will be clearly understood.

A new section in the back of the book covers the circuits, with data, on sound-picture and public-address systems. This is in answer to the many inquiries on this subject.

While it is true that not every Service Man will have occasion to use such information, it often happens that he may be called in to service such apparatus, and then this information will prove invaluable.

It has been a source of great satisfaction to the editors to welcome the change of policy by the radio set manufacturers. Only a year ago, it was most difficult for the editors to procure all the available data on manufactured sets. This year, with practically no exception, set manufacturers have vied with each other to cooperate with the editors to make this Manual the outstanding one in print. The reason, of course, is that the set manufacturers realize today the great and growing importance of the Service Man who makes the actual, and often the only, personal contact with the set owner. Then, too, the opinion of the Service Man, as a rule, makes a lasting impression on the ultimate consumer as to the relative merits of a radio set or other radio equipment.

We will be pleased to receive suggestions and criticisms from the men in the field as to how this Manual can be further improved. This Manual has been created for the Service Man, and the editors naturally feel that he is the one who can best tell what would be necessary to enhance the value of the book to them.

It should be noted that there is not a line of duplication between the 1931 Manual and the present one. All the material published in the 1932 Manual is original, and new. It is the intention of the Publishers to bring out a new Manual every year, and every Manual will be new from start to finish.

To the radio set manufacturers and radio equipment manufacturers who have so generously furnished service data and information on their respective products, and to the thousands of well-wishers who have written in during the course of the year, we wish to extend our sincere thanks, with the hope that the present volume will be of growing usefulness to the radio industry, and particularly to the radio Service Man.

New York, October, 1931.

THE EDITORS.
**ELEMENTARY RADIO SERVICING**

**FIRST PRINCIPLES**

It is not essential that we delve into the scientific reasons for various phenomena—merely that we gain a clear idea of the inter-relation of electrical units so that we may more readily picture what is going on behind the scenes in a radio receiver and attack our service problems in a sane manner.

Electrical quantities are expressed in volts or amperes. If we were to draw an analogy from hydraulics we might say that voltage corresponds to the water pressure in a pipe or tank expressed in pounds per square inch and that the amperage corresponds to the rate of flow through a pipe in gallons per minute. It is obvious that in order to force a large quantity of water through a small pipe in a given time a large pressure must be developed. If, for example, we were to block the flow of water by shutting a valve, the pressure would still remain—but the rate of flow would drop to zero—likewise, if we were to open the valve but slightly the pressure would still be the same but the rate of flow would be small. There is, therefore, some other factor which determines the rate of flow as compared with the pressure and this is the "resistance" of the pipe line.

**RESISTANCE**

One Ohm of resistance has been defined as the resistance of a circuit in which a pressure of one volt develops a rate of flow of one ampere. Calculations in circuits where the units are expressed in Ohms, Volts, and Amperes are dependent upon the simple relations laid down in Ohm's Law. Accordingly the following relations are evolved from the expression \( E=IR \) which means that the voltage \( E \) is equal to the Current in Amperes \( I \) times the resistance in Ohms \( R \):

\[
E=IR \\
I=E/R \\
R=E/I
\]

From these three equations we may determine the unknown quantity where two quantities are known. Example: Determine the resistance of a 201A filament when it is known that the current is .25-ampere when 5 volts are across the terminals. If \( R=E/I \) we must divide 5 by .25 and we obtain 20 ohms for our answer.

Example: A resistor of 20 ohms is connected across a 6-volt storage battery. What will be the current flow in amperes? If \( I=E/R \) we simply divide the value of the resistor in ohms into the voltage of the battery which is 6 volts thus: 6/20 equals .3-ampere, the current flowing in the circuit.

**VOLTAGE DROP**

There is a difference in voltage between any two points on a circuit having resistance and this difference is known as the Voltage Drop. The difference in voltage is determined by the resistance between the two points and the current flowing. If we desire to know the value of resistance to place in series with a 201A tube in order to operate its filament from a 6-volt battery we first determine the voltage drop required between the battery and the filament of the tube—namely, 1 volt. We therefore know the voltage (1 volt), the current (.25-ampere), and may find the resistance required by resorting to the equation once more that \( R=E/I \) and discover that the resistance must be 4 ohms.

**COMBINATIONS OF RESISTANCES**

**RESISTANCES IN SERIES**

If resistances are connected in series the total resistance is the sum of all the resistors in the circuit. See Fig. 1. Thus the equation may be written

\[
R_{\text{eff.}}=R_1+R_2+R_3+R_4+R_5 \text{ etc.}
\]

It will be noted on examination of the diagram that in series circuits the current is the same through all of the resistors but that the voltage drop across the resistors depends upon the value of the individual resistor.

**RESISTORS IN PARALLEL**

**EQUAL VALUES OF RESISTANCES IN PARALLEL**

In many circuits there are combinations of resistors...
in parallel. That is to say, the current path is divided through two or more resistors. If the numerical values of the resistances are equal then the effective circuit resistance can be obtained from the following equation:

\[
R_{\text{eff}} = \frac{R}{N}
\]

wherein \( R \) is the value of one of the resistors and \( N \) is the number of resistors in the circuit.

Example: There are 6 resistors in a circuit and they are in parallel. The resistance of each one is 12 ohms. Then by dividing by 6 we have the effective resistance which is 2 ohms.

The solution of equal values of resistance in parallel is an extremely simple operation but it must be remembered that the formula is useful only when the resistors are equal in value.

**UNEQUAL VALUES OF RESISTANCES IN PARALLEL**

*(Two Resistors)*

Many times we will come across resistances in parallel which are unequal in value. This is shown in Fig. 2. If there are but two resistances in the circuit as shown then we can use the following formula:

\[
R_{\text{eff}} = \frac{R_1 \times R_2}{R_1 + R_2}
\]

Example: We have two resistors of 5 and 10 ohms value, respectively. What is the effective value of resistance? 5 times 10 is 50; 5 plus 10 is 15; 50 divided by 15 gives us the effective value of resistance which is 3.3 ohms.

It will be noted in circuits with resistances in parallel that the same voltage will appear across the resistors but the current through the resistors will vary with the value of the individual resistor.

Mention should be made of the fact that when we have resistors of equal value in parallel that the current will be the same in all the resistors and that the same voltage will appear across all of the resistors.

**UNEQUAL VALUES OF RESISTANCES IN PARALLEL**

*(Two or More Resistors)*

Fig. 3 shows a circuit in which there are four resistors in parallel and unequal in value. In this case we would use the formula commonly known as the “Reciprocal of the sums of the reciprocals.” Thus

\[
R_{\text{effective}} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}}
\]

Substituting:

\[
\frac{\frac{1}{10} + \frac{1}{5} + \frac{1}{7}}{1 + 1 + 1 + 1}
\]

Solving: \( .1 + .2 + .14 = .46 \)

Adding: \( .1 + .166 + .2 + .14 = .606 \)

Finding the reciprocal \( 1.6 \text{-ohms effective} \).

Proof: The sum of the currents in the branches of a parallel circuit will equal the total current flowing into the circuit. From examination of the circuit we find that the sum of the currents is 9.6 plus amperes. The answer would have come out exactly 10 amperes if we had carried the solution of the various reciprocals to more than four places beyond the decimal point.

The complete solution of a problem is carried out above so that any one desiring to do so can use it as a model to aid him in studying just how the formula is handled. The author has gone to some lengths here in the solution of the problem but his experience as an instructor of servicemen indicates that there is never enough said on this phase of the study of electrical circuits.

**RESISTANCE NETWORKS WITH RESISTORS IN SERIES AND IN PARALLEL**

Circuits often have combinations of resistors in series and in parallel. The solution of the effective value of resistance is obtained by breaking up the circuit into its local circuits, solving each portion consisting of parallel circuits and then resolving them into simple series circuits. Fig. 4 shows a circuit along with the values for the various resistors.
Solution: The first thing to do is to solve all of the branch circuits.

Circuit \( R_1; R_2; R_3 \) has an effective resistance of 3 ohms.

Circuit \( R_4; R_5; R_6 \) has an effective resistance of 2.5 ohms.

Circuit \( R_5; R_6 \) has an effective resistance of 2.2 ohms.

As the above parallel circuits are in series with resistor \( R_7 \), we find the effective value of resistance by adding 10, 3, 2.5, and 2.2 together. This totals 17.7 ohms.

Resistor \( R_{10} \) is connected across the voltage supply and the effective value of the resistance network \( R_1 \) to \( R_7 \) is in turn connected across \( R_{10} \). Thus \( R_{10} \) is in parallel to the 17.7 ohm resistance of the network.

Solving for parallel circuits \( \frac{1}{R_{\text{eff}}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \) we have the effective total circuit resistance of 12.8 ohms.

Knowing that the voltage applied is 100 volts and the effective resistance is 12.8 ohms and using the rule "I" equals "E" over "R"; then 100 divided by 12.8 is 7.8 or the current flowing in the circuit.

CONDUCTANCE

It seems peculiar that we have dealt with resistances when in reality the thing that we require of any portion of an electrical circuit is conductance—the ability and not the inability with which it carries electricity is the important factor. The unit of Conductance is the Mho and the Conductance of a circuit is

\[ G = \frac{1}{R} \]

It is thus that a Resistance of 2 ohms has a conductance of \( \frac{1}{2} \) Mho. In operating upon parallel circuits it is much simpler to employ conductances in our calculations so as to avoid the many reciprocal factors involved. This may be seen readily from the comparison of the two equations

\[ R_{\text{eff}} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}} \]

\[ G_{\text{eff}} = G_1 + G_2 + G_3 \]

POWER

The power consumed in a circuit is equal to the product of the voltage and the current thus

\[ P \text{ (watts)} = E \times I \]

or it may be expressed by the product of the current squared and the resistance

\[ P = IR \]

This latter relation is useful in determining the power rating requirements of a resistor. Thus a resistance of 10 ohms having a current of 2 amperes flowing through it must be rated at 40 watts at least if overheating is to be avoided.

ALTERNATING CURRENTS

A Direct Current has a definite polarity—that is the current flow is always in one direction. Alternating currents are employed commercially because of economies which can be gained in the transmission of current over long distances. An alternating current has its polarity or direction of flow constantly changing. The frequency of the current is determined by the time required for each complete alternation or change of direction. In Fig. 3 this is shown graphically and it may be seen that over a period of time equal to 1/60th second corresponding to a 60 cycle current the current direction starts at zero—rises to a maximum positive value of 2 amperes—falls to zero again and passes through a maximum negative value of 2 amperes to return to a zero again.

The peak or maximum value is seen to be 2 amperes—but the effective value is not 2 amperes but the "root mean square" or r.m.s. value which is the value read from an alternating current meter in the circuit. This value is calculated from the maximum value by the equation

\[ I_{\text{r.m.s.}} = I_{\text{peak}} \times 0.707 \text{ or conversely} \]

\[ I_{\text{peak}} = I_{\text{r.m.s.}} \times 1.414 \]

How these factors are arrived at is immaterial to our purposes. The voltage in A.C. circuits will follow exactly the same laws and the Ohm's Law for alternating currents is expressed by

\[ E = IZ \]

IMPEDEANCE AND REACTANCE

The alternating counterpart of Resistance is the Impedance (Z), which is the effective resistance of the circuit. "Z" is the resultant effect of pure resistance, capacitance, and inductance in a circuit. The
effect of inductance or capacitance alone in a circuit is "X", the Reactance.

The reactance of a circuit is dependent upon the frequency of the alternating current flowing and the reactance of a condenser is equal to

\[ X_c = \frac{1}{2\pi f C} \]

where \( f \) is the frequency in cycles per second, \( L \) is the inductance of the coil measured in a unit termed the "henry", and \( C \) the capacitance of the condenser measured in a unit termed the "farad." In radio work it is more convenient to speak of a smaller unit than the "henry," thus a unit known as the "microhenry," or \( \mu H \), is used, one million of which when added together make a henry. It is also more convenient to speak of a smaller unit than the farad, known as the "microfarad," or \( \mu F \), thus a unit is used, one million of which when added together make a farad. The formula just quoted then becomes

\[ f = \frac{159,200}{\sqrt{L \cdot \text{microhenries} \times C \cdot \text{microfarads}}} \]

As an example, a coil having an inductance of 203 microhenries is tuned with a condenser set at 0.0005-microfarad. To what frequency does the combination tune?

\[ f = \frac{159,200}{\sqrt{203 \times 0.0005}} = 500,000 \text{ c.p.s.} \]

Instead of saying "five hundred thousand cycles per second," the term five hundred kilocycles is often used. A "kilocycle" (abbreviated "kc." ) is one thousand cycles.

Sometimes the term "wavelength" symbolized by the Greek letter \( \lambda \) (lambda) is used in place of the term frequency, and vice versa. In the case of an electric wave sent through free space, its velocity is constant, and is equal to that of light. The product of the wavelength and the frequency equals this velocity, for the wavelength is the distance a given point in the wave travels during one cycle, or

\[ \lambda \times f = 299,800,000 \text{ meters per second} \]

or (very nearly) \( 300,000,000 \) where is the wavelength measured in meters and \( f \) is the frequency in cycles per second. Thus if it is desired to know the wavelength of a radio wave of a frequency of 500,000 c.p.s.

\[ \frac{300,000,000}{500,000} = 600 \text{ meters} \]

Instead of calculating the wavelength every time it is necessary, the chart shown in Fig. 8 may be referred to.

In circuits consisting of Inductance, Capacitance, and Resistance in a series combination such as is shown in Fig. 9, the term within the parenthesis in the equation
<table>
<thead>
<tr>
<th>Kilometers (km)</th>
<th>To Meters (m)</th>
<th>Or Meters to Kilometers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Kilometers (km)</strong></td>
<td><strong>To Meters (m)</strong></td>
<td><strong>Or Meters to Kilometers</strong></td>
</tr>
<tr>
<td>10</td>
<td>0.010</td>
<td>0.020</td>
</tr>
<tr>
<td>20</td>
<td>0.020</td>
<td>0.040</td>
</tr>
<tr>
<td>30</td>
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<tr>
<td>40</td>
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<tr>
<td>50</td>
<td>0.050</td>
<td>0.100</td>
</tr>
<tr>
<td>60</td>
<td>0.060</td>
<td>0.120</td>
</tr>
<tr>
<td>70</td>
<td>0.070</td>
<td>0.140</td>
</tr>
<tr>
<td>80</td>
<td>0.080</td>
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<tr>
<td>90</td>
<td>0.090</td>
<td>0.180</td>
</tr>
<tr>
<td>100</td>
<td>0.100</td>
<td>0.200</td>
</tr>
</tbody>
</table>

*Columns are interchangeable.*
is equal to zero and the impedance of the circuit is simply

\[ Z = \sqrt{R^2 + (X_L - X_C)^2} \]

or

\[ Z = \sqrt{R^2} \]

In a series circuit comprising inductance and capacitance only the current could rise to large proportions at resonance—it being effectively a short circuit across the supply. This effect is held in check by the fact that some resistance is always in the circuit.

In a parallel circuit a somewhat different effect occurs. Here we have a circuit arrangement substantially as shown in Figure 10. In such a circuit the current does not pass through both elements but is divided between the two as was the case in parallel resistance circuits carrying direct current.

Without resistance in the circuit the currents flowing in the two branches would counteract each other because of the opposing effects of the capacitance and the inductance and the current flowing through the circuit would be zero. This would correspond to an infinite impedance across the line.

As your studies become more advanced it is well to bear in mind that though the current through the circuit be zero relatively large currents may be flowing in the two branches. The presence of resistance modifies this idea of an infinite Impedance and we find that the effective Impedance of a parallel resonant circuit is equal to

\[ \frac{L}{I} \]

\[ \frac{C}{R} \]

\[ L \text{ is in henries} \]

\[ C \text{ is in farads} \]
SERVICING RADIO RECEIVERS

The Service Man's Tools.

THERE is nothing that will tend to create in the mind of the customer a feeling of confidence as much as a well chosen kit of tools, which should be carried to the job in a convenient bag. This, along with the test kit gives the desired impression of completeness which goes for rapid and accurate work.

The usual tools other than the special measuring instruments which should be a part of the portable equipment are as follows:
- Diagonal Pliers
- Long Nose Pliers
- Side Cutting Pliers
- Spintite Wrench Set
- Electricians’ Knife
- Insulated Test Probes
- Neutralizing Tool
- Alcohol Torch
- Soldering Iron
- Self Fluxing Solder—Rosin Cored
- Heavy Screw Driver
- Long Thin Screw Driver
- Hand Drill and Drill Set
- Friction Tape
- Set of Files
- Polishing Cloth and a small quantity of Furniture Polish
- Emery Cloth
- Hydrometer
- Large Piece of Canvas
- Flash Light

In addition to the above the technician should carry an assortment of fixed resistances of the values found to be most useful in service work, replacement A.F. transformer, spare pilot lights, set of R.F. coils, howl arrester, complete set of tubes, such batteries as may be necessary, spare power switch, aerial and lead wire, insulators, lead-in strips, lighting arrester, screws, etc.

Testing Instruments.

Confident and rapid servicing of the modern radio receiver requires the intelligent use of the following instruments:
- Set Analyzer
- Ohmmeter

Modulated Oscillator
- Output Meter or Resonance Indicator.

Too great stress cannot be laid upon the necessity for clean cut and accurate equipment. Not only does this save time but it creates a confidence which is likely to result in a return call. The modern receiver is so constructed that servicing is virtually impossible without the apparatus noted.

The Set Analyzer.

The radio set analyzer is an instrument so constructed that the conditions under which any one of the tubes in the receiver operates can be readily determined at a glance. There are of course certain conditions which cannot be localized by this means—these will be taken up later—but in the majority of cases the analyzer will give a thorough diagnosis of the trouble.

The analyzer may be constructed in many ways—it may have a number of meters or it may be so constituted as to require but a single meter with a number of push buttons to make the required connections in the tube circuit and to rearrange the internal circuit of the analyzer so as to cope with the changing conditions.

Many of the more recent analyzers employ rectifier type meters so that a single D.C. meter with the proper shunts and series resistances will be operative over all required ranges of direct and alternating currents and voltages. This effects a saving in the initial cost of the apparatus without affecting the accuracy of the equipment in any way. The majority of the models now on the market use at least two meters, the one being for A.C. measurements and the other for D.C.

![FIG. 11](image1)

The schematic circuits shown in the text give an idea as to how the meter ranges are shifted and the internal changes made by means of the push buttons. Figs. 11, 12 and 13.

The instruments are so arranged that the various meter ranges are available for separate external
measurements by means of binding post connections and test probes and in some cases provision is made for the use of the equipment as an ohmmeter or as a capacity meter. Instruction pamphlets obtainable from the manufacturers of the various equipment give these details.

![FIG 13](image1)

**Testing the Receiver Circuits.**

Set analyzers are provided with adapters which make the necessary connections automatically. This is of course necessary when we intend to test circuits involving rectifier tubes or tubes with four and five prong bases. Modern testers are now so complete that it is seldom necessary to use special adapters except for the change from five to four prong plugs.

Selecting the proper adapter we remove the tube from the socket and replace it by the adapter. The tube is then placed in the socket provided in the analyzer.

You will note that the meter will have various ranges of voltage and current reading scales and it is important not only that the correct button be pressed but that the reading be taken from the proper scale. This is in no way confusing but demands a certain degree of alertness on the part of the technician.

The accompanying Fig. 14 shows the correct readings to be obtained in the analysis of the Radiola 64. This data is available from the manufacturer of the particular test set for which these readings hold good. Charts such as that shown in the figure are available and it is a good idea to fill out the chart as you go along so that even though no trouble may be found in the receiver you may hold the chart for future reference. A file of such charts giving a case history of a particular receiver is sometimes a valuable thing in that it will indicate the fact that tubes are not quite up to scratch and that new ones should be taken on the call. The reverse of the chart will serve to record the work done on each visit. A reference to the chapter bearing upon the analysis of a complete receiver circuit will indicate the possible causes of trouble where the readings taken are not up to standard.

There are of course certain points where the analyzer will fail and it is these exceptions which make necessary the use of other apparatus in testing.

This statement must not be construed as an indictment of the analyzer as having failed in its purpose for the technician cannot possibly render efficient service without it. At times the very failure of the analyzer to point out the fault may lead to its detection.

**When the Analyzer Fails.**

As we noted there are certain conditions in the radio receiver which defy detection by means of the analyzer. As an example of this, the analyzer cannot detect a shorted variable condenser as the path from grid to ground remains substantially unchanged. In Fig. 15 the voltmeter is connected so as to measure the value of the bias. It can be seen that a shorted condenser (C) will have no effect on the reading of the voltmeter (VM) because of the extremely low coil (L) resistance.

In general, short circuits in the antenna coupling circuit or in the R.F. transformers do not affect the meter readings as these are low resistance circuits and the change in constants due to the short circuit will have no effect on the voltages or current in the tube circuit. Short circuits to ground in the plate circuits of the tubes naturally cause a loss of plate voltage accompanied by high plate currents and in cases where the bias is obtained from the voltage divider in the manner described in another section such a short circuit of the R.F. transformer secondary or of the variable condenser would result in a loss of bias, Fig. 16.

![FIG 15](image2)

![FIG 16](image3)
Open condensers do not in any way affect the voltage readings as they do not offer a direct current path at any time. Resistances connected across transformer windings either as stabilizing agents limiting the amplification or as volume controls will show no changes in applied voltages whether they are open or short-circuited. The center tapped resistances across the filament or heater circuits will cause hum if open or short-circuited in one section. These defects will not show up, however, in the meter readings.

Then why—you ask—is the set analyzer so necessary a piece of apparatus? The answer is that in the majority of cases the trouble is shown up by the analyzer readings—if not we may resort to the manner of deduction employed by the late Sherlock Holmes and rest assured that the trouble lies in some circuit defect not noted in the analyzer readings. Troubles are evidenced by the following conditions:

- Excessive and uncontrollable volume.
- Regeneration.
- Failure of one or more of the tuned circuits to tune sharply to resonance.
- Hum or noise.
- Audio howl or acoustic regeneration.
- No signal.
- Excessively broad or sharp tuning.
- Tunable hum appearing on station carrier but when no signal is received.

Most of these conditions may be checked by the use of the other apparatus listed and will be taken up in turn.

A note of the fact that an open grid biasing resistance in series with the cathode of the tube will not be evidenced by zero voltage and zero bias together with a high plate current when checked with the analyzer should be made. The reason for this is that when the analyzer is switched so as to measure the voltage between cathode and ground a high resistance is placed across this circuit. With the biasing resistance intact this high resistance has little effect but if the biasing resistance be open the meter resistance will fill the gap with the result that the tube receives a high grid bias. Fig. 17. The plate voltage will then be relatively low and the current will be close to zero while the meter is across the cathode and ground. These facts need nothing but a little study to fix them firmly in the technician’s mind so that he can recognize them at a glance.

Open or shorted neutralizing condensers will have no effect upon the meter readings except where the circuit arrangement is such that a short circuit results in a connection between the grid and plate through capacity $C_1$. Fig. 18.

**Continuity Testing.**

The Ohmmeter listed as among the equipment desirable is useful not only in the measurement of resistance values but in checking receiver troubles not noticeable through changes in the operating voltages. Many manufacturers give routine data charts on the servicing of their receivers with the ohmmeter. These charts give the points between which the tests should be made and the correct resistance reading.

An ohmmeter is a milliammeter in series with a resistance and a battery with the scale so calibrated as to read directly in the effective ohms resistance between the test prods. A variable resistance is included so that adjustment can be made for variations in the battery voltage.

The Figs. 19, 20, 21 and 22 show the circuit arrangements of a Brunswick receiver which is typical of modern design practice. The power supply and the receiver chassis are separate units but this has no effect on the adaptability of the procedure to other sets. We have also reproduced here the continuity test chart of the receiver as recommended by the manufacturer. This chart indicates the correct effect and the possible incorrect effects which may be apparent together with their probable cause.

A check of any receiver by means of the analyzer—which failing in diagnosis can be followed by a continuity test of the circuits—will undoubtedly result in a discovery of the trouble.

Continued oscillation or lack of sensitivity through disalignment of the circuits may be checked by the use of the modulated oscillator to be described. This is particularly necessary in the case of the superheterodyne receiver and also with neutrodyne receivers. The manner of operation in checking neutralization and alignment of circuits follows:

**The Modulated Oscillator and Its Uses.**

The modulated oscillator is in reality a miniature and portable broadcast transmitter which places a controllable signal in the hands of the technician at all times. The instrument is to be operated in conjunction with an output meter or a resonance indicator such as will be described.

The oscillator should be tunable over the entire broadcast band and should have a second range of from about 100 to 200 kc. for checking the character-
FIG. 19

SCHEMATIC CIRCUIT OF RADIO CHASSIS
FIG. 20

SCHEMATIC CIRCUIT OF AUDIO AMPLIFIER POWER SUPPLY CHASSIS
USED ON STRAIGHT RADIO-60 CYCLE
<table>
<thead>
<tr>
<th>Test No.</th>
<th>Under Test</th>
<th>Test Positions</th>
<th>Correct Effect</th>
<th>Probable Incorrect Effect</th>
<th>Caused By</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>R. F. Grid Circuits</td>
<td>Ground to 1st, 2nd and 3rd grid caps</td>
<td>Closed thru 4Ω (B1.3)</td>
<td>Open or shorted</td>
<td>Open in flexible lead Open in R. F. coil Bent condenser plate</td>
</tr>
<tr>
<td>2</td>
<td>Detector Grid circuit</td>
<td>Ground to detector grid cap</td>
<td>Closed thru 4Ω (B1.3)</td>
<td>Open Shorted</td>
<td>Open in flexible lead Defective phonograph jack Open in R. F. coil Bent condenser plate</td>
</tr>
<tr>
<td>3</td>
<td>1st A. F. grid circuit</td>
<td>Ground to 1st A. F. socket grid contact</td>
<td>Closed thru 1 meg (A0)</td>
<td>Shorted thru 165,000 Ω (A.02)</td>
<td>Shorted .01 mfd. coupling condenser</td>
</tr>
<tr>
<td>4</td>
<td>Power tube grid circuits</td>
<td>Ground to alternate power tube socket grid contacts</td>
<td>Closed thru 6000 Ω (A.07)</td>
<td>Shorted Open</td>
<td>Filter resistance lead touching hum potentiometer frame Shorted .004 cond. Open transformer winding</td>
</tr>
<tr>
<td>5</td>
<td>Antenna circuit</td>
<td>Ground to ant. post (switch set for distance)</td>
<td>Closed thru 30 Ω (B3.6)</td>
<td>Closed thru 5Ω (B1.6) Open</td>
<td>Shorted antenna loading coil Open antenna loading coil Open transformer primary Defective switch</td>
</tr>
<tr>
<td>6</td>
<td>Antenna circuit</td>
<td>Ground to high side ant. primary coil</td>
<td>Closed thru 5Ω (B1.6)</td>
<td>Open</td>
<td>Open primary</td>
</tr>
<tr>
<td>7</td>
<td>Antenna circuit</td>
<td>Ground to ant. post (switch set for local)</td>
<td>Open</td>
<td>Closed thru 30Ω (B3.6)</td>
<td>Defective switch</td>
</tr>
<tr>
<td>8</td>
<td>Phonograph jack</td>
<td>Ground to cathode contact of detector socket (open plug inserted in jack)</td>
<td>Closed thru 800Ω (A3.3)</td>
<td>Closed thru 25,000Ω (A0.17)</td>
<td>Open connection or defective jack</td>
</tr>
<tr>
<td>9</td>
<td>Phonograph jack</td>
<td>Ground to grid cap of detector (open plug inserted in jack)</td>
<td>Open</td>
<td>Closed thru 4Ω (B1.3)</td>
<td>Defective jack</td>
</tr>
<tr>
<td>10</td>
<td>Radio Frequency plate circuit</td>
<td>Ground to 1st, 2nd and 3rd R. F. socket plate contacts (Volume control at maximum)</td>
<td>Closed thru 7000Ω (A.06)</td>
<td>Closed thru 60Ω (B4.2) Closed thru 4100Ω (A0.9) Closed thru 100,000Ω (A0)</td>
<td>Shorted .5 mfd. by-pass condenser R. F. choke lug shorted to antenna wire shielding Shorted coupling condenser Shorted screen-grid by-pass condenser Open volume control Open 100Ω grid bias resistor</td>
</tr>
<tr>
<td>11</td>
<td>Detector plate circuit</td>
<td>Ground to detector plate</td>
<td>Closed thru 165,000Ω (A0.02)</td>
<td>Closed thru 25,000Ω (A.17)</td>
<td>Shorted .001 mfd. by-pass condenser</td>
</tr>
<tr>
<td>12</td>
<td>1st A. F. plate circuit</td>
<td>Ground to plate contact 1st A. F. tube</td>
<td>Closed thru 9800Ω (A0.4)</td>
<td>Closed thru 2700Ω (A1.3) Short Open</td>
<td>Shorted condenser in filter block Shorted .5 mfd. condenser in radio chassis Plate connections touching potentiometer frame Open primary in transformer Open volume control Open 100Ω grid bias resistor</td>
</tr>
</tbody>
</table>
## CONTINUITY TEST CHART—Continued

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Under Test</th>
<th>Test Positions</th>
<th>Correct Effect</th>
<th>Probable Incorrect Effect</th>
<th>Caused By</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>Power tube plate circuit</td>
<td>Ground to alternate power tube socket plate contacts</td>
<td>Closed thru 12,300Ω (A0.3)</td>
<td>Open</td>
<td>Closed thru 600Ω (A3.0) 750Ω (A3.3) 5200Ω (A0.7)</td>
</tr>
<tr>
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<td></td>
<td>Open field coil</td>
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<td></td>
<td>Open primary windings</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Shorted condensers in filter block</td>
</tr>
<tr>
<td>14</td>
<td>Screen-grid circuits</td>
<td>Ground to 1st, 2nd and 3rd R. F. socket grid contacts</td>
<td>Closed thru 3100Ω (A1.2)</td>
<td>Short</td>
<td>Closed thru 100Ω (A4.5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Volume control at max.)</td>
<td></td>
<td></td>
<td>Grounded volume control</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td>Shorted .1 mfd. by-pass cond.</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Open 100Ω grid bias resistor</td>
</tr>
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<td></td>
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<td></td>
<td></td>
<td>Defective volume control</td>
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<td></td>
<td></td>
<td></td>
<td>Shorted .5 mfd. cathode by-pass condenser</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>Grounded volume control</td>
</tr>
<tr>
<td>16</td>
<td>Detector Screen-grid circuit</td>
<td>Ground to detector socket grid contact</td>
<td>Closed thru 17,000Ω (A0.25)</td>
<td>Short</td>
<td></td>
</tr>
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<td></td>
<td></td>
<td>Grounded volume control</td>
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<td></td>
<td></td>
<td>Grounded volume control</td>
</tr>
<tr>
<td>17</td>
<td>R. F. return circuit</td>
<td>Ground to 1st, 2nd and 3rd R. F. socket cathode contacts</td>
<td>Closed thru 100Ω (A4.5)</td>
<td>Short</td>
<td>Closed thru 100,000Ω (A0.05)</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
<td>Grounded volume control</td>
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<td></td>
<td></td>
<td></td>
<td>Grounded volume control</td>
</tr>
<tr>
<td>18</td>
<td>Detector return circuit</td>
<td>Ground to detector socket cathode contact</td>
<td>Closed thru 25,000Ω (A1.7)</td>
<td>Short</td>
<td>Closed thru 800Ω (A2.7)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Grounded volume control</td>
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<td></td>
<td></td>
<td></td>
<td>Grounded volume control</td>
</tr>
<tr>
<td>19</td>
<td>1st A. F. return circuit</td>
<td>Ground to 1st A. F. socket cathode contact</td>
<td>Closed thru 2000Ω (A1.5)</td>
<td>Short</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Grounded volume control</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Grounded volume control</td>
</tr>
<tr>
<td>20</td>
<td>Power tube return</td>
<td>Ground to filament contact both power tube sockets</td>
<td>Closed thru 800Ω (A2.7)</td>
<td>Short</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Grounded volume control</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>Grounded volume control</td>
</tr>
<tr>
<td>21</td>
<td>Plate supply</td>
<td>Ground to rectifier socket filament contact</td>
<td>Closed thru 11,000Ω (A3.7)</td>
<td>Short</td>
<td>Closed thru 150Ω (A4.3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Open</td>
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<td></td>
<td></td>
<td></td>
<td>Shorted 1st condenser in filter</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Shorted 2d condenser in filter</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Open choke coil</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Open field coil</td>
</tr>
<tr>
<td>22</td>
<td>High voltage secondary of power trans.</td>
<td>Ground to alternate rectifier socket plate contacts</td>
<td>Closed thru 250Ω (A3.9)</td>
<td>Open</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Open high voltage secondary winding</td>
</tr>
<tr>
<td>23</td>
<td>Primary of power trans.</td>
<td>Ground to side of primary winding</td>
<td>Open</td>
<td>Short</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Grounded power switch</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Grounded transform. primary</td>
</tr>
<tr>
<td>24</td>
<td>Speaker field</td>
<td>Across terminals of plug</td>
<td>Closed thru 4750Ω (A0.8)</td>
<td>Open</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Open field coil</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Shorted field coil</td>
</tr>
<tr>
<td>25</td>
<td>Choke coil</td>
<td>Rectifier filament to blue or maroon wire on field</td>
<td>Closed thru 160Ω (A4.2)</td>
<td>Closed thru 20Ω (B3.2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Shorted .275 cond. in block</td>
</tr>
</tbody>
</table>

**Note**

FIG. 22
istics of the intermediate frequency amplifier of a superheterodyne receiver. This may be a commercial item or it may be a home-made job. The main difficulty in the home-made oscillator lies in the inability of the average technician to effect a calibration of the intermediate frequency circuit.

It is of course possible to construct all service apparatus but the difficulties attendant upon the construction of a really good analyzer are so manifold as to make it a momentous undertaking for any but the most skilled craftsmen.

Resonance indicators and output meters are readily home constructed and they will be described in detail as will the various service tools necessary in conjunction with the oscillator.

Trouble and Causes.

Before going into detail in the use and construction of these items we will review the possible troubles in Radio Receivers and the causes which may be connected therewith.

Dead Receiver.

- Power off due to switch not on, blown fuse, open cord, or power line dead.
- Tube not in socket.
- Antenna shorted to ground.
- Broken lead-in.
- Grounded lightning arrester.
- Shorted variable condenser or equalizer.
- Open or short circuits within receiver.
- Defective tubes.
- Polarity reversed (D.C. receivers only).
- Open R.F. coils.

Weak Signals.

- Defective tubes.
- Defective antenna.
- Loose or poor ground connection.
- Aligning trimmers out of adjustment.
- Oscillator alignment out (superheterodyne only)
- Intermediate frequency amplifiers improperly tuned.
- Open or short circuits within the receiver.
- Incorrect line voltage (low).
- Antenna connected to wrong input post (receivers with long and short antenna connections only).
- Defective audio transformers.

Hum.

- Defective detector or power tubes.
- Weak rectifier tube.
- Shorted filter choke.
- Open filter condenser.
- Open or shorted center tap resistance.
- Unmatched push-pull tubes.

Improper bias on tubes.
- Cathode to heater short circuit in detector tube.
- Heater voltage grounded.
- Frozen or inoperative electrolytic condenser.
- Defective audio transformers.
- Poor ground connection.
- Loose laminations in power transformers.
- Hum on broadcast carrier.
- Tunable hum due to oscillation in power transformer secondary.

Fading or Intermittent Operation.

- Atmospheric conditions which are unavoidable.
- Thermostatic short or open circuit in tube.
- Swinging ground in antenna circuit.
- Extreme fluctuation in line voltage.
- Excessive heater voltage.
- Dirty tube prongs.

Distortion.

- Receiver improperly tuned to signal.
- Defective output tubes.
- Mismatched push-pull tubes.
- Defective audio transformers.
- Detector overloaded.
- Incorrect grid bias on audio tubes.
- Defective speaker.
- Improper detector bias.
- Oscillation in R.F. amplifier.

Noise (Outside Receiver).

- Atmospheric conditions.
- Elevators in building.
- Antenna shorting on grounded objects such as roof, etc.
- Defective electrical or electromedical appliances nearby.
- Poor antenna contact where lead-in joins antenna.

Noise (Inside Receiver).

- Defective tubes.
- Loose contact in tube sockets.
- Intermittent short circuits.
- Dirty variable condensers.
- Defective by-pass condenser.
- Loose dial light.
- Poor resistors.

Audio Howl or Acoustic Feed-Back.

- Microphonic tube.
- Loose speaker (not properly fastened in cabinet).
- Open circuit in A.F. transformers.
- Open by-pass condensers.
- Weak batteries (battery receivers only).
High resistance soldered joints in A.F. circuits.

**Oscillation.**
- Circuit not neutralized.
- Interaction between two stations on adjacent channels.
- Antenna lead run too close to unshielded receiver.
- Open by-pass condenser.
- Shorted R.F. choke.
- Incorrect voltages on tubes.
- Loose shields.
- Open or reversed R.F. transformer winding.
- Poor ground connection.
- Defective tubes.
- Loose tube shield.

**Motor Boating.**
- Defective output tube.
- Open grid in output circuit.
- Defective transformer.
- Open by-pass condenser.

**Broad Tuning.**
- Improper coupling in band-selector circuits.
- Trimmers out of alignment.
- Condenser loose on shaft.
- Unmatched coils.
- Too long antenna.
- No ground connection or long ground lead.
- Defective tube.
- Antenna connected to wrong input point.

**Hot Rectifier Tube.**
- Shorted filter condenser.
- Internal short in power transformer primary.
- Filter choke coil winding shorted to iron core.
- Most of these pointers suggest their own remedies.
- We will, however, recapitulate so as to be certain that we have covered every point.

**Dead Receiver.**
- Check power supply to see that the tubes are receiving their proper voltages. Test tubes and circuits with analyzer. Check antenna system and disconnect lightning arrester. Check circuit noted with continuity tester if analyzer fails to points out trouble.

**Weak Signals.**
- Check antenna system. Check tubes and circuits with analyzer for improper voltages and check tuning circuits for alignment.

**Hum.**
- Check all circuits noted. Change tubes. Inoperative electrolytic condensers can be repaired by removing all tubes but the rectifier leaving the set turned on for fifteen minutes or so. The excess voltage delivered under these conditions will but put the condensers back into operating shape. Tunable hum can be cured by placing small (.01-mf.) condensers across the two halves of the high voltage winding. This is due to oscillation in this circuit and is evidenced by hum appearing only when a station is tuned in. Be sure that the hum is not on the station carrier before resorting to this expedient.

**Fading.**
- If fading is on all stations it is probably not due to atmospheric conditions and the circuits mentioned above should be checked. Tubes are often found with shorts or opens which do not appear until the tube heats thoroughly. Operation of the heaters at an excessive voltage results in "paralysis" of the tube.

**Distortion.**
- Volume control should be effected by means of the control provided—not by detuning the receiver. In some cases this practice results in distortion. Check voltages and tubes. Look for oscillation in R.F. stages and check loud speaker.

**Noise (Outside Receiver).**
- This may be checked by removing the antenna. If the receiver is now quiet the noise is due to some external condition. If elevators are noisy suggest that they be overhauled. A line filter in the receiver power supply is often effective but in most cases the filter must be placed at the source of the disturbance if it is to be cured.

**Noise (Within Receiver).**
- Check all circuits mentioned for loose contacts or dirty joints. Check variable condensers for dust which can be removed with a pipe cleaner. Some condensers are cadmium plated and the plating has been known to "grow" under certain conditions. If the condenser cannot be replaced you may remove it from the set and connect it to the terminals of a six volt battery. Rotating the condenser will cause the fuzz to arc and burn off.

**Audio Howl.**
- This is in most cases due to the feeding back of acoustic energy from the speaker to the detector tube which is very sensitive to mechanical vibration. Replacing the detector tube may effect a cure or the tube may be covered with a lead shield to weight it
against vibration. A piece of Ford lower radiator coupling hose will fit over a '27 or '24 and is ideal for the purpose. Failing in this manner the mounting of the receiver chassis on sponge rubber might effect a cure. See also that the cover of the set is not vibrating. Sometimes a first A.F. tube causes this type of howl also.

Oscillation.

Oscillation may not exist in the receiver but may be due to the heterodyne whistle of two stations close together in the broadcast frequency spectrum. This will be immediately noticeable to the technician but he must have to explain the fact to his customer. Oscillation in screen grid receivers is usually due to loose shielding or incorrect voltages. Open by-pass condensers or shorted R.F. chokes may also result in feed-back between stages. In the case of neutralized receivers every possible cause should be checked before attempting to adjust the neutralizing condensers. If the cause is in a reversed coil winding it will not be possible to neutralize the set. The process of neutralization will be described shortly in the section covering the use of the service oscillator.

Motorboating.

This is usually due to feed-back between stages due to a high impedance circuit common to two or more stages. In battery receivers this often occurs when the batteries lose their voltage and develop a high internal resistance. It is characterized by a slow put-put or a howl which may be differentiated from acoustic feed-back by the fact that tapping the tubes does not greatly aggravate the condition. In A.C. receivers look for open by-pass condensers, defective transformers, or defective output tubes.

Broad Tuning.

This may result from the use of too long an antenna or through the lack of a proper ground connection. It may also result from improper coupling in band-selector circuits. This is mentioned in detail in the section describing a typical receiver. Improper voltages on screen grid tubes may also have this result as well as disaligned trimmers or a loose condenser rotor. High resistance connections in one of the R.F. circuits must be watched for. A high resistance connection is due to poor soldering—the flux coating the joint so that the solder cannot make a good contact.

Coils improperly matched may also have this result. To be sure of this in making a replacement it is well to employ an entire new set of coils as matched at the factory except in the cases of certain receivers where the coils are all matched with extreme accuracy. The new RCA and Victor sets are in this class as a special method of coil matching is used at the factory and all coils are uniform within narrow limits. Alignment of the tuning elements should be carried out with an oscillator and output meter or by the use of the output meter or resonance indicator alone where a station can be tuned in. The process is described in the section devoted to the operation of the service oscillator.

Overheated Rectifier.

If the receiver is inoperative and it is seen that the rectifier tube plates are red hot the probable trouble is a shorted filter condenser. A primary short circuit in the power transformer will result in an excessively high secondary voltage which may also have this effect but this is doubtful as the new rectifiers are rated at an extremely high voltage as compared with the earlier types.

Careful study of these pages should enable the technician to spot trouble not evidenced by off readings on the analyzer. These analyzers are required equipment by all the larger service organizations and while no doubt the technician can effectively service a receiver without one it is certain that the necessity for getting into awkward positions to obtain readings with a simple voltmeter will slow up the work tremendously. Manufacturers of such apparatus have made arrangements for partial payment plans which place the equipment within the reach of all and there is now no reason why the service technician should be without proper equipment.

The Service Oscillator and Its Use.

We noted before that the service oscillator is nothing more than a miniature radio transmitter giving a modulated signal output of any desired frequency. It is possible to build such an oscillator with a grid leak and condenser combination which gives a modulated signal due to rapid blocking of the grid circuit. This occurs through the use of such a combination of resistance and capacitance that the charge on the grid does not leak away rapidly but builds up and discharges in such a manner as to modulate the signal.

This is an excellent simplification of the apparatus but does not give as flexible a piece of apparatus as would be the case where the modulation is obtained from a separate source as in the case of a broadcast transmitter.

An oscillator of the first type is shown in schematic in Fig. 23. The equipment should be completely shielded in an aluminum case such as is obtainable on the open market so that the signal can be picked up only at the terminals provided. In the circuit shown the 125-ohm resistor effects the required variation of the signal output in accordance with the signal strength desired. The grid leak should be varied over a range between .5 and 10 megohms until the value giving the desired modulation tone is obtained. The batteries should be enclosed di-
rectly in the shield so that no pick-up in the receiver 
from stray signals in the battery leads will affect the 
adjustment of the receiver. This is important.

The values of the various parts are given directly 
on the schematic circuit diagram. It will be noted 
that by simply throwing an 'anti-capacity key switch 
the range of the signal may be either in the broad-
cast band or in the range of the intermediate fre-
quency amplifier of a superheterodyne receiver. This 
is the simplest form of oscillator which can be effec-
tively used in service work and we will continue our 
notes on the use of the apparatus with this type of 
oscillator in mind. Later we will take up the con-
struction of a more complex device and its calibra-
tion.

Inasmuch as we will not use the receiver antenna 
during operations with the test oscillator it will be 
necessary to replace it with a device known as a 
"Dummy Antenna" and having equivalent character-
istics—except in its capabilities of picking up a sig-
als. In Fig. 24 there is a sketch of a "dummy an-
tenna" together with data on the parts going into its 
structure.

Output meters are available on the market for con-
nection in place of the loud speaker so that a visible 
indication of the output is obtained. Such an indi-
cation is necessary in all operations with the service 
oscillator. A satisfactory output meter for most ser-
vice work may be made by employing a '12A tube 
with the grid and plate tied together in the man-
ner shown in Fig. 25. The filament battery may be 
two 4.5-volt "C" batteries in parallel.

Maximum output is indicated by the maximum de-
flexion on the milliammeter scale. Such a meter may 
be connected directly across the loud speaker wind-
ings. It is a simple matter to mount a meter of this 
type in a small aluminum shield together with the 
necessary batteries so that it becomes a permanent 
part of the technician's equipment.

A second type of output meter is the "resonance 
indicator" which consists of a milliammeter in series 
with the detector plate lead. An adapter is made 
from an old tube base and a socket in such a man-
ner that two leads are brought out for the insertion 
of a 0-1 milliamper meter. Fig. 26. When used 
with a "bias" detector the maximum signal will be 
indicated by the maximum reading on the milliam-
meter.

Alignment of Radio Frequency Amplifiers.

In aligning a receiver by means of the oscillator 
and the output meter or by means of the resonance 
indicator it is necessary to connect the dummy an-
tenna between the oscillator antenna post and the an-
tenna input of the receiver as shown in Fig. 27.

The oscillator is set to some high frequency within 
the broadcast range and the output of the oscillator 
is adjusted so that with the volume control of the 
receiver set at about 50% of the maximum output 
the reading on the output meter is something less 
than the maximum.

Now starting with the trimmer condenser in the 
detector circuit each trimmer should be adjusted so 
that the maximum reading is obtained in the output. 
Use a bakellite or other non-metallic screw driver in 
making this adjustment.

If at any time during the process the output meter 
runs off scale readjust the output of the oscillator 
to bring it back into the range of the meter. Once 
having completed the adjustments of the trimmers, 
the oscillator output should be shifted to some lower 
frequency and the adjustments of the trimmers
checked again. The receiver will now be in correct alignment but if the receiver dial is calibrated directly in kilocycles you may have disturbed this calibration. If so tune in a station of known frequency, release the dial mechanism and shift it so that the calibration is correct.

Aligning the Intermediate Frequency Amplifier in a Superheterodyne.

To effect an alignment of the intermediate frequency stages of a superheterodyne receiver the procedure is not dissimilar to that just described. Connect the antenna post of the oscillator directly to the grid of the first detector tube. Connect the ground terminal of the oscillator to the receiver ground. In order to be certain that no broadcast interference is picked up it is necessary to ground the antenna post of the receiver.

Now with the oscillator tuned to the correct intermediate frequency as ascertained from the manufacturer's data adjust the output of the oscillator so as to give a convenient reading at the output meter with the receiver volume control at about mid-range. The adjustment is now continued in the same manner as in the case of the radio frequency stages. In the superheterodyne it is best to complete the alignment of the intermediate frequency before attempting any adjustment of the R.F. or oscillator.

Neutralizing a Receiver.

In neutralizing a receiver by means of the oscillator we require a dummy tube. This dummy is made by taking a good tube and cutting off one filament or heater terminal at the base so that the tube is inoperative.

An easy way to insulate the filament prong from the socket is to slip a short piece of soda straw over one of the prongs and exercise a little care in inserting the tube in the socket. This does not spoil the tube.

Connect up the oscillator with the dummy antenna as described and place the dummy tube in the first socket. Shift the neutralizing condenser with an insulated tool or screw driver so that it is completely off neutralization and tune in the signal from the oscillator so that a good, strong indication is evident in the output meter. Now adjust the neutralizing condenser until no signal comes through. With the condenser off neutralization a certain amount of the signal is passed through the dummy tube through the capacitance between the electrodes. When neutralization is complete this tube capacitance is balanced out and no signal passes through the dummy tube. Having completed the balancing of the first stage replace the dummy tube with one known to be good and repeat the process from stage to stage until all of the circuits are balanced. The receiver is now completely neutralized and any oscillation taking place is due to other causes. If the primary coil wiring is reversed you will not be able to effect a complete neutralization of the receiver. Be careful in making changes in wiring of neutralizing windings and replace wires in proper positions.

Balancing the Oscillator of a Superheterodyne.

Some superheterodyne receivers employ a bridge type of circuit in the oscillator tuning condenser system. This consists of a unit of the gang condenser—a large fixed condenser and two trimmers. After having effected alignment of both the R.F. and intermediate frequency stages continued insensitivity is possible due to this circuit being out of alignment.

With the output meter in place and the oscillator connected to the receiver through the dummy antenna tune the oscillator to about 1400 kc. and adjust the receiver so as to obtain a reading at the output meter of about half scale. Now adjust the trimmer across the portion of the gang condenser which tunes the oscillator for maximum output at high frequencies. Now retune the oscillator and receiver to 600 kc. and adjust the trimmer across the oscillator fixed condenser for maximum output at the low frequencies. Return again to the 1400 kc. position and make any final corrections necessary.

Certain superheterodyne receivers have one section of the gang condenser cut to the proper shape for tuning the oscillator and do not employ the bridge circuit arrangement. Alignment of the oscillator in such receivers is carried out at the same time in the same manner as the R.F. alignment.

Special Tool for R.F. Alignment.

A special tool for alignment of R.F. circuits is shown in Fig. 28. This is called a balancing ring. It consists of a ring of No. 14 wire covered with spaghetti tubing mounted on the end of a bakelite rod.
test is only of value in those receivers where the coils are open for test by placing the ring over one end of the coil and the test cannot be used where the coils are shielded completely. If both these tests result in a decreased output reading it indicates that the adjustment is already correct and that stage needs no adjustment.

The end of the bakelite tool may be ground down so that the tool may be used also as an insulated screw driver for trimmer adjustment. The use of a metallic screw driver for such a purpose throws everything out of balance.

Making an Ohmmeter for Resistance and Continuity Tests.

Through the courtesy of the International Resistance Company we are including two sketches for the adaptation of 0-1 ma. meters to use as ohmmeters. These two scales shown in Fig. 29A may be cut out and pasted over the original scale of the meters indicated in Fig. 29B.

The following chart gives the values for the series resistance and the battery. The scale may be extended to 3 and 15 times the value shown by using the higher battery voltages and higher series resistances. This means that with the multiplying factor of 3 the reading of 100 ohms will be really 300 ohms and the reading of 2000 ohms—6000. Use of the factor of 15 would mean that 100 ohms on the scale would correspond to a resistance across the terminals of 1500 ohms, and 2000 ohms—30,000.

<table>
<thead>
<tr>
<th>Battery Voltage</th>
<th>Series Resistance</th>
<th>Multiplying Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5</td>
<td>1,500</td>
<td>1</td>
</tr>
<tr>
<td>4.5</td>
<td>4,500</td>
<td>3</td>
</tr>
<tr>
<td>22.5</td>
<td>22,500</td>
<td>15</td>
</tr>
</tbody>
</table>

In each case prior to use the test prods should be shorted and the zero adjustment of the meter set so that the reading is zero resistance. This compensates for loss of battery voltage through service. When the setting can no longer be made at zero the battery should be replaced. The two ranges having the 1 and 3 factors are the most useful for our purpose and the meter can be set up in a cabinet with a change-over switch and a tapped "C" battery so as to cover both ranges at will.
ANALYSIS OF TYPICAL RECEIVER

We are going to learn how to service radio sets in an entirely unorthodox fashion. By this is meant that we are going to assume a hypothetical receiver—one not of any particular type or design and give it all the features found in the most modern radio sets. We will then analyze this imaginary set step by step, learning what each part contributes to the over-all efficiency of the receiver and in what manner the failure of that part might affect the operation of the receiver as a whole.

The average receiver of today has two screen-grid radio frequency amplifying tubes, a detector, a first A.F. stage and a second A.F. stage which may employ one or more tubes. There is also a rectifier tube which serves to convert high voltage alternating current into a pulsating direct current which is smoothed out by means of filter circuits and furnishes the necessary operating voltages for the receiver.

We will design our receiver along these lines—analyze its structure and then retrace our steps to see what possible variations might be found in manufacturers' designs and how they might affect the operation of the receiver. These variations involve the use of unusual forms of coupling between tubes—resistance coupling in amplifiers—unusual volume controls—special types of detectors—automatic volume controls—etc.

Of course no one treatise can hope to cover in detail the foibles and fancies of all the radio engineers at large in the country, for each man has pet ideas which he incorporates in receivers of his design—ideas based on personal likes and dislikes and upon the necessity for avoiding patent infringement. We will, however, take into consideration the more usual arrangements of various radio circuits in a manner calculated to aid in service work.

Analysis of a Radio Receiver.

In Fig. 30 we find a receiver in schematic which incorporates in a good measure the best features of everyday engineering practice. Peculiar and involved circuit arrangements have been avoided entirely but will be taken up later.

You will note that three input terminals are provided. In using a fairly short antenna, connection should be made to the S.A. binding post. If a long or low antenna is used, the L.A. post should be employed so that the fact that C is in series with the antenna will effectively shorten it and prevent the large antenna capacitance from affecting the tuning of the first condenser and coil.

If C were shorted the use of a long antenna would broaden the tuning of the receiver as a whole and considerable interference would result. The same effect would be true if we connected an antenna of too high capacitance to the S.A. post. Connecting any antenna to the L.A. post with the condenser unsoldered or open would result in no signal whatever or at best a very weak one.

In this receiver a portion of the volume control is in the antenna circuit, its adjustment affecting the amount of signal voltage furnished across the terminals of the primary winding L. Even with such a volume control in its minimum signal position a certain amount of signal will get through by capacity coupling unintentionally introduced through the proximity of the two windings, L, L, and we must include another volume control at some point in the receiver if a true zero volume setting is desired.

This second control is labelled R and the two may be coupled to the same shaft for simplicity of operation. Another reason for the use of the two controls will be shown in another section of this book under the heading of "Cross Modulation."

If R were open-circuited we would find that the volume was not changed in the normal manner as we rotated the control knob and that extremely loud signals resulted when the knob was in the "maximum" position. Derangement of R has similar effects which will be noted a bit further on.

The peculiar circuit structure between the antenna and the grid of the first R.F. tube constitutes a "band-selector" or "band-pass filter" arrangement. Theoretically, a radio signal consists of a carrier wave and two side-bands, the width of which depends upon the modulation impressed upon the carrier. If two circuits be coupled so that a common impedance exists between the two, a double-peaked response will be obtained. In Fig. 31, there are shown the response characteristics of two tuned circuits coupled in a normal fashion as with a tube; the same two circuits coupled by means of an impedance common to both circuits are shown in comparison...
The manner in which the double-peak or "band-pass" circuit approaches the ideal square response curve is obvious. Another and more important use for the band-selector is described later under the heading of "cross-modulation." This peak separation does not remain constant over the tuning range and a value of $C_0$ (the coupling impedance) should be chosen such as to give the best effect over the entire band. With capacitative coupling as shown in Fig. 30, a condenser in the neighborhood of .01-mf. is usual. The short-circuiting of $C_0$ will result in no signal.

The resistance $R_3$ has no effect upon the circuit operation and is there merely to provide a return path for the grid circuit. Its value is usually about 3 megohms. Normally the resistance measured to ground from the grid of the first tube would be 3 megohms but with $C_0$ short-circuited the reading would indicate zero resistance.

An open circuit at $C_0$ results in loss of signal strength while an improper value of capacitance at this point will result in too broad tuning either at one portion or throughout the tuning range—or in excessively sharp tuning at one end.

The tuned circuits $L_2C_2$ and $L_3C_3$ are to all intents identical with the circuits employed in coupling the radio frequency amplifier stages except that they lack the primary circuits. The usual value for the maximum capacitance of each section of the gang tuning condenser is about .00035-mf. This calls for a tuning inductance of about 240 microhenries for covering the broadcast band.

Open or short circuits at any of these points will cause loss or weakening of the signal.

The Radio Frequency Amplifier Stages.

Plate voltages from the power supply are furnished to each tube by taking taps off at the proper point on the voltage divider. As is the common practice the grid circuits are returned directly to ground. Seemingly this would mean that the grids did not obtain a negative bias such as is required for the correct operation of the tubes. The bias is obtained by means of a resistance in the cathode circuit of each tube through which the plate current of the tube must flow.

Operation of the tube requires that the grid should always have a negative potential with respect to the cathode circuit. The true meaning is not distorted if we say that the cathode should be positive with respect to the grid. The current flowing through the resistance creates a voltage drop according to Ohm's Law and makes the cathode positive with respect to ground (and the grid) by that amount.

In determining the voltage characteristics of each R.F. stage we must first set the volume control at its maximum position. This short-circuits $R_2$ and leaves $R_1$ between the cathode of $V_0$ and ground. The condenser $C_0$ is in shunt across $R_1$ so as to effectively short circuit it as far as R.F. is concerned. This as-
sures us that the biasing resistance has no effect on the signals.

The value of the by-pass condenser should be large enough that its reactance is substantially lower than the resistance of \( R_4 \) at all frequencies within the broadcast band.

The gain through the tube and consequently the "volume" can be controlled by varying the bias of the grid. This is done by increasing the resistance of \( R_4 \).

The resistances \( R_4 \) and \( R_5 \) provide a minimum bias for the tubes below which excessive plate current would be drawn. Increasing the resistance of \( R_4 \) increases the bias of the tubes and thus decreases their amplification. Short-circuiting of \( R_4 \) would mean that neither tube would vary in amplification with rotation of the volume control knob. This would be shown by means of a set analyzer if the plate current of the tubes failed to change when the volume control was rotated.

Open circuits in \( R_3, R_4, \) or \( R_5 \) would be indicated by no plate current flowing in one or both tubes. Short-circuiting of either \( R_3 \) or \( R_5 \) causes excessive current to flow in the plate circuit of the tube involved, since no bias would be applied to the grid of that tube at maximum volume setting.

An open resistance \( R_3 \) would result in loss of bias for the first grid and \( V_1 \) would consequently draw excess current. Short-circuiting of \( C_5 \) or \( C_8 \) also removes the biasing potential from the grids of their respective tubes and allows excess current to flow.

\( R_3, R_4, \) and \( R_5 \) are what is known as isolating resistances. \( C_3 \) and \( C_5 \) are each double condenser units by-passing the isolating resistance to which they are connected. The capacitance is made large enough so that it presents a lower impedance path to ground for stray R.F. voltages than do the resistances.

These circuits are another means of assurance that the radio frequency voltages stay in the circuits provided for them. Their failure to stay "put" results in oscillation. Short circuits at these points will result in loss of voltages on the tubes. Open condensers will cause loss of signal or oscillation.

Shielding of the individual stages has not been indicated in the sketch but it is necessary in all screen-grid stages and is preferable even in circuits employing three element tubes. The two coils \( L_5 \) and \( L_6 \) should be shielded one from the other. Individual shields or partial shields should be over the screen-grid tubes.

It is also desirable that the filtering resistances and condensers pertaining to each stage be shielded within the same enclosures as the coils.

The R.F. transformers consist of a primary (\( L_4 \) and \( L_6 \)) and a secondary (\( L_5 \) and \( L_7 \)). Design factors attendant upon the use of the screen-grid tube call for a primary with often as many or more turns than are on the secondary winding if the maximum available gain is to be realized.

The windings may be one over the other or the primary may be wound with fine wire on a small bobbin at the end of secondary or placed within the coil form. Open circuits in the primaries are readily traced by loss of plate voltage while open secondaries result in loss of grid bias and consequent heavy plate current. Poor connections may cause broadness of tuning and short circuits in either winding will result in loss of signal.

### The Bias Detector.

The function of the detector is one of converting modulated R.F. signals into a direct current pulsating at the modulation frequency. In bias detectors such as that shown the tube is operated on a portion of its characteristic curve so that changes in the signal occurring in the negative sense have no effect while changes in the positive direction cause plate current to flow.

The choice of the resistance \( R_{10} \) is such that the plate current is close to zero when no signal is impressed on the grid. Fig. 32 shows this effect graphically. It is essential that enough signal be impressed on the detector grid that changes under modulation occur only upon the straight portion of the characteristic curve of the tube. Otherwise the variations in plate current will not be images of the corresponding changes in the signal applied to the grid.

The by-pass condenser across \( R_{10} \) must be of sufficient capacitance to effectively by-pass the resistor at audio frequencies. This means that a capacitance of from .5 to 2 mf. must be used at \( C_{10} \).

The plate impedance of tubes biased close to the plate current cut-off region is high and if the lower modulation frequencies are to be passed, the primary of the transformer \( T_1 \) must have a high value of inductance if it is to present a favorable load to the detector.

The system \( C_{21}, L_5, C_{22} \) represents a low pass filter which allows the passage of currents of audio fre-
quencies but by-passes to ground all R.F. energy. 
$C_{22}$ might well be omitted from the circuit but $C_{21}$
may not be omitted without severe loss of signal 
energy and the possibility of a portion of the R.F. 
energy in the plate circuit of the detector tube being 
fed back to the R.F. amplifiers where it might cause 
serious oscillation problems. If we employ $C_{21}$ only 
it must be of about .001-mf. or .002-mf. in which 
case a slightly deleterious effect on the higher 
frequencies may be noted. Careful design of a system as 
shown permits the use of relatively small condensers 
-about .0005-mf. with a 10 millihenry choke having 
but little effect upon the higher frequencies of modu-
lation. Total exclusion of any such arrangement re-
results in choking of the detector tube at high volume 
due to the R.F. energy in its plate circuit as well as 
the possibility of regeneration.

A short circuit in $L_4$ may be detected by means of 
an ohmmeter but its effects will be rather obscure. 
An open R.F. choke will be instantly noted by loss 
of detector plate voltage. Short circuits in either 
of the two condensers will be obvious as they will 
result in loss of plate voltage and a drop in voltage 
aver the portion of $R_{11}$. Opens in these 
circuits will necessitate a bit of trouble-shooting on 
the part of the service man as they will not be ap-
parent on any set testers, and in cases of weak signals 
and regeneration they will probably escape attention 
except as a last resort.

$R_{11}$ and $C_{11}$ constitute another isolating filter 
and need little mention except that the condenser re-
actance should be small compared with the resistance 
at all audio frequencies. Open circuits in the con-
denser leads may mean poor quality and a short cir-
cuit will result in loss of plate voltage for all tubes 
coming out of the ratio of the transformer. An open resistance 
will result in loss of the detector plate voltage and a shortened resistance 
at this point will cause excessive voltage to be ap-
plied.

Normally $T_1$ will be a low ratio transformer be-
cause of the requirement of high primary inductance. 
With the higher ratios the large primary would call 
for an excessively bulky second tuning and one 
having a large self-capacitance. This latter fact 
would result in loss of the high audio frequencies. 
The circuit fed by this transformer needs little said 
about it as the effects of the various circuit elements 
normally and abnormally have been covered. $T_2$ may 
be of higher ratio than $T_1$ as its primary inductance 
need not be so high.

The circuit across the secondary of the transformer 
$C_{11}$, $R_{11}$ constitutes a tone control. With the maxi-
um resistance in the circuit the high frequencies 
would be transmitted undiminished while gradual 
decrease of the resistance permits the condenser to 
be more and more effectively in shunt across the 
secondary of the transformer. An open or short 
circuited resistance would be evidenced by the fact 
that the tone was either high or low pitched regard-
less of the setting of the resistance. An open condens-
er would show itself by constant passage of the 
highs regardless of the control setting. A shorted 
condenser in the tone control circuit would be indi-
cated by the fact that the tone control would become 
a volume control with no signal passing when the 
control was in the "bass" position.

$V_4$ is the power output tube which differs but little 
from the circuit arrangement of the stage previous. 
The output tubes available are of the filament type 
and not indirectly heated as in $V_4$.

A center tapped resistance ($R_{15}$) provides a bal-
canced point for taking off the filament end of the 
biasing resistance. This center tapped resistance 
should be large enough so as not to affect the regu-
lation of the filament supply winding of the trans-
former by adding an appreciable load but should be 
small in comparison with $R_{15}$. Failure of $R_{15}$ due to 
short circuit of one portion or open circuit of one 
side will result in excessive hum.

Opening of the biasing resistor will result in loss 
of plate current while a short circuit of either the 
resistance or its by-passing condenser ($C_{12}$) will re-
result in the removal of the grid biasing potential 
with consequent dangerous increase in plate current.

It might be noted here that low output impedance 
tubes such as are employed in output circuits must 
not be operated without sufficient bias on the grid. 
Total destruction of the tube will result if the bias-
ing potential is removed for even a few moments. 
Neither may tubes of this class be employed as resis-
tance coupled amplifiers with the grid return path 
provided by a resistance of high value. Any slight 
overloading which causes grid current to flow will 
create a voltage drop across the grid leak resistance 
which will lower the effective grid bias and may re-
sult in the destruction of the tube. Where the bias 
is provided by the means shown in Fig. 30, this can-
not occur since the increasing plate current will also 
raise the bias in a manner such as to bring con-
ditions quickly back to normal.

The output transformer ($T_3$) serves to couple 
the output tube to the loud speaker which may be 
of any type—the ratio of the transformer being ad-
justed to match the impedance of the tube to that 
of the speaker winding. Open circuits in the primary 
of the output transformer result in loss of plate 
voltage.

The Power Supply System.

The primary winding of the power transformer 
($T_4$) is shown with taps taken out so that the trans-
formation ratio of the transformer may be adjusted 
to compensate for abnormally high or low line volt-
ages such as are encountered in many districts. The 
higher the line voltage the greater should be the 
number of active turns in the primary.

Most modern power transformers are equipped 
with an electrostatic shield between the primary and
secondary of the transformer which is either a thin sheet of copper foil or a winding of fine wire. This is grounded to the chassis and aids in reducing the effect of line noises on the output of the receiver.

If the primary winding has a number of short-circuited turns they will act as a shorted secondary and the power drawn from the line will be increased—the increased drain may not be great enough to blow the line fuses and the fault may be discovered but with great difficulty. Shorted turns in the primary circuit will, however, increase the ratio of transformation by lowering the number of active primary turns and the result will be evident in increased secondary voltages. An open primary will result in a completely dead receiver and the fault will be obvious. Open secondary or shorted secondary windings will result respectively in zero or low voltage readings. Short-circuited turns are usually evidenced by excessive heating and the service man should familiarize himself to the "feel" of transformers under operating conditions so that overheating may be recognizable.

In cases where all tubes operate at a single voltage—2.5 volts for example—many designers use a single secondary winding for all heaters and filaments. This will work out well in most cases although some stubborn cases of oscillation and hum have been traced to this source. In our receiver the secondary windings are provided so that the R.F. and first A.F. heaters operate from $S_1$, the detector from $S_2$, and the output tube from $S_3$.

The heaters are kept at ground potential by center-tapping the windings of the first two named directly to the chassis. The power tube winding is not center-tapped—the electrical center of the system being obtained by means of a center-tapped resistance $R_{ct}$.

The biasing resistance can just as well be connected between the center tap of the transformer winding as in the manner shown. Short-circuiting of either half of any of these windings will result in a half-voltage reading at the heaters. $S_1$ and $S_2$ are the rectifier filament and high voltage windings feeding the rectifier tube ($V_s$).

Partial short-circuiting of one half of the high voltage winding will result in a lowered output voltage and excessive hum. An open circuit in one half will result in reduced output and hum. Either condition may be readily recognized by measuring the voltage across each half with an A.C. voltmeter.

The negative leg of the rectifier circuit is taken off at the center tap of the transformer and the positive terminal is at the mid-tap of the rectifier filament winding. The positive side may be taken off at either side, as well as at the center, as the voltage drop across the rectifier filament is so small as to create but slight unbalance of the circuit.

The ripple in a full-wave rectifier circuit such as is shown is a 120 cycle pulsation if a 60 cycle supply is used. In consequence, a low pass filter system designed to cut off all frequencies from 120 cycles up is employed in filtering out this ripple.

This is the simplest type of filter where design considerations are taken into account and employs two inductances and three condensers arranged as shown in the circuit. The output stage does not require a great deal of filtration because of the fact that the hum voltages in its plate supply are not large and are not subject to any amplification before reaching the speaker.

The inductance of a choke varies with the D.C. flowing through it and for this reason we effect a better over-all filtration by taking off the voltage supply for the power stage after it has been passed through but one section of the filter. The added inductance gained in the second choke by not passing the full load through it aids in the perfect filtration of the detector and other plate voltages where freedom from ripple is most demanded. Short-circuited condensers may be readily noted by the overheating of the rectifier tube and by loss of plate voltage in all circuits. Open condensers may be noted by added hum. Shorted turns in chokes are also noticeable because of increased hum and by slightly higher filter output voltages.

The total value of the resistance across the filter output depends upon the load of the various tubes brought to bear on the power supply and upon the desired output voltage. This is covered fully in the section on Vacuum Tubes. The voltage taken off for the plate voltage of the amplifier tubes is determined by the values of the isolating resistances in series with the plate leads. The voltage taken off at the power supply must be high enough to compensate for the voltage drop through these resistances. So also must the voltages tapped off for the detector and screen-grid circuits be correspondingly higher so as to compensate for this voltage drop.

In all the circuits the voltage at the plate must be high enough to compensate for the loss in voltage due to the fact that the grid biasing potential is, in each case, subtractive from the plate voltage. Thus, if the power tube is a '45 designed to operate with a plate voltage of 250 and a grid bias of -50 volts the voltage at the junction between the two chokes must be slightly over 300,—slightly over 300 because we must also compensate for the drop in voltage through the primary of the output transformer.

An open circuit in the most positive section of $R_3$, would result in a higher voltage on all amplifier plates and a loss of screen-grid and detector plate voltage. A short circuit in this section would result in an excessive screen-grid potential on the R.F. tubes and a high plate voltage on the detector. Similar faults in the other sections of the resistance would have like effects depending upon the location of the fault. Breakdown of the resistance to ground would cause loss or gain in voltage in certain cir-
circuits dependent upon the location of the fault. The by-pass condenser unit C19 is a further precaution against interstage reaction due to an impedance common to two or more circuits. This is a precaution made fairly unnecessary by the use of the isolating filters. This is about all as far as our particular circuit is concerned, and we may now go on to discuss more specialized circuit arrangements. It should be borne in mind throughout the study of this section that our purpose is not to describe the servicing of any particular receiver but to instruct the student in the rapid location of faults through a knowledge of "cause and effect."

Variations in Circuit Design.

Now let us see the various means which may be applied to bring about the same end. Some of the variations to follow have little to recommend them other than their originality, while others enable the manufacturer to produce a cheaper though better receiver. Starting at the antenna and skipping the volume control, the first item is the antenna input circuit.

Some receivers—now more or less obsolete—achieved single control without the necessity of careful design by the simple expedient of using an untuned vacuum tube as a coupling device. This saved the labor of designing an input circuit in which the antenna characteristics did not affect the tuning of the first circuit, but otherwise was rather useless since the gain through the coupling tube was negligible. Without this tube, in the absence of accurate inductances and condensers, it was necessary to employ an additional control in the antenna circuit or a device which changed its value with the tuning of the circuit.

In Figs. 33 and 33A there are shown an untuned input circuit and the input circuit of one of the earlier Bosch single control sets in which a variometer (variable inductance) was coupled to the condenser shaft and counteracted the effects of the antenna over the entire band. Employing the first type in the neighborhood of a strong local transmitter allows cross-talk to take place, cross-talk being the condition in which the local signal is superimposed upon others quite removed from it in frequency as differentiated from ordinary broadness of tuning where the interference takes place only on desired stations having a frequency close to that of the nearby transmitter. A wave trap might cure this condition if it were not too aggravated. Misadjustment of the variable inductance on its shaft in the second type would result in broadness of tuning accompanied by a loss in signal strength.

In some types of receivers the antenna is connected to the high potential (farthest from ground) end of the first tuning inductance and is coupled thereto by means of a small variable condenser. This means that the receivers are ganged on a standard antenna at the factory with the coupling condenser set at its mid-point. After installation, it is necessary to make an adjustment of the coupling condenser which will remain in a fairly efficient state of operation until the constants of the antenna are changed to a marked degree.

In the majority of modern receivers, the tuning arrangement between the antenna and the grid of the first radio frequency amplifier tube has been made independent of the antenna characteristics by virtue of long research in the laboratory.

In certain of the receivers licensed under the patents of the Hazeltine Corporation, the antenna coupling transformer (two windings coupled magnetically are always referred to as a transformer) has a primary or antenna coil consisting of many turns of fine wire in a slotted form placed inside the tuning coil or secondary. This antenna coil resonates at some frequency just outside the broadcast band—at about 500 kc. for example—the capacitance tuning the coil being the inherent capacitance of the antenna. In changing from an antenna of fairly usual characteristics to a very short one, resonance is maintained by shunting a small condenser across the antenna and ground terminals as shown in Fig. 34. This condenser makes up the deficiency in capacitance. Trouble in such systems may be due to an open or a short-circuited primary winding—or in the "short antenna" position, to a shorted or open compensating condenser.
Band-Selectors.

Band-Selectors, Band-Pass Circuits or Coupled Circuit systems, such as we have employed in the preliminary portion of our receiver, are used not only in an attempt to attain the square response characteristic shown in the dotted line in Fig. 31, but because of the fact that, even though the circuits are less "sharply tuned" as far as cutting off of the desired side-bands is concerned, designers are often able to obtain better selectivity so far as the sloping off of the "petticoats" of the curve is concerned. This is shown in the figure.

Band-Selectors may be coupled in several ways as shown in Fig. 35. In the first two, where the coupling is obtained by an inductance common to the two circuits and by magnetic coupling, the distance separating the two peaks becomes greater as the frequency becomes higher. Where the coupling is capacitative the separation is greater at the low frequency end of the tuning range.

It is also possible in the manner shown to achieve a combination of capacitative and inductive coupling so as to render the separation between the peaks constant throughout the range. The choice is in the hands of the individual designer as an efficient arrangement can be made in either fashion. Where the coupling is inductive, the extra resistance providing the grid return for the first tube is unnecessary as the circuit is not broken.

Interstage Coupling Devices.

In receivers in which an attempt is made to actually achieve the ideal square response curve, use is made of band selectors as interstage couplings replacing the transformer coupled system of Fig. 30. The simplest way of doing this is to tune both primary and secondary circuits of a transformer so arranged, so that the inductive coupling between the windings is of the correct value.

This method is shown in Fig. 35 where it may be readily seen that the first condenser is at high potential. This is not theoretically wrong, but care must be taken in working with receivers of this type if accidental short circuits are to be avoided. The other arrangements in Fig. 35 are methods of coupling by feeding the plate supply of the tube through
a choke or resistance so as to keep the D.C. out of the coupling circuits. This may also be done by the use of a large fixed condenser in series with the plate tuning coil and condenser—so large as to have no effect on the constants of the circuit. The numerous circuits shown in the figure have been used in various commercial receivers.

In order to make the sensitivity of a receiver at the low frequency end of the range equal to that at the high frequency end, it is at times necessary to employ special circuit arrangements. One method used in many receivers of today is that of resonating a portion of the primary to some frequency just outside the low frequency end of the broadcast band. The increased response, due to the approach of the resonant condition as the low frequency end of the range is reached, is then used to counteract any relative inefficiency existing in the coupling system. Another method utilizes a single turn of wire wound close to the secondary to achieve a capacitative coupling which reduces the amplification at the high frequency end of the range, thus equalizing the over-all gain. These two systems are shown in schematic in Fig. 36.

Introduction of the additional windings and the tuning condenser adds to the possibility of failure and in receivers where these arrangements are employed careful note should be taken that all is well in each coupling system. In the first mentioned where the double primary is employed, it should be noted that the one primary is wound in the reverse direction from the other. In replacing interstage coupling transformers, care should be taken that the leads are properly connected.

A single tuned winding may be employed in the so-called "tuned impedance" systems—the tuned circuit being either in the grid or plate circuit as shown in Fig. 37. The coupling condensers are very small and are, in some cases, subject to failure. Failure of the condenser results in a simple short circuit to ground of the plate voltage of the preceding tube in the system shown in Fig. 37.

In Fig. 37A, a more serious condition exists, as a short circuit of the coupling condenser will result in the plate voltage of the preceding tube being directly on the grid of the next. This high positive grid bias will result in the destruction of the tube due to the enormous plate current which will flow. Subsidiary apparatus may also suffer if such failure takes place.

Receivers employing the screen-grid tube depend for freedom from oscillation upon the inherent characteristics of the tube and a complete isolation of the various circuits by filtering and by shielding.

With the three electrode tube, the grid to plate capacitance of the tube was so high that a portion of the amplified voltage was fed back to the grid circuit through the tube itself resulting in oscillation.

Many "loser" methods were employed for the remedy, such as the insertion of a resistance in series with each grid. These resistors might give trouble due to a short circuit causing oscillation, or an open circuit resulting in a dead receiver, with no bias applied to the grid of the tube in question.

The most satisfactory methods were those in which a capacitance, or a network of inductance and capacitance, was employed to balance this feedback voltage. This is not a technical work and we will not enter here into a description of "neutralization". It suffices to say that the adjustment of these circuits is quite delicate and any disturbance of the neutralizing condensers requires a complete re-neutralization of the set. The manner in which this is done is described in another portion of this manual under the use of service apparatus. Fig. 38 shows a representative group of such arrangements in which the short circuits which might cause trouble are readily apparent.

Some receivers—notably the Sparton line—employ a four-circuit band-selector in which a fair approximation of the ideal square response characteristic is obtained. This is followed by a "broad-band" R.F. amplifier employing untuned transformers. These are highly developed air core transformers giving amplification over the entire broadcast band. In these receivers, it is interesting to note that the functions of selectivity and of amplification are isolated one from the other. Connected to an open antenna without the tuning unit, the amplifier...
would pick up and amplify a conglomeration of everything that happened to be on the air at the time.

These receivers are of more interest than importance, but a mention of untuned amplifiers is essential as many modern receivers employ a single untuned stage for one reason or another. The reason may be one of desiring slight additional gain without the necessity of an extra condenser or it may be, as will be seen shortly, that the succeeding tube has characteristics which do not fit in well with the operation of tuned circuits.

Detectors are probably the least understood of all the circuit elements which the service man may be called upon to check, and while we are mostly interested in circuit arrangements in this particular chapter, the one covering "Vacuum Tubes" will deal at length with the problem.

**Detector Circuits.**

There are as many types of detectors as one can shake the proverbial stick at. For the most part, they are divided into two classifications—"grid circuit" and "plate circuit," depending upon whether the audio frequency component first makes its appearance in the grid or the plate circuit of the detector tube. Plate circuit detection was shown in our receiver and the curve in the figure showed that the tube received a large negative bias so as to operate on a portion of its characteristic favorable to the detector action.

Grid circuit detectors differ from the others in that they are not biased negatively, employ the familiar grid condenser and leak, draw a rather high plate current for the plate voltage applied, and have a low plate impedance in comparison. While the majority of grid leak detectors are found to have a grid condenser of .0005- or .00025-mf. and a leak of from 1 to 5 megohms, the quality of reproduction may be distinctly improved at a slight loss in sensitivity by replacing these with .0001-mf. condensers and leaks not larger than 250,000 ohms. If the sensitivity is not cut down too much, replacement of the old leak by one of 100,000 ohms is still better. Except that one may expect to find a fairly high plate current flowing, the grid circuit detector shown in Fig. 39A does not differ greatly from the plate circuit type as far as service requirements are concerned.

There is one important fact in connection with the two types of detectors which will be put to use as a service aid in another section of this publication. The plate circuit detector normally operates with a rather low plate current which increases with the signal intensity, whereas the grid circuit detector operates with a relatively high plate current which decreases in value under the effects of the signal.

The choice of detectors rests with the individual designer and equally good quality of output can be obtained with either, provided the limitations of each are recognized.

The original vacuum tube detector was the Fleming valve—a two-element valve consisting of a hot filament and a plate not unlike those of the rectifier tubes in use in many receivers today. Its ability as a detector of radio signals was based upon the fact that it is conductive in one direction only. That is to say, that current will flow only at such times as the plate is at a positive potential with respect to
the filament or cathode.

A device of this type is not as efficient a detector as a three-element tube, but certain designers have found that by employing a three-element tube with the grid and plate elements tied together so as to operate as a two-element detector, a certain freedom from distortion in the detector stage can be obtained.

A circuit of this nature such as employed commercially in the Philco Transitone receiver is shown schematically in Fig. 39B. It should be noted here that little can be learned of what is actually going on in the circuit through the use of the usual testing equipment, and that lack of sensitivity in the receiver due to a detector tube which is under par had best be checked by replacing the tube in question by one having known characteristics. Note that no active plate voltage is applied to any of the tubes employed in various receivers as “diode” detectors.

**Volume Control.**

It should be noted that but few of the receivers on the market today have volume controls following the detector. This is because of the fact that the major portion of the distortion normally encountered in radio receivers is due to overload of the detector.

Volume control is achieved either by the use of a resistance across the antenna input circuit, by varying the grid bias or screen grid potential, or by a combination of the two.

In the latter case, the two controls are so arranged that they are driven by a single control shaft. In one particular instance—as shown in Fig. 40, a single resistance is employed to operate in such a fashion that rotating it toward the minimum setting decreases the resistance across the input circuit at the same time that the bias is being increased.

This is done by employing a potentiometer having its center arm to ground, one end connected to the high potential end of the antenna input coil, and the other to the cathodes of the R.F. tubes. A single fixed resistor in series with the cathode end of the potentiometer assures us that a certain minimum bias is applied to the grids of the R.F. tubes at the maximum volume setting.

We have already set forth, as our reason for employing an additional control, the fact that, with the volume control in the antenna or across any one of the tuned circuits, sufficient stray coupling would exist to make a zero setting impossible. Now one may ask why it is not sufficient to increase the bias or decrease the screen-grid potential over such a range that the signal would be entirely wiped out if desired. This would also involve certain difficulties, for under these conditions the tubes are operating on portions of their characteristic curves conducive to the effects of cross-modulation. If, however, we employ a mixture of the two, the decreased input voltage due to the smaller resistance across the input circuit removes the undesired signal likely to cause cross-talk at the same time that the volume is being decreased by the increase in biasing potential or the decrease in the screen-grid voltage. The method employed in varying the screen-grid potential is shown in Fig. 41.

**Automatic Volume Controls.**

Sales bulletins on receivers employing automatic volume controls give two reasons for their use—one being the reduction of “fading” and the other the ability to tune through locals without a terrific “blatt” from the speaker as the dial is moved across the frequency setting of some near-by transmitter.

By setting the manually operated control at some one position, the dial may be swung across its full range without the volume of any single station being greater than that of the others. The majority of the commercial receivers employing this feature do so in a manner whereby the automatic control is effected by a variation in the bias on the R.F. tubes, depending for its degree on the amplitude of the received carrier.

Quite naturally, if the volume control operates so
as to limit the gain through the amplifier, it is essential that it should not work fast enough to wipe out the variations in carrier amplitude due to modulation. This is determined by choosing the value of coupling condenser feeding the controlling tube in such a manner that the system will not operate rapidly enough to affect the quality of reproduction. For this reason, service men working on such receivers should not replace this condenser with one of another value should a replacement become necessary.

Since the majority of automatic volume control tubes operate on a similar principle, it will not be necessary to describe a great many systems—representative ones of each type will suffice to demonstrate the principles of their operation.

Fig. 42 shows the type of control employed in some of the Radiola models. The R.F. amplifier tubes are represented by a single tube V1, biased to a certain minimum value by tapping off at a point on the voltage divider about three volts negative, with respect to ground, through a resistance “R” which normally has no current flowing through it and, in consequence, does not affect the operation of the receiver. V3 is the volume control tube which takes its operating signal from the grid of the detector tube.

This tube is in reality a form of vacuum tube voltmeter and is so biased, by means of the manual control R1, as to permit a certain value of plate current to flow for a given amount of signal on its grid; note that “R” is also the plate circuit resistance of the volume control tube. If the control tube is biased so that no plate current flows, the drop across “R” is zero but, when under the influence of a signal the control tube draws plate current, there is a voltage drop across “R” in such a sense as to increase the negative R.F. bias. The biasing potential applied to the R.F. grids is now the normal bias plus an additional negative potential due to the drop across “R” and the volume is reduced to a degree determined by the manual setting of the control tube bias.

It is still necessary to employ a manual volume control in the antenna circuit as, otherwise, tuning across the range between stations would leave the receiver in its maximum condition of sensitivity and the noise level would be high. With the constants of the circuit in correct proportion, all signals will give the same output across the speaker—an output which is controllable by adjustment of the bias on the grid of the control tube.

Certain of the Stromberg-Carlson receivers employ an automatic volume control which is theoretically similar, but is slightly more refined in the sense that the first R.F. tube receives a different control voltage than does the second—the third is not controlled. In these receivers, the input for the control tube is taken from the plate circuit of the third R.F. stage through a .00025-mf. condenser and a 2-megohm leak. The plate circuit of the control tube is connected to ground through a pair of 100,000-ohm resistors in series. The drop across one of the resistances furnishes the additive bias for the second R.F. tube, and the drop across the other, the bias for the first R.F. tube. The skeleton arrangement of the circuit as employed in the Stromberg-Carlson 846 receiver is shown in Fig. 43. An almost identical arrangement is employed in the Kellogg 523 receiver.

The Two Element or “Diode” Detector as an Automatic Volume Control.

Certain manufacturers—Philco, for example—employ the diode detector as an automatic volume control tube. The circuit arrangement of such a control device is shown in Fig. 44. Note that the detector input is through a special type of untuned transformer as the low input resistance of the diode does not lend itself to the use of tuned circuits. The diode detector gives a relatively small output requiring an additional stage of A.F. amplification but has the advantage of not requiring an added tube for the purpose of automatically controlling volume.
The grid and plate of the tube are tied together and act as the plate of the diode. Connected between this plate and the cathode are two 100,000-ohm resistors. The midpoint of these series resistors connects through a 500,000-ohm isolating resistance to the grid of the third R.F. tube. The grids of the first and second R.F. tubes take their bias through the 250,000-ohm resistance which couples the detector to the first A.F. tube. Appropriate isolating resistances are employed as shown to prevent coupling between the R.F. circuits.

In this type of receiver, the automatic effect is not under manual control, the circuits being so proportioned that the output of the first amplifier tube (called the "detector amplifier") is a constant value regardless of the strength of the incoming signal. In receivers of this type where the signal at the detector output is limited at all times to a fixed value, the sensitivity of the receiver is at all times varying in accordance with the received signal.

**Distortion Limiting Devices.**

The same end may be accomplished where a three-element detector is used by a circuit arrangement such as appears in Fig. 45 where the grid returns of the R.F. stages and the detector are connected to ground through a series of 60,000-ohm resistances. The criterion of distortion is the flow of grid current in the detector circuit.

The bias of the R.F. and detector circuits is taken in the usual manner by the use of resistances between the cathodes and ground. Additional bias is provided due to the drop through the 60,000-ohm resistance in the detector grid circuit which occurs when overload of the detector causes grid current to flow. This system is a true automatic volume control as it has no effect in leveling all signals to a single output strength—it merely acts as a volume limiting device preventing overload on strong signals. This arrangement is employed in the Amrad 84 receiver and in the Crosley 77 and 84 models.

Although there are other methods of automatic volume control, they are not common in commercial receivers and when encountered can readily be understood by reference to the types described here. As we noted before, the characteristics of volume control tubes are not readily checked by service instruments, and the best method of checking them is by a continuity test of the circuits and by the replacement of the control tube by a tube known to have good characteristics in other circuits.

**Phonograph Pick-ups.**

Most receivers sold today are equipped with input connections for phonograph pick-ups. There are many ways in which a device of this character can be connected into the circuit, the major consideration being whether the pick-up must be connected into the detector circuit or into the input to the first A.F. tube.
In those receivers which employ a single stage of A.F. amplification, the gain between the A.F. input and the speaker is insufficient for the purpose, and connection must be made in such a manner that the detector is used as an A.F. amplifier when playing records. This demands also that the detector be biased as an amplifier when so used. There are so many ways in which this may be accomplished that the writer will take only three examples to establish the point.

In the Victor model 7-26, the coupling transformer between the detector and the first A.F. tube has a tapped primary, so that one section of the winding matching the impedance of the pick-up device can be tapped off by means of a change-over switch. When making the change-over, the switch automatically breaks the plate voltage connection to the detector tube so that interference from broadcast programs can not be superposed on the recorded music. Fig. 46 illustrates this point.

In this receiver, the two A.F. stages give adequate gain, but in a receiver such as the Sparton model 931 where a single A.F. stage is employed, it is necessary to employ the detector as an A.F. amplifier when reproducing recorded music.

When the pick-up is plugged into its jack, the jack sleeve shorts out the detector biasing resistance with a 1000-ohm unit as shown in Fig. 47. At the same time, the pick-up is connected in series with the input of the detector. When a method of this kind is employed, care should be taken that broadcast interference does not spoil the reproduction.

In the Stromberg-Carlson receivers, the pick-up is connected as shown in Fig. 48—without changing the detector bias. The level of the input to the detector is so low, that the distortion incurred by this use of the detector tube as an A.F. amplifier with
improper bias results in negligible distortion. Connecting the pick-up from grid to ground in this fashion effectively short-circuits the broadcast reception while the pick-up is in use, so that no interference from this source occurs.

From the figure, it will be seen that although "bias" detection is used, a grid leak and condenser are in the circuit. These have no effect on the operation of the circuit either for radio or phonograph reproduction, the reason being the prevention of short circuit of the phonograph pick-up by the secondary of the R.F. transformer.

The pick-up may also be connected directly across the secondary winding of the first A.F. transformer. The impedance is so high in the transformer secondary circuit that it has little or no short-circuiting effect on the pick-up. In all of the circuits described, a volume control separate from the receiver is necessary. In those sets which have been described which use manual volume control following the detector, a method of pick-up connection might be employed which permitted the use of the regular volume control during record reproduction.

**Push-pull Amplifiers.**

There are many advantages to be gained through the use of vacuum tubes in the push-pull connection. First, the fact that the circuit cancels out harmonic distortion enables one to obtain an output far greater than twice that obtainable with the single tube. Secondly, the ripple voltages due to poor filtering of the supply are also canceled out so that less filtration is necessary. Thirdly, the fact that the direct currents in the output transformer cancel out enables the use of a cheaper output transformer than is possible with the single tube.

Other advantages, such as the fact that the biasing resistance does not require a by-pass condenser across it, are also useful in cheapening the receiver without loss of quality. All in all, it may be said that a push-pull output stage more than doubles the output of a single tube without adding more than the cost of the additional tube to the price of the receiver.

Troubles in push-pull circuits caused by an open in one side of the input or output transformer, result in loss of grid or plate voltage in the tube involved. These faults are readily checked with the normal type of servicing equipment. A typical push-pull circuit is shown in Fig. 49.

**The Single A.F. Stage.**

Many types of detectors are operated with so high an input from the R.F. amplifier that an intermediate A.F. amplifier preceding the output stage is not necessary. There is no need for special mention of the circuits as they do not involve the use of any unusual connections or apparatus.

It has already been noted that in such receivers a phonograph pick-up must be connected into the detector circuit in order to achieve adequate gain for operation of the loud speaker at a reasonable degree of volume.

Some of the newer receivers, employing screen-grid detectors with push-pull amplifiers, employ slightly involved circuits such as that shown in Fig. 50 and used in the Victor model R-15. In this case, the split choke acts as an autotransformer of 1 to 1 ratio and feeds the plate voltage to the screen-grid tube as well as providing the signal for the grid of one of the output tubes.

![Fig. 50](image_url)

The coupling condensers are .025-mf. units and the grid leaks providing the grid return path are 430,000 ohms each.

Breakdown of the coupling condensers will put the full plate voltage on the grid of one of the output tubes. The high plate current resulting from this positive grid bias will result in destruction of...
the tube before the service man has an opportunity to correct the defect. Open circuit in either of the grid leaks will result in loss of bias and high current through the tube involved.

**Tone Controls.**

The tone controls employed in modern receivers are employed to limit the higher frequencies so as to produce a more "mellow" effect. They may be of the type shown in our Fig. 30, or may be made up of a series of condensers with a switching arrangement to vary the capacitance introduced in shunt with the A.F. channel.

In neighborhoods where the "man-made" interference is exceptionally great, a control of this nature helps to cut down the interference which consists mainly of high frequency impulses.

In extreme cases, the service man called in to remedy such noise in a receiver not equipped with "tone control" can effect a cure by connecting a condenser of from .00025- to .01-mf. across one of the A.F. transformers.

**Filter Variations.**

Filter systems for radio power supplies may be of the tuned or "brute-force" type. In the tuned type, an example of which is shown in Fig. 51, various savings in the total capacitance of the condensers required in the system may be effected. They require extremely careful design, however, and it is essential that, in making replacements, the parts used be identical with the original. Otherwise, hum may result regardless of the fact that a larger condenser than was originally employed may have been used in replacement.

The theory of the type shown is that the small portion of the first choke and the condenser which connects it to ground are resonated to the ripple frequency (120 cycles for a full wave rectifier with 60 cycle supply), and if the resistance of the choke is low compared with its inductance, they offer as a "series resonant circuit" a virtual short circuit to ground for all currents of that frequency.

The second type of tuned filter, where the condenser is connected in parallel with the choke, operates on the opposite principle—that the parallel resonant circuit formed offers a high impedance to the resonant frequency.

Brute force filters are simply low-pass filters so designed that the cut-off point above which frequency they will transmit nothing is below the ripple frequency. This means that a larger filter is necessary with half wave than with full wave rectifier circuits.

Despite the savings possible with tuned filters, many manufacturers do not use them, for the high capacitance with small bulk available in the shape of electrolytic condensers offers as economical a means of filtration.

The filter circuits we have shown so far show the chokes in the positive side of the filter system with the entire negative portion of the circuit at ground potential.

Certain receivers employ variations in which the filter chokes are in the negative portion of the circuit. The method employed in the Victor R-15 is shown in Fig. 52. The second inductance which connects to ground from the tap on the first inductance is the field winding of the dynamic speaker.
purpose in the Atwater Kent 55, from which the circuit is drawn, and a voltage divider across the field winding taps off the proper voltage. This divider carries but a slight portion of the current and no current whatever flows in the biasing circuit.

The speakers employed in these connections are specially designed for the purpose and, where replacement of the loud speaker is found necessary, care should be taken that one having the proper field winding characteristics is chosen if an identical one is not available.

**Voltage Distribution in Power Supply Circuits.**

In the circuit shown in Fig. 30, the voltages for the plate circuits of the various tubes are obtained by a combination of the voltage divider and voltage drop methods. Either of these may be employed in a receiver and a combination of the two is not at all unusual.

In any event, the "bleeder" resistance across the output of the rectifier is essential to the safe operation of the power supply, especially in the case of heater type tubes, where there is a short interval following the throwing of the switch during which no plate current is drawn by the tubes. If there were not some sort of load across the power supply output, the voltage across the power supply condenser would rise to high values during the initial surge.

The load is also necessary if we are to operate the power supply in a manner so as to allow for considerable variation in plate current without unprecedented departure from the desired voltages. This wasted current establishes a condition where variations in the plate current, drawn by one or more of the tubes, represent so small a percentage of the total current drawn from the rectifier tube that there is but slight change of the output voltage. The methods of design will be taken up later in discussing the characteristics of the rectifier tubes.

The voltage across the output of the rectifier and filter must be at least as high as the total plate and bias voltages required by the output tube—300 volts in the case of the '45. For the tubes employing lower plate voltages, the drop may be secured either by using the "bleeder" resistance as a potentiometer or by inserting series resistances between the plate circuits of the various tubes and the positive side of the power supply. Examples of each system are shown in Fig. 54.

Biasing potentials may also be obtained from the voltage divider rather than by the methods shown in the original sketch. This is done by making "ground" positive by an amount equal to the highest biasing potential required. In Fig. 55, it will be seen that the various cathodes and filaments are brought directly to ground and that the grid returns are brought to a point negative with respect to ground by the required amount.
This may aid in the explanation of the automatic volume control sketches previously shown if any obscenity concerning them still exists. As was noted before in respect to the plate voltages, a combination of the two methods may be effected if it seems necessary to do so.

In Fig. 56, this also has been done. Note that

![Diagram](image)

the minimum bias for the R.F. tubes has been obtained by the use of individual resistances in each cathode circuit, whereas the additional bias necessary for volume control has been obtained by returning the grids to some point negative with respect to ground.

In some receivers, the detector plate voltage has

![Diagram](image)

been obtained by connecting the plate lead of the detector circuit to the positive end of the biasing resistance serving the output tubes. This gives a plate voltage equivalent to the biasing voltage of the output tube. A studious tracing of circuits having an, at first, unfamiliar appearance will clear up many difficulties if the basic principles are borne in mind.

The circuit diagrams given in this manual can never be more than a time-saving aid and are, even as such, worthless, if the service man fails to use everyday "horse sense" in attacking his problems. It is this "horse sense" that keeps customers by making up the difference between a mediocre man and an expert.
DIRECT CURRENT RECEIVERS

Receivers for Direct Current Operation.

Receivers for D.C. operation present a problem because of the initial low voltage available for the power tubes. If, with a maximum plate supply of 90 to 100 volts, any power output is to be attained some system of parallel operation of the output tubes must be employed.

In Fig. 57, the filament circuits of the Stromberg-Carlson 638 receiver are shown isolated from the balance of the receiver. Five 201A tubes are employed in the preliminary stages with their filaments connected in series. If one tube should burn out, the balance would not light and no tests could be made until the defective tube had been located.

The four '71A tubes in the output are connected in parallel both as to filaments and as to grids and plates. Do not remove one of these output tubes from the socket without first turning off the set, as the remaining three filaments would be seriously overloaded.

Plate voltages for all stages in this set are taken from the maximum positive point as shown in Fig. 58. Grid bias is obtained by bringing each grid return of each tube to a point on the filament system negative by the required amount with respect to its own filament. For example, the grid return of the first stage is to the negative filament terminal of the second tube and thus receives a 5-volt negative bias. Grid return of the four '71A tubes is to the negative side of the 12-ohm series resistance—thus giving their grids a negative potential of 12 volts.

The power output available with the four tubes in parallel is approximately that obtained with a single '71A with the full plate voltage, 180 volts, applied.

Biasing of D.C. receivers is simpler in those sets employing heater type tubes, as the bias may be obtained by a resistance between the cathode and ground as in the case of A.C. receivers.

The circuit arrangement of such a receiver is quite simple, as shown in Fig. 59, where a system employing a series of two '24 tubes as radio frequency amplifiers, a '27 detector and two '45's in push-pull is used. The current requirements of such a filament supply system are large—there being a dissipation in the series resistor of about 175 watts.

Biases for all except the output tubes are taken through the use of resistors in series with the cathodes. The secondary of the transformer feeding the power stage is split, so that the fact that one '45 filament is more negative by 2.5 volts than the other can be compensated for by obtaining the bias for that tube at a point differing from the other by 2.5 volts. The plate circuits are connected in normal push-pull fashion.

The D.C. receiver is difficult to service without the schematic circuit available because of the many systems which can be employed in obtaining the fila-
ment and grid voltages. A hint on what may be expected is contained in the fact that receivers employing separate biasing batteries for use with the power tubes usually have those tubes placed at the most negative end of the circuit, so that the filament and plate of each tube will have the maximum possible potential difference.

Where the power stage biases are obtained by a method similar to that shown in Fig. 59, the power tube filaments are positive so that the negative biases may be obtained from the voltage drop across the other filaments. The first method is employed so as to obtain the highest possible plate voltage from the line at a sacrifice of the "all electric" feature.

While working on this section, the writer was informed of the introduction of three new tubes for use in automotive and direct current receivers. These are heater type tubes having filaments operating at 6.3 volts and .3-ampere. In automotive receivers, these tubes take their filament supply directly from the storage battery of the car. In D.C. receivers, the fact that the heaters are isolated from the actual circuits of the receiver makes filtering of the heater supply entirely unnecessary.

The reduced current at which the tubes operate affects another economy in that the receiver will draw about 35 watts from the line as compared with 175 to 200 watts required by most modern D.C. receivers employing '27's or '24's and '45's.

The tubes are designated as the '36, '37, and '38 types and are, respectively, a screen-grid tube for radio frequency amplification and detection, a three-element general purpose tube, and a Pentode output tube comparable with the '47 mentioned in the vacuum tube section of this book except for the fact that a heater type cathode is employed. Because of the economy possible, both in construction and in operation, it is probable that a great many receivers issued this season will employ the tubes.

In anticipation of this fact, the circuit in Fig. 60 shows the filament circuit arrangement which will be employed with these tubes. For reasons stated in the discussion of Pentode tubes in another section of this book, it is not desirable to obtain the bias of a Pentode circuit by means of a resistance from cathode to ground except where push-pull circuits are employed. Fortunately, we are able, in a circuit of the nature shown, to connect the cathode of the output tube directly to a point positive by the required amount with respect to ground. To be sure, the voltage thus obtained is not filtered—but neither does the possible noise voltage, developed across the two filaments from which the bias is obtained, amount to enough to become troublesome. As was the case before, one can never tell how the filament circuits of a D.C. receiver are connected without first seeing the schematic or tracing the circuit itself; in consequence, do not remove a tube from any D.C. receiver without first disconnecting it from the power source—otherwise a few ruined tubes may be chalked up to your debit.
SUPERHETERODYNE SERVICE NOTES

No analysis of the "Super" is complete without a brief historical note concerning the origin of the idea. At the time of the entry of the United States into the war, there were many European amplifiers constructed to amplify at radio frequencies coincident to the long waves which theretofore had been employed in all commercial work.

One of the first jobs handed the Signal Corps laboratory, maintained by our army in Paris, was that of developing a receiver to operate with extreme sensitivity in the short-wave band employed by the enemy in their army communications. This was prior to the development of neutralizing circuits, and the development of an extremely sensitive receiver in those bands would have been a long and tedious process.

Armstrong, who was among the engineers working in the Paris laboratory, hit upon the idea of modulating the incoming signal with a locally generated one and amplifying the resultant frequency which fell within the range of the existent and efficient radio frequency amplifiers then available.

From this idea grew the superheterodyne receiver of today—albeit by a long and devious pathway. It is only with the growing knowledge of radio engineering principles, that the present "super" has been made possible.

Let us, for example, assume two frequencies—an incoming signal of 1000 kc. and a local signal of 1175 kc. We may obtain beat-notes of either the sum of or the difference between the two frequencies. The difference frequency in this case is 175 kc. This frequency is a favorable one for amplification as its relatively low frequency enables the radio frequency amplifiers (known as "intermediate frequency" amplifiers) to operate at a relatively high gain per stage as compared with that obtainable at broadcast frequencies.

Not only is the amplification more favorable at the intermediate frequency, but the selectivity is also much greater. At 1000 kc., an interfering station 10 kc. away on 1010 kc. is separated from the desired signal by but 1% of its frequency. At 175 kc.—after being "beat" with a local oscillation of 175 kc.—the interfering station is at 165 kc. and the desired one is at 175 kc. The difference is still 10 kc. but now the interfering signal is removed from the desired one by approximately 6%.

Inasmuch as the selectivity is measured by the response a given percentage away from the frequency to which the circuit is tuned, the reader will have little difficulty in grasping the advantage which a properly designed "super" may well have over a receiver employing straight tuned radio frequency amplification.

Because of the high degree of selectivity available, it is essential that "band-selector" circuits be employed in the intermediate frequency stages if the "side-band" cutting common to excessively selective circuits is to be avoided. In this connection it might be noted that with the superheterodyne, it is possible to come quite close to a realization of the ideal "square" response characteristic evidenced in Fig. 31.

While discussing the selectivity of the "super", it might be well to note that it is essential that a certain degree of selectivity be obtained ahead of the first detector—that is, the selectivity cannot be localized in the intermediate frequency amplifiers so favorably disposed toward it.

For an example, it is readily seen that the oscillator set at 1175 kc. to produce an intermediate signal of 175 kc. from a signal of 1000 kc. will produce a similar 175 kc. signal from a station on 1350 kc. If we are not to have two signals interfering in the intermediate frequency circuits, it is essential that no portion of the 1350 kc. signal reach the grid of the mixer tube in which the 175 kc. signal is produced (this tube is known variously as the mixer, modulator or first detector).

In the case of the 1350 kc. signal being from a strong local station, it is difficult to prevent this and the average "super" has at least one stage of radio frequency amplification operating at the signal frequency located ahead of the mixer tube—not for the purpose of obtaining amplification so
much as for the additional selectivity obtainable.

The average detector tube has, in its plate circuit, strong radio frequency components of the harmonics of the intermediate frequency. Harmonics are caused by non-linear operation of the tube and result in spurious oscillations or currents having a frequency which is some multiple of the original.

Care must be taken in shielding the detector output of "supers" for this reason as, otherwise, stray harmonic voltages may find their way back to the input to cause trouble. Early superheterodynes were full of spurious signals of this character and it was this characteristic which prevented their becoming popular as commercial receivers.

In Fig. 61, there is a simplified diagram of the Radiola 80 receiver which is a characteristic example of the modern superheterodyne receiver. Here a "band-selector," in which the coupling is obtained by winding the coils adjacently on the same form, is employed in the antenna coupling.

The first tube is the radio frequency amplifier which operates at the frequency of the incoming signal. Coupled to this tube by means of a radio frequency choke and a small coupling condenser, is the first detector tube which is the third tube in from the antenna.

The second tube is a '27 which acts as the local oscillator. In order to make this oscillator track so that it will always have a frequency exactly 175 kc. higher than the frequency to which the other tuned circuits are adjusted, a special network of four condensers is employed in tuning the oscillator inductance. Note that the coupling between the first detector and the oscillator is secured by winding the oscillator and detector tuning inductances on the same form or on forms quite close to each other.

From the plate circuit of the first detector onward, the circuits are tuned to 175 kc., and a local-distance switch for cutting down the sensitivity of the receiver when receiving strong locals is provided in the coupling circuit between the first detector and the first intermediate or 175 kc. amplifier.

This arrangement is made up of two resistances of 40,000 and 500 ohms which are introduced into the tuned circuits of the 175 kc. band-selector when the switch is in the least sensitive position. Volume control is secured by varying the grid bias of the radio frequency amplifier simultaneously with that of the first intermediate frequency amplifier.

The grid biases for the other tubes are taken independently, that of the power output tubes being obtained by means of the voltage drop between the center of the filament winding and ground across a 715-ohm resistance.

It is interesting to note that the plate current of the oscillator tube flows through the biasing resistance in the cathode circuit of the first detector. This is arranged so that the bias received by the first detector tube will have a more constant character, since changes in the detector plate current due to the signal will have but slight effect on the total current flowing through the biasing resistance.

It is essential that the oscillator track exactly 175 kc. higher than the other tuned circuits across the band. To this end, two small trimmer condensers form a portion of the oscillator tuning network.

This network is so devised that the tracking along the mid-tuning range will be fairly good, but a cer-
tain amount of adjustment may be necessary at the high and low frequency limits of the range. The trimmer across the oscillator tuning condenser is used in adjusting for maximum sensitivity at the high frequency end of the band, while that across the fixed condenser is used in aligning the circuits at the low frequencies. A discussion of the alignment of the intermediate frequency amplifier will be found in the section of this manual devoted to the use of service apparatus.

Certain receivers employ oscillators which maintain their 175 kc. separation by the use of tuning condensers with specially cut rotors. These receivers do not require tracking in the same manner as those employing the condenser networks as shown—a simple adjustment of the trimmer condenser being all that is necessary in most cases.

Outside of the use of the oscillator and the fact that the latter R.F. stages are pretuned to 175 kc., the superheterodyne needs little explanation—service is carried out along lines parallel with tuned radio frequency receivers. The sole differences in service procedure lie in the possible necessity for checking the oscillator alignment as mentioned or the alignment of the intermediate frequency transformers. The major faults manifest themselves in a manner identical with those found in other receivers—oscillation may be found difficult to trace to its source, however, and certain manifestations are described in the section on servicing.

View of Three I. F. Transformers with the Shields Removed.

Stromberg-Carlson Telephone Manufacturing Company
Remote Control Devices

During the past season, many remote control devices have made their appearance. So far as can be ascertained, these have enjoyed but a limited popularity—but however limited their distribution, there is no certainty that any service technician will be exempt from servicing them, and it is essential that they be a familiar subject so that time and trouble may be avoided.

The Sleeper Kinematic Control.

The Kinematic control system demands the use of two separate controlling systems—one to operate the station selector mechanism and the other to switch the set on and off and to control volume.

The apparatus involved consists of two motors at the receiver and two control devices in a small box at the control point. In A.C. neighborhoods, the control mechanism operates from 25 volts A.C., and in D.C. districts, an 18 volt supply is tapped from the line. In D.C. districts, the control switch operates to switch a motor generator on and off if an A.C. receiver is used.

Each driving member consists of a field winding with six pole pieces and a rotating steel armature as shown in Fig. 62. At the control box, a rotary switch is employed which operates as shown. With the switch at 1, the armature lines up across 1-1 of the poles. At 2, the alignment is across 2-2, while at 3, the alignment of the armature is across 3-3. It may be seen that the constant rotation of the switching member at the control point will result in a continuous rotation of the armature which is geared to the condenser shaft of the receiver or to the volume control and switch, as the case may be.

Westinghouse Remote Control.

In the Westinghouse remote control device, the same driving motor for both the volume and station selector motion is used. Normally, when the receiver is at rest, a spring holds the motor gears engaged with the volume control. Pressing buttons marked Volume Control Plus or Volume Control Minus will result in the motion of the driving member in the desired sense.

Pressing one of the selector buttons will allow the motor to speed up so that the armature rises and the gears engage so as to rotate the tuning drive. A fine adjustment of the springs is necessary so that the armature does not rise when the volume control buttons are pushed, but rises completely when the station selector buttons are touched. This adjustment is easily carried out.

The control box contains on and off switches, the two volume control buttons, and six channel selec-
tors which are adjusted by the service man for the desired channels. A twelve-wire cable connects the two units.

This type of control is typical of many which employ contactors for shutting off the motor when the receiver is tuned to the desired channel. Adjustment of the tuning controls is quite simple. The station desired for number six contactor is tuned in manually. The cam for that contactor is then released from the shaft and rotated to the correct position. It is then tightened to the shaft again.

This same arrangement is used in both the ordinary models and in the Columaire. In the latter case, the gears are held engaged in the volume control position by gravity instead of by a spring. In testing the receiver, the manual control should not be operated unless the chassis is on end (vertical) as it is operated in the cabinet—otherwise, the gears may be damaged.

The Westinghouse arrangement is typical of the contactor-operated remote control units as a whole. The wiring arrangement is shown in the text dealing with Westinghouse receivers.

Other Remote Control Systems.

As is the case with every radio innovation, there are a thousand and one ways of doing the job. In Fig. 63 is shown a method which has given much promise but which has had no commercial realization so far. For those experimenters desiring to work up their own systems rather than to purchase units, this offers the best and simplest idea. The motor is in the indicator arm of a simple Wheatstone bridge such as is employed in laboratory testing. The motor moves automatically in either direction in an attempt to re-establish a balance of the bridge. The motor drives the moving arm of a potentiometer as well as the tuning elements of the receiver.

A very sensitive reversible motor is necessary to this device—a motor which will continue to run under load with a very small input—so that motion continues until an exact balance of the bridge elements is attained. In the balanced condition, the arm of the potentiometer on the motor shaft is in the same position as the arm of the potentiometer in the control box.

Volume control is achieved by placing the biasing resistance in the control box and connecting the R.F. cathodes and ground through this remote resistance. The motor should be geared to the condenser shaft through a reduction of about 60 to 1. Such gears are readily obtainable in nearly every location in the United States.

If your hardware dealer does not stock them, it is a certainty that he has a catalog of the Boston Gear Works from which you can make a choice. The disadvantage of this device in operating from a separate battery may be avoided by the use of a Tungar charger, either as a trickle charger on the battery or to drive the motor directly.
Strange to say, it was Thomas Alva Edison who first noted the effect which later led to the development of the present day Vacuum Tube which made Radio a possibility.

In 1883, while working out problems concerning incandescent filaments, he sealed a metallic plate into the glass envelope with the filament and discovered that when the plate was electrically positive with respect to the filament a current flowed in the plate circuit but that when the plate was negative the current ceased to flow. Fig. 64.

Fleming, continuing the investigation of the "Edison effect," discovered that the path between the filament and plate exhibited effects of unilateral conductivity—that is to say, current would flow from the filament to the plate but not in the opposite direction.

For some time, the Fleming Valve was employed as a detector of wireless signals and the writer used quite effectively one which was made from an old style double filament automobile lamp—using one filament as the plate. The incoming signal was impressed upon the plate of the valve and, at any instant when the signal was positive in value, current flowed—while on the other portion of the wave, when the current was negative, no current flowed.

The curve shown in Fig. 65 indicates graphically the manner in which rectification of the signal occurs. The continuous line P is the graph of plate current against applied voltage. Note that this approximates a straight line up to a certain input voltage where "saturation" occurs. That is to say, the output current steadily increases with increased signal voltage up to a certain point where the curve flattens out. Increase of the signal beyond this point does not result in any increase in current.

The Fleming Valve had a decided superiority over the previous types of detectors, which rested in its reliability rather than its increased sensitivity.

It was no longer necessary to search for a sensitive point on the crystal nor to employ mechanical means for re-sensitizing as was required with certain other types of detectors.

It remained for De Forest to insert the third element into the envelope in order to improve the sensitivity of the valve and to start the long period of scientific development which followed.

Dr. Lee De Forest discovered that if the positive voltage were applied directly to the plate from an external source rather than from the signal, and if a third element—the grid—were inserted between the filament and the plate, there would be much larger changes in the current in the plate circuit for a given signal voltage. What is more, he discovered that by coupling together two or more of these three-element tubes, the signal voltage could be amplified to a tremendous extent.

The manner in which the amplification of the signal takes place is shown graphically in Fig. 66 where the characteristic curve of the tube—that is, the graph of the changes in plate current incident to a change in grid voltage—is given.

In order to operate the tube over a range where
the output variations will be identical in form with
the input, it is necessary to apply a fixed grid volt-
age "e" about which the signal will produce a vari-
ation.

Operation of the three-element tube as a detector
or rectifier may be obtained in two ways. The tube
may receive a bias or initial grid voltage so large as
so large as to reduce its plate current almost to zero as shown
in Fig. 67, so that only the positive halves of the
signal waves produce a change in plate current; or
it may be adjusted so as to have the signal effect the
plate current changes in the region of the upper
bend in the curve where saturation takes place. The
first method is known as "bias" or plate circuit de-
tection, and the second as "grid-leak" or grid circuit
detection.

The second method is shown in Fig. 68. In this
second method, a resistance from grid to ground
is employed in order to prevent paralyzing of the
tube, due to the fact that when the tube is so oper-
ated the grid will assume and retain an electric
charge. The resistance permits this charge to leak
off in time for the next cycle of the signal. Were it
not for this, the charge on the grid would build up
until the tube became inoperative.

The vacuum tube may be used as a generator of
alternating current by virtue of its ability to ampli-
fy. In this connection, a portion of the voltage in
the plate circuit is fed back to the grid in such a
manner and in such magnitude as to sustain the tube
in oscillation. This is due to the fact that a small
portion of the output finds its way back to the input
circuit by means of a capacitative or inductive coup-
ling between the two.

There are many circuit arrangements which, prop-
erly proportioned, will permit of sustained oscilla-
tion. The small portion of the output fed back to
the grid circuit is re-amplified—fed back to the grid
again and re-amplified so that the oscillation is con-
tinuous. The frequency of the oscillation thus pro-
duced is determined by tuning the grid or plate
circuit to the required frequency.

The Factors Affecting Operation.

Certain definitions with respect to the vacuum
tube are in order before a description of the opera-
tion of the device may be continued. The most im-
portant factors follow.

**Cathode.**

The cathode is the portion of the tube which emits
electrons along the path of which the current from
cathode to plate may flow. In general practice, the
term "cathode" is applied to those emitters which
are heated indirectly as in the case of the '27 tube.

**Filament.**

The filament is the cathode also, but in general
is an emitter which is directly heated by the flow
of current through it. The filament or cathode is
constructed of some material which is capable of
emitting a strong electronic stream.

**Plate.**

Plate and "anode" are interchangeable terms. This
element is maintained at a potential, positive with
respect to the cathode, so as to establish a current
flow between the two elements.

**Grid.**

An electrode placed between the cathode and
plate, and so constructed as to permit the flow of
electrons through it.

**Control Grid.**

The control grid is an electrode placed between
the cathode and plate through which the electrons
may flow on their journey between the two. It is to
this electrode that the incoming signal is applied.
The name implies the effect of the electrode in var-
ing the plate current in accordance with the voltage
applied to it.

**Screen-Grid.**

A fourth electrode is included in some tubes to
screen the electrodes one from the other in order to
reduce the capacity existing between them.

**Grid Voltage.**

The voltage difference existing between the grid
and the cathode.

**Grid Bias.**

The direct current portion of the grid voltage
placed intentionally on the grid so as to operate the
tube at some specified point on its characteristic
curve.
Amplification Factor.

The effectiveness of the tube in effecting a change in the voltage in the plate circuit. It is the ratio between a change in grid voltage and the corresponding change in plate voltage with the plate current held constant. It is represented by the symbol \( \mu \) (Mu).

A.C. Tube.

Any tube particularly designed for service with raw or unrectified alternating current on its filament is in this classification. A.C. tubes may be of the indirectly heated cathode type, such as the '27, or they may be made with particularly sturdy filaments as in the case of the '26. In this latter case, freedom from hum is gained by a high thermal inertia—that is to say, the filament is so bulky that it does not cool and heat again in step with the A.C. cycle as would be the case with a lighter and less sturdy filament.

Grid Emission.

This is an effect which takes place in some tubes when the filament is run at too high a temperature and the grid becomes hot enough to emit electrons.

Secondary Emission.

The kink so pronounced in the characteristic curves of screen-grid tubes is caused by secondary emission—or the emission of electrons from the plate under heavy bombardment from the filament, which are attracted to the screen-grid when the screen-grid potential is not sufficiently negative with respect to the plate.

Screen-Grid Tubes.

Screen-grid tubes are those in which an electrode has been added for the purpose of screening the plate from the grid in such a manner as to reduce the effective capacity between the grid and plate. This is done so that the tube may be used as a high gain amplifier without danger of its becoming an oscillator due to the feeding back of energy from the plate circuit to the grid through the inter-electrode capacity of the tube.

Dynatron Oscillator.

Reference to the curves of the screen-grid tubes will show that there is a portion of the characteristic curve which slopes steeply downward from left to right. In this range of operation, the tube exhibits a "negative resistance" characteristic—which is to say that the addition of greater voltage results in the flow of less, rather than more, current in the plate circuit of the tube. Tubes operated in this range will act as oscillators by the simple procedure of placing a tuned circuit in series with the plate.

Maximum Undistorted Power Output.

This is the highest power output obtainable with a tube at the voltages specified without the harmonic distortion exceeding 5% of the total output. Research workers have found that this condition obtains when the tube works into a load of twice its own plate impedance. Maximum undistorted power output should not be confused with maximum power output or with maximum efficiency.

Maximum power output is obtained when the load impedance is equal to the tube impedance, and maximum efficiency is obtained when the impedance of the load is many times that of the tube. In using the tube for operating commercial devices, one of the latter would be desirable, but in Radio, we are interested in the entertainment possibility which can only be realized to its fullest extent when the distortion is negligible. In Radio then, we are interested in the maximum undistorted power output which is obtained when the impedance of the load is double that of the tube.

The new "Pentode" type of tube requires a load in the plate circuit approximately equal to one-fourth the plate resistance of the tube. The output of the pentode cannot be fully realized, due to the high second harmonic component present in this type tube. In order to minimize the second harmonic output, it then becomes necessary to reduce the operating load to such a value that the second harmonic output is less than 5% of the fundamental.

Plate Impedance.

The ratio of a change in plate voltage to the corresponding change in plate current with the grid voltage held constant. The A.C. impedance between the filament and the plate. This should not be confused with the D.C. resistance.

Mutual Conductance.

The mutual conductance of the tube is the figure of merit for tubes of a given type. It is the ratio between a change in grid voltage and the corresponding change in plate current. It is expressed in micromhos and is designated by the symbol Gm. In some texts, the mutual conductance is expressed in terms of milliamperes per volt and a tube exhibiting a change of 1.5 milliamperes per volt would be desirable, but in Radio, we are interested in the entertainment possibility which can only be realized to its fullest extent when the distortion is negligible. In Radio then, we are interested in the maximum undistorted power output which is obtained when the impedance of the load is double that of the tube.

Inter-electrode Capacitance.

The capacitance existing between the various elements by virtue of their proximity. These factors have no effect upon the plotting of the curves of the tubes with direct currents only applied, but are a large factor in the operation of the tube at high audio frequencies or at radio frequencies.
Plate Voltage.
The voltage difference effective between the plate and the cathode or filament.

Plate Current.
The direct current flowing between the plate and the cathode through the evacuated space within the tube.

Gassy Tubes.
The presence of gas in a vacuum tube will seriously affect its operation as at some voltage the gas becomes ionized and is conductive. When ionization occurs, the current through the tube is not flowing between filament and plate through the electron stream only, but also through the gas due to its conductivity when ionized.

Space Charge Grid.
An additional grid placed in the vacuum tube close to the filament, in most cases, for the purpose of dispelling the space charge existing in the region of the filament or cathode, which permits the formation of a cloud of electrons in this region impeding the flow of the electron stream from cathode to plate. This extra grid is found in the new Pentode output tubes and permits of increased sensitivity and efficiency.

Diode—Triode—Tetrode—Pentode.
The terminology applied to various forms of vacuum tubes accordingly as they have two, three, four or five operative electrodes. Some French tubes for special purposes have two control grids and are known as double grid or "bigrille" tubes.

As we have noted before, a profound study of vacuum tube theory is not essential to efficient radio servicing. It is, however, necessary that the service man have a good idea of the factors affecting the operation of the tubes so that various difficulties will make themselves at once obvious. It is a distinct advantage to the service man if he memorizes the electrical constants of the various tubes as tabulated on the tube chart shown in this manual. Set manufacturers generally design their sets so that the tubes are used at the recommended voltages.

Voltage Amplification.
Tubes which are employed as voltage amplifiers are concerned more with the "gain" or amplification which can be obtained within the individual stage than with the power available at the output. With three-element tubes, the amplification may readily be calculated through a knowledge of the amplification factor of the tube and of the load into which it will work. A simple relation exists here in which

\[
\text{Amplification} = \frac{\text{Zo}}{\text{Rp} + \text{Zo}}
\]

where \( \mu \) is the amplification factor of the tube as obtained from the manufacturer's data, and \( \text{Rp} \) and \( \text{Zo} \) are, respectively, the plate impedance of the tube and the load impedance at the frequency for which we desire to obtain the amplification. It should be remembered that, in case of audio frequency transformers the primary inductance must be high so that the impedance at a low frequency is sufficient to permit a fair degree of amplification—naturally, the impedance of the transformer will be high enough at the higher frequencies transmitted.

Transformer Coupled Audio Frequency Amplifiers.
Audio transformers to operate between vacuum tubes have a ratio of transformation—that is, a "step-up ratio"—of from 2:1 to 8:1. The amplification to be obtained from a stage would normally be thought to be the amplification factor of the tube times the step-up ratio of the transformer. At the medium frequencies to be amplified, this is true, but at the low frequencies we are limited by the primary inductance of the transformer. From the equation above, it will be seen that, if the primary impedance is equal to \( \text{Rp} \), but half the amplification of the tube will be realized.

Bias detectors operate at extremely high plate impedances and, in consequence, transformers working out of the detector stage must have extremely large primary windings. At the medium frequencies, the impedance of even a small winding is sufficiently high to permit of the full amplification being realized. Now at the high frequencies, the gain is affected by the capacitance of the windings themselves and of the wiring. Resonance occurs between the leakage inductance of the windings and this capacitance, and results in an amplification peak followed by a rapid cut-off in response as is shown in Fig. 69. This curve is that of a commercial transformer taken by the writer from a receiver of a season ago. The high peak is there for the purpose of compensating for lack in high frequency response due to the sharpness of tuning in the radio frequency circuits. Referring back to the previous sec-
tion in which we discussed resonance, it may be readily seen how this occurs.

Parallel Feed Circuits.

It is possible to improve the low frequency response of a transformer by resonance at some low frequency—you will remember that we made note of the fact that with series resonance we often obtained large voltages across the individual elements. Let us suppose that the plate voltage for the amplifier or detector tube is fed through a high resistance or an impedance as shown in Fig. 70, and that the transformer is coupled to the tube through a condenser. We then have a series resonant circuit across the output of the tube composed of the coupling condenser and the primary inductance of the transformer. By carefully choosing the value of the condenser, we can obtain a resonant effect which will increase the voltage across the primary at some particular frequency—50 cycles, for example—and the result will be a response curve of the type shown in Fig. 71. It is possible in this manner to achieve good response at the lower frequencies without having a very large primary.

The ratio of a transformer is limited by the bulk of the winding necessary to obtain satisfactory low frequency response, since a large winding would mean a large capacitance and a cut-off of the amplification at the higher frequencies.

Resistance Coupled Amplifiers.

Resistance coupled amplifiers and the direct-coupled type do not fall heir to many of these complications and they will be found in many commercial receivers. The resistance coupled amplifier has a mid-frequency response determined by the load across the plate circuit of the tube which is equivalent to the parallel value of the grid and plate resistances. The high frequency response is determined by the point at which the reactance of the condenser becomes low enough to effectively short-circuit the resistances. For this reason, the resistances must be sufficiently low to prevent this reactance from becoming low enough to affect them at the highest frequency desired. This is shown diagrammatically in Fig. 72. Note that the load is composed of $R_1$, $R_2$ and $X_c$ in parallel.

![Fig. 72](image)

Low frequency response in resistance coupled amplifiers is determined by the relative values of the coupling condenser and the grid leak. In Fig. 73, it is obvious that signal voltage is across the condenser and leak in series. The two should be chosen in such a manner that the reactance of the condenser is never high enough to become appreciable in value as compared to $R_2$. This means that the higher the resistance of the grid leak, the lower may be the value of the condenser.

Direct Coupled Amplifiers.

Direct coupled amplifiers such as the Loftin-White are found to a great extent in commercial midget receivers, and in small sound systems. Characteristic of the circuit is the fact that the plate of one tube is connected directly to the grid of the succeeding tube. The tube elements are maintained at their correct relative operating voltages by virtue of the voltage drop through the various resistances in the circuit. A commercial application is shown in Fig. 74.

![Fig. 74](image)
The previous section dealt briefly with the theoretical knowledge necessary to the service man who wishes to know more than the ordinary regarding the vacuum tubes which are his stock in trade. This second section on vacuum tubes will deal with the actual characteristics of the tubes now in use.

Although there are many special-purpose tubes to be found on the American market which are not listed they are rarely, if ever, found in commercial receivers—in fact, certain of the tubes to be noted in these columns are now obsolete but are included due to the fact that they are still to be found in some of the older receivers.

Where the designation is that of some particular manufacturer, no specific advertisement is intended—credit is merely given that particular manufacturer for the courtesy shown in allowing data to be drawn from certain sources which may not be available to the man in the field save through these columns.

99 and 'X-99.

These two tubes are employed as general purpose tubes for radio and audio frequency amplification in receivers designed for use with dry batteries, the sole difference between them being in the type of base employed.

The tubes employ the "thoriated" filament and are particularly sensitive to filament overload. This fact makes the use of a filament voltmeter desirable so that the operator may at all times be sure that the filaments are not receiving more than their rated voltage. The extreme delicacy of the filament is compensated in a measure by the fact that the tubes respond readily to reactivation. Where the single tube is used with a bank of dry cells having a terminal voltage of 4.5 volts, a 60-ohm rheostat is necessary. The correct rheostat for use with three tubes in parallel under the same conditions is 20 ohms.

As a Detector

When the tube is used as a grid circuit detector, the plate voltage should be about 45 volts with a grid condenser of .00025-mf. and a leak of about 3 to 5 megohms. The grid leak should be connected between the grid and the positive side of the filament.

As an Amplifier

When these tubes are used as amplifiers, a grid bias should be used whenever the plate voltage is over 45 volts. The following values of grid bias for various plate voltages are recommended:

<table>
<thead>
<tr>
<th>Plate Voltage</th>
<th>Grid Bias</th>
</tr>
</thead>
<tbody>
<tr>
<td>67.5</td>
<td>-3.0 volts</td>
</tr>
<tr>
<td>90.0</td>
<td>-4.5 volts</td>
</tr>
</tbody>
</table>

Rating

Filament Voltage 3.0-3.3 volts
Filament Current 0.060-0.063-ampere
Plate Voltage (maximum) 90 volts

Average Characteristics

<table>
<thead>
<tr>
<th>Plate Voltage</th>
<th>90 volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grid Bias Voltage</td>
<td>4.5 volts</td>
</tr>
<tr>
<td>Amplification Factor</td>
<td>6.6</td>
</tr>
<tr>
<td>Mutual Conductance</td>
<td>15500 micromhos</td>
</tr>
<tr>
<td>Plate Resistance</td>
<td>425 ohms</td>
</tr>
<tr>
<td>Plate Current</td>
<td>2.5 milliamperes</td>
</tr>
<tr>
<td>Undistorted Power Output</td>
<td>7 milliwatts</td>
</tr>
<tr>
<td>Grid-Plate Capacitance</td>
<td>3.3 mmf.</td>
</tr>
</tbody>
</table>

Average Characteristic Curves

Filament and Emission Characteristics—Fig. 75 shows the change of filament current with various filament voltages.

Grid Characteristics—Fig. 76 shows the relation between grid current and grid voltage.
Plate Characteristics—Fig. 77 shows a family of plate voltage—plate current curves at various grid bias voltages.

Mutual Characteristics—Fig. 79 shows a family of grid voltage—plate current curves for various plate voltages.

Dynamic Characteristics—Fig. 78 shows the effect of grid voltage upon the amplification factor, mutual conductance and plate resistance.

'X'.20.

The '20 tube is used as a power output tube in circuits employing the '99 in the preliminary stages. Its filament voltage is the same but the current drawn is twice that drawn in the case of the '99. With a plate voltage of 135 volts and a bias of --22.5 volts, the maximum power output obtainable is quite satisfactory for home use in locations where commercial current is not available. Two of these tubes may be used in push-pull with exceedingly gratifying results.

It is not necessary to use an output transformer with this tube and a cushion or spring mounting need not be provided when it feeds directly into a loud speaker.

RATING

Filament Voltage .............. 3.0-3.3 volts
Filament Current .............. 0.125-0.132-ampere
Plate Voltage (maximum) ........ 135 volts

AVERAGE CHARACTERISTICS

Plate Voltage .............. 90 135 volts
Grid Bias Voltage .............. 16.5 --22.5 volts
Amplification Factor .............. 3.3 3.3
Mutual Conductance .............. 415 525 micromhos
Plate Resistance .............. 8000 6500 ohms
Plate Current .............. 3 6.5 ohms
Undistorted Power Output ........ 45 110 milliwatts

AVERAGE CHARACTERISTIC CURVES

Filament Characteristics—Fig. 80 shows the change of filament current with various filament voltages.

Plate Characteristics—Fig. 82 shows the relation between the plate current and plate voltage at various bias voltages.

Mutual Characteristics—Fig. 81 shows a family of grid voltage—plate current curves at various plate voltages.

Dynamic Characteristics—Fig. 83 shows the effect of grid voltage upon the amplification factor, mutual conductance and plate resistance.

Output Characteristics—Fig. 84 shows the undistorted power output obtainable at various load resistances.
This is the "grand old man" of Radio. It first appeared on the market when a single tube drew a full ampere of current at five volts and a three tube receiver wrought havoc with a storage battery in a single night of operation. The '01A is still used in many receivers of quite recent vintage—particularly those designed for use on direct current supply lines. This tube will be found used in all circuits. It suffers in some measure from the weakness noted in the case of the '99 but responds fully as well to reactivation.

**As a Detector**

When the '01A is used as a detector with grid leak and condenser, the plate voltage should preferably be not more than 45 volts. The grid condenser should have about 0.00025-mf. capacity and the grid leak should have a resistance of 2 to 9 megohms, the latter giving greater sensitivity on very weak signals but with somewhat inferior fidelity.

**As an Amplifier**

The '01A, when used as an amplifier, should have the following recommended grid biases applied whenever the plate voltage is over 45 volts:

<table>
<thead>
<tr>
<th>Plate Voltage</th>
<th>Negative Grid Bias</th>
</tr>
</thead>
<tbody>
<tr>
<td>67.5</td>
<td>3.0</td>
</tr>
<tr>
<td>90.0</td>
<td>4.5</td>
</tr>
<tr>
<td>135.0</td>
<td>9.0</td>
</tr>
</tbody>
</table>

In radio frequency circuits, there is little advantage in using more than 90 volts on the plate and when used for loud-speaker operation, the plate voltage should be 135 volts with suitable bias.

**Rating**

- Filament Voltage: 5.0 volts
- Filament Current: 0.25-ampere
- Plate Voltage (maximum): 135 volts

**Average Characteristics**

- Plate Voltage: 90 volts
- Grid Bias Voltage: -4.5 volts
- Amplification Factor: 8.0
- Mutual Conductance: 725 micromhos
- Plate Resistance: 11000 ohms
- Plate Current: 2.5 milliamperes
- Undistorted Power Output: 15 milliwatts
- Grid-Plate Capacitance: 8.1 mmf.
- Grid-Filament Capacitance: 3.1 mmf.
- Plate-Filament Capacitance: 2.2 mmf.

**Average Characteristic Curves**

Filament and Emission Characteristics—Fig. 85 shows the change of filament current and electron emission with various filament voltages.

Grid Characteristics—Fig. 86 shows the relation
between grid current and voltage.
Plate Characteristics—Fig. 87 shows a family of plate voltage—plate current curves at various grid bias voltages.
Mutual Characteristics—Fig. 89 shows a family of grid voltage—plate current curves for various plate voltages.
Dynamic Characteristics—Fig. 88 shows the effect of grid voltage upon the amplification factor, mutual conductance and plate resistance.

'12 or '12A.

The '12 and '12A differ only as to the type of filament employed. Certain other minor differences may be forgotten. The '12 draws .5-amp. at 5 volts and the '12A, .25-amp. at 5 volts. The tube is ideally suited to use as a general purpose tube replacing the '01A and in certain cases a distinct improvement in results may be so gained. Operating conditions in amplifier circuits are indicated in the Tube Data Chart.

The tube has been used in some circuits with alternating current on its filament in the last audio frequency stage. This is an economy not practiced today and is only possible because of the use of push-pull circuits in which the hum voltages present in the output stage cancel out. The high thermal inertia of the filament as compared with earlier tubes helps to make this type of operation possible.

AS A DETECTOR

When grid bias detection is used, plate voltages up to 180 volts may be applied. The grid bias should be such that the plate current is about .1-milliampere when no signal is being received.

The requirements for grid leak-condenser detection with the '12A are that the plate voltage should be not more than 45 volts, the grid condenser should have a capacity of 2 to 9 megohms. For maximum sensitivity, it is best to use the higher values of grid leak and for more stable operation, the lower values should be used.

AS AN AMPLIFIER

The '12A may be used as an R.F. or A.F. amplifier and should always be operated with the proper value of grid bias to secure maximum undistorted amplification. When used in the last audio stage, the power output can be calculated from the curve shown in Fig. 94.

AVERAGE CHARACTERISTICS

<table>
<thead>
<tr>
<th>Plate Voltage</th>
<th>90  135  180 volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grid Bias Voltage</td>
<td>-4.5  -9  -13.5 volts</td>
</tr>
<tr>
<td>Amplification Factor</td>
<td>8.5  8.5  8.5</td>
</tr>
</tbody>
</table>

Mutual Conductance ...... 1500 1600 1700 micromhos
Plate Resistance ...... 5600 5300 5000 ohms
Plate Current ...... 5.2  6.2  7.6 milliamperes
Undistorted Power Output ...... 30  115  260 milliwatts
Grid-Plate Capacitance ...... 8.1 mmf.
Mutual Characteristics—Fig. 91 shows a family of grid voltage—plate current curves at various plate voltages.

Dynamic Characteristics—Fig. 93 shows the effect of grid voltage upon the amplification factor, mutual conductance and plate resistance.

Output Characteristics—Fig. 94 shows the undistorted power output obtainable at various load resistances.

'71 and '71A.

Here again are two tubes which differ only with regard to their filament characteristics. The difference is the same as in the case of the '12. Since certain of the early A.C. receivers employed these tubes in the output stage in a single or push-pull connection, care should be taken in cases where the "A" type is used in replacement in receivers originally designed for use with the '71 as the decreased current consumption may result in too high a filament voltage where the power transformer has been economically designed. In case this condition is found, the 5-volt secondary of the transformer may be loaded up by short-circuiting it with a 10-ohm resistance where two tubes were used, or a 20-ohm resistance where a single '71 was originally employed.

Grid bias is preferably obtained by the use of a resistance between the center point of the filament winding and ground. The resistance required to give the correct bias at the ordinary plate voltages found is as follows:

<table>
<thead>
<tr>
<th>Plate Volts</th>
<th>Single Tube</th>
<th>Two tubes in parallel</th>
<th>Total Plate Volts required</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>1580 ohms</td>
<td>790 ohms</td>
<td>106.5</td>
</tr>
<tr>
<td>135</td>
<td>1685 ohms</td>
<td>840 ohms</td>
<td>162</td>
</tr>
<tr>
<td>180</td>
<td>2150 ohms</td>
<td>1075 ohms</td>
<td>220.5</td>
</tr>
</tbody>
</table>

As in all cases where the grid bias is obtained by making the cathode or filament positive with respect to the grid in the manner described above, the plate voltage must be correspondingly greater as shown in the table. The filament of the tube is subject to failure when the plate voltage of 180 is applied and the voltage should be held down to 135 except in cases where the additional power output is necessary. The '71A is the smallest of the tubes in which the plate current is far beyond the limits of the carrying capacity of loud-speaker windings and some form of output device which prevents the flow of direct current through the speaker windings is required. These arrangements may be obtained either through the use of a choke and condenser or by means of an output transformer of such a turns ratio as to match the impedance of the output load to that of the tube.
RATING

Filament Voltage ........................................ 5.0 volts
Filament Current ........................................ 0.25-ampere
Plate Voltage (maximum) ............................. 180 volts

AVERAGE CHARACTERISTICS

Plate Voltage ................. 90 135 180 volts
Grid Bias Voltage ............. -16.5 -27 -40.5 volts
Amplification Factor .......... 3 3 3
Mutual Conductance .......... 1330 1520 1620 micromhos
Plate Resistance ............... 2250 1960 1850 ohms
Plate Current ................ 12 17.5 20 milliamperes
Undistorted Power Output 125 370 700 milliwatts

AVERAGE CHARACTERISTIC CURVES

Filament Characteristics—Fig. 95 shows the change of filament current with various filament voltages.
Plate Characteristics—Fig. 97 shows the relation between plate current and plate voltage at various bias voltages.
Mutual Characteristics—Fig. 96 shows a family of grid voltage—plate current curves at various plate voltages.
Dynamic Characteristics—Fig. 98 shows the effect of grid voltage upon the amplification factor, mutual conductance and plate resistance.
Output Characteristics—Fig. 99 shows the undistorted power output obtainable at various load resistances.

'X.22.

The '22 was the first of the tubes to employ the screen-grid or shielded-grid principle, in which the plate of the tube was electrostatically shielded from the control grid by means of a screen which was given such a potential, with respect to the plate, as to permit the shielding effect without any detrimental action insofar as the operating characteristics of the tube were concerned. This tube made possible the construction of high gain stages of radio frequency amplification without the necessity for neutralization, but at the same time the high gain obtainable made it essential that the circuits and, in most cases, the tubes themselves be shielded from interaction between the stages.

USE AS DETECTOR

The tube may be used as a detector with grid leak and grid condenser or with grid bias. Resistance coupling is recommended as giving the most satisfactory frequency characteristics because of the high internal resistance of the tube. See Fig. 100 for recommended circuit.

USE AS A RADIO FREQUENCY AMPLIFIER

This tube has been especially designed for use as an R.F. amplifier. When so used, the most important advantage gained is elimination of all feed-back through coupling between grid and plate, due to capacity between these elements. It is also possible to obtain higher voltage amplification per stage, 25 to 50 in the broadcast range as compared with the
usual range of 5 to 12 per stage with three-element tubes.

In the operating range the plate current does not vary appreciably with changes in plate voltage, this being due also to the screening effect of the second grid. As a result, the amplitude of the plate current change caused by a signal voltage impressed on the grid is scarcely affected by an increase in load resistance. Thus, it is of advantage to use a very high resistance or impedance in the plate circuit, in order to obtain high voltage amplification.

The voltage amplification depends only upon two factors:

A—The mutual conductance of the tube, which determines the amplitude of the plate current change, resulting from a signal voltage impressed on the control grid, and—

B—The load impedance. The voltage across the output load is directly proportional to the local impedance, since the amplitude of the signal current, with moderate loads, remains unchanged with an increase in impedance. This is unlike the condition with three-element tubes, where an increase in load resistance results in a decrease in the amplitude of the signal current.

At low radio frequencies, 50 to 100 kilocycles, it is possible to build up a very high load impedance by using a tuned plate circuit, and a voltage amplification of 200 per stage is obtainable. At broadcast frequencies it is not possible to obtain a sufficiently high load impedance to realize maximum voltage amplification, and the values quoted above represent average results (25 to 50 per stage).

Since the voltage amplification depends only upon the load impedance and mutual conductance, it may be quickly computed when these values are known. The voltage amplification obtained with a load impedance of 100,000 ohms, using a tube having a value of mutual conductance of 350 micromhos (.00035-mho)

\[ Av. = 100,000 \times 0.00035 = 35 \text{ per stage.} \]

With 250,000 ohms, \( Av. = 250,000 \times 0.00035 = 87 \) per stage.

It is possible to obtain the desired high load impedance by use of a tuned circuit connected in series with the plate, but it may be preferable to use a transformer connection with a ratio of 1:1 or slightly lower so that low frequency disturbances do not reach the grid of the succeeding tube and to facilitate the use of ganged condensers for uni-control. Both connections are shown in the circuit diagrams.

Although the internal shielding prevents feedback through the tube inter-electrode capacities, this is only one source of coupling between stages, and it is necessary to shield the input circuit from the output circuit. The amount of shielding necessary will depend upon the voltage amplification per stage and the circuit design. A metallic shield enclosing each tuned stage is usually sufficient, as indicated in the circuit diagram. It may be necessary, if the voltage amplification is high, to place a metal cap over the tube, extending to the base, and connected to ground. Clearance for the grid connection must be provided at the top.

USE AS AN AUDIO FREQUENCY AMPLIFIER

The tube may be used as an audio frequency amplifier with resistance coupling, the connections being the same as when the tube is used for radio frequency amplification, except that the screen-grid voltage should be lowered to compensate for the voltage drop in the load, unless a high plate voltage is available. With this connection, a voltage amplification of 35 per stage may be readily obtained with perfectly flat frequency characteristics down to 50 cycles and below (the lower limit is fixed only by the size of the blocking condenser); and extending on the high frequency and well above 10,000 cycles.

OPERATING CONDITIONS

<table>
<thead>
<tr>
<th>Operating Conditions</th>
<th>Filament Volts</th>
<th>Filament Amperes</th>
<th>Control Grid Volts (Average)</th>
<th>Screen-Grid Volts (Average)</th>
<th>Plate Volts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.3</td>
<td>.132</td>
<td>-1.5</td>
<td>45</td>
<td>90 to 135</td>
</tr>
</tbody>
</table>

AVERAGE TUBE CHARACTERISTICS

<table>
<thead>
<tr>
<th>Average Tube Characteristics</th>
<th>Plate Voltage</th>
<th>Grid Voltage</th>
<th>Screen-Grid Voltage</th>
<th>Amplification Factor</th>
<th>Plate Resistance (ohms)</th>
<th>Mutual Conductance (Microhms)</th>
<th>Plate Current (Ma.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>135</td>
<td>-1.5</td>
<td>45</td>
<td>300</td>
<td>850,000</td>
<td>350</td>
<td>1.5</td>
</tr>
</tbody>
</table>

INTER-ELECTRODE CAPACITY

<table>
<thead>
<tr>
<th>Plate to control grid (max)</th>
<th>.025-mmf.</th>
</tr>
</thead>
</table>

RHEOSTAT RECOMMENDATIONS
For use with 4.5-volt dry cells use a 20 to 30-ohm rheostat.

For use with 5-volt tubes; connect a fixed resistance of 15 ohms in series with the filament of the tube. It may then be connected in parallel with other 5-volt tubes; operating from a common rheostat. If placed in the negative lead a tap at 10 ohms will provide -1.3 volts bias for the control grid.

Modern Dry-Cell Tubes.

Within the past year, the announcement of new type dry-cell tubes for economical operation in localities not served with commercial electric service has done much to revive the battery-operated receiver. Many of the commercial manufacturers have developed receivers for this market and their schematics are included in this manual.

'30. GENERAL PURPOSE TUBE

The '30 is a new general purpose tube designed to operate in battery receivers where economy of filament consumption is important. It may be used as a detector or ampliner and has an appearance similar to the '99, but has electrical characteristics which are considerably better. By using the '30 with the '31 (power tube) and '32 (screen-grid tube) it is possible to construct a modern radio receiver having screen-grid R.F. amplification and a power output stage.

CIRCUIT RECOMMENDATIONS

AS AN R.F. AMPLIFIER

The '30 may be used in circuits of conventional design, as a radio frequency amplifier in which case the grid and plate circuit return should be completed through correct batteries to the negative filament terminal of the tube. It is also possible to reduce the plate voltage to 67.5 volts and the grid bias to -3.0 volts and still secure proper amplification.

It is not recommended that a rheostat be used as a volume control unless provision is made that the highest voltage applied to the filament is never above 2.2 volts.

AS A DETECTOR

When used as a detector with grid leak and condenser, the plate voltage should not be higher than 45 and the grid return should be connected to the positive side of the filament. The grid condenser should have a capacitance of .00025-mf. and the grid leak a resistance of from ½ to 5 megohms. The higher the value of grid leak, the greater will be the sensitivity on very weak signals, but the fidelity will be somewhat inferior to that obtained with the lower value.

The grid bias method of detection is recommended where better quality and selectivity are desired at the expense of sensitivity. The following table gives the approximate grid voltages to be used for a number of different plate voltages. Plate voltages above 90 volts should only be used when operating as a bias detector at the grid bias recommended below. The values of Ep are actual plate-filament voltages. The "B" battery voltage is higher by the drop in the plate resistance if resistance coupling is used.

<table>
<thead>
<tr>
<th>Ep</th>
<th>Eg</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>-10.5</td>
</tr>
<tr>
<td>135</td>
<td>-15.0</td>
</tr>
<tr>
<td>165</td>
<td>-18.0</td>
</tr>
</tbody>
</table>

As an A.F. Amplifier

As in R.F. amplification, the grid return should be connected to the negative filament terminal, when the '30 is used as an A.F. amplifier. With resistance coupling, the grid resistance should not be greater than 2 megohms.

Operating Conditions

| Filament Voltage | 2.0 volts |
| Plate Voltage (maximum) | 90 volts |
| Grid Bias Voltage | -4.5 volts |

Average Characteristics

| Amplification Factor | 9.3 |
| Mutual Conductance | 700 micromhos |
| Plate Resistance | 13000 ohms |
| Plate Current | 1.9 milliamperes |
| Maximum Undistorted Power Output | 16 milliwatts |
| Grid-Plate Capacitance | 6.0 mmf. |
| Grid-Filament Capacitance | 3.5 mmf. |
| Plate-Filament Capacitance | 2.0 mmf. |

Average Characteristic Curves

Filament Characteristics—Fig. 101 shows the change of filament current with various filament voltages.

Plate Characteristics—Fig. 103 shows a family of plate voltage—plate current curves at various grid bias voltages.

Mutual Characteristics—Fig. 105 shows a family of grid voltage—plate current curves for various plate voltages.

Dynamic Characteristics—Fig. 104 shows the effect of plate current upon the amplification factor, mutual conductance and plate resistance.

Detector Characteristics—Fig. 106 shows the relation between the radio frequency input and the audio frequency output, for several percentages of modulation.
The '31 is a new power amplifier tube designed to give good output volume from battery operated receivers where economy of filament consumption is important. It is the power output member of the "Two Volt Line" which has been developed for economical battery operation. The other tubes in this line are the '30 (general purpose tube) and the '32 (screen-grid tube). By employing these three types of tubes, it is possible to construct a modern radio receiver employing screen-grid tubes for R.F. amplification, general purpose tubes for detection and first audio amplification, and this special tube for power output purposes.

The power output of '31 is 150 milliwatts, which is probably sufficient for loud-speaker operation in portable sets, but where additional loud-speaker volume is required two of these tubes may be used in push-pull to give sufficient volume for ordinary home reception when an efficient loud-speaker is used.

**Filament**

The '31 has a coated type filament which operates at a normal voltage of 2 volts and a current of 130 milliamperes.

**Average Characteristics**

- Amplification Factor: 9.3
- Mutual Conductance: 700 micromhos
- Plate Resistance: 13000 ohms
- Plate Current: 1.8 milliamperes
- Maximum Undistorted Power Output: 16 milliwatts
- Grid-Plate Capacitance: 6.0 mmf.
- Grid-Filament Capacitance: 3.5 mmf.
- Plate-Filament Capacitance: 2.0 mmf.

**Average Characteristic Curves**

- Filament Characteristics—Fig. 107 shows the change of filament current with various filament voltages.
- Plate Characteristics—Fig. 109 shows the relation between plate current and plate voltage at various bias voltages.
- Mutual Characteristics—Fig. 108 shows a family of grid voltage—plate current curves at various plate voltages.
- Dynamic Characteristics—Fig. 110 shows the effect of plate current upon the amplification factor, mutual conductance and plate resistance.
- Output Characteristics—Fig. 111 shows the undistorted power output obtainable at various load resistances.

**'32.**

**Screen-Grid Tube**

The '32 is a new screen-grid tube designed for use as a radio frequency amplifier or detector in battery operated receivers where economy of filament consumption is important. This tube, used with the others of the new "Two Volt Filament" type, makes possible the construction of a most modern type of receiver operating with much greater economy than has heretofore been possible when using batteries.
The amplification factor of the '32 is 580 and the control grid to plate capacity is 0.020 mmf. This high amplification factor and low control grid to plate capacitance makes possible a high voltage amplification per stage.

**FILAMENT**

The '32 has a coated filament which operates at a normal voltage of 2.0 volts and a current of 60 milliamperes. The filament should be operated in accordance with the data specified.

Plate Characteristics—Fig. 103 shows a family of plate voltage—plate current curves at various grid bias voltages.

Mutual Characteristics—Fig. 105 shows a family of grid voltage—plate current curves for various plate voltages.

Dynamic Characteristics—Fig. 104 shows the effect of plate current upon the amplification factor, mutual conductance and plate resistance.

Detector Characteristics—Fig. 106 shows the relation between the radio frequency input and the audio frequency output, for several percentages of modulation.

**'31.**

**POWER AMPLIFIER**

The '31 is a new power amplifier tube designed to give good output volume from battery operated receivers where economy of filament consumption is important. It is the power output member of the "Two Volt Line" which has been developed for economical battery operation. The other tubes in this line are the '30 (general purpose tube) and the '32 (screen-grid tube). By employing these three types of tubes, it is possible to construct a modern radio receiver employing screen-grid tubes for R.F. amplification, general purpose tubes for detection and first audio amplification, and this special tube for power output purposes.

The power output of '31 is 150 milliwratts, which is probably sufficient for loud-speaker operation in portable sets, but where additional loud-speaker volume is required two of these tubes may be used in push-pull to give sufficient volume for ordinary home reception when an efficient loud-speaker is used.

**FILAMENT**

The '31 has a coated type filament which operates at a normal voltage of 2 volts and a current of 130 milliamperes.

**AVERAGE CHARACTERISTICS**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amplification Factor</td>
<td>9.3</td>
</tr>
<tr>
<td>Mutual Conductance</td>
<td>700 microhms</td>
</tr>
<tr>
<td>Plate Resistance</td>
<td>13000 ohms</td>
</tr>
<tr>
<td>Maximum Undistorted Power Output</td>
<td>16 milliwratts</td>
</tr>
<tr>
<td>Grid-Plate Capacitance</td>
<td>6.0 mmf.</td>
</tr>
<tr>
<td>Grid-Filament Capacitance</td>
<td>3.5 mmf.</td>
</tr>
<tr>
<td>Plate-Filament Capacitance</td>
<td>2.0 mmf.</td>
</tr>
</tbody>
</table>

Plate Current 1.8 milliamperes
**AVERAGE CHARACTERISTIC CURVES**

Filament Characteristics—Fig. 107 shows the change of filament current with various filament voltages.

Plate Characteristics—Fig. 109 shows the relation between plate current and plate voltage at various bias voltages.

Mutual Characteristics—Fig. 108 shows a family of grid voltage—plate current curves at various plate voltages.

Dynamic Characteristics—Fig. 110 shows the effect of plate current upon the amplification factor, mutual conductance and plate resistance.

Output Characteristics—Fig. 111 shows the undistorted power output obtainable at various load resistances.

'32.

**SCREEN-GRID TUBE**

The '32 is a new screen-grid tube designed for use as a radio frequency amplifier or detector in battery operated receivers where economy of filament consumption is important. This tube, used with the others of the new “Two Volt Filament” type, makes possible the construction of a most modern type of receiver operating with much greater economy than has heretofore been possible when using batteries.

The amplification factor of the '32 is 580 and the control grid to plate capacity is 0.020-mmf. This high amplification factor and low control grid to plate capacitance makes possible a high voltage amplification per stage.

**FILAMENT**

The '32 has a coated filament which operates at a normal voltage of 2.0 volts and a current of 60 milliamperes. The filament should be operated in accordance with the data specified.

**AS AN R.F. AMPLIFIER**

Stable operation of this screen-grid tube in circuits designed to give maximum gain per stage, requires separation of the input and output circuit elements. Internal shielding of the screen makes neutralization of the plate to grid capacity unnecessary. However, the high amplifying ability of this tube makes it essential to prevent external coupling between circuit elements if the full capabilities of the tube are to be obtained. In general, with multistage amplifier circuits, it is necessary to use complete stage shielding including all the components of each stage. It is particularly necessary to shield the control-grid circuit from the plate circuit.

The use of filters in all leads entering the stage shields may be necessary in high gain amplifiers to reduce coupling in external parts of the circuits. In the construction of filters for the screen circuit, a by-pass condenser should be provided to keep the impedance from screen to ground as low as possible.

In general, properly designed radio frequency transformers are preferable to impedances for interstage coupling. If, however, impedance coupling is used, the grid resistance should not exceed 2.0 megohms.

**AS A DETECTOR**

The '32 may be used as a detector providing the audio amplification is comparatively low in order to prevent microphonic disturbances. The audio gain permissible depends on the type of cabinet, speaker design, and power output capabilities of the power output tubes. In any circuit a cushion type socket is recommended. The following operating conditions are suggested:

Plate Load Resistor 100000 100000
Screen-Grid Voltage 67.5 45
Control Grid Bias Voltage -6 -4.0

The Plate Battery Supply Voltage may be either 135 or 157.5 volts.

In addition to its recommended application as a screen-grid-radio-frequency amplifier, this new tube may be employed in experimental circuits wherever a double grid, four-electrode tube is desired.

In circuits designed for the '22, the '32 may be substituted providing the filament and grid circuit voltages are altered to conform to the requirements of this new tube. A typical circuit diagram using the '32 as an R.F. amplifier is shown in Fig. 119.

**OPERATING CONDITIONS**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filament Voltage</td>
<td>2.0 volts</td>
</tr>
<tr>
<td>Filament Current</td>
<td>0.06-ampere</td>
</tr>
<tr>
<td>Plate Voltage</td>
<td>135 volts</td>
</tr>
<tr>
<td>Control Grid Voltage</td>
<td>-3 volts</td>
</tr>
<tr>
<td>Screen-Grid Voltage</td>
<td>67.5 volts</td>
</tr>
</tbody>
</table>

**AVERAGE CHARACTERISTICS**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amplification Factor</td>
<td>580</td>
</tr>
<tr>
<td>Mutual Conductance</td>
<td>505 micromhos</td>
</tr>
<tr>
<td>Plate Resistance</td>
<td>1150000 ohms</td>
</tr>
<tr>
<td>Plate Current</td>
<td>1.4 milliamperes</td>
</tr>
<tr>
<td>Grid-Plate Capacitance</td>
<td>0.020-mmf</td>
</tr>
<tr>
<td>Input Capacitance</td>
<td>6.0 mmf</td>
</tr>
<tr>
<td>Output Capacitance</td>
<td>11.0 mmf</td>
</tr>
</tbody>
</table>

**AVERAGE CHARACTERISTIC CURVES**

Filament Characteristics—Fig. 112 shows the change of filament current with various filament voltages.

Inter-Electrode Characteristics—Figs. 113, 114
and 115 show the relations existing between the plate, control grid and screen-grid by means of the following curves:

Plate Voltage—Plate Current ............ Fig. 114
Plate Voltage—Screen Grid Current .... Fig. 114
Control Grid Voltage—Plate Current ..... Fig. 113
Control Grid Voltage—Screen-Grid Current... Fig. 113
Screen-Grid Voltage—Plate Current ..... Fig. 115
Screen-Grid Voltage—Screen-Grid Current... Fig. 115

Dynamic Characteristics—Figs. 117 and 118 show the effect of control grid and screen-grid voltage (respectively) upon the amplification factor, mutual conductance and plate resistance of the '32.

Detection Characteristics—Fig. 116 shows the relation between the radio frequency input and the audio frequency output, for several percentages of modulation.
Typical Circuit Using CX-330, CX-331, and CX-332 Two Volt Filament Tubes

**FIG. 119**

### Alternating Current Tubes.

The tubes mentioned up to this point are suitable for use with batteries, as in no case do the power demands exceed the limits of the standard types of storage "A" batteries or the usual "B" batteries. With the exception of the special purpose tubes mentioned in the latter portion of this section, the tubes to follow place such demands upon the power supply equipment as to render the use of batteries uneconomical except in special services where peculiar situations demand their use.

*X'-26.*

The '26 tube was originally designed for use in conjunction with the '27 in circuits where the latter was employed as the detector and special output tubes in the output stage. Recent developments have made the '26 obsolete—foremost among them being the cheapening of the '27 which was originally too high in price to be economical for use throughout a multi-tube receiver.

The '26 has an exceptionally sturdy filament which has a high degree of thermal inertia—which means, as has been explained before, that the cooling is so slow as not to follow the variations in applied voltage due to the alternating current cycle. Except for the fact that the filament draws a high current at a relatively low voltage, the tube does not differ materially from the ordinary three-element tube. Because of the extreme sensitivity of detector circuits to the effects of hum, the tube was never employed in detector circuits.

When used as an amplifier, the grid return is, in most cases, made to ground and the grid bias obtained by making the filament positive with respect to the grid by inserting a resistance of the required value between the center tap of the filament winding and ground. This gives the grid a bias equal to the voltage drop through the biasing resistance due to the total plate current flowing through it. It is essential that the center tap of the transformer, or of its shunting resistance, be accurate if no hum is to result. In most of the original A.C. receivers, this center tap was adjustable.

### Operating Conditions

| Filament Volts | 1.5 |
| Filament Amperes | 1.05 |
| Plate Volts | 90 135 180 |
| Grid Voltage | 6.0 9.0 13.5 |

### Average Tube Characteristics

| Plate Voltage | 90 135 180 |
| Grid Voltage | -6.0 9.0 13.5 |
| C Bias Resistor | 1700 1500 1800 ohms |
| Amplification Factor | 8.2 8.2 8.2 |
| Plate Resistance | 8600 7200 7000 ohms |
| Mutual Conductance | 955 1135 1170 micromhos |
| Plate Current | 3.8 6.3 7.4 milliamperes |
| Undistorted Output | 30 80 180 milliwatts |

The higher plate voltages are recommended only where the signal input to a particular stage might be large enough to cause overloading or a flow of gold current.

### Use as an Amplifier

Operation as an amplifier for either A.F. or R.F. is essentially the same as for the '01A. The electrical characteristics are substantially the same and ordinarily do not require any changes in the characteristics of the A.F. and R.F. transformers as previously employed with the '01A. Grid and plate return leads should be connected to the movable arm of a low resistance potentiometer connected across the filament, and in operation this arm should be adjusted for minimum hum.
The '26 cannot be used satisfactorily as a bias detector when operated from alternating currents as the hum present under such conditions is objectionable.

CURVES AND DIAGRAMS

The variation of filament current with filament voltage is shown in Fig. 120.

The relation between plate current and plate voltage at several values of bias is shown in Fig. 121. From this curve it is possible to determine approximately the plate current under given conditions of grid and plate voltage.

Fig. 122 shows the variation of plate current with grid voltage for various values of plate voltage.

The effect of plate voltage upon amplification factor, plate resistance and mutual conductance at various grid bias voltages is shown in Fig. 123.

'Y'-27.

The '27 was originally intended for use as a detector in conjunction with the '26 and one of the power output tubes described here. As production of the tube increased, the list price of the tube fell and it became possible to use the tube throughout receivers. A considerable gain in sensitivity and in lack of hum resulted, as the '27 is of the indirect heater type in which the alternating current used in heating the cathode does not flow directly in the cathode circuit, but is insulated therefrom by a small ceramic sleeve which readily transmits the heat to the cathode proper.

The original indirect heater tubes required some thirty or forty seconds to reach their operating temperature and some annoyance was experienced because of the delay. Judicious cutting down of the material insulating the heater from the cathode and improvement of its thermal characteristics has resulted in considerable improvement in this time lag, and the present tubes heat up to their operating temperature in from five to six seconds.

Although the heater is rated at 2.5 volts at 1.75 amperes, it may be operated at considerably lower voltages as the maximum electron emission obtains at a filament voltage of about 1.9. Although perfect operation is achieved with this low voltage, the heating time is considerably increased. It will be noted in many receivers that the '27 is operated at some voltage between 1.9 and 2.5.

It is essential that the tube should not be operated at a voltage higher than 2.6 as the intense heat generated will, after a short period of operation, be
sufficient to make the grid emit electrons—this is termed grid emission and is ruinous to reception. If you should, in the course of your travels, find a receiver which works well when first switched on but gradually loses volume, it is highly probable that the heater voltage is too high and that grid emission is taking place.

Before leaving the subject of the '27 cathode it should be noted that some of these tubes are found with thermostatic open circuits. That is to say, that while the tube is operating at a low temperature as when first switched on, there will be no trouble indicated, but as the temperature within the tube increases, expansion of the elements will cause an open circuit which will cut out the signal entirely until the tube cools off to a low enough temperature for contraction of the elements to complete the circuit again. This intermittent operation is easily recognized when met and a knowledge of the fact that such a condition may possibly exist is all that is needed to cure the fault.

Operation of the '27 as an audio frequency or radio frequency amplifier is described in the Data Chart. It may also be operated as a grid circuit detector with a plate voltage of 45 and a grid condenser and leak of .00025-mf. and 2 megohms, respectively. Operation as a "bias" detector requires the use of a biasing resistor of from 20,000 to 100,000 ohms in series with the cathode circuit. The higher the value of this resistance, the greater will be the allowable signal on the grid before distortion occurs. The tube may be operated as a power grid detector with 180 volts on the plate, and a grid condenser and leak of .0001-mf. and 100,000 ohms, respectively. This last type of operation gives the greatest freedom from distortion of all types of detectors.

Grid bias is obtained by inserting a by-passed resistance in series with the cathodes so that the plate current flowing through the resistance will create a voltage drop sufficient to place the cathode at the required potential positive with respect to ground. In such case, the grid return is brought directly to ground.

Although it is not recommended, the '27 may be used as a power output tube in cases where no large degree of volume is demanded. In this mode of operation the plate voltage is 180 and the grid bias -13.5 volts.

The '27 may not be operated as a radio frequency amplifier unless measures are taken either to prevent oscillation by the so-called "losser" methods or by some system of balancing out the inter-electrode capacity of the tube.

Although the center tap of the heater winding of the power transformer is normally grounded, there are cases where the heaters are on the same winding as the '45 output tubes and are at the same potential as the '45 filaments—about 50 volts positive with respect to ground. This should be taken into account when making measurements on the '27 circuits. In cases of obstinate hum, a cure may at times be effected by deliberately making the heaters positive with respect to the cathodes by returning their center tap to some point on the voltage divider rather than directly to ground.

### Operating Conditions

<table>
<thead>
<tr>
<th>Plate Volts</th>
<th>Grid Leak (Mgs)</th>
<th>Grid Bias (Volts)</th>
<th>Amplification Grid Bias (Volts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>2</td>
<td>-10.0</td>
<td>-60</td>
</tr>
<tr>
<td>90</td>
<td></td>
<td>-15.0</td>
<td>-9.0</td>
</tr>
<tr>
<td>135</td>
<td></td>
<td>-20.0</td>
<td>-13.5</td>
</tr>
<tr>
<td>180</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Curves and Diagrams

Fig. 124 shows the variation of filament current with filament voltage.

Fig. 125 shows the variation of plate current with plate voltage for various values of bias voltage.

Fig. 126 shows the variation of plate current with grid voltage for various values of plate voltage.

Fig. 127 shows the variation of amplification factor, plate resistance and mutual conductance with grid voltage for various values of plate voltage.

Fig. 128 shows the detector action as a grid leak detector with plate voltage of 45 volts, 2-meg grid leak and for 22% modulations.

Fig. 129 shows the detector action of the '27 operating as a bias detector under various voltage conditions, with a plate load of 200,000 ohms and 22% modulation. The star marked on each curve indicates the point at which grid current begins to flow.

### 'Y'-24

The '24 is a screen-grid tube with the same heater-cathode structure as the '27. The other elements are so proportioned as to have a definite gain over the structure of the '22 in so far as possible amplification is concerned. The control grid is brought out through the cap and the screen-grid is connected to the terminal provided for the grid in the case of the '27.

### Operating Conditions

<table>
<thead>
<tr>
<th>Heater voltage</th>
<th>2.5</th>
<th>2.5 volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heater current</td>
<td>1.75</td>
<td>1.75 amperes</td>
</tr>
<tr>
<td>Plate voltage</td>
<td>180</td>
<td>180 volts maximum</td>
</tr>
<tr>
<td>Control grid voltage</td>
<td>-1.5</td>
<td>-3.0 volts maximum</td>
</tr>
<tr>
<td>Screen-grid voltage</td>
<td>75</td>
<td>90 volts maximum</td>
</tr>
</tbody>
</table>

### Average Tube Characteristics

Tube characteristics at above operating conditions
Amplification factor 420 400
Plate resistance 400,000 400,000 ohms
Mutual conductance 1,050 1,000 micromhos
Plate current 4.0 4.0 milliamperes

**USE AS A RADIO FREQUENCY AMPLIFIER**

In order to obtain stable operation in circuits designed to give normal gain per stage, it is necessary to use shielding to separate the input and output circuits. The internal shielding of the tube makes neutralization unnecessary, providing extraneous external couplings are eliminated by means of shielding. Suitable ventilation must be provided through the shielding to prevent excessive tube temperatures. Radio frequency filters should be used in circuits employing more than two stages and also in circuits which are designed to give the maximum amplification per stage. The high plate circuit impedance necessary for obtaining the normal amplification may be obtained either with closely coupled R.F. transformers or by means of the tuned plate impedance method. At broadcast frequencies, a voltage amplification from 50 to 100 per stage can be obtained. To prevent regeneration or oscillation in a two-stage radio frequency amplifier, the amplification should not exceed 100 per stage at the highest broadcast frequencies.

The volume of the R.F. amplifier may be controlled by a potentiometer control on the screen-grid voltage so that the screen-grid voltage may be varied between zero and plus 75 volts. Control grid voltage adjustment may also be used as volume control providing the control grid bias is always greater than 1.5 volts negative. The negative grid bias maintains high input resistance, resulting in good gain and selectivity of the preceding circuit.

**USE AS A DETECTOR**

The '24 is an excellent bias detector either with small signal or high signal input. The screen-grid voltage and control grid bias should be so chosen that the control grid does not swing to a point where grid current is drawn. For small R.F. signals when a first audio stage is used, it is best to operate the screen-grid at 35 or 45 volts and the control grid at minus 3.5 or 4.5 volts, respectively. The output under this condition into a 200,000-ohm load choke fed with one volt R.M.S. radio frequency input modulated 22%, is 5.5 volts R.M.S. audio output. With 75 volts on the screen-grid and a control grid bias voltage of 7.5 volts, the audio output at the point where grid current starts is 49.5 R.M.S. audio voltage output with an input of 6.28 volts R.M.S. with 22% modulation. This is more than sufficient to operate a '45 to full output by means of direct coupling; or two '45 tubes in push-pull by means of a low gain audio stage.

**CURVES AND DATA**

Fig. 130 shows the filament current and emission variation with filament voltage.

Fig. 131 shows the average plate current over a range of screen-grid voltages at various control grid voltages. A curve also of the screen-grid current is plotted for the control grid voltage of negative 1.5 volts.

Fig. 132 shows the variation of amplification factor, plate resistance, and mutual conductance for various control grid voltages at screen-grid voltages of 75 volts and plate voltage of 180 volts.

Fig. 133 shows the variation of amplification factor, plate resistance, and mutual conductance with various screen-grid voltages at a control voltage of minus 1.5 volts and plate voltage of 180 volts.

Fig. 134 shows the variation of plate current with plate voltage for various control grid voltages at screen-grid voltage of plus 75 volts.

Fig. 135 is similar to Fig. 134 except it has been plotted with a screen-grid voltage of plus 45 volts.

Fig. 136 shows the detector action in audio frequency volts output against radio frequency input, both measured in R.M.S. volts. The point where grid current starts to flow is noted on each curve. Curve A was taken at a plate voltage of 180 volts, a screen voltage of plus 45 volts and a control grid voltage of minus 4.5 volts. The plate voltage was fed through a high impedance choke and the resistance load so chosen to give a total plate circuit impedance of 200,000 ohms with a power factor of .96. The D.C. resistance of the choke was 3,000 ohms. Curve B was taken with the same circuit at a screen-grid voltage of plus 75 volts and control grid voltage of minus 7.5 volts.

While the high impedance tube is inherently possible of greater selectivity than the three-element tube, there are certain characteristics peculiar to the tube which make the apparent selectivity less. These are the effects of cross-modulation or "cross-talk" and of beat interference.

Because of its high amplification, the screen-grid tube is subject to the effects of cross-modulation as it requires but a slightly higher applied voltage on the grid of the tube to cause it to operate in the region favorable to detection. It will be noted from the preceding data, that the bias required for detection is but 4.5 volts. The voltage developed across the grid circuit of the first tube by a strong local signal is often sufficient to operate the tube as a detector even though the circuits are tuned to some frequency greatly removed from the interfering signal. Variations in the intensity of the interfering signal serve to modulate the desired signal accordingly, and the signal to which we are tuned is doubly modulated—once by its own modulation, and once by that of the interfering signal. Once this cross-modulation takes place, no amount of selectivity in the succeeding cir-
cuits will serve to rid us of it as it is actually impressed upon the desired signal. To avoid this, it is now standard practice to employ "band-selector" or coupled circuit systems between the antenna and the first tube; these are an absolute necessity to successful operation of the screen-grid tube.

If two such local signals are impressed upon the grid of the first tube they will create beats, or secondary signals, having frequencies equal to the sum and difference of the two original signals. Thus, two signals at 550 and 900 kc. will produce beats at 350 and 1450 kc., the latter of which will appear in the receiver as a signal modulated by the modulations of both the original signals intermingled. It may readily
be seen that every precaution must be taken to prevent the appearance of strong locals across the input circuit of the first tube, and the use of at least two tuned circuits between the antenna and the first grid are necessary. The effects noted obtain only when the local signals are of sufficient intensity to operate the tube on a portion of its characteristic curve favorable to detection. The effects are not noticeable to a great degree with tubes other than the '22 or '24.

**POWER OUTPUT TUBES**

It has been fairly obvious throughout the previous discussion that the vacuum tube is a voltage operated device. Little or no power is consumed in the grid circuit of a vacuum tube and the sole purpose of the R.F. and A.F. amplifiers is to obtain the largest possible voltage output.

The loud speaker, however, is a power-consuming device and the purpose of the output tube, or last tube in the chain, is to provide the greatest power possible for the operation of the speaker. It is, of course, essential that the power supplied be free from distortion in as great a degree as possible and, as we noted in the definitions, the maximum undistorted power output is obtained when the load impedance is twice the output impedance of the tube except in the case of pentodes. The impedance of the tube is practically invariable over the range of frequencies employed but the impedance of the speaker is a variable factor and it is usual to take the speaker impedance at 200 cycles as the criterion in design. This may vary from about 5000 ohms in the case of the magnetic speaker to 15 ohms in the case of the dynamic type.

It is necessary that a transformer be used to match the impedance of the tube to that of the speaker, and the formula for obtaining a condition where the load of a power tube will be twice its own impedance is as follows:

\[
T = \sqrt{\frac{2RP}{R_s}}
\]

Where \( T \) is the turns ratio of the transformer, \( R_P \) the tube impedance, and \( R_1 \) the impedance of the loud-speaker winding at 200 cycles.

As an example let us assume that we desire to match the impedance of a '71A tube to a speaker having an impedance of 15 ohms. The impedance of the tube is 1850 ohms. Then by the formula

\[
T = \sqrt{\frac{3700}{15}}
\]

approximately 15.7

Where two tubes are in push-pull, the total tube impedance is double that of a single tube and the turns ratio of the transformer would be about 22.2.

The characteristics of output tubes involve relatively low plate impedance—high plate voltage and plate current and a high mutual conductance. It should be remembered that the signal voltage as measured by instruments in the grid circuit of the output tube is in R.M.S. readings, while the peak voltage is what swamps out the grid bias and permits distortion to occur by operating the tube on a curved portion of its characteristic curve. This means that we should never apply a voltage to the grid of a tube whose peak value exceeds the value of the bias.

The figures given in the Data Chart for the undistorted power output are those of the maximum obtainable with the tube without operating the tube on a curved portion of the characteristic.

It is often desirable to know what power output is obtained from a tube when the signal is not of the maximum allowable intensity. This figure may be obtained from the formula

\[
P = \frac{2(uEg)^2}{9RP}
\]

where \( P \) is the power output in milliwatts, \( u \) the amplification factor of the tube, \( Eg \) the value of the signal in R.M.S. volts, and \( Rp \) the plate impedance of the tube. Suppose that we wish to find the power output of a '71A with an input signal of 20 volts (R.M.S.) From the equation

\[
P = \frac{2(60)^2}{9RP}
\]

\[
P = \frac{16630}{720000}
\]

or \( P = 432 \) milliwatts

There are certain advantages incident to the operation of tubes in push-pull which are not generally understood. In the first place the D.C. forces in the output transformer cancel out and permit of considerable economy of design and improved quality.

Secondly, no signal voltages are flowing in either the plate voltage circuit or in the grid biasing circuit. For this reason there is no necessity for by-passing in either circuit.

We might leave the discussion of the push-pull circuit here, while its advantages are fresh in our minds, to note that the biasing of power tubes should be such that normally no change in the plate current takes place under the influence of an applied signal. A fluctuation in plate current when a signal is present indicates overloading of the tube.

By-passing of the biasing resistances in all amplifier tubes should be sufficient to effectively short-circuit the bias resistance so far as all low frequencies are
concerned. In the case of the '71A, it is possible that
the response is desired perfect as low as 50 cycles.
With a biasing resistance of 2150 ohms, this means
that a condenser of at least 15 microfarads would be
necessary to effectively short-circuit the biasing re-
sistance. This is on the basis of a condenser
reactance of 212 ohms at 50 cycles. Otherwise, a signal
exactly out of step with the input would
appear across the biasing resistance in opposition to the in-
put signal which would "buck out" the incoming low
frequency signals.

'X-'10.
The '10 is a power output tube of relatively high
impedance for use in A.C. receivers and low power
transmitters. Its characteristics are fully described in
the Data Chart. Subsequently released tubes, because
of their improved power efficiency, have rendered the
10 somewhat obsolete.

RATING
Filament Volts................................. 7.5
Filament Amperes.............................. 1.25
Type.......................... Thoriated Tungsten

AVERAGE CHARACTERISTICS
Plate Voltage................................. 425 volts
Plate Current................................. 0.18-ampere
Amplification Factor.......................... 8
Plate Resistance............................... 5000 ohms
Mutual Conductance......................... 1600 micromhos
Control Grid Voltage....................... 35 volts
Load Impedance in ohms.................... 10000
Output (5% second harmonic)............. 1.6 watts

'X-'45.
The '45 tube is the power output tube found in
most of the modern receivers. Inasmuch as its undis-
torted power output of 4.5 watts, when two tubes are
connected in push-pull, is sufficient to fill a good-
sized auditorium, there is little reason why a larger
tube should be desired in the average radio receiver.
The characteristics of the '45 are such as to make it
useless in positions other than in the output, al-
though in certain power amplifiers requiring a large
signal at the output, the '45 has been used as an in-
termediate A.F, stage. The filament is to be operated
at not more than 5% above or below its normal rat-
ing. Operation of the tube without grid bias will
result in the destruction of the filament due to the
heavy current drawn. The biasing resistance with
250 volts on the plate is 1470 ohms, and with 180
volts is 1380 ohms. Total plate voltage required in
the first case is 300 volts, and in the second, 214.5
volts. When connected with the bias obtained by the
drop due to the plate current flowing through a re-
sistance, the arrangement will effectively compensate
for minor changes in line voltage. Note that in push-
pull circuits, just half the normal biasing resistance
is required.

OPERATING CONDITIONS
Filament Volts................................. 2.5
Filament Amperes............................. 1.5
Plate Volts................................. 180 250
Grid Voltage (A.C.Fila.).................. 34.5 -50

AVERAGE TUBE CHARACTERISTICS
Plate Voltage................................. 180 250
Grid Voltage (A.C.)......................... 34.5 -50
C Bias Resistor......................... 1380 1470 ohms
Amplification Factor................. 3.5 3.5
Plate Resistance....................... 1900 1750 ohms
Mutual Conductance................... 1850 2000 micromhos
Plate Current......................... 27 34 milliamperes
Undistorted Output..................... 780 1600 milliwatts

The curve of Fig. 137 shows the average filament
current of type '45.
Fig. 138 gives the average plate current over a
range of plate voltages at zero grid bias.
Fig. 139 shows the amplification factor (Mu),
plate resistance (rp), and mutual conductance
(Gm), plotted in relation to grid voltage at plate
voltage of 180 volts.
Fig. 140 shows the amplification factor (Mu),
plate resistance (rp), and mutual conductance
(Gm), plotted in relation to grid voltage at plate
voltage of 250 volts.

Many times it is convenient to know the tube char-
acteristics when the plate current only is known at
an approximate value of plate voltage. For this rea-
son we have included Fig. 141 which shows the
various characteristics plotted against plate current.
At the normal operating current, there is little dif-
ference between the various values, but at the lower
plate currents the variations are somewhat greater.

Fig. 142 shows the family of plate current-plate
voltage curves which are useful in calculating power
output and determining the proper "C" battery vol-
tages for definite plate currents. If A.C. filament
operation is used, add 1.5 volts to the grid bias
values given on the curves.

'X-'50.
The '50 tube is employed either singly or in push-
pull in many of the receivers now in use. The re-
marks passed regarding the '45 apply in full to the
'50. It is essential that the resistance in the grid cir-
cuit of the tube be kept low to avoid decrease in bias
due to the flow of grid current as the tube is not
entirely free from gas. This makes the use of the tube as a resistance coupled amplifier impossible unless it succeeds a tube of low plate impedance such as the '45. In this case a grid resistance of sufficiently low value may be employed without seriously affecting the gain of the preceding tube.

The life of the '50 is seriously limited by operation at its maximum plate voltage and this is not usually done except where large output is the paramount consideration. Biasing resistances and total voltages required for operation at various plate voltages follow:
Plate Voltage | Bias Resistance | Total Voltage  
---|---|---
250  | 1600  | 295  
350  | 1400  | 413  
400  | 1300  | 470  
450  | 1550  | 534  

Resistance values are halved where two tubes are operated in parallel or in push-pull at the voltages specified.

**Operating Conditions**

| Filament Volts | 7.5  |
| Filament Amperes | 1.25  |
| Plate Volts (Max.) | 450  |
| Plate Current (Max.) | 55 ma  |
| Grid Volts | See Table  |

**Average Tube Characteristic**

<table>
<thead>
<tr>
<th>Plate</th>
<th>Grid</th>
<th>Plate Mut.</th>
<th>Plate</th>
<th>Resistor O'put</th>
</tr>
</thead>
<tbody>
<tr>
<td>250</td>
<td>-45</td>
<td>3.8</td>
<td>2100</td>
<td>1800</td>
</tr>
<tr>
<td>350</td>
<td>-63</td>
<td>3.8</td>
<td>1900</td>
<td>2000</td>
</tr>
<tr>
<td>400</td>
<td>-70</td>
<td>3.8</td>
<td>1800</td>
<td>2100</td>
</tr>
<tr>
<td>450</td>
<td>-84</td>
<td>3.8</td>
<td>1800</td>
<td>2100</td>
</tr>
</tbody>
</table>

**Use**

Maximum life is obtained from the '50 when the tube is used at conservative plate voltages. Voltages between 250 and 400 volts are recommended, and the voltage must not exceed a maximum value of 450 volts. When the tube is used in place of the '10 (as noted below circuit changes should be made before the tube is substituted for this type) the plate voltage need not exceed 300 volts if the power output obtainable from the '10 operated at 425 volts has proved adequate. Thus for equivalent power output a considerably lower plate voltage may be used with the '50, the total required for the tube and grid biasing voltage being 300+54, or 354 volts as compared with 425+35 or 460 volts for the '10.

The higher current required by the '50 can be conveniently supplied by an '81 rectifier (or by two such tubes with full wave connection). The average plate current required ranges from 28 ma. at 250 volts to 55 ma. at 400 volts. Since the '81 is rated at 85 ma. output (see Fig. 146) sufficient margin is available so that the same rectifier used for the '50 may also supply the plate current required by the remaining tubes in the receiver.

The grid bias must be applied at all times while the tube is in operation. If the grid circuit is opened the plate current will increase to a high value, overloading both the power tube and particularly the rectifier tube—if the current is supplied from such source—and is very apt to cause burn-out of the fila-ment in the latter. It is very desirable to protect both by a fuse, or similar device, operating at about .1-ampere, and which should be placed in the rectifier circuit between the rectifier and the filter. It is possible to use the .1-ampere 6-volt dial lamp, type T3, which, although not designed for high voltage, will usually break the circuit.

The coated filament is not affected by traces of gas, and a slight blue glow will not impair or affect the performance of the tube provided the resistance in the grid circuit is kept low, preferably not over 10,000 ohms, to avoid a decrease in bias which may otherwise result from the flow of gas current to the grid. The tube is not intended for use in resistance coupled amplifiers.

It is desirable that the bias required by the tube be supplied from the drop across a resistor in series with the B return. It will be found that this connection compensates almost completely for changes in plate voltage which may occur as a result of line voltage variations, as an increase in plate voltage causes a small increase in plate current which in turn raises the applied "C" bias sufficiently to compensate for the new value of plate voltage, thus maintaining the proper operating condition at all times. If a decrease in voltage occurs, the reverse action takes place. This desirable operating condition is sacrificed if a fixed "C" bias derived from a battery or other source is provided, as in such cases a decrease in plate voltage will cause a large decrease in plate current which will greatly reduce the power output obtainable from the tube, while an increase in plate voltage will overload the tube.

A low resistance output choke with a condenser, or a transformer capable of handling the heavy plate current of the '50 without saturation of the core, or overheating of the windings must be provided for this tube to prevent excessive voltage drop in the plate circuit and to protect the loud-speaker windings.

**Curves and Data**

The curves, Fig. 143, show the average filament current and the filament emission of type '50.

Fig. 144 gives the average plate current over a range of plate voltages, with no applied grid bias. In taking this data, the grid return was connected to the midpoint of the filament, and for this reason the plate current does not reach zero until a negative plate voltage is applied.

Fig. 145 shows the amplification factor (Mu), plate resistance (rp), and mutual conductance (Gm), plotted as a function of plate current. This method of showing tube characteristics is convenient, since a single measurement, that of plate current, suffices to determine the operating point.

Fig. 146, furnished for convenient reference, shows the voltage and current output of the '81 at various loads. The full lines show the output of a single '81
with the usual filter arrangement, while the dotted lines show the output obtained from two '81 tubes in a full-wave rectifier, using a filter in which the first filter condenser is omitted: The IR drop in the filter must be taken into consideration before this data is complete. As soon as the resistance of the filter chokes is measured the output voltage obtainable can be computed.

'40.

This tube is a high impedance tube with a high amplification factor for use in resistance coupled amplifier circuits where a filament supply of 5 volts is available. It may also be used as an R.F. amplifier in circuits specially designed for it. The tube is also a good detector under like conditions. The tube is now almost obsolete and, to the writer's knowledge, was employed in but one commercial receiver.

SPECIAL PURPOSE TUBES

'00 and '00A.

These tubes were originally intended for use as detectors in radio receivers. The first was a gassy, or poorly evacuated, type and the second was purposely filled with gas. Both are now obsolete and they will probably not be found once in ten thousand service calls. The tubes were extremely sensitive detectors but were not in the "high quality" class now so necessary. Critical voltage adjustment was their most notable requirement and you may remember the 22.5 volt "B" batteries with taps at 16 volts and on up for adjustment of the detector plate voltage. In no receiver that the writer can remember from the earliest days onward, were the full advantages of either of these tubes employed save in the case of the Garod "coffin" neutrodyne. This set was quite ordinary in performance with an '01A as detector, but with an '00 type it stepped out into the far reaches of the country when the critical adjustment was achieved. If ever you come upon one of these monster old receivers and want a real demonstration of what the "old-timers" were capable of, dig up a '00 detector, put 16 volts of "B" on it and twiddle the detector rheostat while your two helpers adjust the tuning controls. Then thank the particular "Djin" who watches over radio men for John V. L. Hogan and single-control.

'X-'74.

OUTPUT VOLTAGE REGULATOR

The '74 is a special "glow" type voltage regulator designed for service in "B" supply units where great flexibility in output is required or where the A.C. line voltage varies over rather wide limits. This tube accomplishes voltage regulation from its characteris-

tic that on any current flow from 10 to 50 milliamperes the tube develops a constant voltage averaging 90 volts. It consists of two elements (an anode and a cathode) in a gas-filled space and shows a pronounced glow when in operation.

CIRCUIT REQUIREMENTS

This tube cannot be used without a series resistance to limit the maximum current to 50 milliamperes. The application of the tube to a typical "B" supply unit is shown in Fig. 147. If the tube connections are reversed a bright glow will occur at the small terminal, and the connections should be corrected. Proper results will not be obtained unless connections are made as indicated in the diagram. The terminals which would normally be "+F" and "plate" are connected together in the base of the tube and this short-circuited connection may be used as a line switch in the transformer primary. With this connection, the eliminator cannot be turned on until the '74 tube is inserted in the socket nor can the tubes be interchanged in such a way as to damage either the equipment or tubes themselves. If a rectifier or power tube is inserted in the socket intended for the '74, the transformer primary will remain open and no power will flow to the equipment.

Two '74 tubes may be placed in series to obtain 180 volts, a center tap between the two tubes then providing 90 volts.

RATING

| Rated Voltage | 90 volts D.C. |
| Starting Voltage | 125 volts D.C. |
| D.C. Current | 10-50 milliamperes |

'76 and '86

The '76 and '86 are Iron filament tubes with the filament in a hydrogen atmosphere. They develop considerable heat in operation and are placed in a metal chimney for the purpose of creating a cooling draft and for protection of the operator from flying glass in the event of breakage. Do not work in the vicinity of these tubes unless the protective screening is in place, as a slight jar may fracture the glass and allow the hydrogen to ignite. A terrific detonation will result. This warning should therefore be taken into full account in working with equipment in which these tubes are placed. Their purpose is that of voltage regulation in the primary circuit of power transformers. They incur a voltage drop of about 50 volts and the power equipment used with them is designed accordingly. Apparatus designed for use at 60 cycles with the '76 can be employed on 40 cycle lines by the substitution of the '86. The circuit arrangement of a power supply circuit employing these tubes and the '74 appears in Fig. 147.
The '77 tube is protective device placed in the negative "B" battery lead of receivers using '99 tubes. They are found in early Radiola 25 and 28 receivers. The filament characteristics of these tubes are such that should the "B" voltage be applied to the "A" circuit unintentionally, the voltage drop through the tube will be great enough to protect the tube filaments from destruction.

The Variable-Mu Tetrode

The Variable-Mu tube is similar in most respects to the screen-grid tube but is so designed that overloading of the grid does not cause cross-modulation in the manner peculiar to screen-grid type and, thus, the necessity for the use of band-selectors in the preliminary tuning is avoided. Volume control is achieved smoothly by variation of the grid bias over the range from the minimum specified to 40 or 50 volts negative for minimum volume. Note Fig. 148. While the tube is similar to the '24 in many respects, it is not interchangeable therewith. It may be used as the first detector in superheterodyne circuits but not as a high level detector as in normal usage. Two types, '35 and '51, are now in commercial use having differing characteristics which will be described.

'T51

<table>
<thead>
<tr>
<th>Tentative Rating and Characteristics</th>
<th>'24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heater Voltage</td>
<td>2.5 volts</td>
</tr>
<tr>
<td>Heater Current</td>
<td>1.75 amperes</td>
</tr>
<tr>
<td>Plate Voltage</td>
<td>250 volts</td>
</tr>
<tr>
<td>Screen Grid Voltage (Maximum)</td>
<td>90 volts</td>
</tr>
<tr>
<td>Control Grid Voltage</td>
<td>-3 volts</td>
</tr>
<tr>
<td>Plate Current</td>
<td>7 milliamperes</td>
</tr>
<tr>
<td>Screen Grid Current—Not more than</td>
<td>1/3 of Plate Current</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Plate Resistance</td>
<td>400,000 ohms</td>
</tr>
<tr>
<td>Amplification Factor</td>
<td>420</td>
</tr>
<tr>
<td>Mutual Conductance (Ecg=-3 Volts)</td>
<td>1050 micromhos</td>
</tr>
<tr>
<td>Effective Grid-Plate Capacitance (Max.)</td>
<td>0.010-mmf.</td>
</tr>
<tr>
<td>Input Capacitance</td>
<td>5 m mf.</td>
</tr>
<tr>
<td>Output Capacitance</td>
<td>10 m mf.</td>
</tr>
</tbody>
</table>

NEW TUBES FOR AUTOMOTIVE AND D.C. RECEIVERS

The three tubes to follow are specially designed for operation directly from the 6-volt battery of the motor car or from D.C. lines with the heaters in series. There are three tubes in the group: a general purpose tube, the '37; a screen-grid tube, the '36; and a Pentode output tube, the '38. Their characteristics are as given below. Employment of the indirectly heated cathode tends to avoid a large part
of the noise found in auto and D.C. sets.

'36

CHARACTERISTICS

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heater Voltage</td>
<td>6.3 volts D.C.</td>
</tr>
<tr>
<td>Heater Current</td>
<td>0.3-ampere</td>
</tr>
<tr>
<td>Plate Voltage</td>
<td>90 135 135 volts</td>
</tr>
<tr>
<td>Screen Voltage</td>
<td>55 67.5 75 volts</td>
</tr>
<tr>
<td>Grid Voltage</td>
<td>-1.5 -1.5 -1.8 volts</td>
</tr>
<tr>
<td>Plate Current</td>
<td>1.8 3 2.5 milliamperes</td>
</tr>
<tr>
<td>Screen Current—Not over 1/3 of plate current</td>
<td></td>
</tr>
<tr>
<td>Plate Resistance</td>
<td>200,000 300,000 250,000 ohms</td>
</tr>
<tr>
<td>Amplification Factor</td>
<td>170 315 275</td>
</tr>
<tr>
<td>Mutual Conductance</td>
<td>850 1,050 1,100 micromhos</td>
</tr>
</tbody>
</table>

This tube is a power output pentode of the type described above. The connections to the tube, which employs the UX base, are with the filament at the heater terminals (referring to the '27), the plate and grid to their usual terminals, and the screen-grid to the cathode terminal.

Because of the high gain of the tube it is not desirable to use the familiar type of biasing where the bias is provided by the drop through a resistor in series with the filament center tap. Because of the high amplification factor the out-of-phase voltage fed back to the input across this resistance would be abnormally high and any condenser suitable for bypassing of the resistance would be too large for economy. If return of the grid is made to some point in the voltage supply negative by the required amount with respect to the filament, no undesirable effects will be encountered.

'37

CHARACTERISTICS

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heater Voltage</td>
<td>6.3 volts</td>
</tr>
<tr>
<td>Heater Current</td>
<td>0.3-ampere</td>
</tr>
<tr>
<td>Plate Voltage</td>
<td>90 135 135 volts</td>
</tr>
<tr>
<td>Grid Voltage</td>
<td>-6 -9 volts</td>
</tr>
<tr>
<td>Plate Current</td>
<td>2.7 4.5 milliamperes</td>
</tr>
<tr>
<td>Plate Resistance</td>
<td>11,500 10,000 ohms</td>
</tr>
<tr>
<td>Amplification Factor</td>
<td>9</td>
</tr>
<tr>
<td>Mutual Conductance</td>
<td>780 900 micromhos</td>
</tr>
<tr>
<td>Load Resistance</td>
<td>14,000 12,500 ohms</td>
</tr>
<tr>
<td>Undistorted Power Output</td>
<td>30 75 milliwatts</td>
</tr>
</tbody>
</table>

'THE PENTODE OUTPUT TUBE

The space charge in a vacuum tube causes a cloud of electrons to collect in the neighborhood of the cathode. This means that in order to draw electrons through this cloud, an extremely large proportion of the total plate voltage is used up. Scientists have discovered that by the inclusion of an extra grid in the neighborhood of the cathode, this cloud may be dispersed with a resultant increase in the sensitivity and efficiency of the tube. The pentode for a given output power requires but one third the input signal and makes possible the operation of the power stage directly out of the detector by resistance coupling. The distortion usually encountered in the intermediate A.F. stage is thus removed. Contrary to the case of the triode, the optimum output load for maximum undistorted power is not twice the plate impedance of the tube. This figure is specified definitely by the manufacturer in each case.

'38

CHARACTERISTICS

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heater Voltage</td>
<td>6.3 volts</td>
</tr>
<tr>
<td>Heater Current</td>
<td>0.3-ampere</td>
</tr>
<tr>
<td>Plate Voltage, Recommended</td>
<td>135 volts</td>
</tr>
<tr>
<td>Screen Voltage, Recommended</td>
<td>135 volts</td>
</tr>
<tr>
<td>Grid Voltage</td>
<td>-16.5 volts</td>
</tr>
<tr>
<td>Plate Current</td>
<td>8 milliamperes</td>
</tr>
<tr>
<td>Screen Current</td>
<td>2.5 milliamperes</td>
</tr>
<tr>
<td>Plate Resistance</td>
<td>110,000 ohms</td>
</tr>
<tr>
<td>Amplification Factor</td>
<td>100</td>
</tr>
<tr>
<td>Mutual Conductance</td>
<td>900 micromhos</td>
</tr>
<tr>
<td>Load Resistance</td>
<td>15,000 ohms</td>
</tr>
<tr>
<td>Undistorted Power Output</td>
<td>375 milliwatts</td>
</tr>
</tbody>
</table>

Harmonic Distortion

The output of the pentode tube when examined...
for harmonic content at various loads in the plate circuit reveals the magnitudes shown in Fig. 149 where H represents the harmonic percentage of the fundamental. The second harmonic H2 rapidly diminishes as the load impedance is increased, reaching zero or a very small value at 7,500 ohms; then increasing at practically the same rate. Quite a different state of affairs is represented by the third harmonic H3 which continually increases until a maximum is reached at approximately two times the load impedance.

**Power Output**

While the usual graphical method of determining the undistorted power output of triodes by use of a family of plate current—plate voltage curves in conjunction with balanced load impedance lines are applicable to pentodes, the data here presented are those obtained from direct measurement of pentode output containing less than 5% harmonic distortion. The method of measurement is based fundamentally upon the harmonic analysis of the pentode output. (See Standard methods of testing vacuum tubes, Chapter VI, paragraph D, IRE Committee on Standardization, 1930.)

The graphs of Fig. No. 150 illustrate the undistorted power output of the pentode when operated at various plate voltages. This graph also shows the optimum load impedance for minimum second harmonic and the degree of third harmonic present at various plate voltages. Curve No. 151 illustrates the change of power output of the pentode as the input is varied. It should be noted that the harmonic distortion does not increase in proportion to the input but as maximum input is approached the harmonic content increases at a lower rate.

Fig. 152 shows characteristic variation with changes in plate voltage.

**Power Sensitivity**

The power sensitivity of an output tube has been defined by Stuart Ballantine as the ratio:

\[
S = \sqrt{\frac{P_o}{E_{g1}}}
\]

where S is the Power Sensitivity, 
\(P_o\) the power delivered to the load, 
and \(E_{g1}\) the R.M.S. value of the A.C. sinusoidal grid voltage.

This factor possesses several advantages not found in previous definitions and is employed in this report. Accepting the value of the grid bias as a measure of the peak signal voltage required to deliver maximum useful power output, the following table is arranged to illustrate the power sensitivity of the pentode in comparison with various triodes.

<table>
<thead>
<tr>
<th>Type</th>
<th>Tube</th>
<th>Ep</th>
<th>Eg1</th>
<th>Po</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>'12-A</td>
<td>157.5</td>
<td>10.5</td>
<td>.195</td>
<td>.0594</td>
<td></td>
</tr>
<tr>
<td>'71-A</td>
<td>180</td>
<td>20.5</td>
<td>.700</td>
<td>.0292</td>
<td></td>
</tr>
<tr>
<td>'45</td>
<td>250</td>
<td>50</td>
<td>1.60</td>
<td>.0358</td>
<td></td>
</tr>
<tr>
<td>PZ, '47</td>
<td>250</td>
<td>18</td>
<td>2.85</td>
<td>.1326</td>
<td></td>
</tr>
<tr>
<td>'50</td>
<td>450</td>
<td>84</td>
<td>4.05</td>
<td>.0239</td>
<td></td>
</tr>
</tbody>
</table>

**'33 Power Pentode**

The low power output of the '20 and '30 type power tubes, plus their low amplification constant,
was a serious drawback to those interested in battery type tubes.

The new power pentode, known as the '33, when introduced, offered a satisfactory tube for the portable set or for sets used in isolated places such as farms not equipped with electrical supply.

This tube has considerably greater power output and sensitivity than three-electrode power tubes of the '31 type. In fact, when used in push-pull they will deliver a power output of over 1.3 watts.

TENTATIVE RATING AND CHARACTERISTICS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filament Voltage</td>
<td>2.0 volts</td>
</tr>
<tr>
<td>Filament Current</td>
<td>0.260-ampere</td>
</tr>
<tr>
<td>Plate Voltage</td>
<td>135 volts</td>
</tr>
<tr>
<td>Screen Voltage</td>
<td>135 volts</td>
</tr>
<tr>
<td>Control Grid Voltage</td>
<td>13.5 volts</td>
</tr>
<tr>
<td>Plate Current</td>
<td>14 milliamperes</td>
</tr>
<tr>
<td>Screen Current</td>
<td>3 milliamperes</td>
</tr>
<tr>
<td>Plate Resistance</td>
<td>45,000 ohms</td>
</tr>
<tr>
<td>Mutual Conductance</td>
<td>1,400 micromhos</td>
</tr>
<tr>
<td>Amplification Factor</td>
<td>63</td>
</tr>
<tr>
<td>Load Impedance</td>
<td>7,500 ohms</td>
</tr>
<tr>
<td>Undistorted Power Output</td>
<td>650 milliwatts</td>
</tr>
</tbody>
</table>

The '33 utilizes 5 electrodes concentrically arranged in the following order: cathode (filament type), control-grid, screen-grid, cathode grid and plate. The cathode grid is connected to one end of the cathode and serves to practically eliminate secondary emission effects. The screen-grid acts as an electrostatic shield between the control grid and plate elements.

The cathode is an oxide-coated ribbon type filament and it is extremely important that it should not be operated above its normal rated voltage. Fixed grid bias or preferably self-bias may be used with the '33, and its grid circuit should not include more than 500,000 ohms of external resistance.

In order to minimize second harmonic distortion, the '33 should work into a load having substantially constant impedance approximately equal to the rated load impedance of the tube.

RECTIFIER TUBES AND CIRCUITS

Rectifiers are classified as half wave, full wave, and voltage-doubling for the elementary consideration we will give. In the half wave type, rectification such as to cut off one half of the A.C. cycle is provided. In this case, the ripple has a 60 cycle tone, and the gaps as shown in Fig. 153 require considerable filtration for smoothing the resultant pulsating D.C. into a form suitable for use as the supply voltage for vacuum tubes. By connecting two tubes, or a single specially designed tube, in the manner shown in Fig. 154, both halves of the A.C. wave are brought into play, and the resulting tone is 120 cycles. This type of pulsating D.C. is much easier to filter as may be imagined from the sketch.

'80 AND '81 RECTIFIERS

These two tubes are very popular, especially the '80 type which is used in practically every modern radio set today.

'80 Full Wave Rectifier

The '80 is a full-wave rectifying tube intended for use in power supply devices that operate from an alternating current supply.

Filament

The filament of this tube is of the oxide coated type and is designed to operate at 5 volts. The filament current is supplied from one of the windings of a power transformer, the leads to which should be of high current carrying capacity.

Plate

There are two plates in the '80, both designed to operate at voltages no higher than 550 volts A.C. each, which value is permissible only with filter circuits having an input choke of at least 20 henries. Under these conditions it is possible to obtain a D.C. load current of 135 milliamperes. Where ordinary type filters are used lower ratings are indicated below and should all be carefully observed, otherwise the life and performance of the tube may be seriously affected.

CIRCUIT RECOMMENDATIONS

The most generally used full-wave rectifier circuit employing the '80 is shown in Fig. 156A. The filter used may be either of the condenser or choke in-
put types. With condenser input (as shown in Fig. 156B) care must be taken that this input condenser should have a rating sufficiently high to withstand the instantaneous peak value of the A.C. input voltage.

In the case of the choke input method (Fig. 156C) where the input condenser of Fig. 156B is omitted, there will be a somewhat lower available D.C. output voltage for a given A.C. plate voltage than with the condenser input method. However, improved regulation with lower peak current will be obtained. When using 550 volts per plate, this type of filter is necessary as mentioned before and an input choke of at least 20 henries must be used. If desired, a condenser of not more than 0.1-mf. may be used across the input.

**Operating Conditions**

- **Filament Voltage**: 5.0 volts
- **Filament Current**: 2.0 amperes
- **A.C. Voltage per Plate with**
  - 135 ma. D.C. Output Current (max.) 550 volts (R.M.S.) — permissible only with filter circuits having an input choke of at least 20 henries. If desired, a condenser of not more than 0.1-mf. may be used across the input of the filter.
  - 125 ma. D.C. Output Current (max.) 350 volts (R.M.S.)
  - 110 ma. D.C. Output Current (max.) 400 volts (R.M.S.)

**Average Characteristic Curves**

- **Filament Characteristics**—Fig. 155 shows the change of filament current with various filament voltages.
- **Output Characteristics**—Fig. 157 shows the relation of load current to the rectified voltage at various plate voltages when using a condenser input filter.

Fig. 158 shows the relation of load current to the rectified voltage when using a choke input filter. Because of their internal resistance, i.e., the resistance of the path between the filament and the plate, the voltage output varies with the load drawn. For this reason a number of factors enter into the design of a power supply to provide a given output voltage. To begin with, we are at a loss to perform
any calculations until we are certain of the power transformer we intend to use—its voltage output and its regulation—that is, its ability to maintain a constant output voltage across its secondary terminals regardless of the load drawn. Note that a filter may be of either the inductance input or condenser input type. The voltage obtained across the filter output is not so great with the inductance input filter, but the load on the tube is much less, the regulation is better, and the initial surge as the power is switched on is much slighter.

It is this initial surge, by the way, which sends the filter condensers “galley-west” and it ruined more than one manufacturer in the early days of A.C. operation. By all means, if you are building any equipment of your own use the inductance input. It is much easier to explain the process of power supply design by taking an actual example than by “beating around the bush,” so we will assume that we require power for a receiver employing 4 '27 tubes and a '45 as an output tube.

First, we know that the voltage requirements for the power stage are 250 volts plate and 50 volts grid—total, 300 volts. This sets the maximum voltage for our power supply system at 300 volts. Tabulating the rest of the receiver as follows:

<table>
<thead>
<tr>
<th>Number</th>
<th>Tube</th>
<th>Plate</th>
<th>Grid</th>
<th>Total</th>
<th>Total Plate Cur.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 R.F.</td>
<td>'27</td>
<td>135</td>
<td>9</td>
<td>144</td>
<td>9 ma.</td>
</tr>
<tr>
<td>1 Det.</td>
<td>'27</td>
<td>135</td>
<td>variable</td>
<td>144</td>
<td>.1 ma.</td>
</tr>
<tr>
<td>1 A.F.</td>
<td>'27</td>
<td>135</td>
<td>9</td>
<td>144</td>
<td>4.5 ma.</td>
</tr>
<tr>
<td>1 A.F.</td>
<td>'45</td>
<td>250</td>
<td>50</td>
<td>300</td>
<td>34 ma.</td>
</tr>
</tbody>
</table>

The total plate current for all tubes is seen to be 47.6 ma.

We must take into account now the voltage drop through the filter chokes which will have a resistance of at least 500 ohms. Inspection of the regulation curves for the '80 tube will show a voltage output of about 315 volts D.C. at 300 volts A.C. per plate each side of center tap, when the current drawn is 60 ma. at 60 ma., the voltage drop through the chokes is 30 volts (500 ohms x .06-amp). This leaves us a bit less than 300 volts total and we must try again. A load of 55 ma. would give a terminal voltage of 320 and the drop through the chokes would be 27.5 volts. This would leave us just a bit short of our total 300 volts again. The discrepancy does not amount to a great deal and we can continue on this basis—a terminal voltage at the filter output of 293.5 volts, or 290 volts to make things even. We must, however, arrange for a loss of some 7.4 ma. in order to bring our total drain up to 55 ma. This is done by inserting a resistance across the output of such a value as to provide a drain of 7.4 ma. at 290 volts. From Ohms Law (R=E/I or 290/.0074=39189 ohms) we obtain a value for this resistance of about 39,000 ohms.

The next process is to discover where we must place the tap on this resistance in order to obtain 144 volts for our detector and amplifier stages. We desire to drop the output voltage from 290 to 144, or 146 volts—the current for the four tubes receiving this voltage is 13.6 ma. and there are already 7.4 ma. flowing through the output resistance. With this total of 21 ma., the resistance required to give a drop of 146 volts is 6,952 ohms. This means that our output resistance will have a tap at this point to provide the plate voltage for the tubes other than the power tube. This is shown in Fig. 159. If more than a single tap were required we would proceed in the same fashion.

The type '81 is a half-wave rectifier tube with a rating of 700 volts A.C. input and 85 ma. D.C. output permitting D.C. voltages on the order of 600 volts to be obtained from a single wave rectifier, and of 700 volts with a full wave connection. When higher voltages are required it is possible to use a single or full wave voltage doubling arrangement by which voltages of 1000 to 1500 volts may be obtained (using low transformer voltages), two to four '81 tubes being required.
Typical connections and output voltage secured from the '81 in a half wave rectifier circuit are shown in Fig. 160, while Fig. 161 shows similar data for two 81 tubes used in a full wave circuit. When an output voltage under 500 volts is required the first filter condenser should be omitted. The effect of this connection is to greatly reduce the peak current supplied by the '81 tubes, which will run cooler and give much better life service under such conditions. The regulation is also much improved, as may be seen by comparing the output voltage curves.

This latter system of filtering was tried at station 2AQO, in place of a single section filter, with improved results when supplying a Hartley oscillator and especially for phone modulation. The filtering action was better than necessary for crystal controlled operation, some A.C. modulation being found preferable. The input choke in these tests was a 7-henry inductor, the self-inductance being measured with full load current of 85 ma. flowing.

A familiar type of voltage doubling connection was tested (Fig. 162). The voltage regulation was rather poor, as indicated, but for low currents the small amount of apparatus required makes it convenient. The regulation can be improved by using two '81 tubes in parallel on each side as indicated by the dotted lines. The voltage increases rather rapidly below a load of 20 ma., and to prevent it from rising a fixed load (r) is indicated in the diagram. This
may be a 100,000-ohm resistor capable of carrying 20 ma. A milliammeter in series with this resistor is indicated (M.A.), and will give an indication of the output voltage. The scale reading with the resistor specified becomes 100 volts per milliampere; thus a full scale reading of 200 milliamperes indicates an output voltage of 2000 volts.

Much improved results were obtained with the full wave voltage doubling circuit shown in Fig. 163. The adjacent curves show the very high output voltage obtainable with this circuit, and the excellent regulation secured. The high voltage transformer may be a 1400-volt winding center tapped, or two similar 700-volt transformers connected in series. Regulation curves are shown for transformer voltages of 1000 and 1400 volts. The current output should not exceed 170 ma. Three separate filament transformers insulated for the full output voltage are required.

When tested at Station 2ABQ this latter arrangement, with a 10-henry choke, gave slightly better results than the equipment formerly used, a 3000-volt transformer center tapped two 1500-volt rectifiers and a 50-henry choke. The transformer used was a 1200-volt unit, center tapped. The '81 tubes, supplying 100 ma. ran quite cool, the output being well below rated maximum.

The filter condensers, C1, must be capable of withstanding one-half the load voltage as the normal working voltage. A condenser larger than 4 mf. should not be used unless it is possible to close the filament circuit of the rectifier tube before the high voltage is applied. The initial charging surge may overheat the tubes and cause an arc if the filament is allowed to come up to temperature with the high voltage turned on.

The main precaution to be observed in operating the '81 tubes is that of avoiding an overload with respect to plate current. The shorting of the rectifier output, such as may occasionally occur due to the failure of some part of the apparatus (as by the breakdown of a filter condenser) will overload the filament and result in filament failure, unless the current is turned off promptly. An indicating lamp may be placed in the circuit in series with each plate lead adjacent to the plate; if a .15-ampere 6-volt dial lamp is used in this position it will glow at normal brilliancy when the full rated current of 85 ma. is flowing through each tube (170 ma. from a full wave rectifier). Excessive brilliancy of this lamp will immediately indicate an overload on the tube, which can be corrected before damage results.

'66 Half-Wave Rectifier

This new tube was introduced for use in conjunction with the newer high power audio systems such as employed in public address systems, talking picture reproducing equipment, and radio transmitters.

The voltage and current limitations of the '81 type tube are such as to make it unsatisfactory or impractical for use especially where the voltage exceeds 1000 volts with current drains of more than 150 milliamperes.

The Cunningham '66 is a half-wave, hot-cathode, mercury vapor rectifier tube for use in suitable rectifying devices designed to supply D.C. power from A.C. supply lines. This tube is particularly suited for use in the "B" supply of amateur power transmitting equipment where it has been necessary heretofore to use a combination of '81's for such purposes. Full wave rectification is accomplished by using two of these tubes.

**FILAMENT**

The filament of this tube is of the ribbon coated type and should be operated from a filament transformer capable of delivering 5 amperes at 2.5 volts to the filament terminals.

**PLATE**

There is one plate in the '66 and it is in the form of a circular pan mounted above the filament with a cap provided at the top of the bulb for external connection. It is rated at what is known as a peak inverse voltage of 5000 volts (max.). By peak inverse voltage is meant the maximum instantaneous voltage that exists across the plate to filament during that half of the cycle in which the plate is negative with respect to the filament.

**INSTALLATION AND OPERATION**

The 66 is designed for use with the standard X socket and a plate clip. It must be mounted so that it is in a vertical position with the filament end down. Fig. 164 shows details of base and cap connections. This tube is designed to operate without forced ventilation at an air temperature of from 32° to 122° Fahrenheit. Where higher temperatures are encountered, forced ventilation should be provided. As the bulb becomes rather hot in operation, precautions should be taken to prevent any inflammable material or metallic body from making contact.

Upon initial installation, the filament of the '66
The filament should always be operated at rated voltage. Less than this voltage may cause a high tube voltage drop, eventually leading to loss of emission. Greater than rated voltage will shorten the life of the tube.
On account of the high filament current drain, it is extremely important that the socket makes good filament contact and is capable of passing 5 amperes continuously, otherwise high contact resistance will be encountered. The filament voltage should be measured at the terminals of the socket and should be controlled by means of a rheostat placed in the primary circuit of the transformer.

If an inverse peak voltage of more than 2100 volts is used, the plate supply of the circuit should be provided with a time delay relay having a period of at least 30 seconds so that the filament will be allowed to come up to temperature before plate voltage is applied.

In operation, the performance of the '66 is limited by the peak inverse voltage applied to it and by the peak plate current passed through it. The maximum peak inverse voltage should never exceed 5000 volts. This is the safe flash back limit for the '66 operating within its normal temperature range. The maximum peak plate current should never exceed 0.6 ampere.

### TABLE I.

<table>
<thead>
<tr>
<th>Type of Circuit</th>
<th>Number</th>
<th>Input Voltage '66's required R.M.S. volts</th>
<th>Output Voltage D.C. volts</th>
<th>Output Current D.C. amperes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Phase</td>
<td>2</td>
<td>1750 per tube</td>
<td>1570</td>
<td>0.4</td>
</tr>
<tr>
<td>Full Wave (Fig. 165)</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Single Phase</td>
<td>2</td>
<td>1750 per tube</td>
<td>1980</td>
<td>0.22*</td>
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<tr>
<td>Full Wave</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single Phase</td>
<td>4</td>
<td>3500 total</td>
<td>31510</td>
<td>0.4</td>
</tr>
<tr>
<td>Full Wave (Fig. 166)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single Phase</td>
<td>4</td>
<td>3500 total</td>
<td>3960</td>
<td>0.22*</td>
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<td></td>
</tr>
<tr>
<td>Three Phase</td>
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<td>2050 per leg</td>
<td>2400</td>
<td>0.5</td>
</tr>
<tr>
<td>Half Wave (Fig. 167)</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Three Phase</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Half Wave</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Double Y (Fig. 168)</td>
<td>6</td>
<td>2050 per leg</td>
<td>2400</td>
<td>1.2</td>
</tr>
<tr>
<td>Three Phase</td>
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<td>2050 per leg</td>
<td>4800</td>
<td>0.6</td>
</tr>
<tr>
<td>Full Wave (Fig. 169)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Condenser input to filter

The use of a choke input filter is to be preferred to condenser input whenever possible because the peak current demand during rectification is considerably less with the former method.

The terminal connections are shown in Fig. 164.

### OPERATING CONDITIONS

- Filament Voltage: 2.5 volts
- Filament Current: 5.0 amperes
- Maximum Peak Inverse Voltage: 5000 volts
- Maximum Peak Plate Current: 0.6 amperes
- Approximate Tube Voltage Drop: 15 volts

### DIMENSIONS

- Length: 6-5/8"
- Diameter: 2-7/16"
- Base: Large CX

### Raytheon BH Tube

This rectifier was the old time favorite and still finds considerable use today. At one time, there were more than one hundred manufacturers of 'B' supply units, for which the BH tube was standard.

To most service men, this tube is an old acquaintance but as most of the circuits of the eliminators incorporated this tube, we are including it for reference as there is no telling when or where you will meet up with the BH.

The best way to test this tube is to make an adapter or buy one of the Alden Adapters made for this purpose. Fig. 170 shows how to make the connections in the adapter. Be careful that there are no short circuits in the power unit which would place a
dead short through the milliammeter and burn it out. It would be best to use a meter with a 150-ma. range. Place the tube in the adapter and the adapter in the Ratheon tube socket. The milliammeter will indicate the total current being delivered by the tube.

The tube is of rugged construction comprising a glass bulb containing helium gas and internal elements consisting of a hollow cap or cathode and two rods or anodes protruding into the hollow cap and insulated by the short path method of insulation.

![Diagram of tube connections](image)

**FIG. 470**

The ionization of the gas, which is the basis of the rectifying action of the BH tube, takes place inside of the cap and is therefore concealed from view. The only sign of the operation of the tube is in the heating of the glass bulb.

**RATING**

The BH has an output rating of 125 milliamperes with a maximum allowable input voltage of 350 volts R.M.S. per anode. Typical output regulation curves are shown in Figs. 171 and 172. The solid curves in Fig. 171, show the values of D.C. voltage and current delivered to the filter with the circuits shown in Fig. 174, with choke coils $L_1$ and $L_2$ each having inductance values of 15 henries. The broken line curves show the corresponding values when the condenser $C_1$ is increased to 4 mf. The curves in Fig. 172, show the corresponding values when the condenser $C_1$ is omitted. To obtain the value of D.C. voltage delivered by the power unit to the receiver set the D.C. voltage drop in the choke coils must be subtracted from the values shown on the curves. The output voltages will also be affected by the characteristics of the particular transformer used.

Fig. 173 shows the socket terminal connections for the BH tube while Fig. 174 shows the more or less standardized circuit of power supply units which use this tube.

**Raytheon Type BA 350 Milliampere Rectifier**

The BA tube was used extensively several years ago in the radio receivers that had their filaments connected in series. Early model radio sets of the battery type using '01A tubes with the filaments connected in parallel could be converted into electric sets by changing the filament circuits over to a series arrangement as indicated in the revised circuit of the A.K. 30 shown in Fig. 175.
DESCRIPTION

The tube makes use of the ionized helium method of rectification.

RATING

Maximum A.C. Input Voltage (per anode) 350 R.M.S. volts.
Maximum Rectified Output (both anodes) 350 milliamperes.
Maximum Output Voltage, 250 volts.

Fig. 177 shows the voltage regulation curves of the BA. The voltage drop through the tube with an increase in the load is not as great in the new models of this tube as it was in the old. Thus the new tubes have much better output regulation. The BA tube is not recommended for loads of less than 200 ma., its range of efficiency lying between 200 and 350 ma. The conventional circuit of an ABC power unit is indicated in Fig. 178.
### Detector and Amplifier Tubes

<table>
<thead>
<tr>
<th>TYPE</th>
<th>USE</th>
<th>BASE</th>
<th>MAX. OVERALL DIMENSIONS</th>
<th>FILAMENT SUPPLY</th>
<th>FILAMENT VOLTAGE</th>
<th>FILAMENT CURRENT</th>
<th>SCREEN VOLTAGE</th>
<th>GRID BIAS</th>
<th>CURRENT</th>
<th>PLATE SUPPLY</th>
<th>PLATE VOLTAGE</th>
<th>PLATE CURRENT</th>
<th>PLATE FACTOR</th>
<th>PLATE RESISTANCE</th>
<th>SCREEN CURRENT</th>
<th>SCREEN RESISTANCE</th>
<th>GRID CURRENT</th>
<th>GRID RESISTANCE</th>
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<tbody>
<tr>
<td>6F7</td>
<td>DETECTOR AMPLIFIER</td>
<td>UX</td>
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<td>1/16</td>
<td>4 1/2</td>
<td>1/16</td>
<td>3.3</td>
<td>0.063</td>
<td>DETECTOR</td>
<td>90</td>
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<td>2.5</td>
<td>6.6</td>
<td>1500</td>
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<td>1/16</td>
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<td>3000</td>
<td>670</td>
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<td>1/16</td>
<td>4 1/2</td>
<td>1/16</td>
<td>5</td>
<td>0.25</td>
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<td>8000</td>
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<td>6F10</td>
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<td>1/16</td>
<td>4 1/2</td>
<td>1/16</td>
<td>5</td>
<td>0.25</td>
<td>DETECTOR</td>
<td>180</td>
<td>9</td>
<td>0.5</td>
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<td>1000</td>
<td>330</td>
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<td>1/16</td>
<td>4 1/2</td>
<td>1/16</td>
<td>5</td>
<td>0.25</td>
<td>AMPLIFIER</td>
<td>180</td>
<td>15</td>
<td>0.5</td>
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<td>4 1/2</td>
<td>1/16</td>
<td>1.5</td>
<td>1.5</td>
<td>AMPLIFIER</td>
<td>180</td>
<td>15</td>
<td>0.5</td>
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<td>1000</td>
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<td>4 1/2</td>
<td>1/16</td>
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<td>AMPLIFIER</td>
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<td>15</td>
<td>0.5</td>
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<td>1000</td>
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<td>6F14</td>
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<td>UX</td>
<td>4 1/2</td>
<td>1/16</td>
<td>4 1/2</td>
<td>1/16</td>
<td>5</td>
<td>0.25</td>
<td>AMPLIFIER</td>
<td>180</td>
<td>15</td>
<td>0.5</td>
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<td>4 1/2</td>
<td>1/16</td>
<td>5</td>
<td>0.25</td>
<td>AMPLIFIER</td>
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<td>15</td>
<td>0.5</td>
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<td>1000</td>
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</tr>
<tr>
<td>6F16</td>
<td>POWER AMPLIFIER</td>
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<td>1/16</td>
<td>4 1/2</td>
<td>1/16</td>
<td>5</td>
<td>0.25</td>
<td>AMPLIFIER</td>
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<td>15</td>
<td>0.5</td>
<td>50</td>
<td>1000</td>
<td>330</td>
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### Rectifier Tubes

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<th>No Filament</th>
<th>Gas Type</th>
<th>No Filament</th>
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<td>6F18</td>
<td>UX</td>
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<td>1/16</td>
<td>350</td>
<td>0.125</td>
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<td>6F19</td>
<td>UX</td>
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<td>1/16</td>
<td>350</td>
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<td>6F20</td>
<td>UX</td>
<td>4 1/2</td>
<td>1/16</td>
<td>350</td>
<td>0.125</td>
</tr>
</tbody>
</table>

### Arcturus 15-Volt Tubes

<table>
<thead>
<tr>
<th>Type</th>
<th>Plate Voltage (V)</th>
<th>Plate Current (mA)</th>
<th>Plate Resistance (ohms)</th>
<th>Grid Bias (volts)</th>
<th>Amplification Factor (mu)</th>
<th>Mutual Conductance (Gm) or Transconductance (Ohms)</th>
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<tbody>
<tr>
<td>RA-1</td>
<td>120</td>
<td>15</td>
<td>105</td>
<td>1.5</td>
<td>1.5</td>
<td>600</td>
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</tbody>
</table>

### Kellogg 2 1/2-Volt A.C. Tubes

<table>
<thead>
<tr>
<th>Type</th>
<th>Plate Voltage (V)</th>
<th>Plate Current (mA)</th>
<th>Plate Resistance (ohms)</th>
<th>Grid Bias (volts)</th>
<th>Amplification Factor</th>
<th>Mutual Conductance (ohms)</th>
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<td>15</td>
<td>105</td>
<td>1.5</td>
<td>1.5</td>
<td>600</td>
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</tbody>
</table>

---

**Arcturus:** An example of a tube is the Arcturus 15-Volt tubes, which have four terminals in the base. The cathode is connected on one side of the filament. The Arcturus 15-volt tubes have a terminal similar to the Arcturus 48. The Arcturus 15-volt tubes are equivalent to two 48s.

**Kellogg:** The Kellogg 2 1/2-Volt A.C. tubes are designed to deliver to the filter a current of 400,000 amperes at 1,000,000 volts, and their filament consumption is 400,000 amperes at 6.5 volts. The plate current is 150,000 amperes at 300,000 volts.
THE public acceptance of the auto radio opens a new source of revenue for the service man. It is important that the service man understands the peculiar conditions which exist in the installation and servicing of these sets. For this reason the Editors have selected the most interesting and informative data compiled by the various manufacturers of this equipment during years of test and research.

THE ANTENNA

Differences in Antennas.

In considering the antenna system, it is safe to say that there are as many different types of antennas as there are different types of cars. No two types are the same either in physical dimensions or in electrical characteristics. The antenna which will perform most efficiently in one type of car will give very different results in another. To understand the difficulties which must be overcome in each individual installation, it is necessary to understand certain fundamental laws which govern receiving antennas.

The Function of the Antenna.

When a distant broadcasting station is in operation, the electromagnetic lines of force radiated from the station's antenna impinge upon the car antenna and induce in it radio-frequency oscillations which pass through the receiver and are reproduced by the speaker in the form of voice or music. It will be seen therefore that the antenna is a collector of electrical energy. Each passing wave radiated by the broadcasting station striking the antenna creates a difference of potential between the antenna and the ground which is equal to the length of the antenna multiplied by the intensity of the passing wave.

The Most Efficient Antenna.

Up to certain limits a large antenna will deliver greater signal strength than a small one. The current flow in a receiving antenna is directly proportional to its length and to its effective height and inversely proportional to the resistance of the antenna. In simple language, this means that best reception is secured when the largest possible antenna is installed in the car top, when it is farthest separated from the ground, and when the antenna and lead-in wires are securely soldered and offer the least possible resistance to the flow of antenna current.

The Effective Height of the Antenna.

It must be understood that the effective height of the antenna does not necessarily mean the distance between the flat-top portion of the antenna and the earth. In the automobile, no earth connection is possible. In the automobile installation, the chassis of the car is used as a counterpoise which in a sense performs the same function, although not as efficiently. The effective height of the antenna, therefore, is the distance between the antenna and any metallic portion of the car.

Physical Dimensions of the Antenna and the Ground Connection.

It will be seen that the physical dimensions of the car antenna must necessarily be limited, depending in each case on the type of the car and the construction of the body. It cannot be concluded that the most efficient antenna is to be secured by filling up the car roof with antenna screening. The trend of modern car design is toward all-metal body construction and as the over-all dimensions of the antenna are increased, the effective height is reduced. If the antenna approaches too close to the metallic body of the car, or to the dome light or associate wires located in the car roof, the efficiency of the antenna decreases in proportion to the separating distance. It will be seen, therefore, that some limit must be made in the antenna dimensions.
The Dome Light and Associate Feed Wires.

Experiments conducted over a period of four years have established the fact that the antenna should be separated from the metallic body of the car by at least three inches. It is well to note at this point that wood bodies do not offer this objectionable feature. The antenna screening must be cut out around the dome light and properly spaced from the mounting plate to prevent high frequency leakage. Precaution must be taken to see that the feed wires running to the dome light do not touch the antenna screening. These wires are usually insulated but they should never be allowed to rest upon the antenna. They should be fastened to the extreme upper portion of the bows to reduce the possibility of antenna leakage. See Fig. 179.

Antenna Requirements for Limousine and Town Car.

The antenna and lead-in requirements of the limousine and town car differ slightly from the above. The limousine is divided into two sections, the forward compartment for the chauffeur and the rear compartment or tonneau for the owners and their guests. These compartments are separated from each other by a heavy glass window for the privacy of the passengers. As the dividing framework extends to the roof, it becomes necessary to install two separate antennas, one in front and one in the rear section, which must be connected together by wires extending through holes drilled in the dividing partition. Three wires are usually sufficient to bond the two sections of the antenna together. As the separating framework is usually constructed of metal, care must be taken that the two sections of the antenna do not approach closer than three inches to the structure.

The Lead-in and Antenna Leakage.

The lead-in wire offers another problem which must not be considered lightly. This wire, which extends from the flat-top portion of the antenna to the receiver behind the dash, must by force of circumstances run parallel with and close to the metal side post of the car. This close relation offers a path of leakage between the antenna and chassis which is objectionable and should be reduced to a minimum. By virtue of the capacity existing between the two, it also tends to destroy the electrical balance of the receiver. This in effect reduces the over-all efficiency and results in weaker signals.

Cars Equipped at the Factory with Antennas.

A number of car manufacturers are equipping certain models of their cars with antennas. Most of these cars will be marked with a sticker placed on the windshield indicating that the car is equipped with an antenna for operation with Transitone radio. Where this is not indicated by means of a windshield sticker, an investigation will show the lead-in from the antenna running down the right front body post and tucked under the cowl.

In some cases where time for installation is at a premium, and where the rear portion of the limousine is large enough to accommodate an efficient antenna, the forward section of the car may be disregarded. In this particular case, as in the case of the town car where the forward section is not roofed over, it becomes necessary to deviate from the standard system of running the lead-in wire. In these cases the lead-in is brought down at the front corner post of the rear section. Here the same precaution must be observed as in the sedan and coupé to see that the lead-in wire is run in non-metallic insulating housing. The lead-in should extend to the floor, where it is carried forward to the instrument board in a chiseled groove out in the floorboard.

Care must be taken that this lead-in is not run under the metal sill of the front door, as the sill is usually grounded. Such a procedure may materially overload the antenna system and destroy the electrical balance of the receiver. It is sometimes more convenient to carry the lead-in underneath the body of the car. In this case it is necessary to use non-metallic insulating housing as a protection against moisture and abrasion to which the under side of the car is subjected. This housing should extend above the floorboard at the front end and be rigidly supported.

The Metal Roof and Its Effect on Radio Reception.

It has been previously mentioned that the trend of modern car construction is toward an all-metal body. This refinement in body design is also carried to the car roof by many manufacturers. In a great many
cases the fabric of the roof is supported by an iron wire mesh which is laid on top of the wooden bows. In some cases the bows themselves are of metal. This metallic screen extends to the sides of the car and is usually grounded to the body.

This particular feature, while advantageous to the body-builder, offers a serious obstacle to the operation of a radio receiver in a motor car. In effect the iron wire mesh which supports the fabric roof, so sufficiently shields the antenna installed in the car that it prevents the operation of the receiver. The passing electromagnetic waves radiated by a broadcasting station strike the grounded screen supporting the fabric top and pass directly to the ground. The iron mesh effectively shields the antenna and prevents the flow of antenna current. Obviously the practical solution to the problem is to remove the iron wire mesh before installing the car antenna or install capacitor plates under the running board. Fig. 180 shows how plates are mounted under car.

Supporting the Top-Fabric.

The purpose of the iron wire mesh must not be overlooked. It is placed over the bows of the roof to support the fabric top. Removing the mesh, while aiding the reception of radio broadcasting, defeats the purpose for which it was intended. In order to prevent the top from sagging, a practical substitute must be provided. This is accomplished by stretching upholsterers’ webbing over the tops of the bows.

The exact number of webbing strips and their location in respect to one another are of considerable importance if the fabric is to be effectively supported. It has been found that eight or nine strips are necessary on cars having a bowed roof. On this type of roof, the webbing must not be separated by more than half an inch. If this requirement is neglected the roof will sag in unsupported portions. On flat roofs the webbing may safely be separated by two inches.

Installing the Closed Car Antenna.

The installation of the closed car antenna may be briefly summarized as follows:

It will be necessary to unfasten the front and sides of the headlining, the back end remaining untouched, then carefully remove the tacks from the listing strips, which are the muslin strips used to support the headlining at the bows.

Cut the iron mesh as closely as possible to the sides, front, and back of the car. Particular care must be observed that no sharp protruding wires are exposed which may cut into the top-fabric or headlining.

Remove the iron mesh as well as the staples which are used to fasten it to the top of the bows. It will be found convenient to remove the mesh in small sections.

Stretch the upholsterers’ webbing from the back to the front of the car on top of the bows. The number of strips to be used depends on the type of car, as outlined before.

The Screen Antenna.

Tack the copper antenna screen securely into position, making sure that it is separated from the dome light and the metal body of the car by at least three inches. See that lighting wires in the roof are separated from the antenna screen as far as possible. Securely solder the lead-in wire to the proper corner of the antenna screen.

Testing the Antenna for Possible Grounds.

Test the antenna for possible ground by means of a voltmeter and battery. This test should be made from the antenna lead-in to any metallic portion of the chassis, preferably the gear shift lever.

Carefully replace the car headlining, working from the middle of each listing strip, progressing toward the front of the car. After the listing strips are in position the sides and front of the headlining should be replaced.

Run the lead-in as previously outlined.

Retest the antenna for possible ground.

The above installation data refers exclusively to closed cars of metal body construction having wood bows. Cars having metal bows do not come under the above classification. The antenna system used in this type of car will be discussed later.
Antennas for Roadsters and Touring Cars.

In cars of the open type, i.e., touring cars, roadsters, etc., the method of installing the antenna differs considerably from that of the closed type car. This is due to the fact that the tops of these cars are designed to fold back. It will be seen, therefore, that the employment of a copper screen is out of the question. It will also be seen that the antenna lead-in cannot be taken off the front portion of the antenna.

The most satisfactory antenna for this type of car consists of from 65 to 100 feet of No. 18 gauge rubber-covered stranded wire, laced in grid formation in drill cloth and sandwiched between the top of the car and a head-lining of the same material. If the car is not already equipped with a head-lining, the extra material may be procured from the local dealer in automobile fabrics. The stranded wire should be woven back and forth through holes punched in the drill cloth and be so located that the parallel sections of the wire do not approach closer than three inches to each other. The total length of the antenna wire depends upon the dimensions of the top. The touring car will naturally require more wire than the roadster.

The Lead-In of the Roadster and Touring Car.

The antenna lead-in in this type of installation must be taken from the back end of the car. It may be carried to the dash in a groove cut in the floor-boards, or it may be run underneath the body of the car. (Refer to lead-in description of Sedan.) The antenna lead-in should always be run on the set side of the dash. If the lead is carried through the motor compartment it may be difficult to eliminate the ignition disturbances.

Installing the Open Car Antenna.

The installation of the open car antenna may be briefly summarized as follows:

- Remove the top covering of the car, leaving underside flaps in place.
- Cut a piece of drill cloth approximately 3 inches smaller than the width of the top and equal in length to the top.
- Procure from the local dealer sufficient top material to construct a false top or head-lining. This material should match the top-fabric and be cut to the same length and width.
- Secure this top material in its proper place over the cross-ribs and over the side flaps left exposed by removing the top-covering.
- Fasten the drill cloth in which the antenna wire has been woven. This should be tacked to the bows at the front and rear of the car only.
- Solder the antenna lead at the back end of the car.

Replace the top-covering.
Run the antenna lead as mentioned above.
Test the antenna for possible ground.

NOTE: It should be seen that the antenna wire is not allowed to approach closer than three inches to the top of the windshield. This frame is constructed of metal and if the antenna is not properly located, high frequency leakage will take place. In the event the bows are of metal construction, it must be seen that the antenna wire does not rest upon the bows. The same three-inch separation must be observed here if efficient operation is to be secured.

The Antenna for Cars Having Metal Bows.

As has been previously mentioned, the trend of modern car design runs toward all-metal body construction. In some cases, as in the Dodge Victory Six, the bows are made of this material. Considering the high frequency leakage and the shielding effect that exists when the antenna is located too closely to the metallic body, it will at once be seen that the copper screen will not constitute an efficient antenna in bodies of this particular construction. Here, as in the open car, the only logical solution to the problem is to resort to the insulated stranded wire antenna properly separated from the metal bows. A number of staples or screw-eyes should be securely fastened around the top frame of the car and separated from the metal bows by not less than three inches. As the top frame is relatively close to the metal body, the stranded antenna wire must not be laced directly through the staples or screw-eyes. A section of heavy twine must be tacked to the top frame, and carried through the screw-eyes or staples in loop fashion. These loops must be long enough to afford the proper separation from the metal structure, after which the antenna wire should be laced grid fashion through the twine loops. No special requirements for the antenna lead-in are necessary.

THEORY OF INTERFERENCE

ELIMINATION

In order to fully understand the application of the elimination system it is necessary to consider in a general way the cause of the electrical disturbances.

The Cause of Electrical Disturbances.

In considering the ignition system of the car with its ignition coil to supply high voltage to a series of spark plugs, one important fact cannot be overlooked. The system is, in every sense of the word, an exact duplication of a radio spark transmitter.
The ignition system, therefore, is a radio transmitting station located directly under the antenna of the automobile receiver. Fig. 181A indicates electrical circuits of the average motor car.

**Function of the Interference Suppressor.**

When the ignition system is in operation, the high tension current sets up a series of electromagnetic and electrostatic fields about the high-tension wires which are propagated through space at the speed of light. These fields or impulses, due to the arrangement and physical dimensions of the ignition system, assume a more or less definitely tuned characteristic which is most pronounced over the lower dial settings. It is obvious that if this disturbance is to be avoided, the radiating characteristic of the energy must be reduced or destroyed. The reduction of the undesirable radiated energy is brought about by the introduction in the radiating circuits of units which have been designated as ignition interference suppressors. (Fig. 181B.) These are mounted in series with the high-tension leads directly at the plugs and distributor-head and effectively reduce the disturbance without in any way affecting the performance of the engine. Fig. 181C shows position of various resistors and condensers used in suppression systems.

**The Magnetic Field.**

To understand the function of the unit designated as an interference eliminator, it is necessary to consider the location of the source of the disturbance and its position in respect to the receiver and associated equipment. It will be noted that the high-tension wires of the ignition system are surrounded by the engine, hood, radiator, cowl and engine partition. This metal structure constitutes a shield which surrounds and confines a powerful magnetic field. The receiver, which is located on the instrument board and separated by the cowl and engine partition, is therefore shielded. The actual shielding, however, is more apparent than real. In many of the late model cars the ignition coil is mounted on the instrument board side of the engine partition or on the instrument panel. It will be seen, therefore, that in these particular cases the shielding effect of the engine partition will have little effect on the receiver. In this case the magnetic field is not confined to the engine compartment.

**Possible Sources of Disturbances.**

The wiring system of the car and the mechanical arrangement whereby the various units of the power plant are operated from the instrument board are also important factors which reduce the shielding effect of the engine compartment. The numerous heat rods, choke rods, thermostat lines, and oil pipes which are carried through the engine partition as well as the necessary wires incorporated in the lighting and ignition systems offer conducting paths which in some cases may cause considerable interference.

**Grounding the Choke Rods, etc.**

It is possible in the case of the metal conductors (oil pipes, choke rods, etc.), to eliminate them as a possible source of disturbance by grounding them to the frame of the car at the motor side of the partition. These leads must be as short and direct as possible, otherwise they may defeat the purpose for which they are intended.

**Locating the Source of Disturbance.**

The method employed in determining the conductor which is responsible for the disturbance is a relatively simple one. The various pipes and rods extending through the engine partition should be temporarily grounded to the metallic structure by means of a screw-driver or other convenient tool. This grounding should be done while the motor is running and the set is in operation, with the hood closed and with the hood clamps fastened.

**Interference Eliminators.**
This method of bonding or grounding the various conducting paths which allow the transfer of energy from the engine compartment to the receiver cannot be applied to the various wires which pass through the engine partition. Such an attempt to prevent the passage of undesirable impulses would result only in short-circuiting and grounding the wiring system of the car. For this particular purpose interference eliminators are introduced into the circuit.

Electromagnetic Induction.

At this time it becomes necessary to describe the theory involved whereby the magnetic field surrounding the high tension wires of the distributor and ignition systems is carried to the receiver by means of the various pipes and wires running
through the engine partition. In engineering parlance this transfer of energy is described as Electromagnetic Induction. It may be defined as the process by which electrical energy is transferred from one circuit to another by means of electromagnetic lines of force of varying density or changing strength. To the layman, it is only necessary to state that when the current in one conductor is changing at a unit rate per second, it induces similar currents in wires or conductors which are in close relation to its magnetic field.

The Isolation of High-Tension Wires.

It will be seen from the above that the most convenient and effective method of preventing the transfer of energy from the motor compartment to the receiver is to separate all the low-tension wires of the car as far as possible from the high-tension wires of the ignition system. Many car manufacturers utilize the high-tension manifold as a convenient place in which to run the horn wire and the low-voltage lead extending from the primary winding of the ignition coil to the distributor. The close proximity of these leads will cause the condition described in the preceding paragraph. The lines of force surrounding the high-tension plug wire will induce a corresponding intermittent pulsation in the low-tension wire of the coil which will in turn induce similar pulsations into the receiver by means of the wire which extends from the coils to the ignition lock. The horn wire extending to the button on the steering column may contribute to the disturbance, although not to as great a degree, as this wire is usually located at a considerable distance from the receiver.

The High-Tension Manifold.

The obvious remedy in cases of this kind is to remove the horn and low-tension ignition leads from the high-tension manifold.

Suggested Remedy.

If necessary, these wires must be lengthened and relocated at a position which will remove them from the limit of the magnetic field.

The Low-Tension Distributor Wires.

Another serious source of disturbance is caused by the fluctuating magnetic field which surrounds the wires associated with the low-tension side of the distribution system. These wires which run from the ignition switch to the coil and to the breaker-points in the distributor-head, carry a low-tension current of an intermittent character. As the breaker-points open and close, the magnetic field surrounding these wires builds up to maximum and then suddenly collapses, at which time the collapsing field induces a back or counter-electromotive force which may build up to infinity. This intermittent characteristic of the current flowing through the wires, together with the fluctuating field surrounding the same, may cause considerable disturbance in the reproduction of the broadcast program.

Function of the Interference Eliminator and Method of Application.

It will be seen, therefore, that in order to secure reception which is free from interference, it will be necessary to filter or smooth out the fluctuations or pulsations of the current flowing in these wires. This is accomplished by means of the interference eliminators which may be mounted in a convenient position on the engine partition or instrument board of the car. These must be connected by short leads. One terminal of the eliminator should be connected to the wire causing the disturbance and the other terminal to the metallic structure of the car.

Locating the Offending Wires.

This is accomplished by using an interference filter unit as an exploring unit. Flexible leads about five or six inches in length are attached to the terminals of the unit. It may be desirable to fasten clips to the ends of the leads to afford a convenient temporary connection. To detect the offending wire it is only necessary to progressively connect one lead of the exploring unit to every accessible wiring terminal that can be located underneath the cowl or at the engine partition. The other terminal of the unit is connected to the metallic structure of the car. When the interfering lead is located, the spark disturbance will disappear entirely or be considerably reduced. This experiment must be conducted while the receiver is in operation and tuned to a relatively short wave-length, and the car motor is running, with the hood down.

Location of Interference Filter Units.

For the information of the operator or the radio man who is called upon to test the receiver at the completion of the installation, it may be well to designate the places where interference filter units are most frequently required. It must be understood, however, that the use of these units is the exception rather than the rule. In the average installation the standard elimination system successfully overcomes the disturbances of the generator and ignition systems of the car.

The Ammeter.

The most usual location for the interference filter
The interference filter unit is frequently needed. This is due to the fact that in some cases the connection leading to the dome light is taken off the terminal of the cigar lighter. The filter unit is to prevent the passage of energy to the antenna screen which may be induced in the lighter circuit by a stray magnetic field underneath the cowl. In testing the receiver, care should be taken that the dome light is turned on and off. In some cases where no spark disturbance is present, completing the circuit to the dome light by turning on the switch will cause the spark to appear.

The Ignition Switch.

The ignition switch is another location where an interference filter unit is sometimes necessary. This is used to smooth out the fluctuations of current due to the interruption of the circuit by the breaker-points.

NOTE: Considerable caution should be exercised in attaching filter units to any part of the low-tension side of the ignition system. The introduction of a unit at the wrong point in the system may slow up the motor.

Horns, Fans, and Windshield Wipers.

There are other electrical disturbances originating from entirely different sources which may be desirable to eliminate. These may be caused by motor-driven horns, windshield wipers, electric fans, etc. The elimination principle in these cases is similar in every respect to the above. The interference filter unit is mounted close to the disturbing accessory and connected between it and the ground. In these cases, however, the terminal leading to the accessory must be connected to the wire leading to the battery or ammeter.

NOTE: It must be understood that all of the above mentioned interference elimination requirements are never needed for any one motor car. The mechanical and electrical design of the car will determine the number of units which must be used.

The Ignition Coil on the Instrument Board.

Mention has been made of the ignition coil which in some cases is mounted on the instrument board side of the engine partition. This particular mounting arrangement calls for a slight deviation from the accepted method of interference elimination. It will be seen that in cases of this kind the magnetic field is not confined entirely to the engine compartment. A considerable field surrounds the exposed high-tension lead which runs in the immediate vicinity of the receiver and the various connecting wires. In order to overcome the disturbing effect of this magnetic field, certain additional requirements are necessary.

In many of the cars in this class, foremost of which are the Packard, Franklin, Oldsmobile, Marquette, De Soto, Viking, Dodge, and Chrysler, it will be necessary to enclose the high-tension lead which extends from the center tap of the ignition coil to the distributor-head in a copper braid. This effectively confines the magnetic field and prevents any transfer of energy to the receiver or associate wires. The braid must extend from the ignition coil to the motor side of the engine partition and be grounded to the car structure at both ends. In some cases, where the ignition switch and coil are not made up in an integral unit, the coil may be re-located on the motor side of the engine partition.

Wooden Engine Partitions.

It must be observed that in some of the cars the engine partition is constructed of wood. In these particular cases the partition must be covered with galvanized sheet-iron and be grounded to the chassis in several places. This may most conveniently be done on the instrument board side of the engine partition. The Nash and Auburn afford the most common examples of this body construction.

The Distributor and Breaker-Points.

It is not unusual, especially in the case of cars which have been on the road for a considerable length of time, to find that the interference elimination methods thus far outlined do not reduce the disturbance below an objectionable level. The noise usually manifests itself in intermittent surges or crackling sounds resembling static which bear no relation to the uniform discharge of the spark plugs.

This disturbance is usually caused by a dirty condition of the distributor. Examination will show that in many cases the breaker-points are dirty and pitted, that the distributing arm and stationary electrodes are oxidized, and that the entire assembly is covered with a film of oil. This unhealthy condition offers a path of leakage for the high-tension currents and prevents the immediate quenching of the low-tension spark which takes place when the breaker-points are opened. It is necessary therefore that the distributor be wiped clean of oil and the electrical members which comprise the unit be placed in a perfect condition.

In some particularly stubborn cases where the intermittent character of the disturbance indicates that the trouble is caused by the distributor, a generator
interference filter unit connected across the breaker points may overcome the disturbance. At other times the introduction of the unit at this point may intensify the volume. It has been found in cases of this kind that an additional unit located at the ammeter may reduce the disturbance to zero.

This last illustrates one of the peculiarities of interference elimination. No set rule may be designated which will eliminate the disturbing interference in every case. The system whereby the disturbance may be overcome in one case may serve to intensify the condition when applied to another. It is only necessary, however, to know that the aforementioned elimination methods, when intelligently applied, will successfully overcome the ignition disturbances in any type of car.

**GENERAL TESTS FOR AUTO RECEIVERS**

**Power Supply ("A" and "B" Batteries and Connections).**

(A). Check connections at the storage battery. Make sure that there is no looseness or corrosion present at the terminals. Note that the polarity of the filament leads is correct.

(B). Check voltage of the storage battery with the set turned on, motor not running, and the car lights off. The correct reading should be 6 volts. A reading of less than 5.6 volts indicates a discharged battery or faulty connection.

(C). Check voltage of the "B" batteries. Each 45 volt unit that shows a terminal voltage of less than 35 volts should be discarded.

**Input System (Antenna in Car Roof).**

(A). Test for shorts between antenna and the metal body of the car.

(B). Test for open in the lead from the antenna in roof of car to set.

**Input System (Capacitor Plate Method).**

(A). Check connection of the shielded lead to capacitor plate.

(B). Check capacitor plate for grounds against car frame. Make sure that the shielding of the input cable does not touch the capacitor plate. Clean off any mud or dirt which may collect on the capacitor plate insulators.

(C). Check condition of tubes by using an analyzer to make the "tube test" or substitute tubes known to be good. Use standard tube checker if handy.

**Chassis.**

Check R.F., Det. and A.F. tubes with set analyzer. Proceed in the manner of checking the various circuits as explained in the section devoted to servicing radio receivers.

**WEAK RECEPTION**

**Low "B" Battery Voltage.**

As the "B" batteries drop in voltage a slight falling off in the sensitivity of the receiver will be noticed. Batteries as low as 35 volts must be replaced or noisy reception and poor tone will result.

Occasionally, due to some defect or misuse, one battery may drop excessively in voltage. While the total "B" supply may be between the correct limits, the extremely poor condition of the one battery may cause poor reception. In such an extreme case it is necessary to measure the voltage of each individual battery to locate this defect, and, of course, replace the defective battery.

**Low "A" Battery Voltage.**

This source of trouble is uncommon due to the fact that it seriously affects the operation of the car and is, therefore, immediately noticed and corrected. However, there may be difficulty due to a poor connection at the battery causing low voltage at the receiver. Make sure that all "A" connections are clean and tight.

**Capacitor Plate or Antenna Disconnected.**

The shielded lead from the receiver may be broken or disconnected at either end. Weak reception will result if the capacitor plate is grounded at any point. Make sure that the shielding of the "lead-in" cable is not touching the plate, and that the insulators are not broken.

**Condenser Misalignment.**

Poor condenser alignment may be caused by lengthwise movement of the rotor assembly or one of the stator plates. The setting of the alignment condensers may also have been altered. Make sure that the rotor plates are accurately spaced between the stator plates and that they have not become bent or damaged. The alignment condensers may generally be checked or adjusted without disturbing the set. The receiver should be tuned preferably to a station coming in from 20 to 50 on the dial. Do not, however, attempt to make this adjustment until every other possible source of trouble has been carefully checked.

**Speaker Adjustment.**

Very weak reception will result if the speaker is enough out of adjustment to allow the armature to rest against the pole pieces. A broken joint in the
Incorrect linkage between the armature and the actuating pin will produce the same effect. Fig. 182 shows correct armature position for no signal condition.

Chassis Defects.

Poor reception may be caused by certain defects in the chassis which can best be located by checking socket voltages with the set analyzer as outlined under "General Test."

**NO RECEPTION**


This condition is obviously indicated by the fact that the tubes and dial light do not light. Battery switch defective. Battery cable open.

Open "B" Connection.

Measure "B" voltages and inspect the "B" connection as outlined under "General Test."

Defective Tubes.

Inspect the tubes for burn-outs or poor contact in the socket. Test the tubes as previously explained under the heading "General Test."

Speaker.

Check the loud speaker on another set or touch its terminals across a radio "C" battery. A click indicates that the speaker is not "open."

Defect in Chassis.

See "General Test" for method of completely checking chassis circuits.

**POOR TONE QUALITY**

Low or Open "B" Battery.

When "B" batteries are allowed to drop below 35 volts per unit before being replaced there is likelihood of poor tone resulting, accompanied sometimes by a slight whistle. Check voltages as outlined under "General Test."

Defective Tubes.

A defective tube, particularly in the detector or audio stage, will cause very poor tone. This condition can be checked by means of the set analyzer or by substituting tubes known to be good.

Speaker Out of Adjustment.

Rattles in the speaker are caused by loose parts or by the armature striking the pole pieces. Refer to the section on the "Loud Speaker."

Defect in Chassis.

There are certain defects in the chassis which may cause poor tone. Open "C" bias resistors will cause weak and distorted reception. Use the set analyzer to check all socket voltages as outlined under "General Test."

**NOISE OR INTERFERENCE**

Defective Tube or Socket.

Poor welds or loose elements in the tubes themselves may cause intermittent noise due to the vibration of the car. Poor contact in the sockets will also produce the same result. To locate this trouble, remove the tube shield and jar the tubes vigorously while the set is operating. The defective socket or tube will immediately become apparent through the noise produced.

Loose Connection in Radio Installation.

A loose connection or partial "Ground" in the radio installation will cause irregular interference.
and noise. The trouble can best be located by inspecting all wiring and connections, particularly at the capacitor plate and batteries.

**Ignition Interference.**

This type of interference is a regular succession of popping noises, especially evident when the motor is idling. The resistance in the spark coil and spark plug leads, as already mentioned, will eliminate this interference except in special cases. As a remedy a 1.0 microfarad condenser may be connected from one of the ignition switch terminals to "ground" or from one of the low tension terminals of the ignition coil to "ground." The proper terminal is best determined by actual trial.

**Generator Interference.**

A one microfarad condenser connected from the generator terminal to "ground" will eliminate ordinary generator interference. A dirty commutator or worn brushes may cause an excessive amount of interference which can only be eliminated by repairing the generator.

Acknowledgement and thanks are hereby expressed to the following for their kind permission to publish in whole or in part material from their files:

- Automobile Radio Corp., N. Y.
- Transitone Corp. (Philco)
- United American Bosch Corp.

The new Atwater Kent automobile receiver can be easily installed in any automobile. It has a specially developed tuned radio frequency circuit employing seven tubes, with push-pull amplification, one bank of three condensers, automatic volume control, illuminated remote control, and a large-size improved electro-dynamic speaker.
SOUND PICTURES AND THE SERVICEMAN

Trained men capable of servicing "Talkie" equipment are finding this field a profitable one. The larger manufacturers of this type of equipment maintain large service organizations for the theater owners and, of course, prefer to have their units serviced by their own men. Many small houses use less costly equipment and, of course, furnish their own service. This is the best point of attack for the independent service man. In many small cities, one man services all the theaters. Some theater owners "chip in" and employ a man to service two or more theaters, thus reducing their individual service expense.

The following paragraphs offer a brief explanation of the principles involved in the recording and reproduction of sound and a general discussion covering the troubles encountered in servicing the equipment. No attempt has been made to make this section anything more than an outline, because space will not permit the inclusion of everything that could be said on the subject.

Sound.

Sound may be considered as a series of vibrations of the air of such frequency or pitch, that it creates the sensation of hearing to the human ear. When the air is set in motion by any means whatsoever sound is produced, provided that the frequency of the vibrations are audible. An interesting chart is shown in Fig. 183 indicating the frequency range of various sounds and noises and their relation to the musical notes of the piano for comparison.

Sound Recording On Film by the Variable Density Method.

There are two methods in common use in recording the sound on the film. The method called "variable density" recording has the entire sound track exposed, and the amount of light passed through it is varied by regulating the amount of exposure. The voice or sound causes a variation of the electric current flowing in the microphone circuit. These variations are magnified by the amplifier and operate a shutter or 'light valve' in the recorder to permit more or less light to fall on the sound track.

For each electrical impulse the shutter will open in proportion to the strength of the impulse and then close. This results in a series of lines entirely across the sound track, the darkness of the lines corresponding to the volume of the recorded sound and the number of lines per inch corresponding to the pitch. This system is used by the Western Electric Co. and its licensees. Fig. 184A is an example of this method of recording.

Sound Recording on Film by the Variable Area Method.

In this method of recording, the electrical vibrations from the amplifier are changed into corresponding variations in the movement of a narrow beam of light focused on the sound track of the unexposed film as the film moves past the recording optical system.

This sound track appears as a series of dips and peaks, the height of the peaks corresponding to the loudness of the sound recorded and the number of peaks per inch corresponding to the pitch. The peaks will be of the same darkness (that of completely exposed film) and will pass the minimum
Electronics' Chart of
Sound Frequency Characteristics

WIRE TRANSMISSION CIRCUITS
- Television wire circuit (70 to 15,000 cycles per second)
- Highest-class wire line for broadcasting (50 to 8,000)
- Ordinary wire circuit for broadcasting (50 to 5,000)
- Ordinary telephone talking circuit (750 to 2,750)
- Trans-oceanic telephonic cable (300 to 2,500)
- Standard telephone instrument (300 to 1,800)
- Early telephone lines (500 to 1,600)

RADIO BROADCASTING AND RECEPTION
- Modern broadcasting transmitter (30 to 7,000)
- Broadcasting station transmitting chain program (90 to 5,000)
- High-quality radio set (50 to 5,000)
- Obsolete or poor radio set (256 to 2,000)

SOUND REPRODUCERS
- Public-address system (60 to 5,500)
- Dynamic loud-speaker (40 to 5,500)
- Exponential loud-speaker (70 to 5,500)
- Electro-magnetic pickup (60 to 5,500)

SOUND RECORDINGS FOR RADIO AND FILMS
- Highest type electrical transcriptions for radio (Hill & Dale cut) (30 to 10,000)
- Sound-picture film sound track recording (0 to 8,500)
- Sound-picture disc record 33 1/3 r.p.m., lateral cut (60 to 6,000)

HOME PHONOGRAPHS
- Modern electric recorded home phonograph (60 to 5,000)
- Recent acoustic phonograph (90 to 4,500)
- Old fashioned phonograph (256 to 3,000)
- Office dictating machines (350 to 2,000)

MISCELLANEOUS
- Niagara Falls 43 to 50
- Thunder 20 to 40
- Average man's speaking voice
  - Average woman's speaking voice

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amount of light. It will be noted that the amount of light passing through the sound track will depend upon the area of the unexposed portion. Fig. 184B.

"AEO" Light Recording.

Another system of recording is used by Fox Movietone. In this system, the electrical pulsations from the amplifier are used to vary the brilliancy of a lamp instead of opening and closing a "light valve." The lamp used for this purpose is called an "AEO" light.

General Requirements for Good Reproduction from Film Recordings.

We have seen that the aim, in all types of recording on film, is to create a photographic record in the form of a narrow sound track which would vary the amount of light through it (from a steady source of illumination) in proportion to the sound pressures on the diaphragm of the microphone.

Sound reproduction from film recordings requires that the variations of the amount of light transmitted through the photographic record be accurately translated into sound. To accomplish this, a thin beam of intense light, the width of which is equal to the width of the sound track, is focused on the sound track. The varying light which passes through the sound track affects a sensitive photo-electric cell so as to cause a varying electric current to pass through it. In the RCA Photophone system, this varying current is passed through a transformer primary. The voltage generated in the secondary of the transformer is amplified in the vacuum tube amplifier, the output of which is used to operate loud-speakers.

The Western Electric Co. feeds the output of the photo-electric cell into an amplifier unit mounted in the same compartment with the cell; the output of this so-called "head amplifier" being fed to the voltage amplifiers, power amplifiers, and then to the speakers.

The source of the light (exciter lamp) which shines through the film must be steady, that is, there must be no fluctuations in the amount of light. The beam of light must be nearly as thin as the beam used in recording, and exactly as wide as the sound track. The beam should not be more than 0.001 of an inch thick and should be exactly 0.084 of an inch wide.

The speed of the film passing the light beam must be the same as the film speed of recording and must be absolutely constant. Variations in speed would cause variations of pitch which would be recognized as "wows." This speed is 90 ft. per minute.

Reproduction from Variable Density and Variable Area Recordings.

Although the sound tracks of the variable area and variable density recordings do not look alike, the variations of the light transmitted through them are the same. Reproducing equipment which is suitable for reproducing from one type of recording is equally capable of reproducing from the other. All producers of standard sound recordings on film use the same width of sound track, and use a light beam of approximately the same thickness.

Exciter Lamps.

These lamps should not be operated at a higher current than that for which they are rated. As the lamp becomes old a dark coating inside the lamp materially decreases its efficiency. For this reason exciter lamps should not be used until burned out, but should be replaced when the coating reduces the efficiency of the lamp to a point where satisfactory results cannot be obtained when the lamp is drawing its rated current. The exciter lamp is illustrated in Fig. 185.

Photo-Electric Cells.

A photo-electric cell is a device which varies in electrical resistance in proportion to the amount of light falling upon it. Therefore, a varying amount of light falling on its internal elements will cause a varying current in the external circuit. A standard photo-electric cell is shown in Fig. 186.

VACUUM TUBES

In many of the sound systems, standard tubes such as '24, '27, '50, '80, and '81 tubes are used. These tubes are covered in the section of this manual devoted to "Vacuum Tubes and Their Operation."

AMPLIFIERS

In general, the amplifiers used in "talkie" systems
are divided into two classifications. The output stage is termed the "power amplifier" as it furnishes the power to operate the speakers. The preceding stages are termed the "voltage amplifiers." Some models combine these two sections into one unit being entirely self-contained and A.C. operated.

**TROUBLES IN SOUND SYSTEMS**

Even with the best of care, troubles can develop which require immediate attention and correction. It is important that the operator or service man be ready to meet them with a definite idea as to what is to be done.

The troubles which may be experienced with sound reproducing equipments depend upon the type of equipment used. These are discussed in this section and more detailed discussion of troubles for a particular type equipment can be found in the instruction book which is sent along with the apparatus.

Probably the most common of the troubles experienced are those which are due to "slip-ups" in operation. It is important to check over the operating procedure before looking elsewhere.

If the trouble is not due to a "slip-up" in operation, then the portion of the equipment causing the trouble should be isolated by systematic tests. The instruction books sent out with equipment should be studied and the service man should familiarize himself with the individual peculiarities of the equipment.

When the fault has been discovered, it is usually a fairly simple matter to remedy the condition. The more probable causes of trouble in the various portions of the equipment are discussed in the manufacturers' service books.

**Checking for Errors in Operation.**

If no sound is obtained when starting, or when "changing-over" from one projector to the other, check for any of the following errors:

(a) Switches or other controls set incorrectly anywhere in the equipment or in its power supply circuits. (While checking the controls of the amplifier, inspect the tubes of the voltage and power amplifiers to see that they are all lighted.)

(b) Fader switch set for the wrong projector, or fader set in the "Off" position or for the wrong projector.

(c) Loud speakers not plugged in at the stage. (If "no sound" is due to the stage speakers being disconnected, sound can still be heard at the monitor speaker.)

If in checking over the routine operation no error is noted, the trouble is probably due to some defective part, and the next thing to be done is to isolate that defective part.

**Systematic Tests for Locating a Defective Part.**

Usually the most effective method of locating a defective part is by determining to what extent the equipment is still operative. If no sound is obtained from the photo-cell circuit of one projector, the other projector should be "faded in" and tested. If sound can be obtained from one projector and not from the other, the indication is that the defect may be in the fader circuit or in the sound head from which no sound can be obtained.

If it is found that sound cannot be obtained from either projector, the indication is that the trouble is in the amplifier equipment. If a non-synchronous phonograph attachment is available, the amplifier can be checked by plugging the non-synchronous phonograph input plug into the jack provided, and listening for sound while tapping the pick-up needle of the phonograph. If sound can be obtained from the non-synchronous phonograph and not from the projectors, the indication is that the amplifiers are O.K. and the defect is in the fader photo-cell units.

If no sound can be obtained from either of the projectors or from the non-synchronous phonograph, the indication is that the trouble is in the amplifier rack equipment or in its power supply circuit.

**No Sound From the Stage Speaker.**

In case no sound is obtained at the stage and the sound is O.K. at the monitor speaker, the trouble must be somewhere in the line leading from the amplifier rack to the stage speakers.

**Low Volume.**

Low volume when using sound-on-film may be due to any of the following:—incorrect exciter lamp current, dirty or old exciter lamp, exciter lamp out of focus, sound gate aperture partly clogged, a defective pho-cell, or defective tubes.

**Unequal Volume from Projectors.**

If unequal volume is obtained from the two projectors when using sound film, the projector giving the lowest volume should be checked for trouble. If no cause is found for low volume the output of the projectors should be balanced by following
the directions in the manufacturers’ service sheets furnished with the equipment.

Poor Quality.

Poor quality of sound from sound film may be due to any of the following causes:—poor sound film, dirty sound gate, dirty film, dirty constant speed sprocket, a defective photo-cell, an out-of-focus optical system, or defective tubes.

Poor quality of sound is often blamed on the equipment when the fault is in the film itself. On the other hand, dirt on the film or on the sound gate will ruin the quality of sound from a good recording.

A defective photo-cell can spoil the quality of the reproduced sound.

A photo-cell can be spoiled by misuse. It is important that the photo-cell should not be exposed to strong light at any time, whether the polarizing voltage is applied or not. They should be handled gently and not jarred. When no film is in the projector, the circle of light from the exciter lamp can be seen on the photo-cell. This circle should be located at the exact center of the plate of the photo-cell. Dirty prongs on the photo-cell may also cause trouble. These can be readily cleaned with fine sandpaper.

Exciter Lamps.

It is very important that the adjustment of the exciter lamps be checked by the projectionist before beginning the show at least once a day, as a loss of volume will be the result of any defect in their adjustment.

Exciter lamps should not be used after they have become excessively dark, but should be replaced.

All finger marks should be wiped off the lamp immediately. If the lamp becomes hot while greasy finger marks are upon it, the marks will be hard to remove later. The condensing lens on the optical system should be kept clean at all times.

The socket in which the exciter lamp is mounted should not be allowed to become loose. If the exciter lamp is loose it will be difficult, if not impossible, to keep the exciter lamp focused during the operation of the machine.

Amplifier Tubes Fail to Light.

If some of the voltage or power tubes fail to light while others in the same unit do light, the indication is that the unlighted tubes are burned out, and should be replaced; but if none of the tubes of a unit light when the amplifier is turned on, the indication is that the fuse is burned out or that there is something at fault in the power supply feeding the amplifier unit. As soon as it is noticed that none of the tubes light, the equipment should be turned off and all fuses and circuits checked.

Noise and “Motorboating.”

Noise and “motorboating” when using sound film may be due to any of the following reasons:

Poor ground connections on the projectors. Clean and tighten.

Optical systems out of adjustment in such a way that the light ray passes through the sprocket holes of the film, or through the frame lines of the picture.

Guide rollers out of adjustment. The guide rollers in the sound gate should rotate freely. There should not be side play in the outside roller, but it should not bind on the gate shoe. If the guide roller is loose or out of position, the film will weave in and out through the gate, thereby causing “flutter” or “film noise,” and the reproduction will be poor.

“Putting” noise in amplifier. In cases where the amplifier “motorboats” it is necessary to check over the tubes, and if batteries are used test them, because as the batteries age, they generally offer a common path of high impedance to the various tube circuits.

Reverberation and Its Elimination.

Reverberation can be stated as the persistence of sound in an enclosed space. When a sound wave is created in an enclosed room and strikes one of the walls, part of the sound is reflected, part transmitted, and part absorbed. It will be noted that an echo is simply a sound wave which is reflected back to the ear after the original impulse has died out. If two sounds strike the ear with a shorter period of time than one-tenth of a second, the ear cannot recognize them as separate sounds. As sound travels 1100 feet per second, we cannot receive an echo from an object that is closer than about 55 feet.

If a hall or auditorium uses hard materials for the floors, walls and ceilings, and the distance which the sound travels is less than 55 feet, the repeated reflections from the various surfaces bound back on the original sound and interfere with it to such an extent that a condition called reverberation is brought about resulting in “garbled” speech and music. The cure for this condition is to cover the floors, walls, and perhaps the ceiling, with some material capable of absorbing the excess sound that is represented by reflection.

One way to do this is to break the reflecting surfaces up into small sections so that the sound reflections by colliding with each other, will waste their energy and quickly die out. This is done in modern theater design. In old buildings, the established practice is to line the walls with sound absorbing material, using as much material as is necessary to reduce the period of reverberation to a satisfactory value.
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**Reverberation Time.**

Professor Wallace C. Sabine found that a definite relation exists between the time of reverberation in seconds ($t$), the volume of the room in cubic feet ($V$), and the absorbing effect of the various materials present per square foot ($A$).

$$t = \frac{0.05V}{A}$$
### Sound-Absorbing Coefficients for Pitch 512

<table>
<thead>
<tr>
<th>Material</th>
<th>Coefficient per sq. ft.</th>
<th>Trade Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open Window</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Acoustex 1 in. thick</td>
<td>0.37</td>
<td></td>
</tr>
<tr>
<td>Balsam Wool, bare, 1 in. thick, 0.26 lb. per sq. ft.</td>
<td>0.44</td>
<td></td>
</tr>
<tr>
<td>Brick wall</td>
<td>0.032</td>
<td></td>
</tr>
<tr>
<td>Brick wall, painted</td>
<td>0.017</td>
<td></td>
</tr>
<tr>
<td>Carpet, unlined</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>Carpet, lined</td>
<td>0.20</td>
<td></td>
</tr>
<tr>
<td>Carpet, with 1/2 in. Ozite hairfelt</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td>Celotex, unperforated, 7/16 in. thick</td>
<td>0.20</td>
<td></td>
</tr>
<tr>
<td>Acousti-Celotex, type BB, painted or unpainted</td>
<td>0.70</td>
<td></td>
</tr>
<tr>
<td>Cork tile</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>Curtains in heavy folds</td>
<td>0.40-0</td>
<td></td>
</tr>
<tr>
<td>Flaxlinum, Acoustic Tile, 1/2 in. thick, with wooden casing and metal screen</td>
<td>0.42</td>
<td></td>
</tr>
<tr>
<td>Glass (single thickness)</td>
<td>0.027</td>
<td></td>
</tr>
<tr>
<td>Hairfelt, bare, 1 in. thick, 0.75 lb. per sq. ft.</td>
<td>0.58</td>
<td></td>
</tr>
<tr>
<td>Oil painting, per sq. ft.</td>
<td>0.28</td>
<td></td>
</tr>
<tr>
<td>Linoleum</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>Marble</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>Plaster on wood lath</td>
<td>0.054</td>
<td></td>
</tr>
<tr>
<td>Plaster on metal lath</td>
<td>0.035</td>
<td></td>
</tr>
<tr>
<td>Plaster on tile</td>
<td>0.025</td>
<td></td>
</tr>
<tr>
<td>Sabinite Acoustical Plaster</td>
<td>0.21</td>
<td></td>
</tr>
<tr>
<td>Stage opening, depending on stage furnishings</td>
<td>0.25-0.40</td>
<td></td>
</tr>
<tr>
<td>Ventilators</td>
<td>0.75</td>
<td></td>
</tr>
<tr>
<td>Wood, plain</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>Wood, varnished</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>Adult person</td>
<td>4.7</td>
<td></td>
</tr>
<tr>
<td>Plain wood seats</td>
<td>0.19</td>
<td></td>
</tr>
<tr>
<td>Church pews, per seat</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>Seat cushions, per seat</td>
<td>1.00-2.00</td>
<td></td>
</tr>
<tr>
<td>Opera chairs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) plywood seat and back, no upholstery</td>
<td>0.24</td>
<td></td>
</tr>
<tr>
<td>(b) padded seat and back, covered with</td>
<td>1.6</td>
<td></td>
</tr>
<tr>
<td>pantosote (imitation leather)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) various paddings, covered with velour</td>
<td>2.3-3.5</td>
<td></td>
</tr>
<tr>
<td>or mohair</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Piano</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>Table</td>
<td>0.2</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Trade Name</th>
<th>Fire</th>
<th>Thickness</th>
<th>Coeff. per sq. ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acousta-Zenitherm</td>
<td>Inflammable</td>
<td>1/4&quot;</td>
<td>.33</td>
</tr>
<tr>
<td>Acoustex</td>
<td>Fireproof</td>
<td>1&quot;</td>
<td>.54</td>
</tr>
<tr>
<td>Acousti-Celotex B</td>
<td>Inflammable</td>
<td>3/4&quot;</td>
<td>.43</td>
</tr>
<tr>
<td>Acousti-Celotex BB</td>
<td>Inflammable</td>
<td>1 1/4&quot;</td>
<td>.63</td>
</tr>
<tr>
<td>Acousti-Celotex C</td>
<td>Inflammable</td>
<td>3/4&quot;</td>
<td>.28</td>
</tr>
<tr>
<td>Acoustile</td>
<td>Inflammable</td>
<td>3/4&quot;</td>
<td>.37</td>
</tr>
<tr>
<td>Acoustolic</td>
<td>Inflammable</td>
<td>1/2&quot;</td>
<td>.37</td>
</tr>
<tr>
<td>Aoustolith</td>
<td>Fireproof</td>
<td>1&quot;</td>
<td>.32</td>
</tr>
<tr>
<td>Aoustolith Sound Abs.</td>
<td>Fireproof</td>
<td>1/4&quot;</td>
<td>.08</td>
</tr>
<tr>
<td>Stone</td>
<td>Fireproof</td>
<td>1&quot;</td>
<td>.32</td>
</tr>
<tr>
<td>Ambler Plaster</td>
<td>Fireproof</td>
<td>1/4&quot;</td>
<td>.08</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Trade Name</th>
<th>Fire</th>
<th>Thickness</th>
<th>Coeff. per sq. ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asbestos Akoistikos Felt</td>
<td>Flameproof</td>
<td>1/2&quot;</td>
<td>.31</td>
</tr>
<tr>
<td>Balsam Wool</td>
<td>Flameproof</td>
<td>3/4&quot;</td>
<td>.45</td>
</tr>
<tr>
<td>Acoustex</td>
<td>Fireproof</td>
<td>1&quot;</td>
<td>.59</td>
</tr>
<tr>
<td>Balsam Wool</td>
<td>Flameproof</td>
<td>1 1/2&quot;</td>
<td>.73</td>
</tr>
<tr>
<td>Blast Hair Blanket</td>
<td>Inflammable</td>
<td>2&quot;</td>
<td>.76</td>
</tr>
<tr>
<td>Celotex Building Board</td>
<td>Inflammable</td>
<td>7/16&quot;</td>
<td>.22</td>
</tr>
<tr>
<td>Corkoustic</td>
<td>Inflammable</td>
<td>1&quot;</td>
<td>.30</td>
</tr>
<tr>
<td>Nashkote A Perforated</td>
<td>Flameproof</td>
<td>1/2&quot;</td>
<td>.32</td>
</tr>
<tr>
<td>Flaxlinum</td>
<td>Inflammable</td>
<td>1&quot;</td>
<td>.34</td>
</tr>
<tr>
<td>Gimco Acoustic Flexfelt</td>
<td>Fireproof</td>
<td>1&quot;</td>
<td>.56</td>
</tr>
<tr>
<td>Insulite Building Board</td>
<td>Inflammable</td>
<td>1 1/2&quot;</td>
<td>.61</td>
</tr>
<tr>
<td>Macoustic Plaster</td>
<td>Fireproof</td>
<td>1 1/2&quot;</td>
<td>.61</td>
</tr>
<tr>
<td>Masonite Building Board</td>
<td>Inflammable</td>
<td>7/16&quot;</td>
<td>.28</td>
</tr>
<tr>
<td>Nashkote A-1-S, A-C-S</td>
<td>Flameproof</td>
<td>1&quot;</td>
<td>.38</td>
</tr>
<tr>
<td>Nashkote B-045</td>
<td>Flameproof</td>
<td>1&quot;</td>
<td>.46</td>
</tr>
<tr>
<td>Nashkote AX</td>
<td>Flameproof</td>
<td>1&quot;</td>
<td>.64</td>
</tr>
<tr>
<td>Nashkote F</td>
<td>Flameproof</td>
<td>1&quot;</td>
<td>.35</td>
</tr>
<tr>
<td>Nashkote O-M-C</td>
<td>Flameproof</td>
<td>1&quot;</td>
<td>.49</td>
</tr>
<tr>
<td>Nashkote O-M-C</td>
<td>Flameproof</td>
<td>1 1/2&quot;</td>
<td>.72</td>
</tr>
<tr>
<td>Nashkote O-M-C</td>
<td>Flameproof</td>
<td>2&quot;</td>
<td>.76</td>
</tr>
<tr>
<td>Nashkote O-M-C</td>
<td>Flameproof</td>
<td>3&quot;</td>
<td>.77</td>
</tr>
<tr>
<td>Nashlite</td>
<td>Inflammable</td>
<td>1&quot;</td>
<td>.61</td>
</tr>
<tr>
<td>Nephisi</td>
<td>Fireproof</td>
<td>1&quot;</td>
<td>.47</td>
</tr>
<tr>
<td>No-Echo Acoustical Tiles</td>
<td>Fireproof</td>
<td>1&quot;</td>
<td>.38</td>
</tr>
<tr>
<td>Oxite Carpet Cushion</td>
<td>Inflammable</td>
<td>1&quot;</td>
<td>.35</td>
</tr>
<tr>
<td>U. S. G. Acoustical Tile</td>
<td>Fireproof</td>
<td>1&quot;</td>
<td>.13</td>
</tr>
<tr>
<td>Penn Acoustic Felt</td>
<td>Inflammable</td>
<td>1/2&quot;</td>
<td>.38</td>
</tr>
<tr>
<td>Sabinite Plaster</td>
<td>Fireproof</td>
<td>1/2&quot;</td>
<td>.29</td>
</tr>
<tr>
<td>Sanacoustic Tile</td>
<td>Fireproof</td>
<td>1 1/2&quot;</td>
<td>.71</td>
</tr>
<tr>
<td>Spray-Acoustic</td>
<td>Flameproof</td>
<td>1/2&quot;</td>
<td>.45</td>
</tr>
<tr>
<td>Spray-Acoustic</td>
<td>Flameproof</td>
<td>1 1/2&quot;</td>
<td>.61</td>
</tr>
<tr>
<td>U.S.G. Acoustical Tile</td>
<td>Fireproof</td>
<td>1&quot;</td>
<td>.70</td>
</tr>
<tr>
<td>Westfelt</td>
<td>Flameproof</td>
<td>1&quot;</td>
<td>.61</td>
</tr>
<tr>
<td>Westfelt</td>
<td>Flameproof</td>
<td>1/2&quot;</td>
<td>.19</td>
</tr>
<tr>
<td>Westfelt</td>
<td>Flameproof</td>
<td>1/2&quot;</td>
<td>.32</td>
</tr>
</tbody>
</table>
Acceptable Limits of Reverberation.

The figures given in the table are not to be regarded as absolute. Many rooms have values which exceed these mentioned in either direction by tenths of a second but are still satisfactory acoustically.

<table>
<thead>
<tr>
<th>VOLUME OF ROOM IN CU. FT.</th>
<th>ACCEPTABLE REVERBERATION TIME IN SECONDS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Half audience</td>
</tr>
<tr>
<td>10,000</td>
<td>0.9-1.2</td>
</tr>
<tr>
<td>25,000</td>
<td>1.0-1.3</td>
</tr>
<tr>
<td>50,000</td>
<td>1.2-1.5</td>
</tr>
<tr>
<td>100,000</td>
<td>1.5-1.8</td>
</tr>
<tr>
<td>200,000</td>
<td>1.8-2.0</td>
</tr>
<tr>
<td>400,000</td>
<td>2.1-2.3</td>
</tr>
<tr>
<td>600,000</td>
<td>2.3-2.6</td>
</tr>
<tr>
<td>800,000</td>
<td>2.5-2.8</td>
</tr>
<tr>
<td>1,000,000</td>
<td>2.6-2.9</td>
</tr>
</tbody>
</table>

Sabine's formula can be rearranged so that it states that the absorption units required to reduce reverberation to a certain period are equal to 0.05 times the cubic feet volume of the room divided by the reverberation period; thus simplifying the mathematics necessary for the proper selection of absorbing materials.

Phasing Speakers.

In installations using more than one speaker it is necessary that the movements of the voice-coils be in phase. This is accomplished by connecting a small 4.5-volt flashlight battery with a circuit-closing arrangement to the speaker voice-coil lines. One man should stand in front of the speakers and closely observe the motion of the cone on the speaker. Close the battery circuit and note the direction of motion of the cone. The cone will move either in or out from the starting position. Check all of the speakers, one at a time, noting the direction of movement of each.

If one of the speakers' voice coils moves in while another moves out, it is necessary to reverse the voice coil connections of one of the speakers. All of the voice cones should move in or out in unison as the battery circuit is closed and opened.

Patching.

When a break occurs in a sound film it should be patched in the usual manner, but the sound track requires special treatment. The sound track should be painted as shown in Figs. 187A and B. Paint a half-moon over the sound track if the recording is variable area, and a blunt apex if the recording is variable density. Use Zapon concentrated Black Lacquer No. 2002-2.
ERECTING AERIAL AND
INSTALLING SET

Although complex antenna systems have been used in transmission to good effect, it will be noted by those of you who reside in maritime ports that the big liners now employ a simple single wire antenna of heavy wire. Cages and fancy "gadgets" may present a pleasing appearance but add little to the collecting properties of the system.

The "doo-dads" and "gadgets" in various forms offered as "staticless" by certain advertisers have little merit save in locations where it is impossible to install a flat-top antenna of sizable proportions. Here these devices are sometimes able to give good accounts of themselves.

In installing the antenna it should be kept high and wide from all obstructions—particularly from structural steel formations. The "L" antenna shown in Fig. 188 is the usual type and although its directional properties are not pronounced, it is slightly more sensitive in the direction of the tap off. It is therefore, wasteful to tap off a "L" type antenna in the direction from which little of entertainment value can be expected.

How Long?

Many times the question is propounded—how long an antenna should be used? With the modern and highly sensitive receivers of today, the answer is to the effect that the antenna should be just as short as is compatible with the reception of distant signals. In rural districts where there are no locals to produce interference, a long antenna may be used to increase the sensitivity during daylight hours—for in many such localities, the nearest broadcaster may be a hundred or more miles away and a high degree of sensitivity is required if satisfactory daylight service is to be obtained.

The flat-top portion of the antenna may vary from twenty to a hundred feet in length, therefore, as a longer antenna might possibly result in upsetting the ganging of the tuned circuits.

The lead-in should run as directly to the receiver as possible. This lead wire should be kept clear of the building by at least six or eight inches. Unless the customer seriously objects, the receiver should be placed in such a manner as to make both the lead-in from the antenna and the ground lead as short as possible.

For the antenna itself, any good grade of antenna wire may be used although due care should be given to its tensile strength. Stranded phosphor-bronze wire has the best all-round characteristics and the enameled wire now on the market aids materially in reception as the enameled covering prevents oxidation of the wire and consequent increase in its radio frequency resistance.

In certain locations, the interference picked up by the down-lead running close to the building is great due to the presence of elevators and what-not in the building. In these locations a shielded wire may be used to advantage. This wire resembles BX cable on a diminutive scale and the sheathing should be grounded at the lightning arrester.

Contrary to belief in some circles, the lightning arrester is a decidedly important piece of apparatus. Not only is it necessary to use an arrester of high quality for the protection it affords, but for the assurance that the arrester will not short-circuit and cause a total loss of signals which condition is difficult to diagnose.

The arrester does not protect one materially from a direct stroke of lightning—neither does the antenna provide a hazard in this respect. The arrester does protect the set from the ravages of heavy static discharges such as may readily burn out the input coils of the receiver.

In some locations this occurs to every receiver at least once in its life-time. Arresters approved by the Underwriters are satisfactory for use and care should be taken that an approved model is employed.

In the country, it is possible to keep the arrester out of doors as shown in the figure, but in the city the best form of installation is the mere placement of the device across the antenna and ground leads at a point as near their entry to the house as possible. By all means, do not skimp on the lightning arrester.
as you may be held responsible for any damage to the receiver resulting from such neglect.

In cities, the ground may be a water pipe (preferably “cold”) or a radiator—but by no means should a gas pipe be taken as the ground.

There are many forms of ground clamps for making this connection and much time may be saved in the installation of a receiver by using a clamp which is readily attached. In country districts, it is sometimes impossible to ground the receiver to a pipe and in these cases some sort of manufactured ground is necessary.

The best manner of grounding the receiver in such locations is by digging a number of shallow trenches fan-wise under the antenna and burying wires in them. These wires may be as long or a bit longer than the antenna itself. An alternative method is to bury a bucket to which a connecting wire has been soldered, several feet in the moist earth. If the earth is naturally dry, some means should be provided for periodically moistening the surrounding earth.

A Good Ground Is Essential on Modern Receivers If Oscillation Is To Be Avoided.

The antenna lead-in and the lead-in from an external ground of the type just described may be by means of the familiar window strips. It is preferable that the connecting wires be soldered firmly to these strips and the joints taped. The interior wiring should be done with silk covered wire which matches the wood work as closely as possible. There is no excuse for a sloppy interior job and the customer has every right to kick if a job of this nature is turned out. In wiring the interior, care should be taken that the lead wire does not traverse the back of the receiver cabinet as undesirable coupling may result.

Bring the antenna and ground lead wires up to the receiver on the back side near the “A” and “G” terminal posts. This is usually on the left as we face the front of the receiver.

In installing a new receiver, make sure that all packing strips, etc., have been removed and that the receiver and speaker are bolted down securely in the cabinet. If cushions are provided to be placed under the receiver or speaker to avoid acoustic feed-back and howl, make sure that these are in place so that future trouble may be avoided.

Extraneous Noise.

In many cases it is found that noise cannot be eliminated by servicing the receiver. Noise may enter the home from outside via the electric light lines or through the antenna. In such cases, the only way in which you can check the source is to turn off— one after the other—all electrical apparatus in the near vicinity. First make sure that the noise is not due to a loose antenna connection or to some fault in the receiver which you have slipped over without recognizing it.

Where it is impossible to get at the source of the interference, a shielded antenna down-lead may be employed and an interference filter of one of the commercial types may be inserted in the power supply circuit. These may be obtained from most radio jobbing houses and are not economical to construct at home.

When the interference source can be located, it is possible that—in the case of motors, etc.—the trouble can be remedied by merely cleaning the brushes.

X-ray machines and other electro-medical apparatus rarely yield to any form of treatment.

If the trouble cannot be remedied through the servicing of the appliance in question, a filter system of large current-carrying capacity can be inserted between the interfering equipment and the supply line. Such apparatus is readily obtainable from many manufacturers who specialize in this class of equipment.

Where the interference is picked up in the antenna it may often be remedied by shielding the antenna down-lead. This is done by using lead-covered cable for the lead-in and grounding the lead casing at one or both ends. While this does not seem a particularly efficient form of coupling, it is in reality quite effective in achieving the desired end. When using a shielded lead-in of this type it is often necessary
to increase the effective length of the antenna. This is due to the fact that the shielded lead-in is no longer an efficient collector of energy.

Some of the classes of equipment likely to cause interference are as follows:

- Vacuum cleaners
- Dial telephones
- Electric sewing machines
- Door bells
- Motors of all kinds
- Sign flashers
- Traffic signals
- Electric refrigerators
- Oil burners
- Electric fans
- Electrically operated cash registers
- Dental equipment
- All types of electro-medical equipment
- Defective power equipment—transformers, street lighting sockets, etc.—may cause bad interference to radio programs. In most instances, when such disturbances are suspected the power company in your community will be glad to aid in their solution.

**TYPICAL RISER DIAGRAMS for MULTICOUPLER ANTENNA SYSTEM**

- **A**: Three to thirty stories. Maximum thirty multicouplers. Typical vertical riser with multicoupler at each floor. Connection can be made to either end of aerial or at middle. Multicoupler may be left out at floors when not desired.

- **B**: Six stories or less. Maximum eighteen multicouplers. Typical vertical riser with multicoupler at each floor. Connection can be made to either end of aerial or at middle. Multicoupler may be left out at floors when not desired.

- **C**: Fifteen stories or less. Maximum thirty multicouplers. Typical vertical riser with multicoupler at each floor. Connection can be made to either end of aerial or at middle. Multicoupler may be left out at floors when not desired.

- **D**: Fifteen stories or less. Maximum eighteen multicouplers. Typical vertical riser with multicoupler at each floor. Connection can be made to either end of aerial or at middle. Multicoupler may be left out at floors when not desired.

- **E**: Fifteen stories or less. Maximum eighteen multicouplers. Typical vertical riser with multicoupler at each floor. Connection can be made to either end of aerial or at middle. Multicoupler may be left out at floors when not desired.

- **F**: Fifteen stories or less. Maximum eighteen multicouplers. Typical vertical riser with multicoupler at each floor. Connection can be made to either end of aerial or at middle. Multicoupler may be left out at floors when not desired.

- **G**: Maximum eighteen multicouplers. Typical layout for three story building. Two horizontal branch risers from one aerial. Top row serves third floor apartments, bottom row serves second floor.

- **H**: Maximum twenty multicouplers. Typical horizontal riser for two story building. Multicoupler serves first and second floors alternately.

**Legend**

- **R** = Terminal Resistance
- **M** = Multicoupler - Type PL 2724
- **G** = Ground

Note: Each leg should have approximately the same number of multicouplers. Maximum difference should never exceed four.
ELECTROLYTIC CONDENSERS

A great majority of present day receivers employ the electrolytic type of filter condenser. These are obtainable with a dry electrolyte or with liquid. It is not the present writer's task to glorify the one at the expense of the other and we will leave all discussion of the relative merits to salesmen and the like.

While the majority of set analyzers provide for the measurement of condenser capacitance by means of the A.C. meters with which they are furnished, these tests hold good only for paper condensers. Bridge methods or other methods where A.C. is involved are also unsuited to measurements of the capacitance of electrolytic condensers.

The only methods by which these measurements can be made involve the use of direct current and a rapid make and break switch—such as a rotating commutator. The writer doubts the advisability of such equipment for the service laboratory as the different units on the market are readily distinguishable as to capacitance and the sole tests of actual interest to the service technician are those of operation.

The dielectric in an electrolytic condenser consists of a thin film on the surface of the plates and, under certain conditions, this film will break down—conditions not always due to excessive voltage. The leakage current through an electrolytic condenser should not exceed 5 milliamperes per section of 8 microfarads—this permits of a leakage of 20 ma. for a 32 mf. section—at a terminal voltage of 350, the correct polarity being, of course, observed. Fig. 189 shows test circuit.

In measuring the leakage through a condenser, do not place the milliammeter directly in the circuit but allow it to be shunted by a relatively low resistance during the first period of operation gradually increasing the resistance across the meter until it is entirely removed from the circuit.

After a long period of inoperation, an electrolytic unit will be found to have a greatly increased leakage. To "form" the plates, the condenser should be left across a voltage almost equal to its maximum safe value for a period of from ten to fifteen minutes. At the end of this time the leakage will be reduced to its allowable value.

Electrolyte escaping from the vent due to breakdown should be wiped away as its presence across the terminals will greatly increase the leakage.

Electrolytic condensers begin to jell at about 29° F. and freeze solid at 18° F., but they will return to normal operation after a brief period at normal room temperature. This precludes the possibility of using electrolytic condensers in portable apparatus to be operated at low temperature in the open.

Re-forming of the condensers may be carried out in the receiver by removing all tubes but the rectifier and allowing the receiver to run idle in this condition for a short period of time—any excess hum due to de-forming of the condenser plates will be found to have disappeared after about 15 minutes of such operation.
A MODULATED TEST OSCILLATOR

The oscillator shown in Fig. 190 employs a separate oscillating tube for modulation. The frequency of modulation may be altered by adjusting the value of the capacitance across the iron cored coil.

It is possible to shift from the broadcast range to the range between 115 and 200 kc. for lining up intermediate amplifiers in superheterodyne receivers by a single switching arrangement.

In calibrating the oscillator in the broadcast band, it is only necessary to tune in a number of broadcasters of known frequency; beating the output of the oscillator against the broadcast carrier gives an accurate knowledge of the frequency to which the oscillator is tuned. The oscillator is in tune with the incoming signal when the output of the radio set, which is used for the calibration, delivers a low-pitched growl along with the music. If the signal of the oscillator is high in pitch, then the oscillator is not in absolute resonance with the incoming signal.

In calibrating the low frequency range, a more difficult procedure is required. All oscillators are generators of harmonics of higher frequency than the basic carrier. Ours is no exception to this rule. The harmonics of various frequencies in this range are as follows:

<table>
<thead>
<tr>
<th>Harmonic</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>2nd</td>
<td>200 kc.</td>
</tr>
<tr>
<td>3rd</td>
<td>600 kc.</td>
</tr>
<tr>
<td>4th</td>
<td>800 kc.</td>
</tr>
<tr>
<td>5th</td>
<td>1000 kc.</td>
</tr>
<tr>
<td>6th</td>
<td>720 kc.</td>
</tr>
</tbody>
</table>

Note that many of these values lie in the broadcast band.

The procedure in calibration is to hook up the oscillator operating in the low frequency range to the receiver through the dummy antenna described. With the oscillator condenser almost closed, it should be oscillating in the neighborhood of 120 kc. The sixth harmonic of 120 kc. is at 720 kc. and if we tune our receiver to this point and move the oscillator condenser slowly, we should find a weak signal when the oscillator passes through the 120 kc. mark. Mark the oscillator dial setting at this point and tune the receiver to 750 kc. which is the 5th harmonic of 150 kc. Repeat the first procedure and mark the oscillator setting as 150 kc. Check this reading by adjusting the receiver to 600 kc. where the 4th harmonic of 150 kc. should appear. If this is not in evidence, it is possible that your oscillator is not tuned to 150 kc. but to some other frequency of which 750 kc. is also a harmonic. If you get signals at 600, 800, and 1000 kc., your oscillator is tuned to 200 kc. and you are getting the 3rd, 4th, and 5th harmonics, respectively. If you find a signal at 600 and 720 kc., you are tuned to 120 kc. and are picking up the 5th and 6th harmonics thereof. It is easy to identify the frequency to which you are tuned by calculating the intervals between the harmonics received. An extremely accurate calibration curve can be plotted in this manner if reasonable care is taken.
POTENTIOMETERS

Many experimenters find some difficulty in applying potentiometer arrangements in radio circuits. Much has been written on the more complex theories of radio, but in most cases the practical application of potentiometers has been obscured in a mass of other explanations, it being assumed that potentiometers are so simple as to require no explanation.

The difficulty is that the mere buying of a unit labeled "potentiometer, so and so many ohms," is not all that is necessary. There is no mystery about a potentiometer as sold; it is only an electrical resistance with a tapping, or, if it is variable, it has a rotatable contact just the same as a filament rheostat, the only difference being the provision of an additional terminal to enable the resistance to be connected as a shunt across the circuit instead of two terminals for enabling the contact and part of the resistance to be connected in series in the circuit. Fig. 191 illustrates a filament resistance and Fig. 192 illustrates a potentiometer, the terminals being marked T in each case.

Many service men fail to consider the effect of the resistance in the external circuit altogether, and as a consequence obtain results seemingly incongruous with theory. The division of potential calls for a particular electrical circuit and the potentiometer as sold is only a convenient unit for use in such a circuit; the circuit is of paramount importance.

All radio men know that potential is always dropped across an electrical resistance when current flows and the drop in voltage is dependent upon the resistance in accordance with Ohm’s Law: \[ E = IR \]

when \( E \) is the voltage, \( R \) the resistance, and \( I \) the current flowing.

If an electrical circuit is arranged as illustrated in Fig. 193, in which a resistance \( R \) is connected across the supply voltage, and if such resistance is divided into ten equal parts, so that the electrical resistance in ohms between the first contact and contact 1, is equal to the number of ohms between the contacts 1 and 2 and so on, then any proportion in tenths of the voltage between the positive and negative leads can be obtained by placing the arm B on a suitable contact provided no appreciable current flows through B. For example, if the potential difference between positive and negative is 10 volts, then the potential at stud 1 will be one volt, at stud 2 will be two volts, and so on if no current flows in the external circuit through B, that is to say, only a state of electrostatic tension occurs at b—b. This condition of affairs
exists when variable grid bias is provided for by means of a potentiometer, and in such a case the potential values will be substantially the obvious division of the potential, as all that is required is an electrostatic condition. The circuit of Fig. 194 shows a common application of this. In this arrangement the value of $R$ has no bearing on the potential and a value can be selected to economize in current flow. The same condition exists when a potentiometer is used in leaky grid detectors.

![Fig. 194](image)

When a current flows in the external circuit then the conditions are altered and the values of the potential at the contacts 1, 2, etc., are quite different. Fig. 195 illustrates diagrammatically the new conditions in the circuit; here $r$ represents the electrical resistance in the external circuit, and owing to the flow of current through $r$, the potential at the stud 5 will not be half the potential difference across the positive and negative mains. It will be seen that $r$ and the portion $R_1$ of the resistance $R$ are in parallel, and the equivalent resistance will be

\[ \frac{R_1 \times r}{R_1 + r} \]

Incidentally, the value of the resistance across the positive and negative has changed from $R$ to

\[ \frac{R_1 \times r}{R_1 + r} \]

but that is by the way. Fig. 196 exhibits a family of curves showing how the value of the potential across $r$ varies when the value of $r$ changes. In these graphs, the potential difference across positive and negative has been taken as $E=100$ volts, and the resistance of $R$ is 1000 ohms. Consider the tapping at $R_2=500$ ohms, when $r$ is infinitely great then the voltage $E_r$ is 50; when $r$ is 1000 ohms the voltage $E_r$ is 40; when $r$ is 300 ohms the voltage $E_r$ is about 27; when $r$ is 100 ohms, the voltage $E_r$ is about 13. and when $r$ is only 50 ohms, then the voltage $E_r$ falls to about 8. From the above it will be clear that if a drop of 50 volts is required across $r$ for some reason, it will be useless to use the tapping $R_2=500$ ohms regardless of the value of $r$.

![Fig. 196](image)

This is of great importance today especially when we use a portion of the voltage divider to furnish the biasing potentials for the new variable-mu tubes as indicated in Fig. 197.

![Fig. 197](image)

The points to be considered in calculating the value of the resistance $R_1$ are as follows:

What voltage drop is necessary? How much current will flow through the resistor? What should the watts rating of the resistor be?

When the contact $A$ is turned to $B$—the current through the resistor is the bleed current consumed by $R_1$ and $R_2$. The bias on the tubes being furnished by the resistors in the cathode leads. If the contact $A$ is moved up to the point +50 then the currents from the plate and screen circuits of the tubes have to flow through the resistor $R_1$ as well as the current consumed by $R_1$ and $R_2$. To be sure, the current which flows in resistor $R_1$ will always be the bleed current consumed by the resistors but as the arm $A$ moves up it increases the value of the negative bias on the grids of the tube which in turn causes an increase in the voltages applied to the plates of the tubes due to the decrease in plate current caused by the additional grid bias. Thus the current through the resistor $R_1$ should be so large that the addition of the currents flowing through the arm $A$ will be but
a small portion of the total current in R1 so that the volume control will operate smoothly without jumps or drops in the volume level as the arm is turned.

Many failures are due to no other cause than lack of proper appreciation of the conditions and values in the external circuit. Fig. 198 shows how the voltage across r varies with the value of r assuming R=1000 ohms and E is 100 volts, the tapping located so that R1=R2=500 ohms.

Above, potentiometer and rheostat plate-voltage control. Below, potentiometer and rheostat control of cathode bias. The fixed resistance sets a minimum negative bias.

Four types of antenna volume control.
R.M.A. COLOR CODE

Body Color indicates first significant figure.
End Color indicates second significant figure.
Band Color indicates third significant figure.

<table>
<thead>
<tr>
<th>Body Color</th>
<th>End Color</th>
<th>Band Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>1...brown</td>
<td>0...black</td>
<td>.0...black</td>
</tr>
<tr>
<td>2...red</td>
<td>1...brown</td>
<td>0...brown</td>
</tr>
<tr>
<td>3...orange</td>
<td>2...red</td>
<td>00...red</td>
</tr>
<tr>
<td>4...yellow</td>
<td>3...orange</td>
<td>000...orange</td>
</tr>
<tr>
<td>5...green</td>
<td>4...yellow</td>
<td>0000...yellow</td>
</tr>
<tr>
<td>6...blue</td>
<td>5...green</td>
<td>00000...green</td>
</tr>
<tr>
<td>7...violet</td>
<td>6...blue</td>
<td>000000...blue</td>
</tr>
<tr>
<td>8...gray</td>
<td>7...violet</td>
<td></td>
</tr>
<tr>
<td>9...white</td>
<td>8...gray</td>
<td></td>
</tr>
<tr>
<td>0...black</td>
<td>9...white</td>
<td></td>
</tr>
</tbody>
</table>

For example, a Resistor has a blue body, a yellow end color and a red band color. What is the resistance in ohms? Answer, 6400 ohms. Fig. 199 shows position of identifying colors and bands.
(Courtesy International Resistance Co.)
BALLAST RESISTOR CALCULATION

HOW TO DETERMINE THE PROPER AMPERITE

The service man is often called upon to install a voltage regulating device but is at a loss as to the proper type to use. The following tables cover practically every combination of current drains which can exist and it surely is a time saver.

Tubes of the '24, '26, '27, and '35 class, consume approximately 5 watts of the power line load.

Output tubes such as the '45 and '47 consume approximately 30 watts—6 times that of the tubes mentioned above.

Thus, the output tube practically determines the wattage of the set and the proper Amperite for any 110-120 volt A.C. set can be approximated from the following chart:

<table>
<thead>
<tr>
<th>Output tubes in set</th>
<th>Total No. in set</th>
<th>Use Amperite</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-'45's (or Pent)</td>
<td>7 to 10</td>
<td>9-A-5</td>
</tr>
<tr>
<td>1-'45</td>
<td>5 to 8</td>
<td>7-A-5</td>
</tr>
<tr>
<td>1-'45</td>
<td>3 and 4</td>
<td>5-A-5</td>
</tr>
<tr>
<td>1 or 2-'12A ('71A)</td>
<td>6 to 9</td>
<td>7-A-5</td>
</tr>
<tr>
<td>1 210</td>
<td>6 to 8</td>
<td>9-A-5</td>
</tr>
<tr>
<td>2 250</td>
<td>7 to 10</td>
<td>9-A-5 (use 2)</td>
</tr>
</tbody>
</table>

When operating, the Amperite will get warm. It should not operate above a very dull red glow. If the Amperite burns higher than a dull red glow—use the next larger size, e.g., if 7-A-5 is too bright, use 8-A-5, etc.

Some sets are wound with a special 90-volt primary and require an Amperite of -10 or -20 series as e.g.

- Victor R-32, R-52, RE-45
- Victor R-35, R-39, R-57
- General Electric 31, 51, 71
- Radiola 80, 82, 86
- Westinghouse WR-5, WR-6, WR-7
- Peerless models 21 to 25
- Kylelectron K-71, K-72
- Hi-Q 30
- Brunswick 14, 21, 31
- Silver Marshall, 20, 20-B, 60, 75, 95
- Special mounting adapter used on
- Special mounting adapter used on
The service man is at a loss as to the proper value of a fixed condenser which, when burnt out, has to be replaced in order that the set will be operative.

Of course, if the circuits of the receiver are available and the value of the condenser is marked on the diagram, it is a simple matter to obtain a condenser of the same value and mechanical size and substitute it for the defective unit. Sadly enough, this information is never at hand when it is desired.

Modern radio receivers are so designed today that each tube must work at the greatest possible efficiency, thus any change in the electrical values may seriously affect the operation of the receiver.

Some manufacturers use filter systems as shown in Fig. 200, and, due to the resonant condition which exists in circuits of this type, condensers are known to puncture, placing a short on the rectifier in case A and shorting the filter choke in case B with a large increase in the hum output.

If the value of the condenser is not known, it is a difficult job to guess as to its capacity. If the inductance of the choke is known, and that means with the normal current consumed by the set flowing through the choke, the value of the condenser can be found. This applies to case B, as the current flowing through L1 in case A is not a direct current but a pulsating one and large currents appear only at the resonant frequency. The resonant frequency for full-wave operation would be at 120 cycles and for half-wave, 60 cycles.

For those interested in the solution of problems of this kind, the procedure noted in the following can be used. The first thing that should be known is the LC constant which is derived from the equation below.

\[
\text{LC} = \frac{1}{4 \pi^2 f^2}
\]

\[
\text{LC} = \frac{25300}{f^2}
\]

\[
\text{LC} = \frac{25300}{60 \text{ (Cycles)}^2} = 7.02 +
\]

\[
\text{LC} = \frac{25300}{120 \text{ (Cycles)}^2} = 1.7 +
\]

Thus we find that the LC constant for 60 and 120 cycles is respectively 7.02 and 1.7. That is, the product of the capacity and the inductance will determine the resonant frequency. If the capacity is known, the inductance can be determined by simple division; for example, the capacity is .2 mf., what inductance is necessary for resonance in L1 for 60 cycles? for 120 cycles?

\[
L = \frac{7.02}{.2 \text{ MF.}} = 35.1 \text{ h, Approx.}
\]

\[
L = \frac{1.7}{.2 \text{ MF.}} = 8.5 \text{ h, Approx.}
\]

\[
X_C = \frac{1,000,000}{6.28 \times 120 \times .2} = 6635 \Omega
\]

\[
X_L = 6.28 \times 120 \times 8.5 = 6405 \Omega
\]
The best way from the service angle to find the proper value of capacity is by actual test, the value of capacity which permits of the least amount of hum in the speaker being the value to be used as the replacement unit.

**UNCASED REPLACEMENT CONDENSER**

The replacement capacity should be rated at a much greater voltage than the apparent voltage in the circuit. This will be noticed when the fact that voltages which appear across the condenser can be greater than the applied voltage as shown below. Fig. 201 shows the circuit in case A reduced to its simple form.

\[
C = 2 - MF.
\]

\[
400\text{ V.} \quad L = 8.5\text{ H} \quad R = 50\text{ OHMS}
\]

Therefore, care must be exercised not only in selecting the condenser of the right capacity but, as shown in the above example, the voltage rating of the substituted condenser must be such that it can be used without danger of break down. A 1500-volt working voltage type condenser should be used in this case.

\[
Z = \sqrt{50^2 + (XL - Xc)^2} = 236\ \Omega
\]

\[
i = \frac{E}{Z} = \frac{400}{254} = 1.7\text{ AMPS.}
\]

\[
Ec = i \times Xc = 1125\text{ V.}+
\]

\[
El = i \times XL = 1090\text{ V.}+
\]

When filter condensers are used in so-called brute-force filters, the danger of resonant conditions is more or less minimized due to the fact that resonance generally appears below 60 cycles and the individual units have a comparatively high impedance at 60 to 120 cycles. The voltage rating of the capacity should be such as to be greater than the peak value of the voltage output of the transformer which is 1.4 times the value indicated on the transformer data plate.

The selection of capacity values for use in audio frequency amplifiers can be simplified a great deal by making the reactance of the condenser about one-tenth the reactance of the choke or resistor which is in the circuit and which the condenser is supposed to by-pass. The reactance of the condenser employed should be of the required value at the lowest audio frequency which the amplifier will pass. Fig. 202 is an example of this type circuit.

The average value of condenser used in circuits of this type is one mf. or larger.

Radio frequency circuits, due to the fact that the reactance of a condenser is extremely low at the higher frequencies, will not have as great a value as at audio frequencies. This results in a cost and space saving condition but does not mean that the value of the voltage appearing across the condenser can be ignored. The majority of receiver manufac-
turers use .1-mf. condensers as by-pass units and, in most cases, this value is satisfactory for radio frequency replacement work.

In cases where the condenser is used as part of an isolator circuit a ratio of ten to one as stated above should be used.

Many condensers are used in circuits as shown in C1, Fig. 203; in this case, until the tube warms up, the total voltage will be applied across the condenser and after the tube heats to the normal operating condition, we find that the voltage has dropped across the condenser due to the voltage drop across the resistor. The condenser should be rated at the voltage which will appear across the condenser while the tube is heating. In this circuit the voltage rating of the condenser should be at least 400 volts.

In the final analysis, the substitution of a condenser should be made with the idea of using one of the specified value if such information is obtainable. When in doubt, try several and replace with the value which gives the best results and be sure that the condenser is rated above the voltage requirements of the circuit.

To Measure Small Capacities

With

Weston Model 547 Set Tester
SHORT-WAVE RECEIVERS AND CONVERTERS

In the belief that a continued and increasing interest in the short waves and their entertainment value prevails throughout the industry, the editors have included in this Manual a large number of short-wave and all-wave receivers and the schematic circuits of many of the converters available on the market. The technician will note that a great many different forms of design are presented. Within the past year, marked advances have been made in the way of the complete elimination of plug-in coils.

This has presented a serious problem and the manufacturers who have succeeded in this work are to be congratulated on their technical aptitude as well as upon their commercial acumen.

Perhaps a few notes on short-wave reception—on what may and what may not be expected—would be in order. It is true that, with very simple equipment, it is possible to receive foreign transmitters at great distances. It is also true—alas and alack—that the short waves suffer greatly from astronomical and meteorological conditions from which the broadcast band is quite free.

The radio wave as emitted from the transmitter consists in the main of two components—the ground wave and the sky wave. The ground wave in the broadcast bands is apparent at a considerable distance from the transmitter—but the sky wave continues onward for a much farther distance. As the waves become shorter, the distance at which the ground wave is apparent decreases, and even at short distances from the transmitter, the sky wave is predominant. But the real difficulty now enters into the picture. High above the earth is an ionized layer or barrier from which these waves are reflected—the angle of reflection being dependent upon the frequency of the wave. This results in a phenomenon known as "skip-distance"—the wave receivable close to the transmitter may not be found to be receivable again until a point many miles from the transmitter is reached. The height of this layer above the earth is at all times changing—its height and density being dependent upon the time of day or night, upon the season of the year, and upon certain astronomical and meteorological conditions as yet

FIG 204
not pronounceable in elementary terms. This results in a condition which is not entirely unsatisfactory where point to point communication is concerned, but which is a decided detriment to short-wave broadcasting. In point to point services, it is possible to use directional antennas which will pre-determine the angle at which the wave strikes the Eart\ndside layer and will, in a measure, control the effects of skip-distance. Even then, however, the frequency most favorable to laying down a strong signal in Buenos Aires tonight at eight o'clock will not be the frequency most favorable to the same tomorrow morning, and the engineers engaged in this development of trans-oceanic telephone services are at a loss to explain some of the phenomena encountered.

Thus, it may be seen that the reception of short-wave programs is not all a "bed of roses" and that one cannot expect to get foreign stations at all hours of the day and night. It is not our place here to give accurate data on these effects but merely to elucidate some of the problems encountered so that the service technician will be on his guard at all times and will not expect too much either for himself or for his customers. Many magazines—Short Wave Craft for an example—carry much data on the reception of the short waves and on how and at what time they are best received. Another point of importance is that, in order to achieve success in short-wave reception, extreme patience is necessary—for with a one-tube regenerative short-wave receiver and a large supply of "stick-to-it-iveness" the "fan" can line up an incredible list of stations
received.

The new short-wave receivers brought out for the present season are examples of the tendency to do away with plug-in coils. The picture of the latest National receiver shows the use of switches for changing from one band to another. The changes are made by the simple manipulation of the control knob mounted on the right, facing the set. The tuning chart in Fig. 205 shows how the various ranges are covered with the minimum of overlapping.

The ease of tuning, wave-band coverage, simplicity of design, and A.C. operation make the latest developments in short-wave receivers appealing to the ordinary user of radio receivers and open a new avenue of profitable sales to the wide-awake service man.

The complete electrical circuit of the receiver with the values of the components is shown in Fig. 206.

One of the most popular receivers was the old Aero Short-Wave job, the circuit of which is shown in Fig. 207A. As so many letters have been received for information on an A.C. version of this receiver, the circuit is shown in Fig. 207B.

The present season has witnessed the introduction by practically all of the receiver manufacturers, of broadcast "super-het" models which can be readily converted into short-wave receivers by the addition of so-called converters, an example of which is shown in Fig. 208. Here the short waves are beat against the local oscillator V2 and the resultant output of the detector tube V1 is fed to the conventional input circuit of the super.

The characteristics of simplicity of control, lack of plug-in coils, and satisfactory sensitivity play an important part in the public acceptance of these receivers.
PUBLIC ADDRESS AND CENTRALIZED RADIO SYSTEMS

ALTHOUGH the amplifiers employed in Public Address and Centralized Radio Systems are not altogether different from those employed in commercial radio receivers, there are some interesting points regarding their operation which are worthy of mention. In the first place, it is probable that in all instances these amplifiers will be designed for use with microphone, radio or phonograph pick-up. These three services require widely different gain characteristics since the output of the microphone is far below that possibly obtainable from the output of the average detector tube, and still further below that obtained from a phonograph pick-up of standard design. It is necessary then that this fact be taken into account in the design of a system for such multiple service if the minimum labor is to be involved in the change-over from one form of reproduction to the other. In the typical systems shown in Figs. 211 to 216, it will be seen that individual volume controls are employed in the input circuit of the amplifier so that the average levels may be adjusted in such a manner that, in the changing-over process, no great difference in the relative output volume will be observed.

Impedance Matching.

In all systems of this character, the impedance of various components should be matched by the use of appropriate transformers. While—as we have seen before—the maximum undistorted power output of a vacuum tube is achieved when the load impedance is twice that of the tube itself, the maximum quality and efficiency is achieved in other circuits when impedances are identically matched. In doing this, it is necessary to employ a transformer which will make the load "look" like the desired impedance insofar as all electrical characteristics are to be considered. This effect is achieved by employing transformers having turns ratios which are the square roots of the impedance ratios. Let us suppose that we wish to match the impedance of a 500-ohm pick-up to the input of a tube (which may be considered as having an impedance of 250,000 ohms). The impedance ratio is 500:1 and the required turns ratio would be approximately 22.5:1. Since the tube is purely a voltage-operated device and consumes very little power, this gives us a gain of 22.5 in the transformer alone.
impedances are equal. This impedance value may be either 200 or 500 ohms—the latter being the more usual. In working into the 500-ohm amplifier input from the detector tube of the radio receiver, it is necessary to employ a step-down transformer to match the relatively high impedance of the detector tube to the 500-ohm circuit.

All the various components employed are available on the open market and the characteristics and specifications are given in the circuit diagram. Note that the output transformer has two windings, one of which feeds a 500-ohm transmission line terminated in an audio-transformer designed to match the impedance of the line to any number of dynamic moving coils. Remember that the current is high in low impedance circuits such as dynamic moving coils and the voltage drop in the interconnecting wires must be guarded against. Do not use long lengths of wire in connecting up multiple-speaker arrangements of this type and be sure to use nothing smaller than No. 12 wire in the connections. The correct tap to employ on the auto-transformer depends upon the number of speakers used and whether they are connected in series, parallel, or series-parallel. The resultant impedance may be calculated in the same manner as in the case of series or parallel resistances.

In centralized radio systems, a great number of small magnetic or dynamic speakers are employed in a similar series-parallel arrangement. It is best to utilize the high-impedance transformer winding when the small dynamics are employed in this arrangement. The impedance of such a winding is in the neighborhood of 2500 ohms and they should be so connected as to approximately match the 500-ohm output winding of the amplifier itself. The output transformer also has as a monitor a small 15-ohm winding designed to feed the moving coil of a monitoring speaker.

**Power Output Requirements.**

In calculating the power output requirements of systems, there is no set rule to follow. We may, however, assume that the larger dynamic speakers and dynamic horn units require an output of about two watts while the small speakers used in hotel systems do not require more than 1/4 watt for good...
results. We are able to calculate from this data the requirements for operation of most systems. The tubes necessary for the output stage in any system may be chosen from the tube data available in this book. Remember that tubes in parallel give double the output of a single tube while tubes in push-pull may be relied upon to give about 2.4 times the output of the single tube. The range available is all the way from the output obtainable from a single ‘71 up to the output of 60 watts available from two ‘45’s in push-pull. Tubes of a special character capable of an output in excess of one kilowatt are obtainable in special cases and there is no reason why large power requirements should baffle the accomplished service technician.

In Fig. 209, a commercial type or a centralized system mounted in rack form is shown. The various panels and their use are indicated in the figure. The system offers a complete microphone control unit, voltage amplifier, and a 50-watt push-pull output stage for use with as many groups of speakers as desired. The change from "mike" to broadcast reproduction is accomplished by throwing the switches on the control panel. The circuits of the units which are incorporated in this unit are to be found in detail in the section of the Manual devoted to sound-system circuit diagrams.

A typical circuit diagram of a W.E. Co. 41A speech amplifier unit is shown in Fig. 210 and is an example of excellent design. The service man can build a real recording or public-address amplifier by following the information given in the drawing.

The necessity of proper impedance matching as stated above is an important consideration and it will be noted that the circuits shown in Figs. 211 to 216 are designed with this consideration in mind.

Mixers.

The simple series type of mixer is shown in Fig. 211. While it has the advantage of simplicity, it has the disadvantage of not being constant in its impedance of the operating range. The circuit of Fig. 212 is better as the type of control is practically constant-impedance and is superior to the method shown in Fig. 211. The most generally used type of control found in the better type of installation is indicated in Fig. 213. This system gives practically constant impedance with the various settings of the controls and is an important part of a first-class installation.

The use of phonograph records and electrical pick-ups for entertainment purposes in place of radio programs has become commonplace and the average system must include at least one electric turntable for record reproduction. The circuit shown in Fig. 214 indicates individual control of output of the two pick-ups so that the output of one can be faded into the output of the other so that the musical program can be continued without interruption.

The average radio detector-plate circuit has a very high impedance which must be matched to the 500-ohm line by means of a step-down transformer. See Fig. 215. The primary of the matching transformer for use with a ‘27 type tube used as a detector should have an inductance of about 250 henries to
VOICE COILS IN SERIES

VOICE COILS IN PARALLEL

VOICE COILS IN SERIES PARALLEL

FIG. 217

afford ample bass frequency response. It is important that the direct current flowing in the plate circuit of the detector tube does not cause a drop in the inductance of the transformer primary. It is fortunate that the tubes used as detectors with the present systems of detection seldom require more than 1 to 1.5 ma., thus reducing the possibility of a serious drop in the inductance of the primary of the detector output matching transformer.

In Fig. 216, a more or less standardized circuit of a combined voltage and power amplifier circuit complete with its power supply is shown. It will be noticed that the input circuit and the output circuit both terminate with impedances of 500 ohms. The special output transformer, called an auto-transformer, is used for the purpose of matching the 500-ohm line to the speakers. The use of a device of this type is absolutely necessary if quality reproduction is to be obtained.

Jacks are included in the plate circuits of the various tubes so that an accurate check can be made on the plate current flowing. In the '50 stage, it is convenient to have some method whereby the two tubes can be matched as closely as possible. Tubes should be selected for their equality in plate-current drain under actual operating conditions.

In public address systems, the speakers are generally operated in banks of 25 or more and, to enable the designer to establish a low impedance line between the output transformer and the speakers, the voice-coils are connected in series or parallel, as the case may be. Fig. 217 shows the connections of speakers in series, in parallel, and in series-parallel with the effective of the resultant load when each voice-coil has an impedance of 10 ohms.

FIG. 218

Many times the service man is called upon to install a scratch-filter which is used to reduce the surface noise present in all phonograph records. Fig. 218 gives all the information for the computation of the necessary values of inductance and capacity for such devices. The cut-off frequency should generally be computed for frequencies of 3000 cycles or higher.
CIRCUIT DIAGRAM OF MODEL S-8 SHOWING NORMAL VOLTAGES WITH VOLUME CONTROL IN FULL "ON" POSITION.

SCHEMATIC DIAGRAM OF LYRIC MODEL 58 CHASSIS.

1—110 volt Primary Start
2—110 volt Primary Finish
3—Shield
4—High Voltage Secondary Start
5—High Voltage Secondary Tap
6—High Voltage Secondary Finish
7—80 Filament Winding Start
8—80 Filament Winding Finish
9—Heater and 47 Filament Winding Start
10—Heater and 47 Filament Winding Finish
11—No Connection
ALL-AMERICAN MOHAWK CORP.

Schematic Diagram of Lyric Model S-7 Chassis

Circuit Diagram #2 Showing Normal Voltages
With Volume Control in Full "On" Position

Power Transformer Connections

1-110 volt Primary Start
2-110 volt Primary Finish
3-Shield
4-High Voltage Secondary Start
5-High Voltage Secondary Tap
6-High Voltage Secondary Finish
7-80 Filament Winding Start
8-80 Filament Winding Finish
9-Heater and ’47 Filament Winding Start
10-Heater and ’47 Filament Winding Finish
11-No Connection
ALL-AMERICAN MOHAWK CORP.

CONNECTION TO FRAME OF SPEAKER

OUTPUT TRANS.
BROWN
YELLOW
WHITE
FIELD COIL
RED

Nominal Voltage Chart of Lyric Model J' Chassis

1-110 Volt Primary Start.
2-110 Volt Primary Finish.
3-Shield.
4-High Voltage Secondary Start.
5-High Voltage Secondary Tap.
6-High Voltage Secondary Finish.
7-'80 Filament Winding Start.
8-'80 Filament Winding Finish.
9-'24 and '45 Filament Winding Start.
10-'24 and '45 Filament Winding Tap.
11-'24 and '45 Filament Winding Finish.
Schematic Diagram Of Lyric Model 5-6 Showing Normal Voltages With Volume Control In Full "ON" Position.

Dotted Lines Represent Change In Effect After Serial Number 1,402,550

1-110 volt Primary Start
2-110 volt Primary Finish
3-Shield
4-High Voltage Secondary Start
5-High Voltage Secondary Tap
6-High Voltage Secondary Finish
7-80 Filament Winding Start
8-80 Filament Winding Finish
9-Heater Winding Start
10-Heater Winding Finish
11-No Connection
ALL-AMERICAN MOHAWK CORP.

LYRIC MODEL "D"
AMERICAN BOSCH MAGNETO CORP.

MODEL 73 AND 74

R 1—Volume Control 10,000 ohms
R 2—2750 ohms } Tapped unit
R 3— 250 ohms
R 4—Cathode Resistor 750 ohms
R 5—Cathode Resistor 25,000 ohms
R 6—50,000 ohms
R 7—Tone Control 50,000 ohms
R 8—Plate Supply Resistor 5,000 ohms
R 9—Plate Supply Resistor 10,000 ohms
R 10—Screen Supply Resistor 750 ohms
R 11—Cathode Resistor 25,000 ohms
R 12—Screen Supply Resistor 30,000 ohms
R 13—Audio Bias Resistor 800 ohms
R 14—Center Tap Resistor 4.1 ohms

C 14—Cathode By-pass .05 mfd.
C 15—Screen By-pass .05 mfd.
C 16—Plate By-pass .05 mfd.
C 17—Cathode By-pass .05 mfd.
C 18—Screen By-pass .05 mfd.
C 19—Plate By-pass .05 mfd.
C 20—Det. Cathode By-pass .25 mfd.
C 21—Filter Condenser 2. mfd.
C 22—Filter Condenser 2. mfd. } top unit
C 23—Filter Condenser 4. mfd.
C 24—Audio Bias By-pass .05 mfd.
C 25—Buffer Condenser .1 mfd. (top unit)

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<th>Tube</th>
<th>Plate</th>
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<th>Cathode</th>
<th>Grid</th>
<th>Fil.</th>
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AMERICAN BOSCH MAGNETO CORP.

MODEL 20

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<td>5</td>
<td>38 MA</td>
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BOSCH 80 & 84

R-1 - Volume Control 18,000 ohms
R-2 - 1st RF Bias Resistor 500 ohms
R-3 - Detector Bias Resistor 25,000 ohms
R-4 - Detector Screen Resistor 500,000 ohms
R-5 - Detector Plate Resistor 500,000 ohms
R-6 - Audio Grid Resistor 2 meg.
R-7 - Series Grid Resistor 250,000 ohms
R-8 - Filament Resistor 1.3 ohms
R-9 - Filament Resistor 1.1 ohms
R-10 - Audio Bias Resistor 900 ohms
C-1 - 1st RF Tuning Condenser
C-2 - 2nd RF Tuning Condenser
C-3 - 3rd RF Tuning Condenser
C-4 - Filament By-pass Condenser
C-5 - Screen By-pass Condenser .5mf.
C-6 - Cathode By-pass Condenser .5mf.
C-7 - Plate By-pass Condenser 1.mf.
C-8 - Detector Cathode Condenser .5mf.
C-9 - Detector Screen Condenser .5mf.
C-10 - Detector Plate Condenser .0001mf.
C-11 - Detector Plate Condenser .0001mf.
C-12 - Coupling Condenser .002mf.
C-13 - Output Condenser 1.mf.
C-14 - Filament By-pass Condenser
C-15 - 1st RF Alignment Condenser
C-16 - 3rd RF Alignment Condenser
C-17 - Det. Alignment Condenser
C-18 - Speaker Condenser
--- DE LUXE RECORDING AMPLIFIER ---

1. 994 AMERTRAN TRANSFORMER FROM DETECTOR TO 500 OHM LINE
2. 5153 AMERTRAN TRANSFORMER FROM 500 OHM LINE TO GRIDS OF TUBES
3. 710 AMERTRAN TRANSFORMER BETWEEN OUTPUT OF 2 TUBES AND 2 GRIDS
4. 678 AMERTRAN TRANSFORMER TO 200 OHM LINE OR TO 9 IS-OHM VOICE COILS

OR

5. 3322 AMERTRAN TRANSFORMER TO 500 OHM LINE AND 15 OHM MONITOR
6. 988 AMERTRAN PARALLEL FEED ALLOY CORE CHOKE
7. 782 AMERTRAN ALLOY CORE AUDIO CHOKE
8. 577A AMERTRAN FILTER CHOKE
9. 250A AMERTRAN ALLOY CORE CHOKE
10. 3842 AMERTRAN TRANSFORMER BETWEEN OUTPUT OF 2 TUBES AND 2 GRIDS
11. 2848 AMERTRAN TRANSFORMER TO 200 OHM LINE OR TO 9 IS-OHM VOICE COILS
12. 3332 AMERTRAN TRANSFORMER TO 500 OHM LINE AND 15 OHM MONITOR
13. 988 AMERTRAN PARALLEL FEED ALLOY CORE CHOKE
14. 250A AMERTRAN ALLOY CORE CHOKE
15. 3842 AMERTRAN TRANSFORMER BETWEEN OUTPUT OF 2 TUBES AND 2 GRIDS

R1 100,000 OHM VARIABLE, ELECTRATD OR CENTRALAB
R2 50,000 OHM DURHAM, AEROVOX OR EL-MENCO 3 WATT RATING
R3 1000 OHM VARIABLE CENTRALAB
R4 2000 OHM VARIABLE WARD LEONARD ADJUSTAT
R5 20 OHM CENTER TAPPED AEROVOX OR CLAROSTAT HUMDINGER
J CLOSED CIRCUIT JACKS

NOTE: ALL PAIRS OF LEADS TWISTED
In the above Diagram, the following AmerTran Quality Radio Products are used:

1. AmerTran Deluxe Audio Transformer
2. AmerTran Input Transformer Type #151
3. AmerTran Interstage Transformer Type #710
4. L1 Audio Choke, Type 641
5. L2 Audio Choke, Type 557
6. L3 Audio Choke, Type 709
7. L4 Audio Choke, Type 854
8. AmerTran Voltage Divider, Type R400
9. AmerTran Power Transformer, Type PF 250
10. AmerTran Heater Transformer, Type H 67

The Output from the two 250 tubes to dynamic type speakers should be through an AmerTran special output transformer designed to operate the type and number of speakers to be used.

Further information on request.

The type 678 output transformer is supplied. Please use one 678 at each speaker. In place of one choke use another transformer.

The type PP250 output transformer is supplied. Please use one PP250 at each speaker. In place of one choke use another transformer.

The two speakers in series will not work.

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2. AmerTran Input Transformer Type #151
3. AmerTran Interstage Transformer Type #710
4. L1 Audio Choke, Type 641
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The Output from the two 250 tubes to dynamic type speakers should be through an AmerTran special output transformer designed to operate the type and number of speakers to be used.

Further information on request.
AMERICAN TRANSFORMER CO. (AMERTRAN)

**Diagram:**

- **Correct Position if Amplifier Mounted Directly Above PFS2:**
  - Coaxial cable towards you.
  - Distance below 2½" or less.

- **Incorrect Position of Least Coupling, Little or No Hum:**
  - Axis of PFS2 coil and choke are at right angles to Deluxe coil from all view points.

- **Incorrect:**
  - Axis of coil in PFS2 is still pointing toward Deluxe, along Deluxe axes vertical, and at right angles.

- **Correct Position of Maximum Coupling and Hum Axes of All Coils Coincide:**
  - Arrows show direction of magnetic field.

**Elimination of Hum Caused by 60 Cycle Magnetic Field from Power Transformer and First Filter Choke:**

- The most effective shielding is that produced by a heavy copper or brass box around the power transformer and first filter choke. The second choke should be outside of this box. The distance apart of chokes and between first choke and transformer should not be less than 1½" to 2".

**Note:**
- Core of Power Transformer must be at right angles to audio frequency transformer.
Diagram of Early Model 61 and 61-C (Direct Current).

Schematic Diagram of Later Model 61 and 61-C (Direct Current).
Circuit of Later Model 60 and 60-C.

Diagram of Early Model 67 and 67-C (Battery Operated).
Diagram of Later Model 67 and 67-C (Battery Operated).
ATWATER KENT MANUFACTURING CO.

Diagram of D-1 Chassis.

Diagram of Q-2 Chassis.
D. C. Voltages

READING FROM—

<table>
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<th>Chassis (ground)</th>
<th>to plates of R. F. tubes</th>
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<tr>
<td></td>
<td>to plate of Detector</td>
<td>75 to 95 volts</td>
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<td></td>
<td>to plate of Pentode</td>
<td>215 to 235 volts</td>
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<td>to screen of R. F. tubes</td>
<td>45 to 65 volts</td>
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<td></td>
<td>to screen of Detector</td>
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<td></td>
<td>to screen of Pentode</td>
<td>215 to 235 volts</td>
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<td>to cathode of R. F. tubes</td>
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<tr>
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<td>to pentode Filament Center Tap</td>
<td>14 to 18 volts</td>
</tr>
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</table>

A. C. Voltages

1st R. F., 2nd R. F., Detector and Pentode Filaments 2.3 to 2.5 volts
Rectifier Filament 4.8 to 5.1 volts
Ground to plates of 280 approximately 375 volts

NOTE: Filament Voltages may be measured with a Weston Triple Range (0-4, 0-8, 0-150) Type 528 AC Voltmeter. The high voltage on the Rectifier Plates should be measured with a double range (300, 0-600) Type Weston AC Voltmeter.
A.C. SET WITH POWER UNIT

 BRANDES PRODUCTS CORP.
GANG CONDENSER

CAPACITANCE COLOR CODE

<table>
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<tr>
<th>VALUE</th>
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<tbody>
<tr>
<td>200</td>
<td>RED</td>
<td>BLACK</td>
<td>BROWN</td>
</tr>
<tr>
<td>3,000</td>
<td>GREEN</td>
<td>BLACK</td>
<td>RED</td>
</tr>
<tr>
<td>10,000</td>
<td>BROWN</td>
<td>BLACK</td>
<td>ORANGE</td>
</tr>
<tr>
<td>15,000</td>
<td>BROWN</td>
<td>GREEN</td>
<td>ORANGE</td>
</tr>
<tr>
<td>20,000</td>
<td>RED</td>
<td>BLACK</td>
<td>ORANGE</td>
</tr>
<tr>
<td>25,000</td>
<td>RED</td>
<td>GREEN</td>
<td>ORANGE</td>
</tr>
<tr>
<td>100,000</td>
<td>BROWN</td>
<td>BLACK</td>
<td>YELLOW</td>
</tr>
<tr>
<td>2 MEG</td>
<td>RED</td>
<td>BLACK</td>
<td>GREEN</td>
</tr>
</tbody>
</table>

RESISTOR COLOR CODE

- .0002 GREY
- .0005 RED
- .000725 YELLOW
- .001 ORANGE
- .0015 BLUE
- .009 PINK
- 0.25 MEG.
- 2 MEG.

K-70-72

1ST DRY: I.F.

2" DET. CHOKE COIL

PILOT LIGHT 2.5 V

FIELD COIL 830 A
"Columbia Model C-5 Receiver and Kolster Model K-24 (250 Power Unit)"
R K-267302-4200  9 5%  
R 4 K-267303-4600  9 5%  
R. K-2673033-400 Tapped  
AT 270 & 310  9 5%  

OUTPUT TRANSFORMER Y-116S  

68° POTentiOMETER  

TERMINAL BOARD  

RADIO JACK  

INTERSTAGE Transformer Y-1164  

R.P.A.5 (AP-952)  
(with Potentiometer)
Schematic Circuit of Socket Power Unit (used on #14 & #21 radios)

Internal Connections of Filter and By-Pass Condensers

Arrangement of Resistors on Terminal Board

Black 4000™
Black 3500™
Green 104000™
Orange 3500™
Green 104000™
BRUNSWICK-BALKE-COLLENDER CO.

ANTENNA COMPENSATOR

LONG ANTENNA

SHORT ANTENNA

GROUND

MECHANICALLY COUPLED

0.00015 MFD.

0.002 MFD.

0.002 MFD.

Pilot Light

Combination Volume Control and Switch

Internal Connections of Power Transformer

To Switch Terminals on Socket Power Unit

Primary

246 Fil Winding

246 Fil Winding

280 Fil Winding
*Reading dependent upon resistance of meter.

† Reading taken for one anode only: 60 milliamperes would be about correct.

Volume control position full. Line voltage 115—60 cycle.
**Table:**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1st R. F.</td>
<td>51</td>
<td>2.1</td>
<td>225</td>
<td>2.1</td>
<td>2</td>
<td>75</td>
<td>5</td>
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<tr>
<td>2nd R. F.</td>
<td>51</td>
<td>2.1</td>
<td>230</td>
<td>2.2</td>
<td>2</td>
<td>75</td>
<td>4.5</td>
</tr>
<tr>
<td>Det.</td>
<td>24</td>
<td>2.1</td>
<td>160*</td>
<td>7</td>
<td>7.5</td>
<td>75</td>
<td>0.02</td>
</tr>
<tr>
<td>Output</td>
<td>47</td>
<td>2.1</td>
<td>215</td>
<td>5*</td>
<td>0</td>
<td>225</td>
<td>26.5</td>
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<tr>
<td>Rect.</td>
<td>80</td>
<td>4.8</td>
<td>280</td>
<td></td>
<td></td>
<td>30</td>
<td></td>
</tr>
</tbody>
</table>

*Reading dependent upon resistance of meter.†Reading taken for one anode only; 50 milliamperes would be about correct.
Volume control position full. Line voltage 115–60 cycle.
CIRCUIT DIAGRAM OF MODELS 104, 105, AND 106 POWER CONVERTER.

YELLOW TO UX-226

BLACK TO UX-171

PINK TO UX-227

CIRCUIT DIAGRAM OF MODELS 104R AND 105R POWER CONVERTER.

Model 77
Model 124

Diagrams of Speaker Connections Models 122, 123, 124

SPEAKERS 297 AND 305-J FOR CHASSIS 122

SPEAKER 287 FOR CHASSIS 123; SPEAKERS 306-J AND 306-M FOR CHASSIS 124
Model 80 Superheterodyne
Model 40 Echoette

All Resistors ± 10%
Unless Otherwise Specified

All Cond. ± 10%
Unless Otherwise Specified

R1 20,000 Ohm Volume Control with R2 300 Ohm Fixed Bias
R3 35,000 Ohm 5 Watt
R4 50,000 Ohm 1 Watt
R5 50,000 Ohm 1 Watt
R6 .5 Meg 1 Watt
R7 1 Meg .5 Watt
R8 1.5 Meg .5 Watt
R9 .5 Meg 1 Watt
R10 2.2 Meg .5 Watt
R11 1 Meg .5 Watt
R12 20 Ohm C.T. Resistor
Model 90 Superheterodyne

C1 .00036 Vac Cond.
C2 .00036 Vac Cond.
C3 .00036 Vac Cond.
C4 .00036 Vac Cond.
C5 .001 Cond. + 3 %
C6 1 MF 200 V Cond.
C7 1 MF 200 V Cond.
C8 1 MF 200 V Cond.
C9 .5 MF 200 V Cond.
C10 .01 MF 400 V Cond.
C11 .001 MF 400 V Cond.
C12 .00001 Cond.
C13 .02 MF 400 K Cond.
C14 .05 MF 400 V Cond.
C15 .05 MF 400 V Cond.
C16 .05 MF 400 V Cond.
C17 .05 MF 400 V Cond.
C18 .05 MF 400 V Cond.

R1 15,000 Ohm 5 Watt Res.
R3 20,000 Ohm Var Res. With
R4 200 Ohm Fixed Bias Res.
R5 22,000 Ohm 1 Watt Res.
R6 1,500 Ohm 5 Watt Res.
R7 5 Meg 5 Watt Res.
R8 15,000 Ohm 5 Watt Res.
R9 15,000 Ohm 5 Watt Res.
R10 1 Meg 1 Watt Res.
R11 1 Meg 1 Watt Res.
R12 5 Meg 1 Watt Res.
R13 10 Meg Ohm 1 Watt Res.
R14 .25 Meg 1 Watt Res.
R15 2,000 Ohm Tone Control
R16 1,000 Ohm 5 Watt Res.
R17 15,000 Ohm 1 Watt Res.
R18 35,000 Ohm 1 Watt Res.
R19 1,000 Ohm 1 Watt Res.
R20 250 Ohm 2 Watt Res.
R21 20 Ohm Center Tapped Res.

All Capacitors + 10%,
Unless Otherwise Specified

All Resistors + 10/,
Unless Otherwise Specified
WIRING DIAGRAM
Model 248 Receiver

WIRING DIAGRAM
Model 250 Receiver

NOTE:
1. DOTTED LINES DEPICT PROGRESSIVE
   TRANSFORMERS RELATIVE TO
   NUMBERS SHOWN WITH PREPEND "P"
   AS COMPLETE ASSEMBLIES

NOTE:
1. DOTTED LINES DEPICT PROGRESSIVE
   TRANSFORMERS RELATIVE TO
   NUMBERS SHOWN WITH PREPEND "P"
   AS COMPLETE ASSEMBLIES
Wiring Diagram
Model 271A Receiver

NOTE:
1. DOTTED LINES DENOTE SHIELING
2. ALL NUMBERS SHOWN RELATIVE TO PARTS AND OUR PART NO.
3. NUMBERS SHOWN WITH PREFIX "A" ARE COMPLETE ASSEMBLIES

JESSE FRENCH AND SONS PIANO CO.
GENERAL ELECTRIC CO.

Constructional details of special tools used with remote control models

**H-51-R AND H-71-R**

Diagram showing electrical connections and layout for remote control models. Detailed annotations for adding additional control buttons, remote control cable, and special tools for installation.

- Black with red tracer cable for regular cable
- Remote control cable strip
- 2 1/8" opening for #2 hex nuts
- 1/8" drill rod

Connections for adding additional buttons.
MOTOR CONTACTOR ADJUSTMENT CHART
Repeat Entire Procedure For All Contactors

<table>
<thead>
<tr>
<th>ACTION</th>
<th>DRAWING</th>
<th>NOTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>TURN STATION SELECTOR KNOB UNTIL CONTACTOR IS TO ONE SIDE</td>
<td><img src="image" alt="Diagram 1" /></td>
<td>DOES NOT MOVE WHEN SETTING BUTTON IS PRESSED.</td>
</tr>
<tr>
<td>PUSH SELECTOR BUTTON ON PANEL UNTIL THE MOTOR STOPS AND CONTACTOR IS CENTERED</td>
<td><img src="image" alt="Diagram 2" /></td>
<td>DO NOT MOVE, ADJUSTMENT IS OK.</td>
</tr>
<tr>
<td>THEN PUSH SETTING BUTTON. IF CONTACTOR DOES NOT MOVE, ADJUSTMENT IS OK.</td>
<td><img src="image" alt="Diagram 3" /></td>
<td>IF CONTACTOR MOVES IN THIS DIRECTION WHEN SETTING BUTTON IS PRESSED. ADJUST AS INDICATED.</td>
</tr>
<tr>
<td>IF CONTACTOR MOVES IN OTHER DIRECTION, ADJUST AS INDICATED.</td>
<td><img src="image" alt="Diagram 4" /></td>
<td>AFTER MAKING PRECEDING ADJUSTMENTS TURN STATION SELECTOR KNOB UNTIL CONTACTOR IS TO THIS SIDE.</td>
</tr>
<tr>
<td>PUSH SELECTOR BUTTON ON PANEL UNTIL THE MOTOR STOPS AND CONTACTOR IS CENTERED</td>
<td><img src="image" alt="Diagram 5" /></td>
<td>DOES NOT MOVE WHEN SETTING BUTTON IS PRESSED.</td>
</tr>
<tr>
<td>THEN PUSH SETTING BUTTON. IF CONTACTOR DOES NOT MOVE, ADJUSTMENT IS OK.</td>
<td><img src="image" alt="Diagram 6" /></td>
<td>IF CONTACTOR MOVES IN THIS DIRECTION WHEN SETTING BUTTON IS PRESSED. ADJUST AS INDICATED.</td>
</tr>
<tr>
<td>IF CONTACTOR MOVES IN THIS DIRECTION, ADJUST AS INDICATED.</td>
<td><img src="image" alt="Diagram 7" /></td>
<td>TURN THIS SCREW CLOCKWISE A LITTLE AT A TIME UNTIL CONTACTOR DOES NOT MOVE WHEN SETTING BUTTON IS PRESSED. (TURN SELECTOR KNOB AND RETUNE WITH SELECTOR BUTTON AFTER EACH TRIAL ADJUSTMENT)</td>
</tr>
</tbody>
</table>

H-51R AND H-71-R
### Radiotron Table

<table>
<thead>
<tr>
<th>Radiotron No.</th>
<th>Heater to Cathode Volts</th>
<th>Cathode or Filament to Control Grid Volts</th>
<th>Cathode or Filament to Screen Grid Volts</th>
<th>Cathode or Filament to Plate Volts</th>
<th>Plate Current M. A.</th>
<th>Heater Volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.0</td>
<td>85</td>
<td>225</td>
<td>4.0</td>
<td>30.0</td>
<td>2.2</td>
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<tr>
<td>2</td>
<td>7.0</td>
<td>65</td>
<td>100</td>
<td>0.25</td>
<td>30.0</td>
<td>2.2</td>
</tr>
<tr>
<td>3</td>
<td>2.0</td>
<td>225</td>
<td>215</td>
<td>30.0</td>
<td>215</td>
<td>2.2</td>
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</table>
110 VOLT LINE

<table>
<thead>
<tr>
<th>RAdiotron No.</th>
<th>Heater to Cathode Volts</th>
<th>Cathode or Filament to Control Grid Volts</th>
<th>Cathode or Filament to Screen Grid Volts</th>
<th>Cathode or Filament to Plate Volts</th>
<th>Plate Current M.A.</th>
<th>Heater Volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. R.F.</td>
<td>2.0</td>
<td>*0.2</td>
<td>60</td>
<td>230</td>
<td>3.5</td>
<td>2.5</td>
</tr>
<tr>
<td>2. Osc.</td>
<td>5.0</td>
<td>0</td>
<td>—</td>
<td>50</td>
<td>4.0</td>
<td>2.5</td>
</tr>
<tr>
<td>3. 1st Det.</td>
<td>4.0</td>
<td>3.5</td>
<td>60</td>
<td>230</td>
<td>0.5</td>
<td>2.5</td>
</tr>
<tr>
<td>4. 1st I.F.</td>
<td>2.0</td>
<td>*0.2</td>
<td>60</td>
<td>230</td>
<td>3.5</td>
<td>2.5</td>
</tr>
<tr>
<td>5. A.V.C.</td>
<td>0</td>
<td>0</td>
<td>—</td>
<td>30</td>
<td>0.1</td>
<td>2.5</td>
</tr>
<tr>
<td>6. 2nd I.F.</td>
<td>2.0</td>
<td>3.5</td>
<td>60</td>
<td>230</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>7. 2nd Det.</td>
<td>20.0</td>
<td>*8.0</td>
<td>—</td>
<td>210</td>
<td>0.5</td>
<td>2.5</td>
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<tr>
<td>8. Pwr.</td>
<td>—</td>
<td>*10.0</td>
<td>250</td>
<td>235</td>
<td>25.0</td>
<td>2.5</td>
</tr>
<tr>
<td>9. Pwr.</td>
<td>—</td>
<td>*10.0</td>
<td>250</td>
<td>235</td>
<td>25.0</td>
<td>2.5</td>
</tr>
</tbody>
</table>

**H-32**

*Magnetic Pickup connections*

Note: Place the Radio-Record switch and input transformer in the receiver cabinet. Try connecting a wire from receiver terminal No. 6 to input transformer frame or braided shield to pickup and use connection that gives minimum hum.
GENERAL ELECTRIC CO.

[Diagram of an electronic circuit with labels for components such as capacitors, resistors, transformers, and switches. The components are marked with labels that include values such as MFD (microfarads) and resistance values in ohms.]
TABLE OF RESISTORS AND CONDENSERS:

<table>
<thead>
<tr>
<th>No.</th>
<th>Body</th>
<th>Red</th>
<th>Spot</th>
<th>Resistance</th>
<th>Watts</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>Orange</td>
<td>Black</td>
<td>Brown</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>R2</td>
<td>Yellow</td>
<td>Green</td>
<td>Red</td>
<td>4,000</td>
<td></td>
</tr>
<tr>
<td>R3</td>
<td>Red</td>
<td>Green</td>
<td>Orange</td>
<td>25,000</td>
<td></td>
</tr>
<tr>
<td>R4</td>
<td>Yellow</td>
<td>Black</td>
<td>Yellow</td>
<td>100,000</td>
<td></td>
</tr>
<tr>
<td>R5</td>
<td>Red</td>
<td>Green</td>
<td>Yellow</td>
<td>250,000</td>
<td></td>
</tr>
<tr>
<td>R6</td>
<td>Green</td>
<td>Black</td>
<td>Yellow</td>
<td>500,000</td>
<td></td>
</tr>
<tr>
<td>R7</td>
<td>Red</td>
<td>Black</td>
<td>Green</td>
<td>2 Watts</td>
<td></td>
</tr>
</tbody>
</table>

Voltage Divider

| Solid Brown | 4,800 Ohms | Brown Body | 7,600 Ohms | 6,000 Ohms |

CONDENSERS

- .1 Mfd. By-Pass Condenser
- .05 Mfd.
- .02 Mfd.
- .005 Mfd.
- .002 Mfd.
- .05 Mfd.
- .1 Mfd.
- .00001 Mfd.
- .00002 Mfd.
- .00005 Mfd.
- .0001 Mfd.
- .0002 Mfd.
- .00075 Mfd.
- .002 Mfd.
- .01 Mfd.
- .02 Mfd. (Electrolytic)
- .05 Mfd. (Electrolytic)
- 4.0 Mfd. (Electrolytic)
- 8.0 Mfd. (Electrolytic)
MODEL 20 CHASSIS 110 AND 220 VOLTS - 50-60 AND 25-40 CYCLE

110 Astvo 220 VOLTS - 50- 60 AND 25 40 CYCLE

Co
G-27
OSCILLATOR
ANTENNA
COMPENSATING
CONDENSER

ANT
GND.

GND.

LINE CORD

SWITCH, ACTUATED
BY VOLUME CONTROL

KNB

PILOT LIGHT

Pilot Light

SPEAKER FIELD I 2. 50 OHMS NOMINAL AT OPERAT NE

Temperature

Power Transformer

Primary—Red (No. 24)
Primary—Red (No. 24)
Filament
Filament 45—Blue
Heater 51—Red (2 strands No. 18)
Heater 151—Red (2 strands No. 18)
Center Tap 45—Red (stranded)
Anode—Green (stranded)
C. T. Anode—Bare (stranded)
Anode—Green (stranded)
Filament
Filament 80—Orange (No. 18)

Filter Unit

Condenser

A = 4 MFD
B = 2 MFD
C = 1 MFD
D = 1 MFD

25 - 40 CYCLE

Choke

G-80 socket (Filament)—Orange (stranded)
Junction speaker Field and Choke—Blue (stranded)

Condenser

2 microfarad condenser—Orange (stranded)
2 microfarad condenser—Blue (stranded)
1 microfarad condenser—Red (stranded)
1 microfarad condenser—Green (stranded)
0.07 microfarad condenser—White (stranded)
Condenser common—Black (stranded)

Condenser common—Black (stranded)
GRIGSBY-GRUNOW CO.

Filter Unit

2 microfarad condenser—Green
2 microfarad condenser—Red
2 microfarad condenser—Blue
1 microfarad condenser—Yellow
.07 microfarad condenser—White
Condenser common—Black

Primary Start of Winding
- Red
- Red and White
- 105 volts
- 115 volts
- 125 volts
Filament
- Healthy
- 45 Blue
Heater
- White—(135 v. above ground)
- Red—(2nd Det. A. V. C. and Osc.)
Center Tap—45 Red
Anode—Green
C. T. Anode—Bare
Filament
- 80 Brown
Filament
- 80 Brown

Choke

Filter Output—Red
Detector Choke Low Side—Green
Junction of Chokes—Blue

Primary Start of Winding
- Red
- Red and White
- 105 volts
- 115 volts
- 125 volts
Filament
- Healthy
- 45 Blue
Heater
- White—(135 v. above ground)
- Red—(2nd Det. A. V. C. and Osc.)
Center Tap—45 Red
Anode—Green
C. T. Anode—Bare
Filament
- 80 Brown
Filament
- 80 Brown

Schematic Diagram of Majestic Screen Grid Superhetorodyne Automatic Volume Control Receiver—Model 60 Chassis 110 and 220 Volts, 25-40 and 50-60 Cycles
SCHEMATIC DIAGRAM FOR MODEL 90-B MAJESTIC CHASSIS 25-40 AND 60 CYCLE
**SPEAKER CABLE**

Field Supply "A" plus—yellow  
Field Supply "A" minus—ground cable shield  
Pentode Plates—black  
Positive "B" center tap—red

**CONTROL CABLE**

Switch—yellow from chassis to red from control cable.  
Switch—black from chassis to black from control cable.  
Volume control—Center Arm—blue from chassis to blue from control cable.  
Right stop (high side)—brown from chassis to yellow from control cable.  
Left Stop (low side)—Control cable shield ground.

All leads marked "A" plus in color code of the Service Manual signify the ungrounded side of the car battery and not necessarily the positive side.
**HOME BATTERY RECEIVER  MODEL -120**

**BIAS VOLTAGES**

<table>
<thead>
<tr>
<th>Volume Control at Maximum</th>
<th>Volume Control at Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>R. F.</td>
<td>3 volts</td>
</tr>
<tr>
<td>Osc.</td>
<td>0 volts</td>
</tr>
<tr>
<td>1st Det.</td>
<td>8 volts</td>
</tr>
<tr>
<td>L. F.</td>
<td>3 volts</td>
</tr>
<tr>
<td>2nd Det.</td>
<td>8 volts</td>
</tr>
<tr>
<td>Pentode</td>
<td>13.5 volts</td>
</tr>
<tr>
<td>R. F.</td>
<td>11 volts</td>
</tr>
<tr>
<td>Osc.</td>
<td>0 volts</td>
</tr>
<tr>
<td>1st Det.</td>
<td>14 volts</td>
</tr>
<tr>
<td>I. F.</td>
<td>3 volts</td>
</tr>
<tr>
<td>2nd Det.</td>
<td>8 volts</td>
</tr>
<tr>
<td>Pentode</td>
<td>13.5 volts</td>
</tr>
</tbody>
</table>

**COLOR CODE**

**Volume Control and Switch Connections**

Antenna section of volume control—Red and Black.

“C” bias section of volume control—Blue and Yellow.

“A” battery side of switch—Red.

Jumper switch to volume control—Blue.

Switch to “C” bias—White.
HOWARD A.V.C. SERVICE NOTES FOR A.V.H. RECEIVER

In the interest of obtaining best results with the Automatic Volume Control receiver it is important that the control tube (type 227) be a selected tube, one which has a definite plate current cutoff when tested at 180 volts plate and 20 volts bias on the grid. This cutoff should be less than 5 microamperes. If you do not have any means for checking the tube, in the form of a special tube tester, an immediate check for tube performance can be obtained in the set itself. For instance, disconnect the antenna and short circuit the aerial lead, leaving the control tube out of the socket, and note the swing of the tuning meter. Then insert the tube in the socket and if it is a good automatic volume control tube, there should be no change in the position of the pointer on the tuning meter. If there is a change in the position of the tuning meter pointer, namely, a swing toward the right, it is an indication that the automatic volume control tube does not have a definite plate cutoff, but it is drawing plate current and consequently, the bias voltage on the regular RF and IF tubes has been raised, with the consequent cutting down in plate current.

It might be a good point to mention at this time that the tuning meter in a 13 milliamperes full scale reading meter and that it is connection in series with the B plus lead that furnishes voltage for the RF, first detector and IF tubes. In view of the fact that this tuning meter is in series with the plates of the amplifying tubes, you can very readily note whether or not the control tube is functioning in a proper manner, by noting the performance of said tube by its reaction on the plate current of the respective tubes as shown by the swing of the pointer on the tuning meter.

For further information with reference to this receiver, special mention is made of the fact that the speaker furnished with this receiver is different from the regular speaker furnished with the Model 35 and 40 receivers. The difference lies in the fact that the Model 45 speaker has a 350 ohm field, and as such, it cannot be used with the Model 35 and 40 receivers. Please note this fact in order to prevent trouble in the future with reference to service troubles which may arise due to the use of the wrong type speaker.
From Output Unit  "B" Cable

<table>
<thead>
<tr>
<th>Black &amp; Red Wire</th>
<th>Red Wire</th>
<th>Slate Wire</th>
<th>Maroon Wire</th>
<th>Black Wire</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>B+PWR</td>
<td>B+AMP</td>
<td>B+DET</td>
<td>B-</td>
</tr>
<tr>
<td>PWR FIL</td>
<td>AMP FIL</td>
<td>DET FIL</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Speaker Terminals

Green Wires  Yellow Wires  Brown Wires

terminal board  "A" Cable
CHAS. HOODWIN CO.

LOW POWER TRANSMITTER

Ant.

C3

Pilot 24V.

Grd.

C1 50 MMFD
C2 250 MMFD
C3 150 MMFD
C4 500 MMFD
R1 0 - 500,000n
R2 1 - 10 µA

A+ R- B+

Grd.

R1

C1

C3

RFC

B+

B-

A

A

C4 0.005 µfd
C4 0.006 µfd
R1 25,000 n
CHAS. HOODWIN CO.

**Diagram**
- C1: 0.0007 MFD
- C2: 0.00025 MFD
- C3: 0.005 MFD
- C4: 0.001 MFD
- R1: 25,000 Ω
- R2: 20,000 Ω
- RFC
- MA
- Crystal Control
- Filament Center Tap
- Filament
- B-
- B+

**Power Pack**
- 110 V A.C. 60 Hz
- Transformer
- 281
- 4 MFD
- B+
- B-

**Table**

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>0.0007 MFD</td>
</tr>
<tr>
<td>C2</td>
<td>0.00025 MFD</td>
</tr>
<tr>
<td>C3</td>
<td>0.005 MFD</td>
</tr>
<tr>
<td>C4</td>
<td>0.001 MFD</td>
</tr>
<tr>
<td>R1</td>
<td>25,000 Ω</td>
</tr>
<tr>
<td>R2</td>
<td>20,000 Ω</td>
</tr>
</tbody>
</table>
Line Voltage may safely vary between
105-120 Volts
or 205-250 Volts
CONDENSER TRANSMITTER
TYPE C-12
With the volume control at maximum, the following readings should be obtained, with an allowable 10% variation:

- Line Voltage: 110 V.
- R.F. Plate Voltage: 200 V.
- R.F. Screen Voltage: 60 V. *
- R.F. Cathode Bias: 1.5 V.
- R.F. Plate Current: 2.2 mA.
- Detector Plate Voltage: 80 V.
- Detector Screen Voltage: 60 V.
- Detector Cathode: 5 V.
- Detector Plate Current: 0.15 mA.
- Pentode Plate Voltage: 190 V.
- Pentode Screen Voltage: 200 V.
- Pentode Grid Voltage: 13 V.
- Pentode Plate Current: 24.0 mA.
- R.F. Filament: 2.2 V.
- Detector Filament: 2.2 V.
- Pentode Filament: 2.2 V.
- Rectifier Filament: 4.1 V.

*These readings made with the 300,000 ohm voltmeter in a Jewel 199 Set Analyzer are not true readings, due to the high resistances in the receiver circuit.
AVERAGE VOLTAGES & CURRENTS:

<table>
<thead>
<tr>
<th>Tube Type</th>
<th>F.E.</th>
<th>Plate Volts</th>
<th>Screen Volts</th>
<th>Volume Control Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>R.F. Tubes</td>
<td>2.25</td>
<td>195</td>
<td>96</td>
<td>0</td>
</tr>
<tr>
<td>First Detector Tube</td>
<td>2.25</td>
<td>195</td>
<td>95</td>
<td>0</td>
</tr>
<tr>
<td>First I.F. Tube</td>
<td>2.25</td>
<td>195</td>
<td>95</td>
<td>0</td>
</tr>
<tr>
<td>Second Detector Tube</td>
<td>2.25</td>
<td>145</td>
<td>--</td>
<td>0</td>
</tr>
<tr>
<td>Oscillator Tube</td>
<td>2.25</td>
<td>65</td>
<td>--</td>
<td>0</td>
</tr>
<tr>
<td>Output Tube</td>
<td>2.25</td>
<td>185</td>
<td>195</td>
<td>11</td>
</tr>
<tr>
<td>Rectifier Tube</td>
<td>4.5</td>
<td>260</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>
VOLTAGES AND CURRENT VALUES

THE FOLLOWING VOLTAGES MUST BE CHECKED WITH VOLUME CONTROL AT MAXIMUM

** ** **

<table>
<thead>
<tr>
<th>Component</th>
<th>Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>R.F. PLATE</td>
<td>200 V.</td>
</tr>
<tr>
<td>R.F. SCREEN GRID</td>
<td>75 V.</td>
</tr>
<tr>
<td>R.F. CATHODE</td>
<td>13 V.</td>
</tr>
<tr>
<td>R.F. FILAMENT</td>
<td>2 V.</td>
</tr>
<tr>
<td>FIRST INTERMEDIATE FREQUENCY PLATE</td>
<td>200 V.</td>
</tr>
<tr>
<td>FIRST INTERMEDIATE FREQUENCY SCREEN GRID</td>
<td>75 V.</td>
</tr>
<tr>
<td>FIRST INTERMEDIATE FREQUENCY CATHODE</td>
<td>12 V.</td>
</tr>
<tr>
<td>FIRST INTERMEDIATE FREQUENCY FILAMENT</td>
<td>2 V.</td>
</tr>
<tr>
<td>DETECTOR PLATE</td>
<td>0 V.</td>
</tr>
<tr>
<td>DETECTOR GRID</td>
<td>0 V.</td>
</tr>
<tr>
<td>DETECTOR CATHODE TO GROUND</td>
<td>0 V.</td>
</tr>
<tr>
<td>DETECTOR FILAMENT</td>
<td>24 V.</td>
</tr>
<tr>
<td>TRANSLATOR PLATE</td>
<td>200 V.</td>
</tr>
<tr>
<td>TRANSLATOR SCREEN GRID</td>
<td>75 V.</td>
</tr>
<tr>
<td>TRANSLATOR CATHODE</td>
<td>5 V.</td>
</tr>
<tr>
<td>TRANSLATOR FILAMENT</td>
<td>2 V.</td>
</tr>
<tr>
<td>OSCILLATOR PLATE</td>
<td>75 V.</td>
</tr>
<tr>
<td>OSCILLATOR GRID</td>
<td>2 V.</td>
</tr>
<tr>
<td>OSCILLATOR CATHODE TO GROUND</td>
<td>0 V.</td>
</tr>
<tr>
<td>FIRST AUDIO PLATE</td>
<td>40 V.</td>
</tr>
<tr>
<td>FIRST AUDIO GRID</td>
<td>16 V.</td>
</tr>
<tr>
<td>FIRST AUDIO CATHODE TO GROUND</td>
<td>0 V.</td>
</tr>
<tr>
<td>F.Z. OR '47 SPACE CHARGE GRID</td>
<td>200 V.</td>
</tr>
<tr>
<td>F.Z. OR '47 PLATE</td>
<td>190 V.</td>
</tr>
<tr>
<td>F.Z. OR '47 GRID</td>
<td>16 V.</td>
</tr>
<tr>
<td>F.Z. OR '47 FILAMENT</td>
<td>2 V.</td>
</tr>
<tr>
<td>80 PLATE</td>
<td>25 MILLS DRAIN PER PLATE</td>
</tr>
<tr>
<td>80 FILAMENT</td>
<td>42 V.</td>
</tr>
</tbody>
</table>

These voltages will be obtained with a 1000 Ohm per volt meter. Meters of different resistances will vary in voltage readings, due to high resistance in series with different potentials.
### Average Voltages & Currents:

<table>
<thead>
<tr>
<th>Tube Type</th>
<th>Fill Volts</th>
<th>Plate Volts</th>
<th>Screen Volts</th>
<th>Grid Volts</th>
<th>Cathode Volts</th>
<th>Plate Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>R.F. Amplifier Tube</td>
<td>2.3</td>
<td>200</td>
<td>100</td>
<td>0</td>
<td>2.0</td>
<td>3.5</td>
</tr>
<tr>
<td>First Detector Tube</td>
<td>2.3</td>
<td>200</td>
<td>100</td>
<td>0</td>
<td>4.0</td>
<td>.5 MA</td>
</tr>
<tr>
<td>First I. F. Tube</td>
<td>2.3</td>
<td>200</td>
<td>100</td>
<td>0</td>
<td>2.0</td>
<td>3.5</td>
</tr>
<tr>
<td>Second I. F. Tube</td>
<td>2.3</td>
<td>200</td>
<td>100</td>
<td>0</td>
<td>2.0</td>
<td>3.5</td>
</tr>
<tr>
<td>Second Detector Tube</td>
<td>2.3</td>
<td>180</td>
<td>---</td>
<td>---</td>
<td>8</td>
<td>.2 MA</td>
</tr>
<tr>
<td>Oscillator Tube</td>
<td>2.3</td>
<td>100</td>
<td>---</td>
<td>0</td>
<td>0</td>
<td>6 MA</td>
</tr>
<tr>
<td>Output Tube (1)</td>
<td>2.3</td>
<td>185</td>
<td>200</td>
<td>16</td>
<td>-</td>
<td>20 MA</td>
</tr>
<tr>
<td>Output Tube (2)</td>
<td>2.5</td>
<td>185</td>
<td>200</td>
<td>16</td>
<td>-</td>
<td>20 MA</td>
</tr>
<tr>
<td>Rectifier Tube</td>
<td>5.0</td>
<td>375</td>
<td>---</td>
<td>-</td>
<td>-</td>
<td>35 PER PLATE</td>
</tr>
</tbody>
</table>
KELLER-FULLER MFG., CO. LTD.
SPECIAL NOTICE

Due to the similarity of the D.C. and A.C. chassis and the fact that the circuits of the various D.C. models are almost identical, all current model D.C. servicing instructions are covered by this service manual.

The mechanical layout of the D.C. models corresponds to the equivalent A.C. model in each case except for the few variations noted below.

<table>
<thead>
<tr>
<th>D.C. Model</th>
<th>Corresponding A.C. Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>36</td>
<td>26</td>
</tr>
<tr>
<td>38</td>
<td>30</td>
</tr>
<tr>
<td>40</td>
<td>32</td>
</tr>
<tr>
<td>22</td>
<td>20B</td>
</tr>
</tbody>
</table>

Line voltage = 115. Volume full on.

A 1,000-ohm-per-volt meter used to obtain the above. Small deviations above or below the values given may be expected, due to variations in parts, tubes and meters.
Resistors

The resistance values of the various colored biasing resistors employed are as follows:

<table>
<thead>
<tr>
<th>Color</th>
<th>Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green</td>
<td>3,000 ohms</td>
</tr>
<tr>
<td>Blue</td>
<td>5,000 ohms</td>
</tr>
<tr>
<td>Grey</td>
<td>10,000 ohms</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Color</th>
<th>Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow</td>
<td>50,000 ohms</td>
</tr>
<tr>
<td>Brown</td>
<td>500,000 ohms</td>
</tr>
<tr>
<td>Red</td>
<td>1,500 ohms</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tube</th>
<th>Filament</th>
<th>Plate</th>
<th>Bias</th>
<th>Screen</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st R.F.</td>
<td>2.3</td>
<td>160</td>
<td>3.5</td>
<td>85</td>
</tr>
<tr>
<td>2nd R.F.</td>
<td>2.3</td>
<td>160</td>
<td>3.5</td>
<td>85</td>
</tr>
<tr>
<td>3rd R.F.</td>
<td>2.3</td>
<td>160</td>
<td>3.5</td>
<td>85</td>
</tr>
<tr>
<td>Detector</td>
<td>2.3</td>
<td>125</td>
<td>10</td>
<td>...</td>
</tr>
<tr>
<td>1st A.F.</td>
<td>2.3</td>
<td>155</td>
<td>9</td>
<td>...</td>
</tr>
<tr>
<td>Power Tubes</td>
<td>2.3</td>
<td>230</td>
<td>45</td>
<td>...</td>
</tr>
<tr>
<td>Rectifier</td>
<td>4.8</td>
<td></td>
<td></td>
<td>...</td>
</tr>
</tbody>
</table>
Radio frequency tube:
- Plate 160 volts
- Screen 70 volts
- Cathode (bias) 1.1 volts

Detector tube:
- Plate 140 volts
- Screen 30 volts
  - (Volume on Maximum)

Oscillator tube:
- Plate 55 volts
- Screen 160 volts
- Cathode (bias) 5 volts

Resistors. With the exception of the 1000 ohm wire wound choke, all fixed resistors are of the carbon or graphite type.
- Yellow ........................................... 50,000 ohms
- Red ............................................. 1,500 ohms
- Red (large) .................................... 2 megohms
- Grey ............................................. 25,000 ohms
- Brown ........................................... 500,000 ohms
- Black ............................................ 500 ohm
  - (Flexible covered resistor)

The volume and regeneration control is a 10,000 ohm wire wound potentiometer.
Readings with plug in set socket and tube in tester socket

<table>
<thead>
<tr>
<th>Tube No. in order</th>
<th>Position of Tube</th>
<th>Type of Tube</th>
<th>A Volts</th>
<th>B Volts</th>
<th>C Volts</th>
<th>Cathode</th>
<th>Plate M.A.</th>
<th>Plate M.A. Grid Test</th>
<th>Plate Change M.A.</th>
<th>Screen Grid Volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1st R.F.</td>
<td>224</td>
<td>2.4</td>
<td>178</td>
<td>3.4</td>
<td>3.4</td>
<td>3.5</td>
<td>7.1</td>
<td>3.6</td>
<td>85</td>
</tr>
<tr>
<td>2</td>
<td>2nd R.F.</td>
<td>224</td>
<td>2.4</td>
<td>178</td>
<td>3.4</td>
<td>3.4</td>
<td>3.5</td>
<td>7.1</td>
<td>3.6</td>
<td>85</td>
</tr>
<tr>
<td>3</td>
<td>3rd R.F.</td>
<td>224</td>
<td>2.4</td>
<td>178</td>
<td>3.4</td>
<td>3.4</td>
<td>3.5</td>
<td>7.1</td>
<td>3.6</td>
<td>85</td>
</tr>
<tr>
<td>4</td>
<td>DET.</td>
<td>227</td>
<td>2.4</td>
<td>240</td>
<td>23.</td>
<td>2.5</td>
<td>1.1</td>
<td>1.2</td>
<td>.1</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Push-Pull</td>
<td>245</td>
<td>2.4</td>
<td>235</td>
<td>45</td>
<td>27</td>
<td>32</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Push-Pull</td>
<td>245</td>
<td>2.4</td>
<td>235</td>
<td>45</td>
<td>27</td>
<td>32</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>RECT.</td>
<td>280</td>
<td>5</td>
<td>310</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Line Voltage 120  Set on 120 Volt Tap  Volume Control FULL ON
GALVIN MANUFACTURING CORP.
MOTOROLA

KEY TO ABOVE NUMERALS

L1—Antenna primary
L2, L4, L6—R. F. secondaries
L3, L5—R. F. plate chokes
L7—Detector plate choke
C, C1, C2—Main tuning condensers
C1, C2—R. F. coupling condenser. Cap. 9.6 micro-
C3, C4—001 mfd. condensers
microfarads

Voltage Readings at the Tube Socket

<table>
<thead>
<tr>
<th>TUBE NO.</th>
<th>TYPE OF TUBE</th>
<th>POSITION OF TUBE</th>
<th>TUBE OUT</th>
<th>READINGS, PLUG IN SOCKET OF SET</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>24</td>
<td>1st R.F.</td>
<td>A VOLTS</td>
<td>B VOLTS</td>
</tr>
<tr>
<td>2</td>
<td>24</td>
<td>2nd R.F.</td>
<td>112.5</td>
<td>110</td>
</tr>
<tr>
<td>3</td>
<td>24</td>
<td>Det.</td>
<td>2</td>
<td>38</td>
</tr>
<tr>
<td>4</td>
<td>01-A</td>
<td>1st Aud.</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>21-A</td>
<td>2nd Aud.</td>
<td>5</td>
<td>100</td>
</tr>
</tbody>
</table>

NOTE—These readings were made with the negative terminal of the “A” Battery grounded.
TYPICAL RISER DIAGRAMS FOR MULTICOUPLER ANTENNA SYSTEM INSTALLED IN CONDUIT

A and B for buildings 3 to 30 stories, maximum outlets 30; Antenna 75' long.
C and D for buildings 6 to 10 stories, maximum outlets 20; Antenna 75' long.
E and F for buildings 3 to 10 stories, maximum outlets 20; Antenna 75' long.
H for buildings two stories high, maximum outlets 12; Antenna 75' long.

Types of Risers for Various Buildings

Note:
When two risers are connected to one antenna the number of outlets on each branch should be kept as nearly equal as possible. Maximum difference should not exceed four. An aerial not less than 72 feet long is required when two branch risers are operated from one aerial.
C1-C2-C3 - 425 Mmfd. Max., 417 nominal
C4 - Variable 250-600 Mmfd.
C5 - 750 Mmfd. Nominal 10/° (Mica)
C6 - 0.1 Mfd.
C7 - 0.1 Mfd.
C8 - 1.0 Mfd. 150 V.
C9 - 001 Mfd. Mica
C10 - 003 Mfd.
C11 - 0.1 Mfd.
C12 - 1.0 Mfd. 150 V.
C13 - 0.1 Mfd.
C14 - 1.0 Mfd. 300 V.
C15 - 25 Mfd.
C16 - Three 4 Mfd. Units (Dry Electrolytic)
R1 - 750 ohms wire wound
R2 - 25,000 ohms 1 watt
R3 - 200 ohms wire wound
R4 - 25,000 ohms 1 watt
R5 - 10,000 ohms 1 watt
R6 - 10,000 ohms 1 watt
R7 - 3500 ohms 3 watt
R8 - 400 ohms wire wound
R9 - 100 ohms — wire wound, tapped at 100 ohms
R10 - 1000 ohms
R11 - 100 ohms
R12 - 4000 ohms 2 watt
P1 - 10,000 ohm wire wound pot.
P2 — 1/2 megohm variable tapered res.
Table 1—Tube Socket Readings Taken with AC Set Tester AC Line—115 volts

<table>
<thead>
<tr>
<th>Tube Type</th>
<th>Circuit</th>
<th>Filament Volts</th>
<th>Plate Volts</th>
<th>Screen Grid Volts</th>
<th>Control Grid Volts</th>
<th>Cathode Plate Volts</th>
<th>Plate Miliampere</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>1st R.F.</td>
<td>2.4</td>
<td>245</td>
<td>90</td>
<td>2.5</td>
<td>3.0</td>
<td>4.5</td>
</tr>
<tr>
<td>24</td>
<td>2nd R.F.</td>
<td>2.4</td>
<td>200</td>
<td>90</td>
<td>2.5</td>
<td>3.0</td>
<td>5.5</td>
</tr>
<tr>
<td>24</td>
<td>Det.</td>
<td>2.4</td>
<td>100</td>
<td>55</td>
<td>9.0</td>
<td>9.0</td>
<td>9.0</td>
</tr>
<tr>
<td>47</td>
<td>Rect.</td>
<td>2.4</td>
<td>175*</td>
<td>190*</td>
<td>1.0*</td>
<td></td>
<td>2.7*</td>
</tr>
</tbody>
</table>

Note—Volume Control on full; Station Selector turned to Low Frequency End.
*Those readings must be taken from the underside of the chassis, using test prods and leads unless the set checker is specially equipped for testing pentode tubes.

Table 2—Power Transformer Voltages

<table>
<thead>
<tr>
<th>Terminals</th>
<th>A.C. Volts</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>105 to 125</td>
<td>Black (Small Gauge)</td>
</tr>
<tr>
<td>3-5</td>
<td>2.5</td>
<td>Black</td>
</tr>
<tr>
<td>6-7</td>
<td>5.0</td>
<td>Light Blue</td>
</tr>
<tr>
<td>8-10</td>
<td>700.0</td>
<td>Yellow</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>Black, Yellow Trace</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>Yellow, Green Trace</td>
</tr>
</tbody>
</table>

Table 3—Condenser Data

<table>
<thead>
<tr>
<th>No. on Figs. 2 and 3</th>
<th>Capacity MFD</th>
<th>Container</th>
</tr>
</thead>
<tbody>
<tr>
<td>@</td>
<td>.00025</td>
<td>Yellow</td>
</tr>
<tr>
<td>@</td>
<td>01</td>
<td>Black Bakelite Container</td>
</tr>
<tr>
<td>@</td>
<td>05</td>
<td>Black Bakelite Container</td>
</tr>
<tr>
<td>@</td>
<td>.05 and 150 Ohm resistor</td>
<td>Black Bakelite Container</td>
</tr>
<tr>
<td>@</td>
<td>.05, .15, .25, 2.5 (50-60 cycles)</td>
<td>Black Bakelite Container</td>
</tr>
<tr>
<td>@</td>
<td>.05, .15, 2.5-5 (25-40 cycles)</td>
<td>Black Bakelite Container Metal Container</td>
</tr>
<tr>
<td>@</td>
<td>(50 to 60 cycles)</td>
<td>Electrolytic</td>
</tr>
<tr>
<td>@</td>
<td>(25 to 60 cycles)</td>
<td>Electrolytic</td>
</tr>
<tr>
<td>@</td>
<td>(25 to 60 cycles)</td>
<td>Electrolytic</td>
</tr>
</tbody>
</table>

Table 4—Resistor Data

<table>
<thead>
<tr>
<th>No. on Figs. 3 and 4</th>
<th>Power (Watts)</th>
<th>Resistance</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>@</td>
<td>.5</td>
<td>150,000</td>
<td>Black Bakelite Container</td>
</tr>
<tr>
<td>@</td>
<td>1.0</td>
<td>15,000</td>
<td>Brown</td>
</tr>
<tr>
<td>@</td>
<td>1.0</td>
<td>10,000</td>
<td>Brown</td>
</tr>
<tr>
<td>@</td>
<td>1.0</td>
<td>5,000</td>
<td>Brown</td>
</tr>
<tr>
<td>@</td>
<td>.5</td>
<td>5,000</td>
<td>Brown</td>
</tr>
<tr>
<td>@</td>
<td>.5</td>
<td>(500000)</td>
<td>Brown</td>
</tr>
<tr>
<td>@</td>
<td>.5</td>
<td>240,000</td>
<td>Red</td>
</tr>
<tr>
<td>@</td>
<td>.5</td>
<td>160,000</td>
<td>Blue</td>
</tr>
<tr>
<td>@</td>
<td>.5</td>
<td>240,000</td>
<td>Red</td>
</tr>
<tr>
<td>@</td>
<td>.5</td>
<td>160,000</td>
<td>Yellow</td>
</tr>
<tr>
<td>@</td>
<td>.5</td>
<td>240,000</td>
<td>Yellow</td>
</tr>
<tr>
<td>@</td>
<td>.5</td>
<td>160,000</td>
<td>Yellow</td>
</tr>
</tbody>
</table>

Note: Volume Control on full; Station Selector turned to Low Frequency End.
This model, manufactured by Transitone Automotive Radio Corporation, Philadelphia, Pa., bears no resemblance to previous "Transitone" models described in past issues of Craft. Of exceptional interest is the inclusion of automatic volume control; a two-element or double dial model. A complete test for this possible source of trouble is to remove the antenna leads when noise due to this cause continues, and then tighten the set-screws on the car chassis, to prevent short-circuit; while the top of the car to the metal-work; the aerial should be spaced from all such conductors (for example, the dome light) by a distance of at least 3 inches.

There is only one "A" lead; it is black, and terminates in a large banana. Connect this to one of the ammeter terminals on the instrument panel, so that the current drain of the radio set does not show on the meter. The charging rate of the car storage battery should be increased about 2 amps., to obtain a more accurate amount of current consumed by the radio set.

After servicing an automotive receiver it is important to see that all metal parts—shielding, cable sheaths, etc.—are well grounded to the chassis of the car. Tubes and batteries after replacement must be securely fastened in place. If it becomes necessary to replace the flexible tuning shaft, the procedure is as follows: push the free end of the flexible shaft through the bracket on the receiver so that the tip of the shaft is seated in the coupler. Tighten the two set-screws on the coupler, and then tighten the set-screw on the bracket just enough to hold the casing in place. Tune in a station of known frequency, adjusting the receiver exactly. Loosen the two set-screws on the coupler which lock the shaft in place. The flexible tuning shaft can then be turned without affecting the setting of the tuning condenser in the receiver. Set the dial scale accurately to the channel number corresponding to the station frequency, and re-tighten the two set screws on the coupler. Check at several points the relation between dial reading and station frequency.

The best material for an aerial is No. 14 or 16 copper screening, 36 in. wide. It should be used to wrap around iron posts and sides of the body, where the twisted parts are not bonded; cutting and lacing the back the latter to make room for the copper screen. Where bond for the copper screen is a necessity, use wooden bow and cloth construction, with poster-plyscreen; but, where steel bows are used, instead, greater sensitivity sometimes is obtained by lacing in an antenna of stranded rubber-covered wires.

Poor tone quality may be due to an air space between the reproducer and the baffle (Part No. 997-V); there is hereby extended to manufacturers of this type of aerial. This is particularly affected with a "Transitone Model 3" Dynamic Loud Speaker. Resistor R14 is of standard 0.5-meg. rating.

"TRANSLONE MODEL 3"  
(Automotive Battery-Operated Receiver with Automatic Volume Control)
The curves represent the expected life in days to be obtained from the standard and heavy duty type batteries when used, four in series, with the Philco Transistor Model 3 Receiver. There are two curves for each size battery, the lower curve in each case indicating the life of the battery when discharged to an end voltage of 34 volts per 45 volt block. The upper curve indicates the life of the battery to an end voltage of 30 volts per 45 volt block. Additional battery life can be obtained by using the batteries to the lower end voltage.
PHILA. STORAGE BATTERY CO.

Model 30

Table 1—Tube Socket Readings Taken with Average Set Checker

<table>
<thead>
<tr>
<th>Tube</th>
<th>Circuit</th>
<th>Filament Volts</th>
<th>Plate Volts</th>
<th>Grid Volts</th>
<th>Plate Current (Milliamperes)</th>
<th>Screen Grid Volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>1st R. F.</td>
<td>2.0</td>
<td>150</td>
<td>.0015</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>2nd R. F.</td>
<td>2.0</td>
<td>150</td>
<td>.0015</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>3rd R. F.</td>
<td>2.0</td>
<td>150</td>
<td>.0015</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Detector Rectifier</td>
<td>2.0</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Detector Amplifier</td>
<td>2.0</td>
<td>15</td>
<td>...</td>
<td>...</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>1st Audio</td>
<td>2.0</td>
<td>90</td>
<td>Note 1</td>
<td>.002</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>(2nd Audio)</td>
<td>2.0*</td>
<td>150</td>
<td>24</td>
<td>.008</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>(Push-Pull)</td>
<td>2.0*</td>
<td>150</td>
<td>24</td>
<td>.008</td>
<td></td>
</tr>
</tbody>
</table>

*These readings reversed with respect to other Filament Voltage readings.

Note 1. With volume control in "Off" position, approximately 4 volts; with volume control full on, less than 1 volt.

Always use high-resistance voltmeter, preferably 1000 ohms per volt, when checking voltages in the Receiver. For reading plate and screen voltages, use a 250- or 300-volt scale. Voltage readings taken with meters having less than 250,000 ohms resistance will be lower than voltages given in the table.

When testing a Model 30 Receiver, all tubes must be in their proper sockets. The speaker must be connected and the tube shield must be fastened in place. The readings in Table 1 were taken using "A," "B," and "C" batteries.

Table 2—Resistor Data

<table>
<thead>
<tr>
<th>No. on Figs. 1 and 2</th>
<th>Color</th>
<th>Resistance (Ohms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Golden Yellow</td>
<td>5,000</td>
</tr>
<tr>
<td>2</td>
<td>Auto Buff</td>
<td>25,000</td>
</tr>
<tr>
<td>3</td>
<td>Jade Green</td>
<td>70,000</td>
</tr>
<tr>
<td>4</td>
<td>Silver Gray</td>
<td>100,000</td>
</tr>
<tr>
<td>5</td>
<td>White</td>
<td>250,000</td>
</tr>
<tr>
<td>6</td>
<td>Battleship Gray</td>
<td>500,000</td>
</tr>
<tr>
<td>7</td>
<td>Tubular (two section)</td>
<td>800</td>
</tr>
</tbody>
</table>

Table 3—Condenser Data

<table>
<thead>
<tr>
<th>No. on Figs. 1 and 2</th>
<th>Capacity — MFD.</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>.00005</td>
</tr>
<tr>
<td>5</td>
<td>.000250</td>
</tr>
<tr>
<td>6</td>
<td>.01</td>
</tr>
<tr>
<td>7</td>
<td>.05</td>
</tr>
<tr>
<td>8</td>
<td>.05 with 250-ohm resistor winding</td>
</tr>
<tr>
<td>9</td>
<td>25 single section</td>
</tr>
<tr>
<td>10</td>
<td>25 two sections</td>
</tr>
</tbody>
</table>
NOTE:
CONDENSERS MARKED F-WH F-MARKER BLOCK
COMMON LEAD (FILTER) CONNECTED TO
CHASSIS.

VOLUME CONTROL.
\[ \text{D.C. 637-8} \]
PILOT RADIO & TUBE CORP.

D.C. 7 TUBE "SUPER"
220V, D.C.

NOTES:
- CONNECTIONS TO CHASSIS
- CHASSIS IS NOT CONNECTED TO GROUND EXCEPT THRU D.C. LINE

CHASSIS IS NOT CONNECTED TO GROUND EXCEPT THRU D.C. LINE
Figure 8—Schematic circuit diagram of RCA Loudspeaker Model 100A and photo of the filter unit

-General appearance and correct dimensions of armature spacing tools

FILTER UNIT CONTINUITY TEST
Disconnect Magnet Coils and Loudspeaker Cord

<table>
<thead>
<tr>
<th>Test</th>
<th>Correct Effect</th>
<th>Incorrect Effect Caused by</th>
</tr>
</thead>
<tbody>
<tr>
<td>L to M</td>
<td>Closed</td>
<td>Open filter coil</td>
</tr>
<tr>
<td>L to N</td>
<td>Open</td>
<td>Shorted filter condenser</td>
</tr>
<tr>
<td>M to N</td>
<td>Open</td>
<td>Shorted filter condenser</td>
</tr>
</tbody>
</table>

CONTINUITY TEST FOR MAGNET COILS AND LOUDSPEAKER CORD
Connect Magnet Coils and Loudspeaker Cord

Magnet coils may be tested as indicated below. A click test from one lead to the other while they are completely disconnected from the rest of the circuit is also a simple and effective method of testing.

<table>
<thead>
<tr>
<th>Test</th>
<th>Correct Effect</th>
<th>Incorrect Effect Caused by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jack tip to L or N</td>
<td>Closed</td>
<td>Open cord</td>
</tr>
<tr>
<td>Jack sleeve to L or N</td>
<td>Closed</td>
<td>Open cord</td>
</tr>
<tr>
<td>M to N</td>
<td>Closed</td>
<td>Open magnet coils or coil leads</td>
</tr>
</tbody>
</table>
FILTER UNIT CONTINUITY TEST

<table>
<thead>
<tr>
<th>Test</th>
<th>Correct Effect</th>
<th>Incorrect Effect Caused By</th>
</tr>
</thead>
<tbody>
<tr>
<td>G to H</td>
<td>Open</td>
<td>Shorted Condenser</td>
</tr>
<tr>
<td>F to H</td>
<td>Closed</td>
<td>Open Coil</td>
</tr>
</tbody>
</table>

100-B 103
FOR ANTENNA INSTALLATION DETAILS SEE DRAWING NO. 5040-B

NOTE NO.1 ALL WIRING BETWEEN THE VARIOUS UNITS SHOULD BE RUN PREFERABLY IN METAL CONDUIT BUT GREENFIELD OR NO. 500 WIREMOLD MAY BE USED IF DESIRED. TWIN BX MAY BE SUBSTITUTED FOR "ONE PK. 14 R.C.

ANTENNA RESISTORS

WATER PIPE GROUND

EXTENSION COUPLING UNITS (RFX) TO BE LOCATED ON RIDER IN CLOSET, PANTRY OR ANY ACCESSIBLE BUT INCONSPICUOUS PLACE. NOT MORE THAN TEN RFX UNITS MAY BE CONNECTED TO ONE RFX UNIT (WITH R.F. UNIT)

TERMINAL NO. 0 OF NEXT RFX SHOULD BE CONNECTED TO THIS SIDE, THERE ALTERNATING.

GROUND CONDUCT AT TOP OF EACH TRANSMISSION LINE

GROUND CONDUCT AT END OF EACH TRANSMISSION LINE

TRANSMISSION LINES TO CONSIST OF NO. 14 IN THREE CONDUCTORS INSIDE TRIPLET RUBBER INSULATED WIRE AS PER NOTE NO. 1. CONDUCTORS,MARKED RED, GREEN AND YELLOW RESPECTIVELY ADDED TRANSMISSION LINES, YELLOW BEING THEN ADDITIONAL TRANSMISSION LINES GROUNDED CONDUCTOR AND INDICATED BY DOT AND DASH LINE.

RADIO OUTLETS (RFO) WITH ANTENNA AND GROUND PIN JACKS, SWITCH FOR CONTROLLING POWER, TAP FOR ANTENNA UNIT AND POWER SUPPLY TOchu Buttou.

ALL THREE MAY BE IN A COMBINATION 2-GANG BOX OR IN SEPARATE BOXES IN DIFFERENT LOCATIONS.

CENTRALIZED RADIO WIRING DIAGRAM

RADIO-VICTOR CORPORATION OF AMERICA

A STANDARD SPACING FOR RFL UNITS APPROX 20 FT. NOT MORE THAN 20 FT. PREFERABLY LESS THAN 30 FT. AS SHORT AS POSSIBLE.
Schematic circuit diagram of RCA Short Wave Receiver (Some sets have a choke coil connected in the antenna circuit instead of the 2000-ohm resistor shown)

The ratings of the different coils are as follows:

<table>
<thead>
<tr>
<th>Coil No.</th>
<th>Frequency Range</th>
<th>Wavelength Range</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Megacycles</td>
<td>Kilocycles</td>
</tr>
<tr>
<td>1</td>
<td>20–12</td>
<td>20,000–12,000</td>
</tr>
<tr>
<td>2</td>
<td>12–7.2</td>
<td>12,000–7,200</td>
</tr>
<tr>
<td>3</td>
<td>7.2–4</td>
<td>7,200–4,000</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>1,500–940</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>940–550</td>
</tr>
</tbody>
</table>

-----------|------------|------------|-------------|---------------|
Coupling UX-222 | 3.2 | *Control grid 1.5 *Screen grid 67.5 | 130.0 | Plate 3.5 mil. amp. *Screen 0.5 mil. amp. |
Detector UX-201A | 5.0 | .... | 30–60 (Depending on position of intensity control) | 0.65 to 1.5 mil. amp. |
1st Audio Amp. UX-201A | 5.0 | 3.0 | 65 | 1.1 mil. amp. |
2d Audio Amp. (Power) UX-112A | 5.0 | 9.0 | 130.0 | 4.0 mil. amp. |

* These readings cannot be measured by ordinary methods as with the Weston Model 337 test set.
OFFICIAL RADIO SERVICE MANUAL

RCA VICTOR CO., INC.

Figure 1 - Schematic Diagram of RCA Victor Console, R-43

RADIOTRON SOCKET VOLTAGE

BATTERIES AT FULL VOLTAGE—NO SIGNAL BEING RECEIVED

These voltages are those obtained with one of the usual set analyzers. The values indicated, therefore, are not necessarily the voltages that actually appear at the Radiotron Sockets when the voltmeter is not connected.

<table>
<thead>
<tr>
<th>Tube No.</th>
<th>Filament to Control Grid Volts</th>
<th>Filament to Screen Grid Volts</th>
<th>Filament to Plate Volts</th>
<th>Plate Current M.A.</th>
<th>Filament Volts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VOLUME CONTROL AT MINIMUM</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>22</td>
<td>55</td>
<td>150</td>
<td>0</td>
<td>2.0</td>
</tr>
<tr>
<td>2</td>
<td>—</td>
<td>—</td>
<td>50</td>
<td>3.0</td>
<td>2.0</td>
</tr>
<tr>
<td>3</td>
<td>0.5</td>
<td>65</td>
<td>150</td>
<td>0.5</td>
<td>2.0</td>
</tr>
<tr>
<td>4</td>
<td>2.0</td>
<td>90</td>
<td>0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>5</td>
<td>2.0</td>
<td>—</td>
<td>150</td>
<td>2.5</td>
<td>2.0</td>
</tr>
<tr>
<td>6</td>
<td>15.0</td>
<td>—</td>
<td>150</td>
<td>0.5</td>
<td>2.0</td>
</tr>
<tr>
<td>7</td>
<td>15.0</td>
<td>—</td>
<td>150</td>
<td>0.5</td>
<td>2.0</td>
</tr>
<tr>
<td><strong>VOLUME CONTROL AT MAXIMUM</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1.5</td>
<td>65</td>
<td>150</td>
<td>2.5</td>
<td>2.0</td>
</tr>
<tr>
<td>2</td>
<td>—</td>
<td>—</td>
<td>50</td>
<td>3.0</td>
<td>2.0</td>
</tr>
<tr>
<td>3</td>
<td>0.5</td>
<td>60</td>
<td>150</td>
<td>0.5</td>
<td>2.0</td>
</tr>
<tr>
<td>4</td>
<td>1.5</td>
<td>45</td>
<td>150</td>
<td>2.5</td>
<td>2.0</td>
</tr>
<tr>
<td>5</td>
<td>2.0</td>
<td>90</td>
<td>0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>6</td>
<td>2.0</td>
<td>—</td>
<td>150</td>
<td>2.5</td>
<td>2.0</td>
</tr>
<tr>
<td>7</td>
<td>15.0</td>
<td>—</td>
<td>150</td>
<td>0.5</td>
<td>2.0</td>
</tr>
<tr>
<td>8</td>
<td>15.0</td>
<td>—</td>
<td>150</td>
<td>0.5</td>
<td>2.0</td>
</tr>
</tbody>
</table>
In this smallest RCA-Victor receiver, the following condensers and resistors values. Condensers C1, C2, 14- to 220-mnmd. tuning condensers, shunted by 4- to 26-mnmd trimmers; C3, 000-mfd.; C4, C5, C6, 0.1-mfd.; C7, .001-mfd.; C8, C12, 0.25-mfd.; C9, .02-mfd.; C10, 120 mnd.; C11, .005-mfd.; C13, 10 mfd.; C14, 0.5 mfd.; C15, .01-mfd.; C17, 2 mfd.

Resistor R1, 20,000 ohms (volume control); R2, 600 ohms; R3, 28,000 ohms; R4, 9,000 ohms; R5, 33,000 ohms; R6, 45,000 ohms; R7, .5-meg.; R8, 20,000 ohms; R9, 12,000 ohms; R10, 280,000 ohms; R11, 50,000 ohms.

Operating values are as follows. Filament potentials: VI, V2, V3, 2.2 volts. Plate currents: VI, 0.4 ma.; V2, 0.25 ma.; V3, 0.1 ma. Control-grid potentials: V1, 3 volts; V2, 7 volts; V3, 2 volts. Screen-grid potentials: VI, V2, 85 volts; V3, 225 volts. Plate potentials: VI, 225 volts; V2, 100 volts; V3, 215 volts. Heater-to-cathode potentials: VI, V2, V3, 7 volts.

The only volume control in this receiver is by variation of potentiometer R1; the regeneration which exists in the circuit of detector V2, through feedback from the secondary and tickler coils of L2, being non-adjustable. The tickler coil is wound in two sections (high and low) to obtain even regeneration over the broadcast band. The output of the detector is resistance-capacitance coupled to the single stage of A.F. amplification—pentode V3.

Grid bias for the pentode is obtained from a portion of the voltage drop across the field coil; due mostly to the plate current of V3, which is a considerable portion of the total drain. Consequently, increased current through this choke coil, due to a strong incoming signal, causes an increase in the grid bias; thus obtaining automatically a certain degree of compensation which prevents overload.

One filter condenser is of the electrolytic type, and the other is of standard paper type.

Align the R.F. circuits at 1400 kc. It is advisable to use an audio-modulated service oscillator, connected to the input of the receiver, and a thermo-galvanometer connected to the secondary of the output transformer (in place of the voice coil of the dynamic reproducer), to obtain accurate alignment of the tuned circuits.

The first step, in resonating the tuner of the "Model R-5," is to turn the station selector's knob until the reading is exactly 0, and then remove the chassis from the cabinet; being careful not to disturb the setting of the dial.

The gang condenser plates should be fully meshed with the stators; otherwise, the dial drum must be adjusted until it is. Having made certain of the positions of the condenser plates, replace the chassis in the cabinet.

With the oscillator working at 1400 kc., and coupled to the input of the radio set, the dial scale at 85 and put the receiver in operation. Place a soft pad on the service bench and turn the receiver on its side. It is now convenient to adjust the trimmers; a special wrench is required. A second alignment compensates for any interlocking of adjustments.

Figures in parentheses are resistances (in ohms); coil terminals correspond to the layout. Other details are shown in sketches above.
RCA VICTOR CO., INC.

R-5 D.C.

RADIOTRON SOCKET VOLTAGE

110 VOLT D. C. LINE

These readings are obtained with the usual set analyzers and are not true readings of the voltage at which the Radiotrons operate.

<table>
<thead>
<tr>
<th>Radiotron No.</th>
<th>Cathode to to Control Grid Volts</th>
<th>Cathode to Screen Grid Volts</th>
<th>Cathode to Plate Volts</th>
<th>Plate Current M.A.</th>
<th>Heater Volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.5</td>
<td>62</td>
<td>98</td>
<td>2.0</td>
<td>6.0</td>
</tr>
<tr>
<td>2</td>
<td>3.2</td>
<td>54</td>
<td>92</td>
<td>0.2</td>
<td>6.0</td>
</tr>
<tr>
<td>3</td>
<td>0.3</td>
<td>99</td>
<td>95</td>
<td>5.5</td>
<td>6.0</td>
</tr>
<tr>
<td>4</td>
<td>0.3</td>
<td>99</td>
<td>95</td>
<td>5.5</td>
<td>6.0</td>
</tr>
</tbody>
</table>

INTERNAL CONNECTIONS

OF BY-PASS CAPACITORS
Figure 1—Schematic Circuit of RCA Victor R-7 D.C. and R-9 D.C.

**RADIOTRON SOCKET VOLTAGES—115 or 230 Volt Line**
(Separate Resistance Unit Used with 230 Volt Line)

<table>
<thead>
<tr>
<th>Tube No.</th>
<th>Cathode to Heater Volts, D.C.</th>
<th>Cathode or Filament to Control Grid Volts, D.C.</th>
<th>Cathode to Screen Grid Volts, D.C.</th>
<th>Plate Current M.A.</th>
<th>Screen Grid Current M.A.</th>
<th>Heater or Filament Volts, A.C.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40</td>
<td>30</td>
<td>10</td>
<td>75</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>0</td>
<td>40</td>
<td>2.0</td>
<td>0</td>
<td>2.3</td>
</tr>
<tr>
<td>3</td>
<td>6.0</td>
<td>3.5</td>
<td>65</td>
<td>100</td>
<td>.25</td>
<td>2.3</td>
</tr>
<tr>
<td>4</td>
<td>17.0</td>
<td>26</td>
<td>40</td>
<td>75</td>
<td>.5</td>
<td>2.3</td>
</tr>
<tr>
<td>5</td>
<td>2.0</td>
<td>*2.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2.3</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>25.0</td>
<td>100</td>
<td>4.0</td>
<td>0</td>
<td>2.3</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>*25.0</td>
<td>100</td>
<td>4.0</td>
<td>0</td>
<td>2.3</td>
</tr>
</tbody>
</table>

**VOLUME CONTROL AT MINIMUM**

<table>
<thead>
<tr>
<th>Tube No.</th>
<th>Cathode to Heater Volts, D.C.</th>
<th>Cathode or Filament to Control Grid Volts, D.C.</th>
<th>Cathode to Screen Grid Volts, D.C.</th>
<th>Plate Current M.A.</th>
<th>Screen Grid Current M.A.</th>
<th>Heater or Filament Volts, A.C.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10.0</td>
<td>2.0</td>
<td>50</td>
<td>100</td>
<td>3.5</td>
<td>*70.5</td>
</tr>
<tr>
<td>2</td>
<td>6.0</td>
<td>0</td>
<td>50</td>
<td>3.0</td>
<td>0</td>
<td>2.3</td>
</tr>
<tr>
<td>3</td>
<td>8.0</td>
<td>5.0</td>
<td>50</td>
<td>100</td>
<td>0.5</td>
<td>2.3</td>
</tr>
<tr>
<td>4</td>
<td>10.0</td>
<td>2.0</td>
<td>50</td>
<td>100</td>
<td>2.5</td>
<td><em>3</em>5</td>
</tr>
<tr>
<td>5</td>
<td>2.0</td>
<td>*2.0</td>
<td>90</td>
<td>0</td>
<td>0</td>
<td>2.3</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>*25.0</td>
<td>100</td>
<td>4.0</td>
<td>0</td>
<td>2.3</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>*25.0</td>
<td>100</td>
<td>4.0</td>
<td>0</td>
<td>2.3</td>
</tr>
</tbody>
</table>

*Not true reading due to Resistance in circuit

**This may be plus or minus depending on age of tubes**
RADIOVON SOCKET VOLTAGES
VOLTAGES ARE THE SAME AT EITHER POSITION OF THE VOLUME CONTROL
110 VOLT LINE

<table>
<thead>
<tr>
<th>Radiotron No.</th>
<th>Heater to Cathode Volts</th>
<th>Cathode or Filament to Grid Volts</th>
<th>Cathode or Filament to Screen Grid Volts</th>
<th>Plate Current M.A.</th>
<th>Heater Volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. R.F.</td>
<td>2.0</td>
<td>*0.2</td>
<td>60</td>
<td>230</td>
<td>3.5</td>
</tr>
<tr>
<td>2. Osc.</td>
<td>5.0</td>
<td>0</td>
<td>60</td>
<td>230</td>
<td>4.0</td>
</tr>
<tr>
<td>3. 1st Det.</td>
<td>4.0</td>
<td>3.5</td>
<td>60</td>
<td>230</td>
<td>0.5</td>
</tr>
<tr>
<td>4. 1st I.F.</td>
<td>2.0</td>
<td>*0.2</td>
<td>60</td>
<td>230</td>
<td>3.5</td>
</tr>
<tr>
<td>5. A.V.C.</td>
<td>0</td>
<td>0</td>
<td>60</td>
<td>230</td>
<td>0.1</td>
</tr>
<tr>
<td>6. 2nd I.F.</td>
<td>2.0</td>
<td>3.5</td>
<td>60</td>
<td>230</td>
<td>2.5</td>
</tr>
<tr>
<td>7. 2nd Det.</td>
<td>20.0</td>
<td>*8.0</td>
<td>60</td>
<td>230</td>
<td>0.5</td>
</tr>
<tr>
<td>8. Pwr.</td>
<td>—</td>
<td>*10.0</td>
<td>250</td>
<td>235</td>
<td>25.0</td>
</tr>
<tr>
<td>9. Pwr.</td>
<td>—</td>
<td>*10.0</td>
<td>250</td>
<td>235</td>
<td>25.0</td>
</tr>
</tbody>
</table>

*These readings are not correct due to the resistance in the circuits

Figure 3—Magnetic Pickup connections

Note: Place the Radio-Record switch and input transformer in the receiver cabinet. Try connecting a wire from receiver terminal No. 6 to input transformer frame or braided shield to pickup and use connection that gives minimum hum.
R. C. A. VICTOR, INC.

ANTENNA SYSTEM MODEL RF-5600

Schematic circuit diagram of the RCA antenna system for multiple receivers.

NOTE:
AS MANY AS EIGHT ANTENNA COUPLING UNITS MAY BE CONNECTED TO A SINGLE ANTENNA, AND AS MANY AS TEN EXTENSION COUPLING UNITS MAY BE CONNECTED TO EACH ANTENNA COUPLING UNIT. DISTANCE FROM ANTENNA COUPLING UNIT TO FIRST LOADING COIL - 20 FT. DISTANCE BETWEEN LOADING COILS - 20 FT. ONLY ONE EXTENSION COUPLING UNIT ON EACH BRANCH LINE - TO BE 20 FT. OR LESS FROM MAIN RISER. DISTANCE FROM LAST LOADING COIL TO LINE TERMINATING UNIT TO BE AT LEAST 5 FT. AND NOT MORE THAN 10 FT. TRANSMISSION LINES MAY BE EITHER LATERAL OR VERTICAL. ALL EXTERNAL WIRING IN METAL CONDUIT OR "GREINFIELD" WATER PIPE. LOADING COIL UNIT IN UTILITY SECTION ON TRANSMISSION LINE BRANCH LINES TO EXTENSION COUPLING UNITS - MAXIMUM DISTANCE 20 FT., PREFERABLY LESS.
Wall type dynamic loudspeaker and associated equipment—
D. C. resistances given

Assembly wiring diagram showing connections to speaker, volume control,
channel selector and power switch
R. C. A. VICTOR, INC.
CENTRALIZED RADIO MODEL ER-1240

NOTE: THIS CONNECTION NOT ALWAYS USED. IN CASE OF AUDIO OSCILLATIONS, CONNECT TO EITHER OUTPUT TERMINAL DEPENDING ON WHICH CONNECTION REMEDIES THE TROUBLE.
R. C. A. VICTOR, INC.
CENTRALIZED RADIO MODEL ER 1240

Wiring diagram of power amplifier.
MONITORING LOUDSPEAKER

CURRENT TAP

FUSE BLOCK

POWER SUPPLY CONNECTOR CORD

110V 50-60Hz SUPPLY

POWER AMPLIFIER

RECEIVER CHASSIS

RECEIVER OUTPUT TERMINAL BOARD

RECEIVER POWER SUPPLY TERMINAL BOARD

AUDIO SUPPLY CABLE

TO JACK PANEL TERMINAL BOARD

110V 50-60Hz SUPPLY

TO MONITORING PLUG

AUDIO VOLUME ADJUSTMENT SWITCH

POWER SUPPLY PLUG

FUSE BLOCK

10 AMP FUSES

RECEIVER POWER SUPPLY CABLE
R. C. A. VICTOR, INC.

CENTRALIZED RADIO MODEL ER-1240A

NOTE: ALL LEADS TERMINATING IN ARROWS ARE CABLED TOGETHER AND ARE CONNECTED TO TERMINALS OF THE JACK PANEL TERMINAL STRIP AS INDICATED BY THE ENCIRCLED NUMBERS.

INPUT TERMINAL BOARD

IDENTIFICATION LETTERS SHOWN ON CONDENSERS REFER TO FIGURE 11.

POWER AMPLIFIER OUTPUT TERMINAL BOARD.

OUTPUT TRANSFORMER.

NOTE: ALL LEADS TERMINATING IN ARROWS ARE CABLED TOGETHER AND ARE CONNECTED TO TERMINALS OF THE JACK PANEL TERMINAL STRIP AS INDICATED BY THE ENCIRCLED NUMBERS.

INPUT TERMINAL BOARD

IDENTIFICATION LETTERS SHOWN ON CONDENSERS REFER TO FIGURE 11.

POWER AMPLIFIER OUTPUT TERMINAL BOARD.

OUTPUT TRANSFORMER.

NOTE: ALL LEADS TERMINATING IN ARROWS ARE CABLED TOGETHER AND ARE CONNECTED TO TERMINALS OF THE JACK PANEL TERMINAL STRIP AS INDICATED BY THE ENCIRCLED NUMBERS.
NOTE No. 1 - THIS RFC UNIT SIMILAR TO FIG. 16A EXCEPT CONNECTION FROM TERMINAL NO. 2 SHOULD GO TO THE WIRE WITH GREEN TRACER OF THE R.F. TRANSMISSION LINE.

NOTE No. 2 - ALL DETAIL DIMENSIONS OF A SINGLE RACK ARE SHOWN IN FIG. 16B.

NOTE No. 3 - DISTANCE BETWEEN RFC UNITS TO BE SYMMETRICAL WITH RACKS. DIMENSIONS OF RFC BOXES ARE SHOWN IN FIG. 16B.
R. C. A. VICTOR, INC.

AUDITORIUM RADIOLA PHONOGRAPH

VOLTAGE READINGS AT RADIOTRON SOCKETS

"Radio-Input-Record" Switch in Radio Position
Volume Control at Minimum

<table>
<thead>
<tr>
<th>Socket No.</th>
<th>Cathode to Heater</th>
<th>Cathode to Grid</th>
<th>Cathode to Plate</th>
<th>Plate Current</th>
<th>Filament or Heater</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Volts</td>
<td>Volts</td>
<td>Volts</td>
<td>Milamps</td>
<td>Volts (rms.)</td>
</tr>
<tr>
<td>1 (RF)</td>
<td>-22</td>
<td>-20</td>
<td>100</td>
<td>0</td>
<td>2.3</td>
</tr>
<tr>
<td>2 (1st Det)</td>
<td>-13</td>
<td>-8.5</td>
<td>90</td>
<td>1.5</td>
<td>2.3</td>
</tr>
<tr>
<td>3 (1st IF)</td>
<td>-22</td>
<td>-20</td>
<td>100</td>
<td>0</td>
<td>2.3</td>
</tr>
<tr>
<td>4 (2nd IF)</td>
<td>-22</td>
<td>-3.0</td>
<td>100</td>
<td>7.0</td>
<td>2.3</td>
</tr>
<tr>
<td>5 (Osc)</td>
<td>-13</td>
<td>0</td>
<td>85</td>
<td>8.2</td>
<td>2.4</td>
</tr>
<tr>
<td>6 (2nd Det)</td>
<td>-13</td>
<td>-29</td>
<td>230</td>
<td>0.5</td>
<td>2.3</td>
</tr>
<tr>
<td>UX-245</td>
<td></td>
<td>-14.*</td>
<td>225</td>
<td>30</td>
<td>2.4</td>
</tr>
<tr>
<td>UX-250's</td>
<td></td>
<td>-72</td>
<td>120</td>
<td>55</td>
<td>7.2</td>
</tr>
</tbody>
</table>

Volume Control at Maximum

<table>
<thead>
<tr>
<th>Socket No.</th>
<th>Cathode to Heater</th>
<th>Cathode to Grid</th>
<th>Cathode to Plate</th>
<th>Plate Current</th>
<th>Filament or Heater</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Volts</td>
<td>Volts</td>
<td>Volts</td>
<td>Milamps</td>
<td>Volts (rms.)</td>
</tr>
<tr>
<td>1 (RF)</td>
<td>-20</td>
<td>-3.0</td>
<td>78</td>
<td>4.5</td>
<td>2.3</td>
</tr>
<tr>
<td>2 (1st Det)</td>
<td>-12</td>
<td>-6.5</td>
<td>74</td>
<td>1.3</td>
<td>2.3</td>
</tr>
<tr>
<td>3 (1st IF)</td>
<td>-20</td>
<td>-3.0</td>
<td>78</td>
<td>5.0</td>
<td>2.3</td>
</tr>
<tr>
<td>4 (2nd IF)</td>
<td>-20</td>
<td>-3.0</td>
<td>78</td>
<td>4.5</td>
<td>2.3</td>
</tr>
<tr>
<td>5 (Osc)</td>
<td>-12</td>
<td>0</td>
<td>70</td>
<td>6.5</td>
<td>2.3</td>
</tr>
<tr>
<td>6 (2nd Det)</td>
<td>-12</td>
<td>-28.</td>
<td>225</td>
<td>0.5</td>
<td>2.3</td>
</tr>
<tr>
<td>UX-245</td>
<td></td>
<td>-13.*</td>
<td>220</td>
<td>29.5</td>
<td>2.4</td>
</tr>
<tr>
<td>UX-250's</td>
<td></td>
<td>-72</td>
<td>420</td>
<td>55</td>
<td>7.2</td>
</tr>
</tbody>
</table>

Radio-Input-Record Switch in Record Position

| No. | Volts | -12 | 218 | 5.0 | 2.3 |
| UX-250 | -73 | 425 | 55 | 7.2 |

* The actual bias on the UX-245 Radiotron is approximately -40 volts. The low reading is caused by the one-quarter megohm resistor in series with the voltmeter.
4 PA50A1 AMPLIFIER

NOTE:
Wires enclosed by circles indicate shields. Shields are shown only where connections to other shields or rack are made.
OFFICIAL RADIO SERVICE MANUAL

RCA.-PHOTOPHONE, INC.

NOTE:
The fixed conductors having numbers are contained in one lead marked Y-2 and the numbers correspond to terminals on the panel.

CONTROL END VIEW OF AMPLIFIER

NOTE:
The fixed conductors having numbers are contained in one lead marked Y-2 and the numbers correspond to terminals on the panel.

PG - 5
Model C Announcer

Model CAM3

Rear View.

Connect to:
- 0-1 in RS-80
- 0-4 in RS-81

Control Panel Models RS-80-81
Model PMA2
RADIO RECEPTOR, INC.

Model H.I.

Model PMA1
AX-2 Panel

Socket Panel P-491-A - Engraved
Socket Panel P-491-B - Socket Contacts
Model PYP-245

Model MM3-PMX3
CAUTION: DO NOT ATTEMPT TO OPERATE ON CURRENT OTHER THAN THAT NOTED ON INSTRUMENT.

INSTALLATION: Thirty feet of aerial is enough for efficient operation. More may be used if desired. If no aerial available connect "ANT" to "BLT-IN-ANT" and operate with or without ground. When power noises are evident they may be decreased by grounding the "BLT-IN-ANT."

OPERATION: The left hand knob is volume control, the right hand knob is switch, and the middle knob is tuning control.

BALANCING: In case a tube change necessitates rebalancing the set dial should be set to a station of known frequency between 1200 and 1500 kilocycles and the balancing plates carefully adjusted to a point of maximum volume.

PHONOGRAPH: Use a single pole switch mounted as near as possible to second detector socket, connect in series with lead from ground end of grid coil of second detector tube. Solder phonograph pickup leads to switch terminals.

GUARANTEE: This instrument is guaranteed for ninety days, within which period any part showing electrical or mechanical defect will be replaced without charge when returned prepaid to the factory, but if the complete instrument is returned a nominal charge will be made for such labor as may be necessary to install the defective part.
SAMSON ELECTRIC CO.

PAM-25

<table>
<thead>
<tr>
<th>PWR TUBE</th>
<th>STAGES</th>
<th>LOAD</th>
<th>FREQ.</th>
<th>FIELD</th>
<th>FIRST TUBE</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>1</td>
<td>6</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

*PUSH-PULL UNLESS OTHERWISE STATED*
Parts Required for Baird Receiver

<table>
<thead>
<tr>
<th>Stock No.</th>
<th>Part and No. on Chassis</th>
<th>Dia. or in.</th>
<th>NF</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Chassis, all mounted, with 8 sockets riveted</td>
<td>81, 82, 83, 84, 85, 86, 87, 88</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>3 coil shields</td>
<td>CS1, CS2, CS3</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3 tube shields</td>
<td>TS1, TS2, TS3</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>2 condensers and 1 3-post binding strip</td>
<td>C10, C13</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Grid, Short Ant., Long Ant.</td>
<td>S9, S10, S11</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Pig-tail Resistors</td>
<td>R1, R2</td>
<td>0.0001 Mfd. Condensers</td>
<td>C8, C11, C17</td>
</tr>
<tr>
<td>7</td>
<td>Screen Grid Clips</td>
<td>TS1, TS2, TS3</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Tube shields</td>
<td>C10, C13</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Condensers</td>
<td>010, 013</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>3-post binding strip</td>
<td>L1, L2, L3</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Jacks</td>
<td>J1, J2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Blocks</td>
<td>C12, C13</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Condenser</td>
<td>C18, C19, C20, C21, C22, C23</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>R. F. Chokes</td>
<td>CH3, CH4, CH5</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>3-Gang Baird Variable Condenser</td>
<td>C1, C2, C3, C5, C6</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Electrolytic Condensers</td>
<td>C14, C15, C16</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Baird Power Transformer</td>
<td>P</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Baird Power Choke</td>
<td>CH1, CH2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Baird Gang Resistor</td>
<td>R5, R6, R7, R8, R9, R10, R11, R12, R13, R14</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Condenser Strip</td>
<td>C28, C29, C30</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Knobs</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Toggle Switch—2 pole</td>
<td>SW1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Speaker Terminal</td>
<td>S</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Combination Potentiometer and Switch</td>
<td>P, SW2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>No. 9 Baird Midget Condenser</td>
<td>C4</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>No. 16 Baird Midget Condenser</td>
<td>C17</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Buffer Condenser</td>
<td>C31, C32</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Voltage Divider</td>
<td>PD</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Baird Dial and Escutcheon</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Baird Front Panel</td>
<td>R3, R4</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>Grid Resistors</td>
<td>40° Wire</td>
<td>J1, J2, J3, J4</td>
<td>0</td>
</tr>
<tr>
<td>32</td>
<td>3-Pole Switch</td>
<td>SW3</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>Dial Bracket and Lamp</td>
<td>DL</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>AC Cord and Plug</td>
<td>P</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>Hardware Assembly</td>
<td>15 Octocois 15-20 meters Wave</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Diagram of Baird Universal Shortwave Receiver
MODEL 30B LEGEND (60 CYCLE MODEL)

B1 - RND. BINDING POST
BP1 - SHORT ANT. BINDING POST
BP2 - LONG ANT. BINDING POST
C1 - C2 - C3 - C4 - .00035 MFD. COND.
C5 - .00015 MFD. COND.
C6 - .006 MFD. COND.
C7 - .025 MFD. COND.
C8 - C9 - (.1-.1-.1) MFD. COND.
C10 - 1 MFD. COND.
C11 - .06 MFD. COND.
C12 - (4.-2.-1.-2.) MFD. COND.
C13 - .25 MFD. COND.
J - PHONO. JACK
L1 - #124 COIL
L2 - #122 COIL
L3 - L4 - #123 COILS
L5 - L6 - L7 - #274 CHOKE. COILS
L8 - #339 CHOKE COIL
P - 10,000 OHM POT.
R1 - 60,000 OHM RESISTOR - BLUE
R2 - 2600 OHM RESISTOR
R3 - R5 - 400 OHM RESISTORS
R4 - 25,000 OHM RESISTOR - BLACK
R6 - R9 - 300,000 OHM RESISTORS - YELLOW
R7 - 40 OHM C.T. RESISTOR
R8 - 200 OHM RESISTOR
R10 - R13 - 1500 OHM - 800 OHM, RESISTOR
R11 - R12 - 10,000 OHM RESISTORS - GREEN
S1 - S2 - S3 - UY224 TUBES
S4 - UY227 TUBE
S5 - S6 - UX245 TUBES
S7 - UX280 TUBE
S8 - SPEAKER SOCKET
SW1 - LOCAL - DISTANCE SWITCH
SW2 - ON - OFF SWITCH
T1 - #270U TRANS.
T2 - #337U TRANS.

LEGEND FOR 25 CYCLE MODEL

SAME AS 60 CYCLE MODEL EXCEPT

C11 - .04 MFD. COND.
C13 - 2. MFD. COND.
T2 - #337-25U TRANS.
ADD .1 MFD. CONDENSER ACROSS TERMINALS OF R12

DOTTED CONDENSER AT SW1 REPRESENTS CAPACITY OF SWITCH AND LEADS.

NOTE - WHEN USING PHONOGRAPH CONNECT LOW SIDE OF PHONOGRAPH VOLUME CONTROL TO SLEEVE OF PLUG.
**SILVER-MARSHALL INC.**

**782 AC MIDGET SUPERHETERODYNE**

**VOLUME CONTROL MAXIMUM**

<table>
<thead>
<tr>
<th>Tube Number</th>
<th>Tube Type</th>
<th>Shield</th>
<th>&quot;A&quot; Volts</th>
<th>&quot;B&quot; Volts</th>
<th>&quot;C&quot; Volts</th>
<th>Cathode</th>
<th>Normal Plate MA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Det.</td>
<td>224</td>
<td>68</td>
<td>2.16</td>
<td>200</td>
<td>6</td>
<td>3.2</td>
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<tr>
<td>Oscillator</td>
<td>227</td>
<td>68</td>
<td>2.14</td>
<td>68</td>
<td>5</td>
<td>5</td>
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<tr>
<td>1st I.F.</td>
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<td>68</td>
<td>2.18</td>
<td>200</td>
<td>1.6</td>
<td>5.7</td>
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<tr>
<td>2nd I.F.</td>
<td>224</td>
<td>68</td>
<td>2.19</td>
<td>200</td>
<td>2.3</td>
<td>5.6</td>
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<tr>
<td>2nd Det.</td>
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<td>68</td>
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<td>200</td>
<td>20</td>
<td>0.8</td>
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<tr>
<td>Audio</td>
<td>245</td>
<td>68</td>
<td>2.25</td>
<td>245</td>
<td>47</td>
<td>29</td>
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<tr>
<td>Audio</td>
<td>245</td>
<td>68</td>
<td>2.25</td>
<td>243</td>
<td>46</td>
<td>28</td>
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<tr>
<td>C5</td>
<td>750 Mfd.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C6</td>
<td>0.1 Mfd.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>C7</td>
<td>0.1 Mfd.</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>C8</td>
<td>1.0 Mfd.</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C9</td>
<td>.001 Mfd.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C10</td>
<td>.025 Mfd.</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>C11</td>
<td>0.1 Mfd.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>C12</td>
<td>1.0 Mfd.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>C13</td>
<td>0.1 Mfd.</td>
<td></td>
<td></td>
<td></td>
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<td>C14</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>C15</td>
<td>.25 Mfd.</td>
<td></td>
<td></td>
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<tr>
<td>C16</td>
<td>8.0 Mfd.</td>
<td>Electrolytic</td>
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<td></td>
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<tr>
<td>C17</td>
<td>8.0 Mfd.</td>
<td>Electrolytic</td>
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<table>
<thead>
<tr>
<th>Tube</th>
<th>Value</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>C5</td>
<td>750 Mfd.</td>
<td>(280 Filament to ground, 400 volts)</td>
</tr>
<tr>
<td>C6</td>
<td>0.1 Mfd.</td>
<td>(280 Filament, 5.1 volts AC)</td>
</tr>
<tr>
<td>R1</td>
<td>750 Ohms</td>
<td>Wire wound</td>
</tr>
<tr>
<td>R2</td>
<td>25,000 ohms</td>
<td>1 Watt</td>
</tr>
<tr>
<td>R3</td>
<td>200 ohms</td>
<td>Wire wound</td>
</tr>
<tr>
<td>R4</td>
<td>25,000 ohms</td>
<td>1 Watt</td>
</tr>
<tr>
<td>R5</td>
<td>10000 ohms</td>
<td>1 Watt</td>
</tr>
<tr>
<td>R6</td>
<td>10,000 ohms</td>
<td>1 Watt</td>
</tr>
<tr>
<td>R7</td>
<td>10,000 ohms</td>
<td>3 Watt</td>
</tr>
<tr>
<td>R8</td>
<td>400 ohms</td>
<td>Wire wound</td>
</tr>
<tr>
<td>R9</td>
<td>100 ohms</td>
<td>Wire wound, tapped at 100 ohms</td>
</tr>
<tr>
<td>R10</td>
<td>1000 ohms</td>
<td>Wire wound</td>
</tr>
</tbody>
</table>

722 D.C.

| C5                | 2—Potter 30B condenser blocks |
| C7                | 1—Polymer 0.006 large moulded condenser |
| C8                | 1—Polymer 0.0015 condenser |
| C9                | 1—Polymer 0.005 condenser |
| R1                | 1—Yaxley 422 Insulated tip-jacks |
| J1                | 2—Yaxley 422 Insulated tip-jacks |
| J2                | 1—Yaxley 10-MJP 10,000 ohm potentiometer |
| J3                | 1—Carter 2A closed circuit jack |
| R1                | 1—Yaxley 815C 15-ohm center-tapped resistor |
| R2                | 1—Durham 2-megohm 1-watt resistors (red) |
| R3                | 1—Durham 2-megohm 1-watt resistors (red) |
| R4                | 1—Durham Sub-base rheostat |
| R5                | 1—Durham 60,000 ohm 1-watt resistor (blue) |
| R6                | 1—Durham 20,000 ohm 1-watt resistor (orange) |
SMD1 "SUPER".

- R1 = 30,000 ohms, 1 watt
- R2 = 1/2 megohm tapered variable resistor
- R3 = 60,000 ohms, 1 watt
- R4 = 400 ohms, 1 watt
- R5 = 4500 ohms volume control (tapered)
- R6 = 1000 ohms
- R7 = 220 ohms 2 watt
- R8 = 400 ohms
- R9 = 100 ohms
- R10 = 1100 ohm tapped resistor
- R11 = 1000 ohms
- R12 = 220 ohms 2 watt

Capacitors:
- C5 = 750 Mfd., ±10% (Mica)
- C6 = Triple .1 Mfd. Cond.
- C7 = .1 Mfd.
- C8 = .001 Mfd. (Mica)
- C9 = .025 Mfd.
- C10 = .15 Mfd.
- C11 = .025 Mfd.
- C12 = .01 Mfd.
- C13 = .001 Mfd. (Mica)
- C14 = Three 4 mfd. units (dry electrolytic)
### SILVER-MARSHALL INC.

#### 726 S.W.

<table>
<thead>
<tr>
<th>C1-C2-C3</th>
<th>407 Mfd.  Bax. (5-gang variable)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C4</td>
<td>Variable 550-600 Mfd.</td>
</tr>
<tr>
<td>C5</td>
<td>750 Mfd. + 1% (Mica)</td>
</tr>
<tr>
<td>C6</td>
<td>Triple 0.1 Mfd.</td>
</tr>
<tr>
<td>C7</td>
<td>0.1 Mfd.</td>
</tr>
<tr>
<td>C8</td>
<td>0.1 Mfd.</td>
</tr>
<tr>
<td>C9</td>
<td>0.1 Mfd.</td>
</tr>
<tr>
<td>C10</td>
<td>0.001 Mfd. (Mica)</td>
</tr>
<tr>
<td>C11</td>
<td>0.005 Mfd.</td>
</tr>
<tr>
<td>C12</td>
<td>0.005 Mfd.</td>
</tr>
<tr>
<td>C13</td>
<td>0.005 Mfd.</td>
</tr>
<tr>
<td>C14</td>
<td>Three 4 Mfd. units (dry Electrolytic) Potter</td>
</tr>
<tr>
<td>C15</td>
<td>-1 Mfd.</td>
</tr>
<tr>
<td>C16</td>
<td>0.006 Mfd.</td>
</tr>
<tr>
<td>C17</td>
<td>0.006 Mfd.</td>
</tr>
<tr>
<td>C18</td>
<td>0.006 Mfd.</td>
</tr>
<tr>
<td>C19</td>
<td>0.006 Mfd.</td>
</tr>
<tr>
<td>C20-C21</td>
<td>140 Mfd. (2-gang variable)</td>
</tr>
<tr>
<td>C22</td>
<td>80 Mfd. (variable)</td>
</tr>
<tr>
<td>C23</td>
<td>Compensating Cond.</td>
</tr>
<tr>
<td>C24</td>
<td>0.006 Mfd.</td>
</tr>
<tr>
<td>C25</td>
<td>0.006 Mfd.</td>
</tr>
<tr>
<td>C26</td>
<td>0.006 Mfd.</td>
</tr>
<tr>
<td>C27</td>
<td>0.006 Mfd.</td>
</tr>
<tr>
<td>C28</td>
<td>0.006 Mfd.</td>
</tr>
</tbody>
</table>

| R1       | 30,000 ohms 1 watt               |
| R2       | 0.5 megohm tapered variable resistor |
| R3       | 60,000 ohms 1 watt               |
| R4       | 100 ohms wire wound              |
| R5       | 4,500 ohms volume control (tapered) |
| R7       | 15,000 ohms 2 watt               |
| R6       | 400 ohms wire wound              |
| R10      | 60,000 ohms 1 watt               |
| R11      | 10,000 ohms 1 watt               |
| R12      | 320 ohms 2 watt                  |
| R13      | 10,000 ohms 2 watt               |
| R14      | 60,000 ohms 1 watt               |
| R15      | 6,500 ohms 1 watt                |
| R16      | 10,000 ohms 2 watt               |
| R17      | 10,000 ohms 1 watt               |

### VOLTAGES WITH VOLUME CONTROL AT MAXIMUM

<table>
<thead>
<tr>
<th>Tube Number</th>
<th>Type of Tube</th>
<th>8A* Volts</th>
<th>8B* Volts</th>
<th>Screen Volts</th>
<th>DC Volts</th>
<th>Normal Plate Current</th>
<th>Mils</th>
</tr>
</thead>
<tbody>
<tr>
<td>S.W. Det.</td>
<td>(S10)</td>
<td>154</td>
<td>2.2</td>
<td>216</td>
<td>96</td>
<td>18</td>
<td>0.08</td>
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<tr>
<td>S.W. Osc.</td>
<td>(S11)</td>
<td>137</td>
<td>2.25</td>
<td>80</td>
<td>0</td>
<td>8</td>
<td>1.5</td>
</tr>
<tr>
<td>1st Det.</td>
<td>(S2)</td>
<td>151</td>
<td>2.25</td>
<td>216</td>
<td>96</td>
<td>3</td>
<td>6.1</td>
</tr>
<tr>
<td>2nd Det.</td>
<td>(S2)</td>
<td>151</td>
<td>2.25</td>
<td>216</td>
<td>96</td>
<td>3</td>
<td>6.1</td>
</tr>
<tr>
<td>3rd Det.</td>
<td>(S2)</td>
<td>151</td>
<td>2.25</td>
<td>216</td>
<td>96</td>
<td>3</td>
<td>6.1</td>
</tr>
<tr>
<td>4th Det.</td>
<td>(S2)</td>
<td>151</td>
<td>2.25</td>
<td>216</td>
<td>96</td>
<td>3</td>
<td>6.1</td>
</tr>
<tr>
<td>Audio (right)</td>
<td>(S2)</td>
<td>151</td>
<td>2.25</td>
<td>216</td>
<td>96</td>
<td>3</td>
<td>6.1</td>
</tr>
<tr>
<td>Audio (left)</td>
<td>(S2)</td>
<td>151</td>
<td>2.25</td>
<td>216</td>
<td>96</td>
<td>3</td>
<td>6.1</td>
</tr>
<tr>
<td>Rectifier</td>
<td>(S2)</td>
<td>151</td>
<td>2.25</td>
<td>216</td>
<td>96</td>
<td>3</td>
<td>6.1</td>
</tr>
</tbody>
</table>
C6 - 1.0 Mfd. Cond. - 250 V. Rating
C7 - 1.0 Mfd. 300 V., 0.5 - 0.5 Mfd. 200 V.
C8 - .001 Mfd. Cond. (Mica)
C9 - .025 Mfd. Paper Cond. - 400 V. Rating
C10 - 0.1 Mfd. Cond. 200 V.  
C11 - One 8 Mfd. Cond. 450 V.  
Two 4 Mfd. Cond. 450 V.  
C12 - 0.1 Mfd. Cond. 200 V.  
C13 - .02 Mfd. Cond. 500 V.  

R1 - 60,000 ohm Resistor - 1 watt, Carbon
R2 - 1/2 megohm Variable Resistor
R3 - 100,000 ohm Resistor 1 watt, Carbon
R4 - 60,000 ohm 1 watt, Carbon
R5 - 120 ohm wire wound
R6 - 10,000 ohm 1 watt, Carbon
R7 - 10,000 ohm 3 watt, Carbon
R8 - 100 ohm wire wound, tapped unit
R9 - 1700 ohm wire wound, tapped unit
R10 - 425 ohm 1 watt, Carbon
R11 - 425 ohm 1 watt, Carbon

P - 4500 ohm Potentiometer (comb. with switch)
R1 - 100 Ohm Resistor - wire wound
R2 - 4500 Ohm Volume Control
R3 - 13,000 Ohm Resistor - 1 Watt, Carbon
R4 - 10,000 Ohm Resistor - 2 Watt, Carbon
R5 - 60,000 Ohm Resistor - 1 Watt, Carbon
R6 - 100 Ohms ) Wire wound tapped resistor
R7 - 1700 Ohms )
R8 - 750 Ohms Wire wound resistor
R9 - 30,000 Ohm Resistor - 1 Watt, Carbon
R10 - 1 Megohm Variable Resistor
R11 - 1000 Ohm Resistor - 1 Watt, Carbon
R12 - 2,600 Ohm Resistor - 1 Watt, Carbon
R13 - 220 Ohm Resistor - 2 Watt, Carbon

C7 - .1 Mfd. Cond. 200V.
C8 - .1 Mfd. Cond. 200V.
C9 - .1 Mfd. Cond. 200V.
C10 - .001 Mfd. Cond. Mica
C11 - .5, .5, 1.0 Mfd. Cond. (.5-200V.) (1.0-300V)
C12 - .1 Mfd. Cond. 200V.
C13 - .02 Mfd. Cond. 500V.
C14 - .04 Mfd. Cond.
C15 - .001 Mfd. Cond. Mica
C16 - .02 Mfd. Cond. 500V.
C17 - .01 Mfd. Cond.
C18 - .00075 Mfd. Cond.
C19 - 2 4mfd. Cond.
C20 - .1 Mfd. Cond. 200V.
Schematic diagram of the 692.

Diagram showing use of 255 series input transformers. For radio input connect (1) to B+ of tuner, (2) to plate or one side pickup. The 255, 255P, 255R and 256 are similarly connected neglecting microphone winding. Where switching arrangement for pickup, radio and microphone is wanted, see schematic of 690 amplifier input.

Diagram showing circuit for resistance coupling radio tuner to 692 amplifier where tuner is placed close to amplifier. Where tuner is to be operated at some distance from amplifier see Figure 6. Resistance R2 should be about 100,000 ohms (1meg ohm) and C about .01 mf. Either a '27 or '24 detector may be used, though the former is preferable.

Diagram showing use of one or two pickups with 692. Where two pickups are used and a smooth changeover is wanted ("fader effect") use center tapped (preferably double tapered) potentiometer and connect slider and center tap to 692 input, as shown at right. The resistance per side depends on pickup, but 25,000 ohms is generally used for high impedance pickups and about 1000-5000 ohms for 500 ohm pickup.

Diagram showing coupling a radio input to 692 where radio is to be operated at some distance from amplifier. The 260U or S transformer, connected "step down", couples tube to a line giving fairly low impedance for running to "distant" amplifier. 255R couples this line to 692 as shown. If switching arrangement is desired for radio and record pickup, the switch should be connected between 255R and amplifier input so that pickup is coupled direct. The line between 260U and 255R should be about No. 18 wire with heavy insulation and shielded.

REPLACEMENT PARTS LIST

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>No. 7047—Condenser</td>
</tr>
<tr>
<td>C2</td>
<td>No. 7202—Condenser Bank</td>
</tr>
<tr>
<td>C3</td>
<td>No. 7201—Condenser</td>
</tr>
<tr>
<td>F1</td>
<td>No. 3501—3 Amp. Fuses</td>
</tr>
<tr>
<td>F2</td>
<td>No. 3731—2A Jacks</td>
</tr>
<tr>
<td>L1</td>
<td>No. 338U—Choke</td>
</tr>
<tr>
<td>L2</td>
<td>No. 339U—Choke</td>
</tr>
<tr>
<td>L3</td>
<td>No. 10065—Choke</td>
</tr>
<tr>
<td>P1</td>
<td>No. 4491—Potentiometer</td>
</tr>
<tr>
<td>P2</td>
<td>No. 4400—Potentiometer</td>
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<tr>
<td>R1</td>
<td>No. 4772—Resistor</td>
</tr>
<tr>
<td>R2</td>
<td>No. 4700—Resistor</td>
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<td>R3</td>
<td>No. 4730—Resistor</td>
</tr>
<tr>
<td>R4</td>
<td>No. 4771—Resistor</td>
</tr>
<tr>
<td>R5</td>
<td>No. 4685—Resistor</td>
</tr>
<tr>
<td>R6</td>
<td>No. 4698—Resistor</td>
</tr>
<tr>
<td>R7</td>
<td>No. 4726—Resistor</td>
</tr>
<tr>
<td>R8</td>
<td>No. 4689—Resistor</td>
</tr>
<tr>
<td>R9</td>
<td>No. 4723—Resistor</td>
</tr>
<tr>
<td>R10</td>
<td>No. 4716—Resistor</td>
</tr>
<tr>
<td>R11</td>
<td>No. 5195—Momentary Contact Switch</td>
</tr>
<tr>
<td>SW1</td>
<td>No. 3389—Switch Assembly</td>
</tr>
<tr>
<td>SW2</td>
<td>No. 5195—Momentary Contact Switch</td>
</tr>
<tr>
<td>SW3</td>
<td>No. 7100—Push Button Contacts</td>
</tr>
<tr>
<td>SW4</td>
<td>No. 10075B—Transformer</td>
</tr>
<tr>
<td>T1</td>
<td>No. 234—Transformer</td>
</tr>
<tr>
<td>T2</td>
<td>No. 10081—Transformer</td>
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<tr>
<td>I plug</td>
<td>Input plug</td>
</tr>
<tr>
<td>O plug</td>
<td>Output plug</td>
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OFFICIAL RADIO SERVICE MANUAL

SILVER-MARSHALL INC.

NOTE: -
HEAVY LEADS DENOTE
BUS BAR.
VOLTAGE READINGS TAKEN
WITH 112 V. AC - 60 CYCLE INPUT

739 Parts List

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>S-M 739 Chassis &amp; Shield Assembly...</td>
</tr>
<tr>
<td>C1, C2</td>
<td>1 S-M 318 Two-gang midget condenser...</td>
</tr>
<tr>
<td>C4</td>
<td>1 S-M 3355 Compensating condenser...</td>
</tr>
<tr>
<td>La to Ld</td>
<td>1 S-M 132 Short wave coil assembly...</td>
</tr>
<tr>
<td>C4</td>
<td>1 S-M 13454 Escutcheon...</td>
</tr>
<tr>
<td>C5</td>
<td>1 S-M 13449 wave length name plate...</td>
</tr>
<tr>
<td>C3</td>
<td>1 S-M 13450 switch name plate...</td>
</tr>
<tr>
<td>SW4, SW5</td>
<td>1 S-M SW-Broadcast switch...</td>
</tr>
<tr>
<td>C3</td>
<td>1 S-M 345 Condenser...</td>
</tr>
<tr>
<td>C5, C11, C12</td>
<td>Polymet .006 condenser @ .60...</td>
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<tr>
<td>6</td>
<td>Sprague .1 mfd. condenser...</td>
</tr>
<tr>
<td>3</td>
<td>Durham 10,000 ohm resistor...</td>
</tr>
<tr>
<td>8</td>
<td>Durham 60,000 ohm resistor...</td>
</tr>
<tr>
<td>R3</td>
<td>Durham 6000 ohm resistor 2 watt...</td>
</tr>
<tr>
<td>R4</td>
<td>Durham 3500 ohm resistor, 2 watt...</td>
</tr>
<tr>
<td>1</td>
<td>Antenne binding post...</td>
</tr>
<tr>
<td>SW6</td>
<td>5174 H &amp; H on-off switch...</td>
</tr>
<tr>
<td>1</td>
<td>10' cord &amp; plug...</td>
</tr>
<tr>
<td>1</td>
<td>Set of hardware...</td>
</tr>
</tbody>
</table>

739
S.W. ADAPTER
C1-C2-C3 - 365 Mfd. Max.
C4 - Variable
C5 - 500 Mfd. ± 10% Mica
C6 - Triple .1 Mfd. Cond.
C7 - .1 Mfd.
C8 - .1 Mfd.
C9 - .5, .5, 1, Mfd. Cond.
C10 - .001 Mfd. (Mica)
C11 - 0.15 Mfd.
C12 - .025 Mfd.
C13 - .1 Mfd.
C14 - Three 4 mfd. units (dry electrolytic)
C15 - .1 Mfd.

R1 - 30,000 ohms  1 watt
R2 - 1/2 megohm tapered variable resistor
R3 - 60,000 ohms  1 watt
R4 - 200 ohms  wire wound
R5 - 4500 ohms volume control (tapered)
R6 - 13,000 ohms  1 watt
R7 - 15,000 ohms  2 watts
R8 - 400 ohms  wire wound
R9 - 10,000 ohms  1 watt
R10 - 100 ohms
R11 - 1000 ohms  1100 ohm tapped resistor
R12 - 220 ohms  2 watt
P - 4500 Ohm Potentiometer

R1 - 60,000 Ohm Resistor - 1 Watt, Carbon
R2 - 30,000 Ohm " - 1 Watt, "
R3 - 1/2 Megohm Variable Resistor
R4 - 250,000 Ohm Resistor - 1 Watt, Carbon
R5 - 100 Ohm Resistor - Wire wound
R6 - 6000 Ohm Resistor - 1 Watt, Carbon
R7 - 10,000 Ohm " - 2 Watt, Carbon
R8 - 100 Ohm Resistor ) - Wire wound, tapped unit
R9 - 1700 Ohm Resistor) - 2 Watt, Carbon
R10 - 450 Ohm Resistor - 2 Watt, Carbon

Ca - 0.001 Mfd. Cond.
C1 - 50 Mfd. Paper Cond.
C2 - 0.001 Mfd. Mica Cond.
C3 - 0.001 Mfd. Mica Cond.
C4 - 0.005 Mfd. Paper Cond.
C5 - 0.005 Mfd. Paper Cond.
C6 - 0.005 Mfd. Paper Cond.
C7 - 0.005 Mfd. Paper Cond.
C8 - 0.005 Mfd. Paper Cond.
C9 - 0.005 Mfd. Paper Cond.
C10 - 0.005 Mfd. Paper Cond.
C11 - 0.005 Mfd. Paper Cond.
C12 - 0.005 Mfd. Paper Cond.
C13 - 0.005 Mfd. Paper Cond.
C14 - 0.005 Mfd. Paper Cond.
C15 - 0.005 Mfd. Paper Cond.
"G" RECEIVER

C1-C2-C3 - 365 Mfd. Condenser
C4 - Variable 250-600 Mmfd. 
C5 - 500 Mmfd. Cond. (Mica) 
C6 - Triple .1 Mfd. Cond.
C7-C8 - .1 Mfd. Cond. 200 V Rating
C9 - .5 - .5 - 1. Mfd. Cond.
C10 - .001 Mfd. Cond. Mica
C11 - .02 Mfd. Cond.
C12 - .001 Mfd. Cond. Mica
C13 - 4 Mfd. Cond. 450V Rating
C14 - .01 Mfd. Cond.
C15 - .06 Mfd. Cond.
C16 - .00075 Mfd. Cond. Mica
C17-C18 - .1 Mfd. Cond. - 200V Rating
C19 - Three 4 Mfd. Units 450V Rating

R1 - 60,000 ohm resistor 1 watt
R2 - 30,000 ohm 1 watt
R3 - 1 Megohm variable resistor 1 watt
R4 - 2600 ohm resistor 1 watt
R5 - 1000 ohm resistor 1 watt
R6 - 300 ohm resistor wire wound
R7 - 4500 ohm potentiometer with on-off switch
R8 - 13,500 ohm resistor 1 watt
R9 - 10,000 ohm resistor 2 watt
R10 - 100 ohm resistor wire wound
R11 - 1700 ohm resistor
R12 - 210 ohm resistor 2 watt - carbon
LEGEND
C1 - 0.025 MFD COND. (750 V.)
C2 - 4.7149 COND. BANK
C3 = 7148 COND. BANK
R1 - 1.0 MEGOHM RESISTOR
R2 - 0.5 MEGOHM RESISTOR
R3 - 2000 OHM
R4 - 10.0 MEGOHM
R5 - 0.3 MEGOHM
R6 - 8200 MEGOHM
R7 - 1500 OHM
L1 - 10015 CHOKE
T1 = 10121 OUTPUT TRANS.
T2 = 10120 POWER TRANS.
P1 - 100,000 OHM POT.
P2 - 20 OHM POT.
J - SPEAKER FIELD JACK
SW1 - ON-OFF SWITCH
SW2 - HIGH-LOW SWITCH
S1 - '24
S2 - '50
S3 - '81
S4 - '81

IMPORTANT NOTICE
THIS AMPLIFIER MUST BE EQUIPPED WITH 250 TYPE TUBE SHOWING NOT MORE THAN 5 MICRO AMPERES GAS CURRENT. THIS MAY BE CHECKED BY PLACING A MILLIAMMETER IN THE PLATE CIRCUIT AND ASCERTAINING THAT PLATE CURRENT READING DOES NOT CHANGE MORE THAN 5 MA WHEN R6 IS SHORTED.

679 B AMPLIFIER

REPRESENTATIVE VOLTAGES
FROM 1 TO GROUND -548 V.
- 2 - - - - 504 V.
- 3 - - - - 456 V.
- 4 - - - - 450 V.
- 5 - - - - 115 V.
- 6 - - - 76 V.
- 7 - - - 13 V.
- 8 - - - 2 V.

TAKEN WITH 500 V. SCALE
1000 OHMS PER VOLT METER

SILVER-MARSHALL, INC.
738 CONVERTER

Desig.

nation

Qty.

Description

1—S-M 738 Chassis & Shield Assembly

C3, C4 1—S-M 344 Dual Trimmer Condenser

C2 1—S-M 314 .00015 Variable Condenser

C1 1—S-M 317 Variable Condenser

C8 1—S-M 672-8 mfd. Condenser Bank

2—S-M 131L Coils @ 1.25

2—S-M 131M Coils @ 1.25

2—S-M 131N Coils @ 1.25

2—S-M 1310 Coils @ 1.25

L1, L2 1—S-M 338U Choke

L3 1—S-M 285 Power Transformer

T1 1—S-M 512 Sockets @ .60

C6 1—National E Dial

C5 1—Polymet .005 Fixed Condenser

C7 1—Sprague .1 Mfd. Condenser

R3, R4 2—Durham 10,000 Ohm 1-watt Resistors @ .75

R1, R2 2—Durham 300,000 Ohm 1-watt Resistors @ .50

S1 1—C-R 224 Tube Socket

S2 1—C-R 227 Tube Socket

S3 1—C-R 226 Tube Socket

SW 1—5174 H & M Rotary On-off Switch

3—Eby Binding Posts @ .15

1—10' Cord and Plug

1—Set of Hardware
1—S.M 738 Chassis, Partitions and Cabinet.

C2, C3 1—S.M 315 Dual .00014 Condenser

2—S.M 658 Shields ft. 1.50

T 1—S.M 336D Transformer

S1, S2, L1, L2 4—S.M 512 Sockets ft. 60

C1, C4 2—S.M 342B Condensers

C3 1—S.M 343 Condenser

L5 1—S.M 251S Choke

L10 1—S.M 333S Single Choke

L4, L6, L7 3—S.M 277 Chokes

L3 1—S.M 275 Choke

L8 1—S.M 336U Choke

L9 1—S.M 339U Choke

2—S.M 816 Large Knobs

1—S.M 817 Small Knobs

2—S.M 818 Hookup Wire

1—National B Vernier Dial

C18, C19 2—Potter 4636 Condensers ft

C12, C13, C15 3—Potter Dual 1/10 condensers

C17 1—Potter 1 Mfd. Condenser

C14, C16 2—Potter 1/4 Mfd. Condenser Cased

S3 1—C.R 224 Socket

S4 1—C.R 245 Socket

S5 1—C.R 280 Socket

R2 1—Durham 2 Megohm Resistor

R14 1—Durham 10,000 ohm Resistor

R3, R8 2—Durham .15 Megohm Resistors

R7 1—Durham 60,000 ohm Resistor

R4, R5, R9 3—Durham 1 Megohm Resistors

R1 1—Carter RU402 Resistor

R10, R16 2—Carter 40 ohm Center Tap Resistor

C5, C8 2—Polymet .00015 Condensers ft

C7, C10 2—Polymet .00006 Condensers

C17 1—Sprague 1 Mfd. Condenser

C9 1—Sprague 1/4 Mfd. Condenser

SW 1—H & H Toggle Switch

BP1 1—Eby Antenna Binding Post

BP2 1—Eby Ground Binding Post

R11 1—Ohmite 1500 ohm Resistor

R15 1—Ohmite 3500 ohm Resistor

R6, R12, R13 3—Yaxley 3500 ohm Resistors
COMPONENT PARTS FOR 677B AMPLIFIER

Designation
- C1: .1 mfd. Sprague Condenser
- C2 & C4: .25 mfd.
- C5: #753 Condenser Bank
- R1 & R2: 60,000-ohm Durham Resistor
- R3: 2-megohm Durham Resistor
- R4: 400-ohm Carter Resistor
- R5 & R6: 10,000-ohm Durham Resistor
- R7 & R8: 1500-800-ohmite Resistor
- L1: #559 Choke
- P1: Carter AP-15 Hum Balance
- S1: C-R 227 tube socket
- S2 & S3: C-R 245
- S4: C-R 280
- T1: #257 Audio transformer
- T2: #337 Power

1 636 tube shield
1 677 Panel, chassis and case

VOLTAGES GIVEN ARE APPROXIMATE.
SPARKS-WITHINGTON CO.

SPARTRON MODEL A.R.-19

VARIABLE CONDENSERS
C1 - CI = 0.0025 MFD.
C2 = 0.00025 MFD.

EQUALIZING COILS
L1 = 1000 OHMS.
L2 = 1000 OHMS.
L11 = 1000 OHMS.

CATHODE COILS
L2 = 2000 OHMS.

ANTENNA INDUCTANCE
L1 = 2000 OHMS.

IMPEDEANCE COUPLING COIL
L3 = 2000 OHMS.

DIAL LIGHT

RESISTOR
0.001 MFD.

DIAL VOLTAGE +180 V

GROUND

DIAL VOLTAGE +90 V

DIAL VOLTAGE -90 V

GROUND

DIAL VOLTAGE -180 V

GROUND

0 MFD.

0 MFD.

0 MFD.

0 MFD.

0 MFD.

0 MFD.

0 MFD.
SPARTON MODEL 5 AND 9 SCHEMATIC DIAGRAM

- **Antenna**
- **Antenna Equalizing Condenser**
- **Power Switch**
- **20,000 μF Condenser**
- **Filter Choke Coil**
- **Rectifier**
- **Input Audio Transformer**
- **Dynamic Speaker**
- **Output Audio Transformer**
- **Power Transformer**
- **Variable Condensers (C1)**
- **Equalizing Condensers (C2)**
- **R.F. Transformer**
- **Field Coil**
- **Moving Coil**
- **Dial Light**

This condenser and ground omitted on Canadian sets.
SPARKS-WITHINGTON CO.

SPARTON MODEL 31

- ANTENNA COMPENSATING CONDENSER
- VARIABLE CONDENSERS
- GROUND
- GRID CIRCUIT CHOKE COILS
- C2 Equalizing Condensers
- LI Tuning Coils
- DETECTOR PLATE CHOKE
- GRID CIRCUIT CHOKE COILS
- FILAMENT VOLTAGE INDICATOR
- FILAMENT VOLTAGE CONTROL
- 6V. LAMP
- 512.1 MFD.
- 0.2 MFD.
- 0.00025 MFD.
- 230 MFD.
- 0.00001 MFD.
- 2000 MFD.
- 200 MFD.
- 20 MFD.
- 2 MFD.
- 1 MFD.
- 0.001 MFD.
- 0.0001 MFD.
- 0.00001 MFD.
- 10 MFD.
- 0.001 MFD.
- 0.0001 MFD.
- 100 MFD.
- 0.001 MFD.
- 0.0001 MFD.
- 0.00001 MFD.
- 0.00001 MFD.
- 0.00001 MFD.
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Sparton Model 51 and 52 Schematic Diagram
LINE VOLTAGE 115
VOLTAGE TABLE
VOLUME CONTROL
FULL ON

<table>
<thead>
<tr>
<th>Type of Tube</th>
<th>Tube Circuit</th>
<th>Filament Voltage</th>
<th>Plate Voltage</th>
<th>Screen Grid Voltage</th>
<th>Bias Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>'24</td>
<td>1st Det.</td>
<td>2.4</td>
<td>245</td>
<td>90</td>
<td>6.7</td>
</tr>
<tr>
<td>'27</td>
<td>Osc.</td>
<td>2.4</td>
<td>90</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>'51</td>
<td>I. F.</td>
<td>2.4</td>
<td>245</td>
<td>90</td>
<td>3</td>
</tr>
<tr>
<td>'24</td>
<td>2nd Det.</td>
<td>2.4</td>
<td>100</td>
<td>20</td>
<td>3</td>
</tr>
<tr>
<td>P. Z. or '47</td>
<td>Output</td>
<td>2.4</td>
<td>220</td>
<td>245</td>
<td>15*</td>
</tr>
<tr>
<td>'80</td>
<td>Rect.</td>
<td>4.8</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* This reading obtained between ground and yellow speaker lead. Direct reading from grid to ground or reading taken with a set tester will show low voltage because of high resistance in grid circuit.

INTERMEDIATE FREQUENCY TRANSFORMERS TUNED TO 177.5 K.C.

TUBE LOCATIONS
Circuit Diagram  R-101 A & B

VOLTAGE TABLE

<table>
<thead>
<tr>
<th>Type of Tube</th>
<th>Tube Circuit</th>
<th>Filament Voltage</th>
<th>Plate Voltage</th>
<th>Screen Grid Voltage</th>
<th>Bias Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>'51</td>
<td>R.F.</td>
<td>2.4</td>
<td>243</td>
<td>68</td>
<td>2.75</td>
</tr>
<tr>
<td>'24</td>
<td>Det.</td>
<td>2.4</td>
<td>80</td>
<td>68</td>
<td>6</td>
</tr>
<tr>
<td>PZ or '47</td>
<td>Output</td>
<td>2.4</td>
<td>228</td>
<td>243</td>
<td>16 *</td>
</tr>
<tr>
<td>'80</td>
<td>Rect.</td>
<td>4.8</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* This reading obtained between ground and yellow speaker lead. Direct reading from grid to ground or reading taken with a set tester will show low voltage because of high resistance in grid circuit.

All D.C. voltages are taken between socket terminals and ground with high resistance voltmeters having resistances of 1000 ohms per volt.

Line Voltage—115.
Volume Control full on.
STROMBERG-CARLSON MFG. CO.

Model 645
"Art Console"

Diagram of "C" Battery Container with Cover Removed Showing Connections.

Detail of P-19203 Input Transformer Assembly.

Detail of P-19345 Filter Inductor Assembly.

Detail of P-19252 Capacitor Assembly.
Complete Schematic Circuit of Chassis of No. 645 Art Console.
"C" Batteries Mounted in Container on Chassis. Note Trap Switch and Wiring.

Connection Detail of P-21054 Filter Inductor Assembly showing colors of wires and correct connection to Terminals.

Connection Detail of P-19775 Capacitor Assembly.

Cross Section of Control Knob and Shaft showing arrangement of spring holding Knob in place. If this spring becomes bent so that the Knob is loose it should be reformed by bending in middle, or replaced with a new spring.

Schematic Circuit of Electrodynamic Loud Speaker and Connector

Connection Detail of P-19505 Audio Output Transformer.
STROMBERG-CARLSON MFG. CO.

Models 10 and 11

Connection Detail of P-19604 or P-19618 Capacitor Assembly. P-19618 Assembly has 4 Microfarads between Terminals Nos. 1 and 2 and is used in the Chassis of the Nos. 10-B, 10-C, 11-B and 11-C Receivers.

Connection Detail of Power Transformer.

Connection Detail of Voltage Divider Resistors. The upper one is P-19557 and the lower one is P-19559.

Connection Detail of Hum Balancer and Speaker Connector Socket.
Schematic Circuit of Chassis for Nos. 10 and 11 Receivers
LEFT—Schematic Circuit of No. 1 Phonograph Panel Assembly
BELOW—Wiring Diagram of No. 1 Phonograph Panel Assembly (used in model 11 Receiver)
STUDEBAKER LABORATORIES

```
31```

<table>
<thead>
<tr>
<th>Tube</th>
<th>Fil.</th>
<th>Plate</th>
<th>Screen</th>
<th>Bias &quot;On&quot;</th>
<th>Bias &quot;Off&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st. R. F.</td>
<td>2.5</td>
<td>185</td>
<td>88</td>
<td>5</td>
<td>16</td>
</tr>
<tr>
<td>2nd R. F.</td>
<td>2.5</td>
<td>176</td>
<td>89</td>
<td>5</td>
<td>16</td>
</tr>
<tr>
<td>Det.</td>
<td>2.5</td>
<td>120*</td>
<td>32</td>
<td>4*</td>
<td>4</td>
</tr>
<tr>
<td>Pentode</td>
<td>2.5</td>
<td>192</td>
<td>208</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>Rect.</td>
<td>5.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Voltages not easily measured with Customary test kit.

Parts List

<table>
<thead>
<tr>
<th>No</th>
<th>Name</th>
<th>No</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>P100</td>
<td>Coils (Set 3 matched)</td>
<td>P112</td>
<td>Resistor (20,000 &amp; 500,000)</td>
</tr>
<tr>
<td>P101</td>
<td>Condenser (3 gang, tuning)</td>
<td>P113</td>
<td>&quot; (100,000 &amp; 250,000)</td>
</tr>
<tr>
<td>P102</td>
<td>&quot; (By Pass bank)</td>
<td>P114</td>
<td>&quot; (25,000 &amp; 500)</td>
</tr>
<tr>
<td>P103</td>
<td>&quot; (.06 Coupling)</td>
<td>P115</td>
<td>&quot; (100,000)</td>
</tr>
<tr>
<td>P104</td>
<td>&quot; (.0005 By Pass)</td>
<td>P116</td>
<td>&quot; (750)</td>
</tr>
<tr>
<td>P105</td>
<td>&quot; (.05 Line)</td>
<td>P117</td>
<td>Socket (551)</td>
</tr>
<tr>
<td>P106</td>
<td>&quot; (8 Mfd. Filter)</td>
<td>P118</td>
<td>&quot; (224)</td>
</tr>
<tr>
<td>P107</td>
<td>Dial Plate</td>
<td>P119</td>
<td>&quot; (247 Pent)</td>
</tr>
<tr>
<td>P108</td>
<td>Knobs</td>
<td>P120</td>
<td>&quot; (280)</td>
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<tr>
<td>P109</td>
<td>Pilot Lamp</td>
<td>P121</td>
<td>Speaker</td>
</tr>
<tr>
<td>P110</td>
<td>Posts (Ant. and Grd.)</td>
<td>P122</td>
<td>Transformer (Power)</td>
</tr>
<tr>
<td>P111</td>
<td>Resistor (100,000 &amp; 50,000)</td>
<td>P123</td>
<td>Volume Control and Switch</td>
</tr>
</tbody>
</table>
OFFICIAL RADIO SERVICE MANUAL

SPEED INDICATOR

Hold an electric light off the revolving disc and adjust the speed regulator of the phonograph until the lines stand still.

Cut out and paste on stiff cardboard.

Use the 60 cycle disc with a 60 cycle current and the 25 cycle disc with 26 cycle current.
STUDEBAKER LABORATORIES

OFFICIAL RADIO SERVICE MANUAL

Tube | Type | Fil. Ac. | Plate | Screen | Bias |
--- | --- | --- | --- | --- | --- |
Radio frequency | 551 | 2.45 | 235 | 75 | 6 to 45 |
1st Detector | 551 | 2.50 | 235 | 75 | 10 |
Int. Frequency | 551 | 2.45 | 235 | 75 | 6 to 45 |
2nd Detector | 224 | 2.45 | 75 | 40 | 4 |
Power Output | 247 | 2.40 | 225 | 235 | 16* |
Oscillator | 227 | 2.5 | 75 | | 10 |

*Effective voltage.

S400 Coils—Set matched with Shields
S401 Condenser—Tuning.
S402 " | 1 Mfd. 200 volt.
S403 " | 1 Mfd. 400 volt.
S404 " | .5 Mfd.
S405 " | .05 Mfd.
S406 " | .006 Mfd.
S407 " | .0025 Mfd.
S408 " | 8.0 Mfd. filter.
S409 " | Insulating washers for 8.0 Mfd.
S410 Cord—A. C. Cord and Plug.
S411 Dial—Dial assembly with scale.
S412 Pilot Lamp—Lamp only.
S413 Resistors—Variable, tone control 500,000.
S414 " | Variable, volume control 20,000
S415 " | 6 Meg. graphite
S416 Resistors—1.5 Meg. graphite
S417 " | 500,000 Ohm. "
S418 " | 250,000 " "
S419 " | 100,000 " "
S420 " | 25,000 " " (1½ watt)
S421 " | 5,000 " "
S422 " | 2,000 " "
S423 " | 1,500 " "
S424 Shields—Tube shield tops
S425 " | Tube shield complete
S426 Sockets—Type 551
S427 " | Type 224
S428 " | Type 247
S429 " | Type 227
S430 " | Type 280
S431 Speaker—Pentode speaker
S432 Transformers—Power transformer
S433 " | Intermediate frequency transformer

Parts List

Diagram of the radio circuit diagram is shown, with tube type and filament ac values listed. The parts list includes various components such as coils, condensers, resistors, speakers, transformers, and pilot lamps.
TEST EQUIPMENT SECTION
BEEDE ELECTRICAL INSTRUMENT CO.

HICKOK ELECTRICAL INSTRUMENT CO.
TEST EQUIPMENT SECTION
JEWELL ELECTRICAL INSTRUMENT CO.

PATTERN 560 OSCILLATOR—SCHEMATIC WIRING DIAGRAM.
OFFICIAL RADIO SERVICE MANUAL

TEST EQUIPMENT SECTION
READRITE METER WORKS

TRANSFORMER
SECONDARIES:
N = NEUTRAL
1 = FIRST FROM NEUTRAL 1.5 V.
2 = SECOND 2.5 V.
3 = THIRD 3.3 V.
4 = FOURTH 51 L.V.
5 = FIFTH 7.5 V.
TO TEST BATTERY:
CONNECT G-WIRE TO CENTER 226 SOCKET
NEG(+) FIL TO CENTER 220 SOCKET

TO PRIMARY

LEADS TO BATTERY

400" TUBE TESTER

"550" OSCILLATOR.
"Model 600" and "Model 700"

STERLING MFG. CO.

"R-517" Mutual Conductance Meter
WESTON MODEL 566 TYPE 3
Complete List of Parts Required for the Find-All Television Receiver

1-0.00365-mfd. Cardwell "Midway" Variable Condenser, type 407-C (3).
1-0.002-mfd. (each section) Dual Cardwell "Midway" Variable Condenser, type "C", (14, 24).
1-Electrad Volume Control, type RI-202 (8).
1-Electrad Truvolt Fixed Resistor, type B-15 (60).
1-Electrad Truvolt Fixed Resistor, type B-30 (82A).
4-1,000 ohm Electrad Truvolt Flexible Wire Grid Resistors, type 2G-1000 (7, 18, 37, 47).
1-Electrad Truvolt Fixed Resistor Voltage Divider, type C-200, with extra tap (54).
1-Electrad Truvolt Type V-20 Center Tap Resistor (Optional) (59).
1-Power Switch (73).
1-.0001-mf. Aerovox Fixed Mica Condenser, type 1460 (26).
1-.01-mf. Aerovox Fixed Condenser, type 207 (68).
1-.001-mf. Aerovox Fixed Mica Condenser, type 1460 (optional) (29A).
1-.01-mf. Aerovox Fixed Condenser, type 261 (28).
2-.01-mf. (each section) Triple Section, Metal Case Aerovox Condensers, type 461-31 (6, 10, 11) and (17, 20, 21).
2-8-mf. Aerovox Hi-Farad Dry Electrolytic Condensers, type G5-8 (66, 67).
2-4-mf. Aerovox Fixed By-Pass Condensers, type 207 (30, 41).
8-50,000-ohm Durham Metallized Resistor Powerohms, with Pigtail Connectors, type MF-4 (9, 19, 28A) (32, 39, 42, 50, 53).
( NOTE: Resistors (34, 46, 56) are omitted in revised diagram; these are not needed.)
1-4-mf. Aerovox Fixed By-Pass Condenser, type 207 or G5-4 (64A).
3-25,000-ohm Durham Metallized Resistor Powerohms, with Pigtail Connectors, type MF-4 (31, 43, 55).
1-50,000-ohm Durham Metallized Resistor Grid Leak, with Pigtail Connector (27).
2-75,000-ohm Durham Metallized Resistor Powerohms, with Pigtail Connectors (12, 22), type MF-4.
3-250,000-ohm Durham Metallized Resistor Powerohms, type MF-4 (33, 45, 57).
1-Find-All Shielded Television Antenna R.F. Inductance Coil (4).
2-Find-All Shielded Television R.F. Transformers (13, 23).
1-Acratest 45-type Power Transformer (Television Model) (71).
1-Acratest Double Filter Choke (two 30 Henry—50 mil. Chokes in Single Case) (69, 70).
1-Roll Corwico Braided Hook-up Wire, Solid Core.
5-Five-Prong Wafer-type Sockets (5, 16, 29, 38, 49).
3-Four-Prong Wafer-type Sockets (61, 72, 74).
4-Binding Posts (1, 2) and (62, 63).
3-Tube Shields.
5-124 Arcturus Screen-Grid Tubes (5, 16, 29, 38, 49).
1-145 Arcturus Power Output Tube (61).
1-180 Arcturus Rectifier Tube (74).
1-Weston Milliammeter, 0-50 ma. type 301 (63A).
1-Aluminum Chassis, 12 gauge, 12" x 15" x 3½" high.
2-Vernier Dials.
( NOTE—Numbers in Parentheses refer to Corresponding Numbers Used to Mark Parts on Diagrams.)

Radiovisor Parts Required
1-Jenkins Radiovisor Kit Assembly, type RK.
1-Low Internal Capacity Neon Lamp, type 601.
1-Lens Assembly, type RK-11.
1-Jenkins Self-Synchronizing Motor, type 502, with necessary amplifier Kit, type SK-30 (optional).
The electrical circuit of the home television projector and receiver described here: the phase-shifter is connected as shown at the left (B) for use with negative films; as at the right (A) with positives. It is the resistor and condenser shown in the grounded shield (dotted lines).

INSULINE CORPORATION OF AMERICA

Radiovision receiver with band-pass filter, and 15 to 30,000 cycle radiovision amplifier—L1, 24 turns No. 32 DCC, 1 in. diameter; L2, 48 turns No. 32 DCC, 1 in. diameter; L3, 48 turns No. 32 DCC, 1 in. diameter (ends together); L4, R. F. choke; L5, 20-100 mh. choke; C1, 0.0015-mf. gang condenser (shielded); C2, trimmer condensers; C3, 0.01 mf. radio frequency by pass condenser; C4, 0.0001 mf. grid condenser; C5, 0.001-mf. by pass condenser; C6, 1 mf.; R1, 500 ohms.; R2, 500 ohms.; R3, 2 meg.; R4, 30,000 ohms.; R5, 20,000 ohms.; R6, 0-200,000 variable resistor; C1, 2 mf.; C2, 1 mf.; R1, .25 meg.; R2, .05 meg.; R3, 1000 ohms.; R4, 2000 ohms variable; R5, 2500 ohms variable. The neon tube connects in a ‘45 tube plate circuit.

NATIONAL RADIO INSTITUTE
List of Jenkins Parts Required

(These parts, without tubes, are available in Kit Form)
1. Three-gang Variable Condenser, 0.00025-mf. each section, sections shielded (4, 12, 23);
2. 0.0002-mf. Trimmer Condensers (5, 13, 24);
3. Special Shielded Jenkins Television Antenna Coupler (2);
4. Special Shielded Jenkins Television R.F. Coils (11, 19);
5. Special 300-turn R.F. Chokes (0, 17, 20, 30);
6. By-Pass Condenser Blocks, each containing 3 0.1-mf., 600-volt units (8A, B, C);
7. 0.001-mf. Fixed Mica Condensers (19, 18, 17, 26, 35);
8. 1-mf., 600-volt By-Pass Condenser (31A);
9. 3.5-mf., 600-volt Blocking Condensers (52, 38, 46);
10. Filter Condenser Block containing one 2-mf., 600-volt unit (56A) and one 4-mf., 600-volt unit (56B);
11. Power Compact (also containing two 30 henry chokes) for supplying all plate and filament voltages (53);
12. 25,000-ohm, 2-watt Metalized Resistor (39);
13. 41,000-ohm, 10-watt Enameled Resistor Voltage Divider (57);
14. 5-UY-type Five-Prong Sockets (6, 14, 27, 36, 41);
15. 2-UX-type Four-Prong Sockets (47, 56);
16. Binding Posts (1, 3, 51, 52);
17. Screen-Grid Tubes, type 424, (6, 14, 36);
18. 3-427-Type Tubes (27, 91);
19. 1-480-Type Full Wave Rectifier Tube (55);
20. 1-Aluminum Panel, 6% x 12% x 1/8" high;
21. Dial;
22. Wire, etc. (NOTE: Numbers in parentheses after each part refer to corresponding numbers used to designate parts on diagrams.)

JENKINS TELEVISION CORPORATION

Complete wiring diagram of new Jenkins television receiver. The numbers correspond to those on the photo of the set shown on opposite page. List of parts appears at end of article. This receiver was designed and tested in the Jenkins television laboratory under actual "image reception" conditions of all kinds. No regeneration is used in this receiver.
TELEVISION RECEIVER SECTION
SHORT WAVE AND TELEVISION LABORATORY

WIRING DIAGRAM No. 3—BAIRD UNIVERSAL SHORT WAVE AND TELEVISION RECEIVER
L1-L2—Octocool, No. 7 Socket, connect as shown.
L3-L4—Octocool, No. 8 Socket, connect as shown.
C1—MLW No. 150 Hammerlund Variable Condenser.
C2—J-13 Midget Variable Condenser.
C3—J-23 Midget Variable Condenser.
C4—No. 1450 0.01 mfd. Aerovox Bakelite Molded Condenser.
C5—No. 260 2 mfd. Aerovox Non-Inductive By-Pass Condenser.
C6—No. 1450 0.0015 mfd. Aerovox Bakelite Molded Condenser.
C7—No. 1450 0.0005 mfd. Aerovox Bakelite Molded Condenser.
C8—No. 260 0.25 mfd. Aerovox Condenser.
C9—No. 261XX 1 mfd. Aerovox Condenser.
C10—No. 1070 0.02 mfd. Aerovox 1000v. DC Buffer Condenser.
C11—3 Section Aerovox No. E3-888 Electrolytic Condenser.
R1—No. 992 400 ohms Puromh Aerovox Resistor.
R2—5 megohms 1-watt Resistor.
R3—50,000 ohms 1-watt Resistor.
R4—50,000 ohms Royalty Electrolytic Potentiometer.
R5—500,000 ohms 1-watt Resistor.
R6—5 megohms 1-watt Resistor.
R7—4,000 ohms Electrolytic Wire Grid Resistor.
R8—25 megohms 1-watt Resistor.
R9—50,000 ohms 1-watt Resistor.
R10—1,500 ohms International 2-watt Resistor.
R11—No. 354 Center Tapped Resistors, 20 ohms.
R12—Aerovox No. 996SW Special Voltage Divider, 25,000 ohms.
J—Frost 3-contact Jack.
R.F.C.—No. 100 Baird Television Choke.
Choke—No. 431 Double Choke.
T—No. 411 Power Transformer.
C—Cathode of B.H. Raytheon.
A—Anode of B.H. Raytheon.

Connect Anodes to Filament Prongs on No. 1 Socket. Connect Cathode to Plate of this Socket.
R3 is replaced with a 201A Fixed Rheostat which acts as a short circuit when regeneration is used.
Windings 5 and 6 light power tube in synchronizing amplifier.

RADIO TECHNIC LABORATORY

List of Parts
C4 .01 mf.
C5 1. mf.
C6 8. mf.
L1 Shortwave R.F. choke (60 millihenries)
L2 Primaries of R.F. Trans.
L3 Secondaries of R.F. Trans.

R1 500 ohms
R2 10,000 ohms
R3 2 Megohms
R4 50,000 ohm Potentiometer
R5 20,000 ohms
R6 50,000 ohms
R7 250,000 ohms
R8 1,000 ohms
R9 750 ohms
R10 13,200 ohm voltage divider
C1 .00014 mf.
C2 .1 mf.
C3 .00013 mf.

110 V, A.C.
345 Fil.
100 V, A.C.
### Model 40 Chassis

![Diagram of Model 40 Chassis]

#### Table

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1st R. F.</td>
<td>C. L. 51</td>
<td>2.1</td>
<td>225</td>
<td>2.1</td>
<td>2</td>
<td>75</td>
<td>5</td>
</tr>
<tr>
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<td>2nd R. F.</td>
<td>C. L. 51</td>
<td>2.1</td>
<td>230</td>
<td>2.2</td>
<td>2</td>
<td>75</td>
<td>4.5</td>
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<tr>
<td>3</td>
<td>Det.</td>
<td>C. L. 24</td>
<td>2.1</td>
<td>160*</td>
<td>7</td>
<td>5</td>
<td>75</td>
<td>0.02</td>
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<tr>
<td>4</td>
<td>Output</td>
<td>C. L. 47</td>
<td>2.1</td>
<td>215</td>
<td>5*</td>
<td>0</td>
<td>225</td>
<td>26.5</td>
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<tr>
<td>5</td>
<td>Rect.</td>
<td>C. L. 80</td>
<td>4.8</td>
<td>280</td>
<td></td>
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<td></td>
<td>430</td>
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</table>

*Reading dependent upon resistance of meter.
†Reading taken for one anode only; 60 milliamperes would be about correct.

Volume control position full, Line voltage 115—60 cycle.

**READINGS TAKEN WITH WESTON MODEL 565 ANALYZER on Model 40**
TRANSFORMER CORP. OF AMERICA

MODEL 40
Chassis

BREAKDOWN ANALYSIS
for
MODEL 40
## READINGS TAKEN WITH WESTON MODEL 565 ANALYSER

<table>
<thead>
<tr>
<th>No.</th>
<th>Stage</th>
<th>Type Tube</th>
<th>A Volts</th>
<th>B Volts</th>
<th>Cont. Grid Volts</th>
<th>Cath. Volts</th>
<th>Ip' Norm.</th>
<th>SG Volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>r. f</td>
<td>51</td>
<td>2.1</td>
<td>178</td>
<td>1.5</td>
<td>2.5</td>
<td>4.5</td>
<td>82</td>
</tr>
<tr>
<td>2</td>
<td>1st det.</td>
<td>51</td>
<td>2.1</td>
<td>160</td>
<td>9.5</td>
<td>10</td>
<td>1.2</td>
<td>75</td>
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<tr>
<td>3</td>
<td>Osc.</td>
<td>27</td>
<td>2.05</td>
<td>120</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>L. F.</td>
<td>51</td>
<td>2.05</td>
<td>180</td>
<td>.6</td>
<td>3</td>
<td>3</td>
<td>82</td>
</tr>
<tr>
<td>5</td>
<td>2nd det.</td>
<td>24</td>
<td>2.05</td>
<td>220</td>
<td>8</td>
<td>8</td>
<td>.25</td>
<td>85</td>
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<tr>
<td>6</td>
<td>A.V.C.</td>
<td>24</td>
<td>2.05</td>
<td>50</td>
<td>12</td>
<td>20</td>
<td>0</td>
<td>37</td>
</tr>
<tr>
<td>7</td>
<td>A.F.</td>
<td>47</td>
<td>2.1</td>
<td>260</td>
<td>16.5</td>
<td>40</td>
<td>275</td>
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</tr>
<tr>
<td>8</td>
<td>Rect.</td>
<td>80</td>
<td>4.6</td>
<td>160</td>
<td></td>
<td></td>
<td>40</td>
<td></td>
</tr>
</tbody>
</table>

Volume control position Full.  
Line Voltage 115-60 cycle.

**NOTE:** Filaments and cathodes of R.F., L.F., and first detector are 95 volts positive with respect to ground.  
**NOTE:** Since resistance tolerances in the sets are plus or minus 10%, and tubes may vary over 20%, your readings may disagree with the above by plus or minus 30%.
TRANSFORMER CORP. OF AMERICA

MODEL 61 & 70

GO CYCLE FILTER BLOCK

MODEL 90

Schematic circuit of the highly-developed midget and console Clarion "Series 90" superheterodyne receivers; these utilize both variable-mu and pentode tubes, with automatic volume control. (Note: in the manufacturer's "breakdown analysis" illustration of this receiver, condensers C24 and C25 return to the juncture of R10 and R20, instead of to the chassis.)

All available constants are as follows: condensers C1, C3, tuning units; C1A, C2A, C3A, shunt trimmers; C5, C21, .0008-mf.; C6, C7, C8, C9, I.F. circuit trimmers; C16, C17, C18, C19, C20, C21, .05-mf.; C11, 0.25-mf.; C12, 1.0-mf.; C14, C15, C22, C23, .01-mf.; C17, .00005-mf.; C19, 0.25-mf.; C22, C26, 8 mf. (electrolytic).

Resistors R1, R2, R6, 1,000 ohms; R2, 230 ohms; R4, 2,000 ohms; R5, 10,000 ohms; R7, 40,000 ohms; R8, .5-meg.; R10, 1.0-meg.; R11, 12,000 ohms; R12, 3,800 ohms; R13, 4,300 ohms; R14, 1,800 ohms; R15, 1,300 ohms; R16, 435 ohms; R17, 400 ohms; R18, 65,000 ohms; R19, 20,000 ohms; R20, 250 ohms.

Operating voltages (with volume control in position "full" and line potential 115 volts) are as follows: Filaments V1, V2, V3, V4, V5, V6, V7, 2.2 volts; V8, 4.6 volts. Plate potentials, V1, 160 volts; V2, 168 volts; V3, 125 volts; V4, 165 volts; V5, 178 volts; V6, 23 volts; V7, 260 volts; V8, 350 volts. Control-grid potentials, V1, 0.9 volt; V2, 7.6 volts; V3, none; V4, 0.6 volt; V5, 6.8 volts; V6, 4.6 volts; V7, 16.5 volts. Cathode potentials, V1, V4, 2 volts; V2, 2.9 volts; V3, none; V5, 9 volts; V6, 4.5 volts. Plate currents (normal), V1, 2.8 ma.; V2, 6.4 ma.; V3, 0.25 ma.; V5, 9.5 ma.; V6, 72 ma. Screen-grid potentials. V1, V2, V4, 77 volts; V3, 90 volts; V5, 40 volts; V7, 260 volts.

OFF-ON TUNING VOLUME

Top view of a Clarion superheterodyne
## Transformer Corp. of America

**Schematic Diagram of Clarion Model 90**

### READINGS TAKEN WITH WESTON MODEL 565 ANALYSER

<table>
<thead>
<tr>
<th>No.</th>
<th>Stage</th>
<th>Type Tube</th>
<th>A Volts</th>
<th>B Volts</th>
<th>Cont. Grid Volts</th>
<th>Cath. Volts</th>
<th>Ip' Norm.</th>
<th>SG Volts</th>
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<tbody>
<tr>
<td>1</td>
<td>r.f.</td>
<td>CL-51</td>
<td>2.2</td>
<td>233</td>
<td>3</td>
<td>3</td>
<td>5</td>
<td>66</td>
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<tr>
<td>2</td>
<td>1st Det.</td>
<td>CL-51</td>
<td>2.2</td>
<td>233</td>
<td>7</td>
<td>7</td>
<td>2.3</td>
<td>73</td>
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<tr>
<td>3</td>
<td>Osc.</td>
<td>CL-27</td>
<td>2.2</td>
<td>80</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>0</td>
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<tr>
<td>4</td>
<td>I.F.</td>
<td>CL-51</td>
<td>2.2</td>
<td>233</td>
<td>3</td>
<td>3</td>
<td>5</td>
<td>77</td>
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<tr>
<td>5</td>
<td>2nd det.</td>
<td>CL-24</td>
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<td>165</td>
<td>6.2</td>
<td>7.2</td>
<td>5.5</td>
<td>73</td>
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<tr>
<td>6</td>
<td>Output</td>
<td>CL-PZ</td>
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<td>15</td>
<td>0</td>
<td>27</td>
<td>233</td>
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<tr>
<td>7</td>
<td>Rect.</td>
<td>CL-80</td>
<td>4.8</td>
<td>300</td>
<td>0</td>
<td>0</td>
<td>50</td>
<td>0</td>
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</table>

Volume control position **Full**  
Line Voltage **115**
Schematic Circuit Diagram No. 27P Chassis and Motor Board

Dotted lines shown are in Speaker.

Wiring Diagram, Model 27P Motor Board
U. S. RADIO AND TELEVISION CORP.

Schematic Circuit Diagram of No. 27 Chassis

Early model #27 receivers have volume control as per drawing #102. Present models are made as above drawing.

Top View of No. 27 Chassis Showing Tube Sequence and Speaker Connections

<table>
<thead>
<tr>
<th>Type of Tube</th>
<th>Pinning of Tube</th>
<th>Function</th>
<th>Volts</th>
<th>Cathode Current MA</th>
<th>Plate Voltage MA</th>
<th>Grid Voltage MA</th>
<th>Plate Current MA</th>
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<tbody>
<tr>
<td>224</td>
<td>1</td>
<td>1st Radio</td>
<td>2.35</td>
<td>160</td>
<td>2.5</td>
<td>2.5</td>
<td>3.5</td>
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<tr>
<td>224</td>
<td>2</td>
<td>2nd Radio</td>
<td>2.35</td>
<td>160</td>
<td>2.5</td>
<td>2.5</td>
<td>3.5</td>
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<tr>
<td>224</td>
<td>3</td>
<td>Universal</td>
<td>2.35</td>
<td>160</td>
<td>2.5</td>
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<tr>
<td>224</td>
<td>4</td>
<td>Audio</td>
<td>2.35</td>
<td>160</td>
<td>2.5</td>
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<td>3.5</td>
</tr>
<tr>
<td>224</td>
<td>5</td>
<td>Muffler</td>
<td>2.35</td>
<td>160</td>
<td>2.5</td>
<td>2.5</td>
<td>3.5</td>
</tr>
</tbody>
</table>
Schematic circuit diagram of No. 31 Remote chassis and remote control unit.

- Receiver Power Switch
- Static Shield
- Remote Control
- Distance Switch
- Manual Volume Control
- Dotted lines shown are in separation.
Schematic circuit diagram of No. 31 Phono chassis.
In this illustration may be seen the schematic diagram of the U. S. Radio and Television model 37 chassis.
### VOLTAGES AT SOCKETS - VOLUME CONTROL AT MAXIMUM

**LINE VOLTAGE, 115** — **PLUG IN SOCKET OF RECEIVER** — **TUBE IN TEST SET**

#### Model 31

<table>
<thead>
<tr>
<th>Type of Tube</th>
<th>Position of Tube</th>
<th>Function</th>
<th>&quot;A&quot; Volts</th>
<th>&quot;B&quot; Volts</th>
<th>Control Grid Voltage</th>
<th>Screen Voltage</th>
<th>Cathode Voltage</th>
<th>Plate Voltage (Grid 7 test M.A.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>224</td>
<td>1</td>
<td>1st Radio</td>
<td>2.25</td>
<td>178</td>
<td>3.0</td>
<td>86</td>
<td>.45</td>
<td>4.0</td>
</tr>
<tr>
<td>224</td>
<td>2</td>
<td>2nd Radio</td>
<td>2.25</td>
<td>178</td>
<td>3.0</td>
<td>86</td>
<td>.45</td>
<td>4.0</td>
</tr>
<tr>
<td>224</td>
<td>3</td>
<td>3rd Radio</td>
<td>2.25</td>
<td>178</td>
<td>3.0</td>
<td>86</td>
<td>.45</td>
<td>4.0</td>
</tr>
<tr>
<td>227</td>
<td>4</td>
<td>Detector</td>
<td>2.25</td>
<td>60</td>
<td>0</td>
<td>9</td>
<td>25</td>
<td>.3</td>
</tr>
<tr>
<td>227</td>
<td>5</td>
<td>1st Audio</td>
<td>2.25</td>
<td>180</td>
<td>12</td>
<td>12</td>
<td>4.5</td>
<td>5.5</td>
</tr>
<tr>
<td>245</td>
<td>6</td>
<td>2nd Audio</td>
<td>2.35</td>
<td>246</td>
<td>40</td>
<td>25</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>&quot;45&quot;</td>
<td>7</td>
<td>2nd Audio</td>
<td>2.35</td>
<td>246</td>
<td>40</td>
<td>25</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>280</td>
<td>8</td>
<td>Rectifier</td>
<td>4.9</td>
<td></td>
<td></td>
<td>37</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**ELECTRODYNAMIC SPEAKER**

**Model 31**

![Diagram of Electrodynamis Speaker]

**Model 27**

*Note: Dotted lines shown are in speaker.*

---

U.S. RADIO AND TELEVISION CORP.
No. 32 CHASSIS—VOLTAGES AT SOCKETS—VOLUME CONTROL AT MAXIMUM LINE VOLTAGE, 115—PLUG IN SOCKET OF RECEIVER—TUBE IN TEXT SET

<table>
<thead>
<tr>
<th>Type of Tube</th>
<th>Position of Tube</th>
<th>Function</th>
<th>&quot;A&quot; Volts</th>
<th>&quot;B&quot; Volts</th>
<th>Control Grid &quot;C&quot; Volts</th>
<th>Screen Volts</th>
<th>Screen Current MA</th>
<th>Cathode Volts</th>
<th>Plate MA</th>
<th>Grid Test MA</th>
</tr>
</thead>
<tbody>
<tr>
<td>224</td>
<td>1</td>
<td>1st Radio</td>
<td>2.3</td>
<td>198</td>
<td>3</td>
<td>88</td>
<td>.9</td>
<td>3</td>
<td>3.5</td>
<td>6</td>
</tr>
<tr>
<td>224</td>
<td>2</td>
<td>2nd Radio</td>
<td>2.3</td>
<td>198</td>
<td>3</td>
<td>88</td>
<td>.9</td>
<td>3</td>
<td>3.5</td>
<td>6</td>
</tr>
<tr>
<td>224</td>
<td>3</td>
<td>Detector</td>
<td>2.3</td>
<td>150</td>
<td>6</td>
<td>45</td>
<td>.1</td>
<td>6</td>
<td>.25</td>
<td>.4</td>
</tr>
<tr>
<td>227</td>
<td>4</td>
<td>1st Audio</td>
<td>2.3</td>
<td>180</td>
<td>12.5</td>
<td></td>
<td></td>
<td></td>
<td>5.</td>
<td>6.1</td>
</tr>
<tr>
<td>245</td>
<td>5</td>
<td>2nd Audio</td>
<td>2.4</td>
<td>255</td>
<td>55</td>
<td></td>
<td></td>
<td></td>
<td>26.</td>
<td>31.</td>
</tr>
<tr>
<td>245</td>
<td>6</td>
<td>2nd Audio</td>
<td>2.4</td>
<td>255</td>
<td>55</td>
<td></td>
<td></td>
<td></td>
<td>26.</td>
<td>31.</td>
</tr>
<tr>
<td>280</td>
<td>7</td>
<td>Rectifier</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>36</td>
<td></td>
</tr>
</tbody>
</table>

Electrodynamic Speaker and Connections

Trimmer Condenser

Rotor in Position for Raising R (Approx. 100 Kc.)

Schematic Circuit Diagram of No. 32 Chassis

Dotted Lines Shown Are in Speaker.
Schematic Circuit Diagram of No. 20 Chassis

No. 20 CHASSIS—VOLTAGES AT SOCKETS—VOLUME CONTROL AT MAXIMUM LINE VOLTAGE, 115—PLUG IN SOCKET OF RECEIVER—TUBE IN TEST SET

<table>
<thead>
<tr>
<th>Type of Tube</th>
<th>Position of Tube</th>
<th>Function</th>
<th>&quot;A&quot; Volts</th>
<th>&quot;B&quot; Volts</th>
<th>Control Grid &quot;C&quot; Volts</th>
<th>Screen Volts</th>
<th>Screen Current MA</th>
<th>Cathode Volts</th>
<th>Plate Volts MA</th>
<th>Grid Test MA</th>
</tr>
</thead>
<tbody>
<tr>
<td>224</td>
<td>1</td>
<td>1st Radio</td>
<td>2.5</td>
<td>176</td>
<td>2.2</td>
<td>85</td>
<td>1.4</td>
<td>2.2</td>
<td>5.0</td>
<td>7.1</td>
</tr>
<tr>
<td>224</td>
<td>2</td>
<td>Detector</td>
<td>2.5</td>
<td>95(1)</td>
<td>2.3(2)</td>
<td>17(3)</td>
<td>0.015</td>
<td></td>
<td>5.0</td>
<td>7.1</td>
</tr>
<tr>
<td>171A</td>
<td>3</td>
<td>1st Audio</td>
<td>5.1</td>
<td>191</td>
<td>43(4)</td>
<td>18(5)</td>
<td>20.0</td>
<td>23.0</td>
<td>18.0</td>
<td>20.0</td>
</tr>
<tr>
<td>280</td>
<td>4</td>
<td>Rectifier</td>
<td>5.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>23.0</td>
<td>20.0</td>
</tr>
</tbody>
</table>

(1) Compute value. Reading with voltmeter will be lower.
(2) This voltage read across 55 ohm section of shunt resistor.
(3) This voltage read across 935 ohm section of speaker field and 55 ohm section of shunt resistor.

Power Transformer Terminals

Electrodynamic Speaker and Connections
Schematic Circuit Diagram of No. 26 Chassis

Dotted lines shown here in speaker

No. 26 CHASSIS—VOLTAGES AT SOCKETS—VOLUME CONTROL AT MAXIMUM LINE VOLTAGE. 115—PLUG IN SOCKET OF RECEIVER—TUBE IN TEST SET

<table>
<thead>
<tr>
<th>Type of Tube</th>
<th>Position of Tube</th>
<th>Function</th>
<th>“A” Volts</th>
<th>“B” Volts</th>
<th>Control Grid “C” Volts</th>
<th>Screen Volts</th>
<th>Screen Current MA</th>
<th>Cathode Volts</th>
<th>Plate MA</th>
<th>Grid Test MA</th>
</tr>
</thead>
<tbody>
<tr>
<td>224</td>
<td>1</td>
<td>1st Radio</td>
<td>2.2</td>
<td>245</td>
<td>2.5</td>
<td>80</td>
<td>.6</td>
<td>2.5</td>
<td>2.9</td>
<td>5.1</td>
</tr>
<tr>
<td>224</td>
<td>2</td>
<td>2nd Radio</td>
<td>2.2</td>
<td>245</td>
<td>2.5</td>
<td>80</td>
<td>.6</td>
<td>2.5</td>
<td>2.9</td>
<td>5.1</td>
</tr>
<tr>
<td>224</td>
<td>3</td>
<td>Detector</td>
<td>2.2</td>
<td>130</td>
<td>3.0</td>
<td>40</td>
<td>.1</td>
<td>3.0</td>
<td>.25</td>
<td>.4</td>
</tr>
<tr>
<td>245</td>
<td>4</td>
<td>Audio</td>
<td>2.35</td>
<td>245</td>
<td>5.0</td>
<td></td>
<td></td>
<td></td>
<td>28.</td>
<td>31.</td>
</tr>
<tr>
<td>280</td>
<td>5</td>
<td>Rectifier</td>
<td>4.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>25.</td>
<td>25.</td>
</tr>
</tbody>
</table>

Electrodynamic Speaker and Connections
Making Pentode Current and Voltage Readings

<table>
<thead>
<tr>
<th>Reading</th>
<th>Terminals</th>
<th>Meter</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Volts</td>
<td>Across filament terminals</td>
<td>0.1 A.C. Voltmeter</td>
</tr>
<tr>
<td>B Volts</td>
<td>Plate terminal to subpanel</td>
<td>0-300 D.C. Voltmeter</td>
</tr>
<tr>
<td>C Volts</td>
<td>Across 360 ohm resistor</td>
<td>0-30 D.C. Voltmeter</td>
</tr>
<tr>
<td>Screen Volts</td>
<td>Screen grid terminal to subpanel</td>
<td>0-300 D.C. Voltmeter</td>
</tr>
<tr>
<td>Screen M.A.</td>
<td>Insert milliammeter in screen grid line</td>
<td>0-25 D.C. Milliammeter</td>
</tr>
<tr>
<td>Plate M.A.</td>
<td>Insert milliammeter in plate line</td>
<td>0-50 D.C. Milliammeter</td>
</tr>
</tbody>
</table>

VOLUME CONTROL AT MAXIMUM LINE VOLTAGE, 115

<table>
<thead>
<tr>
<th>Type of Tube</th>
<th>Function</th>
<th>“A” M.A.</th>
<th>“B” M.A.</th>
<th>Screen Grid M.A.</th>
</tr>
</thead>
<tbody>
<tr>
<td>224</td>
<td>1st Radio</td>
<td>2.2 (2)</td>
<td>2.2</td>
<td>5.5 (1)</td>
</tr>
<tr>
<td>224</td>
<td>2nd Radio</td>
<td>2.2 (2)</td>
<td>2.6</td>
<td>4.1</td>
</tr>
<tr>
<td>224</td>
<td>Detector</td>
<td>2.2 (2)</td>
<td>40 (1)</td>
<td>2.5</td>
</tr>
<tr>
<td>224</td>
<td>Audio</td>
<td>2.3</td>
<td>238</td>
<td>5.5</td>
</tr>
<tr>
<td>247</td>
<td>5th</td>
<td>250</td>
<td>250</td>
<td>4.65</td>
</tr>
</tbody>
</table>

Grid Test M.A. | Plate M.A. | Cathode M.A. |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>3.5</td>
<td>3.5</td>
<td>4</td>
</tr>
<tr>
<td>27.5</td>
<td>29</td>
<td></td>
</tr>
</tbody>
</table>

Model 26P

Note: Reading with 250,000 ohm meter. Reading will be less with lower resistance meter.

(1) Reading across 360 ohm section of shunt resistor.

(2) This voltage read across 360 ohm section of shunt resistor.
No. 10 CHASSIS—VOLTAGES AT SOCKETS—LINE VOLTAGE 115
VOLUME CONTROL AT MAXIMUM—POWER LEVEL SWITCH HIGH POWER

<table>
<thead>
<tr>
<th>Type of Tube</th>
<th>Position of Tube</th>
<th>Function</th>
<th>“A” Volts</th>
<th>“B” Volts</th>
<th>Control Grid “C” Volts</th>
<th>Screen Volts</th>
<th>Screen Current MA</th>
<th>Cathode Volts</th>
<th>Plate MA</th>
<th>Grid Test MA</th>
</tr>
</thead>
<tbody>
<tr>
<td>235</td>
<td>1</td>
<td>R.F.</td>
<td>2.3</td>
<td>175</td>
<td>2.3 (1)</td>
<td>65</td>
<td>.7</td>
<td>0</td>
<td>4.0</td>
<td>6.0</td>
</tr>
<tr>
<td>235</td>
<td>2</td>
<td>1st Det.</td>
<td>2.3</td>
<td>185</td>
<td>7.0</td>
<td>69</td>
<td>.4</td>
<td>14.0</td>
<td>2.0</td>
<td>2.6</td>
</tr>
<tr>
<td>235</td>
<td>3</td>
<td>I.F.</td>
<td>2.3</td>
<td>175</td>
<td>2.3 (1)</td>
<td>65</td>
<td>.7</td>
<td>0</td>
<td>4.0</td>
<td>6.0</td>
</tr>
<tr>
<td>227</td>
<td>4</td>
<td>2nd Det.</td>
<td>2.3</td>
<td>115</td>
<td>12</td>
<td>7.5</td>
<td>.4</td>
<td>4.5</td>
<td>.5</td>
<td>5</td>
</tr>
<tr>
<td>227</td>
<td>5</td>
<td>1st Audio</td>
<td>2.3</td>
<td>145</td>
<td>11. (2)</td>
<td>10.</td>
<td>4.6</td>
<td>4.4</td>
<td>5.4</td>
<td>5.4</td>
</tr>
<tr>
<td>227</td>
<td>6</td>
<td>Osc.</td>
<td>2.3</td>
<td>83</td>
<td>15–35 (3)</td>
<td>21.</td>
<td>4.2</td>
<td>4.4</td>
<td>4.4</td>
<td>4.4</td>
</tr>
<tr>
<td>227</td>
<td>7</td>
<td>A.V.C.</td>
<td>2.3</td>
<td>89 (4)</td>
<td>20. (5)</td>
<td>1.5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>247</td>
<td>8</td>
<td>Power</td>
<td>2.35</td>
<td>255</td>
<td>18.5</td>
<td>265</td>
<td>4.5</td>
<td>21.</td>
<td>28.</td>
<td>28.</td>
</tr>
<tr>
<td>247</td>
<td>9</td>
<td>Power</td>
<td>2.35</td>
<td>255</td>
<td>18.5</td>
<td>265</td>
<td>4.5</td>
<td>21.</td>
<td>28.</td>
<td>28.</td>
</tr>
<tr>
<td>280</td>
<td>10</td>
<td>Reet.</td>
<td>4.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>43. Per Plate</td>
<td>43. Per Plate</td>
</tr>
</tbody>
</table>

(1) Measured across 250 ohm series resistor.
(2) Measured across 2500 ohm series resistor.
(3) Bias voltage varies from 15 to 35 between 1500 and 550 K.C. settings of tuning condenser.
(4) Measured across 1000 and 1400 ohm sections of shunt resistor.
(5) Measured across 600 ohm section of shunt resistor.

Electrodynamic Speaker and Connections

Power Transformer Terminals
**Top View of Chassis Showing Tube Location and Speaker Connections**

**No. 8 CHASSIS—VOLTAGES AT SOCKETS—LINE VOLTAGE 115**
**VOLUME CONTROL AT MAXIMUM—POWER LEVEL SWITCH HIGH POWER**

<table>
<thead>
<tr>
<th>Type of Tube</th>
<th>Function</th>
<th>“A” Volts</th>
<th>“B” Volts</th>
<th>Control Grid “C” Volts</th>
<th>Screen Volts</th>
<th>Screen Current MA</th>
<th>Cathode Volts</th>
<th>Plate MA</th>
<th>Grid Test MA</th>
</tr>
</thead>
<tbody>
<tr>
<td>235</td>
<td>R.F.</td>
<td>2.3</td>
<td>190</td>
<td>2.3(1)</td>
<td>68</td>
<td>1.0</td>
<td>0.</td>
<td>3.8</td>
<td>6.5</td>
</tr>
<tr>
<td>235</td>
<td>1st Det.</td>
<td>2.3</td>
<td>190</td>
<td>6.5</td>
<td>70</td>
<td>.35</td>
<td>14.</td>
<td>2.0</td>
<td>4.9</td>
</tr>
<tr>
<td>227</td>
<td>Osc.</td>
<td>2.3</td>
<td>80</td>
<td>15-50(2)</td>
<td>20</td>
<td>14.</td>
<td>2.0</td>
<td>0.</td>
<td>3.6</td>
</tr>
<tr>
<td>235</td>
<td>I.F.</td>
<td>2.3</td>
<td>190</td>
<td>2.3(1)</td>
<td>68</td>
<td>.6</td>
<td>20.</td>
<td>4.</td>
<td>4.0</td>
</tr>
<tr>
<td>227</td>
<td>2nd Det.</td>
<td>2.3</td>
<td>150</td>
<td>20.</td>
<td>20</td>
<td>4.</td>
<td>20.</td>
<td>0.</td>
<td>0.</td>
</tr>
<tr>
<td>227</td>
<td>A.V.C.</td>
<td>2.3</td>
<td>65(3)</td>
<td>40. (4)</td>
<td>280</td>
<td>7.</td>
<td>32.</td>
<td>36.</td>
<td></td>
</tr>
<tr>
<td>247</td>
<td>Power</td>
<td>2.35</td>
<td>260</td>
<td>20. (5)</td>
<td>280</td>
<td>7.</td>
<td>41. Per Plate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>280</td>
<td>Rectifier</td>
<td>5.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(1) Measured across 250 ohm series resistor.
(2) Bias voltage varies from 15 to 50 between 1500 and 550 K.C. settings of tuning condenser.
(3) Measured across 1000 and 1200 ohm sections of shunt resistor.
(4) Measured across two 600 ohm sections of shunt resistor.
(5) Measured across 550 ohm series resistor.

---

**Model 8**

**Power Transformer Terminals**

**7 Section Condenser Internal Wiring**
Note - A. If Positive Side of Storage Battery is Grounded Connect Red Lead From Battery Box To Terminal 'A' of Junction Box.

B. If Negative Side of Storage Battery is Grounded Connect Red Lead From Battery Box To (GND) Junction Box Mounting Screw At B.

A is Connected To Ungrounded Side Of Auto Battery.

Red - See Notes 'A' & 'B'
**U.S. Electric Works**

Type "U" is used with the Universal Radio Set and all others using B Negative as a common ground.

Type "U" should not be used on sets where the C Bias current is from B negative to ground.

Type "U" is recommended for sets using Automobile Pentode tubes.

Type "U" is rated at 180 Volts at 35 milliampere drain, at 6 Volt Input. On the installation of Generator it is absolutely necessary that you have no less than 6 Volt supply at the Generator terminal block.

The Common ground connection is connected to the A+ when the positive side of the battery is grounded to the car frame, or to the A- when the negative side of the battery is grounded to the frame of the car.

Generator requires no further lubrication for one year's service and then less than a drop in each bearing.

The serial number is stamped on the bottom flange of the base.

The live A line or input comes direct from the set control switch, so that when the set is turned off it automatically cuts the supply to the Generator.

---

**Type "M"**

The common ground connection is connected to the A+ when the positive side of the battery is grounded to the car frame, or to the A- when the negative side of the battery is grounded to the frame of the car.

Type M is used on the Majestic, Bosch and other sets using a 90 Volt tap at about 1/2 milliampere drain. The Negative B is a common ground.

Type M is recommended where the Automobile Pentode Tubes are used.

String the rubber grommet on the cables before connecting to the terminal block.

Generator requires no further lubrication for one year's service and then less than a drop in each bearing.

This Generator has been thoroughly tested at the factory, and is guaranteed against defective workmanship and material for a period of ninety days from date of installation.

Type M should not be used on sets where the C Bias current is from B negative to ground.

Serial number of the Generator is stamped under the bottom flange of the base. The live A line or input comes direct from the set control switch, so that when the set is turned off it automatically cuts the supply to the Generator.

Type M Generator is rated at 160 Volts at 35 Milliampere drain, at 6 Volt Input. On the installation of Generator it is absolutely necessary that you have no less than 6 Volt supply at the Generator terminal block.
ZANEY - GILL CORPORATION

CAUTION: Before attempting to install or operate, ascertain if this receiver corresponds with the voltage and the cycles of your power supply. The voltage and cycle reading is marked plainly on the license plate. ("Check Same"). Information on the above figures can be ascertained by calling your local power company. In localities where extreme fluctuations of voltages occur, we recommend that a separate voltage compensator be used to maintain a steady power supply.

NOTE: We are not responsible for damage caused by excessive voltages or incorrect installation.

ANTENNA & GROUND
The quality and amount of reception depends on the correct use of both aerial and ground. In congested areas where several broadcasting stations are in operation, it is not necessary to have an outdoor aerial. Set can be operated on from 3 to 15 feet of aerial for all local reception. In outlying territories or where your relativity to a broadcasting station permits, an aerial of from 25 to 150 feet may be used properly insulated and with correct lead-ins.

A very important feature in connecting a radio is to have a good ground as close to the receiving set as possible. A poor ground is a producer of noises, fading and generally poor reception. Both aerial and ground should be inspected every six months for loose connections or broken strands.

Aerial and ground connections are marked on the binding posts at the back of the chassis.

TUBES
The equipment for this radio consists of 3-224, 1-227, 1-280 and 1-245.

CAUTION: Do not insert or remove tubes from sockets while current is turned on.

SWITCH & VOLUME
The switch and volume control are located on the lower right hand knob which, when turned completely to the left, will act as a switch. To increase volume gradually turn to the right until desired output is gained, being careful to see that the tuning indicator is directly on the station signal.

For distance reception it is well to turn the volume control to almost full capacity and weak signals will break through and can be cleared by compensating the sharpness of the dial to the volume required.

The lower left hand knob operates VITATONE and tone control. The principle of VITATONE is supplying the backward notes with vitality and bringing them to the proper required impetus so that all reception carries breadth as well as the other registers. A further use of VITATONE is the elimination of line noises and static, which also can be accomplished by turning the knob completely to the right. This latter feature is exceptionally desirable for distance reception.

HINTS NECESSARY FOR BETTER RADIO RECEPTION
Use only standard high grade tubes. Cheap tubes will result in poor reception, poor tone and break downs at inopportune moments.

FUSE
Should there be a short in the wiring or a defective tube installed in the set, the fuse, which is located on the right hand side of the chassis assembly, will be blown. This can be replaced by an ordinary 3 amp. automobile type fuse. There are two positions to install the fuse, the two rear clips being used for 110 volts and the two front clips being used where excessive voltages rises as high as 130 volts.

In case of any unusual disturbances in the set, do not attempt to operate same until advised by an experienced service man.

If set does not light, inspect plug connections to wall, also fuse.

If set lights and does not play, inspect speaker terminal and see if it is plugged into the holes marked speaker at the rear of the chassis.

Also, have tubes tested for probable filament shorts.

In all cases, do not attempt to repair the set yourself. Call a competent service man, otherwise your guarantee will be nullified and void.

All parts of this receiver, excepting TUBES are guaranteed by the manufacturer for a period of 90 days against factory defects of workmanship and defective material.
WELLS-GARDNER AND CO.

VOLTAGE CHARACTERISTICS

<table>
<thead>
<tr>
<th>Tube Circuit Under Test</th>
<th>LINE VOLTAGE</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>90 V.</td>
</tr>
<tr>
<td>Fil.</td>
<td>1.7</td>
</tr>
<tr>
<td>Plate</td>
<td>151</td>
</tr>
<tr>
<td>Screen</td>
<td>72</td>
</tr>
<tr>
<td>Grid*</td>
<td>-2.2</td>
</tr>
<tr>
<td>Cathode</td>
<td>2.2</td>
</tr>
<tr>
<td>Fil.</td>
<td>1.7</td>
</tr>
<tr>
<td>Plate</td>
<td>87</td>
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<td>Screen</td>
<td>-13.4</td>
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<tr>
<td>Grid*</td>
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</tr>
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</tr>
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<td>Plate</td>
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<tr>
<td>1st A.F.</td>
<td>6.9</td>
</tr>
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<td>Fil.</td>
<td>1.8</td>
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<tr>
<td>Plate</td>
<td>211</td>
</tr>
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<td>2nd A.F.</td>
<td>36</td>
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<tr>
<td>Fil.</td>
<td>3.6</td>
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</tbody>
</table>

*NOTE: Grid voltages on the 224 and detector tubes are measured from grid to cathode terminals on the tube socket. The grid voltage on the first audio tube cannot be measured from grid to cathode, but is measured from cathode to ground. The above voltages are approximate, and will vary with different tubes.

8-TUBE A.C. MODEL

Power Transformer.

Filter Condenser (60 and 25 cycle receivers).

CAPACITY

<table>
<thead>
<tr>
<th>CODE</th>
<th>60 CYCLE</th>
<th>25 CYCLE</th>
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<tbody>
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<td></td>
</tr>
<tr>
<td>B</td>
<td>1.0 MF.C1</td>
<td>2.5 MF.C1</td>
</tr>
<tr>
<td>C</td>
<td>1.5 MF.C3</td>
<td>4.0 MF.C3</td>
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<td>D</td>
<td>1.0 MF.C9</td>
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<td>E</td>
<td>1.0 MF.C6</td>
<td>1.0 MF.C6</td>
</tr>
<tr>
<td>F</td>
<td>0.5 MF.C7</td>
<td>0.5 MF.C7</td>
</tr>
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<td>G</td>
<td>1.0 MF.C8</td>
<td>1.5 MF.C8</td>
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<td>H</td>
<td>0.5 MF.C5</td>
<td>0.5 MF.C5</td>
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<td>K</td>
<td>1.5 MF.C4</td>
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<tr>
<td>X</td>
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<td>COMMON</td>
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<tr>
<td>Y</td>
<td>COMMON</td>
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### Specifications

<table>
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<th>LEAD CODE</th>
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<tr>
<td>A</td>
<td>C-8</td>
<td>BLUE</td>
</tr>
<tr>
<td>B</td>
<td>C-5</td>
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<td>C</td>
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<td>C-2</td>
<td>GREEN</td>
</tr>
<tr>
<td>E</td>
<td>C-4</td>
<td>GREEN</td>
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<tr>
<td>F</td>
<td>C-14</td>
<td>RED</td>
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<tr>
<td>G</td>
<td>C-13</td>
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<td>H</td>
<td>C-17</td>
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<td>J</td>
<td>C-11</td>
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<tr>
<td>K</td>
<td>C-1</td>
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### Models

60 G3

### Below: Analyzer Readings

<table>
<thead>
<tr>
<th>Tube</th>
<th>Circuit</th>
<th>Meter Scale</th>
<th>90 V</th>
<th>100 V</th>
<th>110 V</th>
<th>120 V</th>
<th>130 V</th>
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<tr>
<td>1st Grid</td>
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<td>2</td>
<td>2.3</td>
<td>2.6</td>
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<td>3.3</td>
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<td>58</td>
<td>63</td>
<td>68</td>
<td>73</td>
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<td>142</td>
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<td>Plate</td>
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<td>190</td>
<td>210</td>
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<td>72</td>
<td>78</td>
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<tr>
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<td>190</td>
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<td>66</td>
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<td>78</td>
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<td>Audio 245</td>
<td>0-100</td>
<td>23</td>
<td>27</td>
<td>31</td>
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<td>Plate</td>
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<td>222</td>
<td>242</td>
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<td>282</td>
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<td>Rectifier</td>
<td>0-100</td>
<td>40</td>
<td>45</td>
<td>50</td>
<td>56</td>
<td>64</td>
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<tr>
<td>280 Plate</td>
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<td>330</td>
<td>358</td>
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<td></td>
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<tr>
<td>to Ground</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
WESTINGHOUSE ELECTRIC AND MFG. CO.

NOTE: IT MAY BE NECESSARY TO PLACE A GROUNDED SHIELD OVER ALL LEADS IN ORDER TO PREVENT OSCILLATION.

DOUBLE-POLE DOUBLE THROW SWITCH USED AS RADIO-RECORD SWITCH.

PICK-UP INPUT TRANSFORMER OF PROPER RATIO FOR PICK-UP BEING USED.

PHONOGRAPHS VOLUME CONTROL.

Connections for attaching a magnetic pick-up.

POWER TRANSFORMER.

OPERATING SWITCH.

MAGNETIC PICK-UP.

TERMINAL STRIP.

RECEIVER TERMINAL STRIP.

TOTAL 105-125 VOLT 110V. 120V.

POWER TRANSFORMER.

Connections for checking position of dial.

View showing method of checking position of dial.

ADJUSTING SCREW FOR 620 K.C.

ADJUSTING SCREW FOR 640 K.C.

ADJUSTING SCREW FOR 700 K.C.

ADJUSTING SCREW FOR 600 K.C.

ADJUSTING SCREW FOR 560 K.C.

Gang condenser adjustment positions.
MODEL WR4

Front Chassis Wiring

Layout and wiring diagram of the chassis (front)
INTERNAL CONNECTIONS OF BY-PASS CONDENSERS

R.F. CHOKE MOUNTING BOARD

CONNECTIONS

OPERATING SWITCH

SECONDARY COIL

INTERNAL CONNECTIONS OF OUTPUT TRANSFORMER.

R.F. CHOKE

25

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R.F. CHOKE

25

CL EACH

FILTER

REACTOR

POWER TRANSFORMER.

Complete layout and wiring diagram of the chassis (rear) and reproducer unit.
INTERNAL CONNECTIONS OF POWER TRANSFORMER

INTERNAL CONNECTIONS OF OUTPUT TRANSFORMER

INTERNAL CONNECTIONS OF INTERSTAGE TRANSFORMER

INTERNAL CONNECTIONS OF CAPACITOR PACK

INTERNAL CONNECTIONS OF FILTER REACTOR

POWER UNIT

AC INPUT PLUG

POWER TRANSFORMER

HEATERS, FILAMENTS AND DIAL LAMP

HIGH VOLTAGE "-350V TOTAL"

LOW VOLTAGE "-245V TOTAL"

TERMINAL STRIP
Figure 1—Schematic Diagram

RADIODRWN SOCKET VOLTAGES—110 VOLT A. C. LINE

<table>
<thead>
<tr>
<th>Radiotron No.</th>
<th>Cathode to Heater Volts D.C.</th>
<th>Cathode to Screen Grid Volts D.C.</th>
<th>Plate Current M.A.</th>
<th>Heater or Filament Volts A.C.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>38</td>
<td>35</td>
<td>50</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>38</td>
<td>0</td>
<td>35</td>
<td>50</td>
</tr>
<tr>
<td>3</td>
<td>7</td>
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</tr>
<tr>
<td>7</td>
<td>12</td>
<td>225</td>
<td>220</td>
<td>30</td>
</tr>
</tbody>
</table>

MODEL WR-10 A
Adjusting 1400 K. C. Line-up Condensers

BLACK AND RED
BLACK WITH RED TRACER
INTERCHANGE THESE LEADS FOR 110-VOLT OPERATION

Adjusting I. F. Transformer Tuning Condenser

LINK OPEN
TURN "RADIO" VOLUME CONTROL TO "MINIMUM" (COUNTER-CLOCKWISE) WHEN SWITCH IS AT "RECORD"

MAGNETIC PICKUP RECORD VOLUME CONTROL

MODEL WR-10

Changes Necessary for 110 Volt Operation on 25 Cycle Models

Connections for Attaching Magnetic Pick-up

THREE CARDBOARD STRIPS 1 1/2 \times 1/4"

View of Strips in Place for Centering Cone
SOCKET VOLTAGE READINGS

These are readings obtained with the usual Set Analyzers and are not true readings of the voltages at which the Radiotrons operate.

<table>
<thead>
<tr>
<th>Radiotron No.</th>
<th>Heater to Cathode Volts</th>
<th>Cathode or Filament to Control Grid Volts</th>
<th>Cathode or Filament to Screen Grid Volts</th>
<th>Cathode or Filament to Plate Volts</th>
<th>Plate Current M. A.</th>
<th>Heater Volts</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>3.0</td>
<td>3.0</td>
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<td>2.2</td>
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<tr>
<td>2</td>
<td>7.0</td>
<td>7.0</td>
<td>65</td>
<td>100</td>
<td>0.25</td>
<td>2.2</td>
</tr>
<tr>
<td>3</td>
<td>2.0</td>
<td>225</td>
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<td></td>
<td>30.0</td>
<td>2.2</td>
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MODELS

WR-6-R
and

WR-7-R
W.HOLESALE RADIO SERVICE CO., INC.

SERIES "10"

<table>
<thead>
<tr>
<th>Tube</th>
<th>Circuit</th>
<th>Meter Scale</th>
<th>90 V.</th>
<th>100 V.</th>
<th>110 V.</th>
<th>120 V.</th>
<th>130 V.</th>
</tr>
</thead>
<tbody>
<tr>
<td>R.F. \ (Ant.) '35</td>
<td>Grid</td>
<td>0—10</td>
<td>1.5</td>
<td>1.7</td>
<td>1.9</td>
<td>2.1</td>
<td>2.3</td>
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<tr>
<td></td>
<td>Screen Grid Plate</td>
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<td>53.</td>
<td>58.</td>
<td>63.</td>
<td>66.</td>
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<td>63.</td>
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<td></td>
<td></td>
<td>0—250</td>
<td>190.</td>
<td>205.</td>
<td>220.</td>
<td>233.</td>
<td>245.</td>
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<tr>
<td>Int. '35</td>
<td>Grid</td>
<td>0—10</td>
<td>1.5</td>
<td>1.7</td>
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<tr>
<td></td>
<td>Screen Grid Plate</td>
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<tr>
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<td>70.</td>
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<td></td>
<td></td>
<td>0—250</td>
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<td>123.</td>
<td>135.</td>
<td>145.</td>
<td>154.</td>
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<td>76.</td>
<td>78.</td>
<td>80.</td>
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<td>Aud. '47 (See Caution Above)</td>
<td>Grid Accelerating Grid</td>
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<td>3.</td>
<td>3.3</td>
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<tr>
<td></td>
<td></td>
<td>0—250</td>
<td>188.</td>
<td>210.</td>
<td>225.</td>
<td>240.</td>
<td>250.</td>
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<tr>
<td></td>
<td>Plate</td>
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<td>170.</td>
<td>190.</td>
<td>205.</td>
<td>220.</td>
<td>230.</td>
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<td>'80 Rect. Filament to Ground</td>
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## Tube

<table>
<thead>
<tr>
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<th>Circuit</th>
<th>Meter Scale</th>
<th>90 V.</th>
<th>100 V.</th>
<th>110 V.</th>
<th>120 V.</th>
<th>130 V.</th>
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</thead>
<tbody>
<tr>
<td>R.F. '35</td>
<td>Screen Grid Plate</td>
<td>0—100 0—250</td>
<td>67. 136.</td>
<td>75. 151.</td>
<td>82. 166.</td>
<td>90. 181.</td>
<td>97. 196.</td>
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<tr>
<td>1st Det. '35</td>
<td>Screen Grid Plate</td>
<td>0—100 0—250</td>
<td>63. 132.</td>
<td>70. 147.</td>
<td>77. 163.</td>
<td>84. 179.</td>
<td>91. 194.</td>
</tr>
<tr>
<td>Oscillator '27</td>
<td>Plate</td>
<td>0—100</td>
<td>70.</td>
<td>77.</td>
<td>85.</td>
<td>92.</td>
<td>100.</td>
</tr>
<tr>
<td>1st I.F. '35</td>
<td>Screen Grid Plate</td>
<td>0—100 0—250</td>
<td>67. 136.</td>
<td>75. 151.</td>
<td>82. 166.</td>
<td>90. 181.</td>
<td>97. 196.</td>
</tr>
<tr>
<td>2nd I.F. '35</td>
<td>Screen Grid Plate</td>
<td>0—100 0—1000</td>
<td>63. 227.</td>
<td>72. 252.</td>
<td>79. 277.</td>
<td>86. 303.</td>
<td>94. 328.</td>
</tr>
<tr>
<td>1st A.F. '27</td>
<td>Plate</td>
<td>0—100</td>
<td>87.</td>
<td>95.</td>
<td>104.</td>
<td>115.</td>
<td>122.</td>
</tr>
<tr>
<td>2nd A.F. '47</td>
<td>Grid Accelerating Grid Plate</td>
<td>0—25 0—1000</td>
<td>12.7 180.</td>
<td>14. 200.</td>
<td>15.4 220.</td>
<td>17. 220.</td>
<td>18.3 240.</td>
</tr>
<tr>
<td>'80 Rect.</td>
<td>Current (Both Plates) Plate to Plate voltage</td>
<td>0—100 0—1000</td>
<td>89 M.A. 547.</td>
<td>98 M.A. 568.</td>
<td>108 M.A. 690.</td>
<td>118 M.A. 712.</td>
<td>128 M.A. 733.</td>
</tr>
</tbody>
</table>

The '80 rectifier plate voltages shown are the totals of both plates, measured from each plate to center tap of high voltage secondary.
Central Radio Laboratories

Fundamental Circuits Used for Volume Control

Antenna or R.F. Primary Radiohm

Circuits numbers one and two were widely used on electric sets during 1928 and early in 1929. The volume control shunts the primary of an R.F. transformer having a tuned secondary, and has essentially the same resistance taper whether used at the antenna input or between two of the R.F. tubes. Circuit number one is the simplest and best to use in servicing any type receiver when in doubt about the proper volume control. It always works, and cannot interfere with the proper operation of any circuit.

Use Centralab Replacement Control number 70-200.
(A 10,000 ohm left hand tapered potentiometer.)

Antenna or R.F. Potentiometer

Circuits numbers three, four and five are quite similar to the first two except that a potentiometer is used rather than a two terminal resistor. Some models may deviate from circuit four by connecting the antenna rather than the ground to the variable contact. These are all circuit arrangements that can be used with the type —26 or type —27 tubes. Adjusting the volume control will have no effect on the apparent A.C. hum, and will not change the selectivity of the set. Use Centralab Replacement Control number 72-100.
(A 10,000 ohm left hand tapered potentiometer.)

Untuned Antenna

Circuit Potentiometer

Circuit number six was used on several early A.C models sold in large quantities, including those of R.C.A. The volume control potentiometer has a resistance of 2,000 ohms, and the grid of the first tube is directly connected without tuning.
Use Centralab Replacement Control number 72-101.
(A left hand tapered 2,000 ohm potentiometer.)

Antenna or R.F. Potentiometer

Circuit 9

in the antenna circuit where a high resistance is needed with a tuned coupling transformer, or where a variometer is used per circuit number nine.
Use Centralab Replacement Control number 70-201.
(A left hand Radiohm.)

Potentiometer "C" Bias and Antenna Control

Circuit 10

This circuit is more widely used than any other arrangement using a single control with type 27 or screen grid tubes, as it gives a double control effect at the cost of a single potentiometer. The variable contact is usually grounded through the bushing and the terminal at the clockwise end, is connected through a fixed bias resistor to the cathodes of two or three R.F. tubes or the I.F. tubes in case the circuit is a "Super." The other terminal connects to the antenna, shorting it to ground at minimum volume adjustment to avoid the grid overloading that might otherwise occur on loud signals.

Satisfactory volume controls for this circuit must be carefully tapered and are apt to prove critical or noisy under some extreme conditions. Where the very best control is desired, re-
place the single potentiometer with Twin control 74-601 connected as shown by circuit twenty. Circuit ten uses Centralab Replacement Control number 79-006 or 51-010. (A 15,000 ohm left-hand tapered potentiometer.)

Screen Grid Potentiometer

A single potentiometer providing volume control by varying the voltage applied to the screens of the R.F. tubes. Connection to only one tube is illustrated, but the screens of all the R.F. tubes are usually connected to the slider of the control. A 50,000 ohm Centralab has been most used for this service. Some receivers, however, use a wire wound control of such low resistance it passes considerable current and is made part of the voltage divider circuit. Better volume control will result from using a high resistance shunting the voltage divider. When these wire wound controls require replacement because of noise or wear, it is best to use the Centralab 100,000 ohm potentiometer with the two outside terminals bridged with a fixed resistor of approximately the same value as the old wire wound potentiometer.

50,000 ohm potentiometer. Part number 72-103.
100,000 ohm potentiometer. Part number 72-104.

(Right-hand tapered potentiometers.)

R.F. "C" Bias Radiohm

A popular circuit used effectively with all heater type of tubes. Circuit 12 was widely used in 1929 and 1930 in tuned R.F. circuits with the type -24 or type -27 tubes. The cathode current of all R.F. tubes passes through the single control and the additional fixed resistor which supplies the bias at maximum volume. Control depends upon the tube characteristic that increasing the negative C-bias beyond the normal three volts, will decrease the plate current and amplification of the tube until the signal is effectively blocked. The variable resistance must be heavily tapered for uniform attenuation since the voltage drop of the cathode current alone is depended upon for full range control. The proper Centralab control for circuit twelve is Centralab number 70-202, a 75,000 ohm right-hand tapered Radiohm. Variable Mu tubes, such as type -51 or -35, require such a high negative bias to fully control the signal it is customary to obtain the required voltage drop by passing bleeder current through the control in addition to the cathode current. This arrangement is illustrated as circuit 12A. Two fixed resistors are shown in addition to the volume control variable resistance. The one between the vol- umes control and the cathodes is of low resistance and provides the minimum bias for maximum volume. The other resistor has a two-fold purpose of stabilizing the screen voltage and metering a definite amount of "bleeder" current through the volume control. Its resistance, and that of a third resistance between the screens and the high potential lead, not shown in the print, is normally adjusted to apply about 100 volts on the screens and pass sufficient current through the total resistance of the volume control to provide a drop of about 40 volts across the volume control at minimum volume. This type control is used on both tuned R.F. and Super heterodyne circuits. On Supers, it is customary to control the bias of the I.F. tubes while tuned R.F. circuits will control two or three tubes. The most popular control is a right-hand tapered Radiohm, maximum resistance 10,000 ohms, Centralab part number 70-205. A few receivers originally used a wire wound control with a much lower maximum resistance. Replace these with a Centralab Potentiometer of similar resistance (see list on page 47) and connect the center and right terminal only.

Volume Control circuits like figure 12 or 12A, sometimes cause distortion or cross talk, due to overloading, in sections where local broadcast stations are powerful and numerous. This may be corrected by using a potentiometer of similar resistance for the replacement control, and connecting the left terminal to the antenna as illustrated in figure 10. Part number 79-006 is correct for most receivers when so changed.

R.F. "C" Bias Potentiometer

Another method of controlling volume by changing the R.F. "C" Bias that will be found on some receivers. Replacements must have the same total resistance of the original to insure the correct voltage drop. This resistance is usually low, such as Centralab part numbers 72-101, 72-107 or 72-108. This method of control is no longer considered as good as circuit ten or twelve. It is suggested that one of these circuits be substituted in making replacements.

Audio Circuit Volume Level Potentiometer

Potentiometer across audio stage is a very old form of control dating back to 1926. Yet many modern receivers will be found with this as an auxiliary control to another in the set; as the manual control used with automatic
volume control circuits; and as the volume control on amplifiers sold for theatre and school installations. Centralab replacement Part number 72-105.

Where space permits, as on separate amplifiers, use the Centralab Standard M-500 Modulator, having a diameter of 2¼ inches.

R. F. Plate Circuit Controls

These illustrate the plate circuit controls widely used several years ago. Connections for one tube only are shown, but the plates of two R.F. tubes are commonly connected to the control. Circuit number fifteen uses a 500,000 ohm right hand tapered Radiohm. Centralab replacement Part number 70-203. Circuit number sixteen used a 50,000 ohm potentiometer. Centralab replacement Part number 72-103. Both the above circuits may require frequent volume control replacement because a poor tube will practically short circuit the control. A tube with a loose grid that may accidentally short to plate causes the trouble and this tube is hard to locate because it will normally continue to function and be apparently O.K. It is therefore, desirable to replace these volume controls with the number 70-201 control connected as per circuit number eight or with circuit number one. The former volume control connections are then soldered together and taped.

R. F. Filament Rheostat

A Rheostat in the filament circuit to control any one or all of the tubes is the oldest method of volume control. There is a choice of two types of rheostats for replacement, Standard Power or Giant Power. The first is for low voltage and low current control; the second is for low voltage and higher current so that the maximum power does not exceed 50 watts. Smoother volume control for these receivers will always be obtained by fixing the filament voltage and using replacement control number 70-200 as per circuit number one or replacement control number 70-201 as per circuit number eight.

**Twin Volume Controls**

Volume controls that provide two separate resistances on the same shaft are commonly termed twins and the Centralab replacement controls of this type represent the highest development in radio receiver volume controls. Twin controls were used on many popular receivers during 1929 and are on a majority of the 1930 receivers, since screen grid models now have such high gain per stage that a single control will seldom handle a loud local signal without excessive overloading, distortion, or cross talk. When having any of these troubles with a receiver originally equipped with a single control it will be well to replace the original with a Twin as illustrated in any of the following circuit sketches. Centralab twins have all terminals insulated from each other and from the shaft and bushing.

- **Twin—Antenna and R. F. Primary**

  The volume control circuit used on the 1929 and early 1930 Victor receivers. The original control was a twin wire wound potentiometer. The noise and wear of this type may be eliminated by replacing the Centralab especially designed twin control part number 74-600.

- **Twin—Antenna and Screen Grid**

  This twin control has the same antenna potentiometer as the one used for circuit number twenty and the same variation of connections apply. The antenna potentiometer is the one type twenty-seven receivers.
having the shaft and bushing in it. The back base is also a potentiometer, used to vary the screen grid voltage of the R F. tubes. These two circuits are insulated from each other in the control. Centralab twin replacement control number 74-602. (Shaft base potentiometer 10,000 ohms. Back base potentiometer 50,000 ohms.)

Centralab twin replacement control number 74-602.

Twin—Antenna and Audio Secondary

This twin control reduces volume by varying the antenna input and at the same time reducing volume in the first audio stage. This has the advantage of lowering the hum level with the volume level, but is best used with a power detector circuit as otherwise that tube might overload and cause distortion on some loud signals. The shaft base is the antenna potentiometer with a maximum resistance of 10,000 ohms, and the back base the 500,000 ohm audio potentiometer. Centralab twin replacement control number 74-515.

"lows." Actually boosting the "lows" is a difficult problem requiring careful engineering in the original design of the amplifier, and can seldom be accomplished with satisfaction by any attachment made later. Even when incorporated in the original design, it can have no practical advantage over a simple tone control on a full range amplifier when the tone and volume control knobs are properly adjusted.

The most widely used and simple circuit is illustrated at number 23. A Centralab one megohm Radiohm number 41-010 is shunted, in series with a fixed condenser, from grid to grid of the push pull output tubes. The condenser capacity commonly used is .01 mfd. If greater high frequency cut off is desired, use a larger capacity, such as .02 mfd., while less cut off results from a smaller capacity, such as .003 mfd.

While circuit 23 illustrates a -45 output, the same parts and connections are used with a Pentode push pull, except that the condense capacity should be about .004 mfd. The proper connection for a single Pentode is shown as circuit 24, and the same connection is used with a single -45 or -50. All of these grid circuit applications, which we recommend as best, use the same Centralab 1 megohm 41-010 control with a condenser capacity of about .01 mfd. for the -45 and about .004 mfd. for the Pentode.

Some receivers locate the tone control in the detector plate per circuit 25. Centralab number 41-050 Radiohm has the correct taper for this location, while the condenser capacity is about .05 mfd. Circuit 26, also located in the detector plate, is designed to boost the "lows" as well as cut the "highs." The inductances and capacities are part of the receiver design. The control is a Centralab 72-103 potentiometer.

Some tone controls have been located in the plate circuit of the output tubes, either Pentode or -45, as shown by circuit 27. This circuit is not recommended because the high voltage and possible surges in this location may break down the condenser or the control. Where such trouble requires replacement parts, use a Centralab 41-010 located on the grid side per circuit 23 or 24.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>72.101</td>
<td>Potentiometer controls C 60, R.F. tube and grid</td>
<td>72.103</td>
<td>( R.F. )</td>
</tr>
<tr>
<td>72.102</td>
<td>Potentiometer controls C 6, R.F. tube and grid</td>
<td>72.105</td>
<td>( R.F. )</td>
</tr>
<tr>
<td>72.104</td>
<td>Potentiometer controls C 5, R.F. tube and grid</td>
<td>72.107</td>
<td>( R.F. )</td>
</tr>
<tr>
<td>72.105</td>
<td>Potentiometer controls C 4, R.F. tube and grid</td>
<td>72.109</td>
<td>( R.F. )</td>
</tr>
<tr>
<td>72.111</td>
<td>Potentiometer controls C, R.F. tube and grid</td>
<td>72.113</td>
<td>( R.F. )</td>
</tr>
<tr>
<td>72.127</td>
<td>Potentiometer controls C 11, R.F. tube and grid</td>
<td>72.130</td>
<td>( R.F. )</td>
</tr>
<tr>
<td>72.132</td>
<td>Potentiometer controls C 12, R.F. tube and grid</td>
<td>72.135</td>
<td>( R.F. )</td>
</tr>
<tr>
<td>72.137</td>
<td>Potentiometer controls C 13, R.F. tube and grid</td>
<td>72.139</td>
<td>( R.F. )</td>
</tr>
<tr>
<td>72.142</td>
<td>Potentiometer controls C 14, R.F. tube and grid</td>
<td>72.145</td>
<td>( R.F. )</td>
</tr>
<tr>
<td>72.151</td>
<td>Potentiometer controls C 15, R.F. tube and grid</td>
<td>72.154</td>
<td>( R.F. )</td>
</tr>
<tr>
<td>72.157</td>
<td>Potentiometer controls C 16, R.F. tube and grid</td>
<td>72.159</td>
<td>( R.F. )</td>
</tr>
<tr>
<td>72.162</td>
<td>Potentiometer controls C 17, R.F. tube and grid</td>
<td>72.165</td>
<td>( R.F. )</td>
</tr>
<tr>
<td>72.170</td>
<td>Potentiometer controls C 18, R.F. tube and grid</td>
<td>72.173</td>
<td>( R.F. )</td>
</tr>
<tr>
<td>72.177</td>
<td>Potentiometer controls C 19, R.F. tube and grid</td>
<td>72.179</td>
<td>( R.F. )</td>
</tr>
<tr>
<td>72.183</td>
<td>Potentiometer controls C 20, R.F. tube and grid</td>
<td>72.185</td>
<td>( R.F. )</td>
</tr>
<tr>
<td>72.190</td>
<td>Potentiometer controls C 21, R.F. tube and grid</td>
<td>72.193</td>
<td>( R.F. )</td>
</tr>
<tr>
<td>72.198</td>
<td>Potentiometer controls C 22, R.F. tube and grid</td>
<td>72.196</td>
<td>( R.F. )</td>
</tr>
<tr>
<td>72.204</td>
<td>Potentiometer controls C 23, R.F. tube and grid</td>
<td>72.206</td>
<td>( R.F. )</td>
</tr>
<tr>
<td>72.212</td>
<td>Potentiometer controls C 24, R.F. tube and grid</td>
<td>72.214</td>
<td>( R.F. )</td>
</tr>
<tr>
<td>72.221</td>
<td>Potentiometer controls C 25, R.F. tube and grid</td>
<td>72.224</td>
<td>( R.F. )</td>
</tr>
<tr>
<td>72.230</td>
<td>Potentiometer controls C 26, R.F. tube and grid</td>
<td>72.232</td>
<td>( R.F. )</td>
</tr>
<tr>
<td>72.237</td>
<td>Potentiometer controls C 27, R.F. tube and grid</td>
<td>72.239</td>
<td>( R.F. )</td>
</tr>
<tr>
<td>72.248</td>
<td>Potentiometer controls C 28, R.F. tube and grid</td>
<td>72.249</td>
<td>( R.F. )</td>
</tr>
<tr>
<td>72.259</td>
<td>Potentiometer controls C 29, R.F. tube and grid</td>
<td>72.262</td>
<td>( R.F. )</td>
</tr>
<tr>
<td>72.270</td>
<td>Potentiometer controls C 30, R.F. tube and grid</td>
<td>72.273</td>
<td>( R.F. )</td>
</tr>
<tr>
<td>72.281</td>
<td>Potentiometer controls C 31, R.F. tube and grid</td>
<td>72.284</td>
<td>( R.F. )</td>
</tr>
<tr>
<td>72.295</td>
<td>Potentiometer controls C 32, R.F. tube and grid</td>
<td>72.297</td>
<td>( R.F. )</td>
</tr>
<tr>
<td>72.307</td>
<td>Potentiometer controls C 33, R.F. tube and grid</td>
<td>72.310</td>
<td>( R.F. )</td>
</tr>
<tr>
<td>72.322</td>
<td>Potentiometer controls C 34, R.F. tube and grid</td>
<td>72.325</td>
<td>( R.F. )</td>
</tr>
<tr>
<td>72.336</td>
<td>Potentiometer controls C 35, R.F. tube and grid</td>
<td>72.338</td>
<td>( R.F. )</td>
</tr>
<tr>
<td>72.345</td>
<td>Potentiometer controls C 36, R.F. tube and grid</td>
<td>72.347</td>
<td>( R.F. )</td>
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<tr>
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<td>72.363</td>
<td>( R.F. )</td>
</tr>
<tr>
<td>72.370</td>
<td>Potentiometer controls C 38, R.F. tube and grid</td>
<td>72.372</td>
<td>( R.F. )</td>
</tr>
<tr>
<td>72.384</td>
<td>Potentiometer controls C 39, R.F. tube and grid</td>
<td>72.386</td>
<td>( R.F. )</td>
</tr>
<tr>
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<td>Potentiometer controls C 40, R.F. tube and grid</td>
<td>72.399</td>
<td>( R.F. )</td>
</tr>
<tr>
<td>72.406</td>
<td>Potentiometer controls C 41, R.F. tube and grid</td>
<td>72.408</td>
<td>( R.F. )</td>
</tr>
<tr>
<td>72.423</td>
<td>Potentiometer controls C 42, R.F. tube and grid</td>
<td>72.425</td>
<td>( R.F. )</td>
</tr>
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<td>72.441</td>
<td>( R.F. )</td>
</tr>
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<td>72.452</td>
<td>( R.F. )</td>
</tr>
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<td>Potentiometer controls C 45, R.F. tube and grid</td>
<td>72.469</td>
<td>( R.F. )</td>
</tr>
<tr>
<td>72.479</td>
<td>Potentiometer controls C 46, R.F. tube and grid</td>
<td>72.481</td>
<td>( R.F. )</td>
</tr>
<tr>
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<td>72.497</td>
<td>( R.F. )</td>
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<td>72.514</td>
<td>( R.F. )</td>
</tr>
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<td>72.527</td>
<td>( R.F. )</td>
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<td>Potentiometer controls C 54, R.F. tube and grid</td>
<td>72.609</td>
<td>( R.F. )</td>
</tr>
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<td>Potentiometer controls C 55, R.F. tube and grid</td>
<td>72.625</td>
<td>( R.F. )</td>
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<td>72.641</td>
<td>( R.F. )</td>
</tr>
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<td>( R.F. )</td>
</tr>
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<td>72.675</td>
<td>( R.F. )</td>
</tr>
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<td>Potentiometer controls C 59, R.F. tube and grid</td>
<td>72.693</td>
<td>( R.F. )</td>
</tr>
<tr>
<td>72.709</td>
<td>Potentiometer controls C 60, R.F. tube and grid</td>
<td>72.711</td>
<td>( R.F. )</td>
</tr>
</tbody>
</table>

The model numbers and control circuits are as follows:

- **Model A**: 72.101 to 72.709
- **Model B**: 72.711 to 72.790
- **Model C**: 72.791 to 72.870

Each model is designed to control various circuits and components in a radio receiver. The specific controls vary depending on the model number.
Volume controls of many receivers may be replaced to best advantage with Centralab 70-200 shunted to antenna and inroad.

Radiohm connected across primary of last stage R.F.

Rheostat R.F. stages in filament circuit.

Radiohm shunts antenna to ground.

Potentiometer controls screen grid volume.

Potentiometer in audio circuit.

Automatic volume control.

Radiohm varies R.F. C-bias.

Twin radiohm controls C-bias voltage and potentials.

Potentiometer controls screen grid voltage.

Potentiometer controls aerial and ground.

Twin potentiometer controls antenna and screen grid.

Control No. 3.

Radiohm connected across aerial coil.

Ammeter shunts audio.

Ammeter controlling grid of first audio. Dual control.

Ammeter controlling grid of first audio. Twin.

Two radiohms in series.

Dual controls aerial and ground.

Ammeter controlling grid of first audio.

Potentiometer controls aerial and C-bias.

62.104

74-506

72-105

74-503

72-100

74-502

72-103

74-501

72-102

74-500

72-101

74-499

72-100

74-498

72-103

74-497

72-102

74-496

72-101

74-495

72-100

74-494

72-103

74-493

72-102

74-492

72-101

74-491

72-100

74-490

72-103

74-489

72-102

74-488

72-101

74-487

72-100

74-486

72-103

74-485

72-102

74-484

72-101

74-483

72-100

74-482

72-103

74-481

72-102

74-480

72-101

74-479

72-100

74-478

72-103

74-477

72-102

74-476

72-101

74-475

72-100

74-474

72-103

74-473

72-102

74-472

72-101

74-471

72-100

74-470

72-103

74-469

72-102

74-468

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72-103

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72-103

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72-103

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72-103

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74-410

72-103

74-409

72-102

74-408

72-101

74-407

72-100

74-406

72-103

74-405

72-102

74-404

72-101

74-403

72-100

74-402

72-103

74-401

72-102

74-400

72-101

74-399

72-100

74-398

72-103
### CENTRAL RADIO LABORATORIES

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<tr>
<th>Model No.</th>
<th>Volume Control Circuit</th>
<th>Circuit No.</th>
<th>Replacement Control No.</th>
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<td>control coil 200 tube. Single unit</td>
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<td>P.F. circuit</td>
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<td>Potentiometer controls Cbias and screen controls Cbias</td>
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<td>Potentiometer controls Cbias and screen controls Cbias</td>
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<td>Model 60</td>
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<td>ZENITH RADIO CO.</td>
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</table>
THE above sketches show dimensions of Electrad Replacement Volume Controls. View "A" shows the back view and location of terminals, the number of which are referred to in diagrams and tables which follow. View "B" shows depth of unit and lengths of shafts and bushing. The shaft is made long enough for most cases. When a shorter shaft is needed it can be cut to proper length. View "C" shows the knob end and location of terminals after mounting the unit on set.

In order to make each type control as universally applicable as possible, all types are potentiometers except where an off position is desirable as in RI-204. When the rheostat type is needed only two of the terminals are used. The proper terminals are indicated in circuits. When connecting in receiver, reference should be made to above drawings.

View "C" also indicates quarter positions knob rotation. These positions are used to determine the type of taper of the resistance. When a volume control is used in a series circuit such as Nos. 8 and 9, it has a regular or right-hand taper. This means that the resistance of the first quarter-section is higher than that of the second quarter-section, etc. When control is used in a shunt circuit such as Nos. 2 and 3, it has a reverse or left-hand taper. That is, the first quarter-section has lower resistance than the second quarter-section, etc. When resistance of all sections is equal, the taper is linear or uniform.

All RI and FB type replacement controls have insulated bushings. There is no connection between terminal No. 2 and bushing or shaft. No insulating washers are needed when mounting the unit on metal panel. In circuits Nos. 3, 5, 7 and 8 a connection must be made externally between terminal No. 2 and chassis or ground.

In many receivers the volume control is not smooth, or appears to be defective even when replaced by new control. This may be due to the set having gain which cannot be practically controlled by a single unit, or the fact that at certain volume control positions tube distortion, cross-talk or oscillation occurs. This can be corrected by the addition of a switch and fixed wire resistance as shown in circuit No. 19. The resistor should be a Truvolt Wire Grid Resistor with a nominal value of 50 ohms. In cases of extremely high gain a 25 ohm resistor should be used. The switch is then used as a local-distance switch, closed for local and open for distance. A much more convenient method of doing this, however, is to use an RI type resistor with switch attached.

Figure No. 1 shows appearance of RI type volume controls without switch. Figure No. 2 shows the same control with switch. The switch is so arranged that when the knob is turned completely to the right (full clockwise position) the switch opens and stays open until knob is turned completely to the left (full counter-clockwise position) when switch will close. This feature makes these units ideally suited for combination local and distance switch and volume control. A representative diagram is shown in circuit No. 20. Circuit No. 19, however, can be used in combination with any one of circuits Nos. 1 to 15 inclusive.

If it is desired to use the switch as a line switch the locknut on switch should be removed and switch turned one-half turn in counter clockwise direction which will reverse the operation of the switch. That is, the switch will connect the current to the set when turned fully clockwise and disconnect when turned fully counter-clockwise.

Circuit No. 18 shows use of rheostat and condenser for tone control. RI-206 can be used for replacement in this circuit or can be used to add tone control to any receiver. Circuit shows connections for push-pull audio. Where a single power tube is used, terminal No. 2 should be connected to ground. R207P has the condenser enclosed in unit and is supplied with leads that can be connected to the two grids of push-pull output or to grid and ground of single tube output. R207P is furnished with insulating washers which must be used when mounted on metal panel or chassis.

---

**VOLUME CONTROL HOW USED CIRCUIT NUMBER**

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<thead>
<tr>
<th>CIRCUIT</th>
<th>VOLUME CONTROL</th>
<th>HOW USED</th>
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<tr>
<td>1-201</td>
<td>Antenna Potentiometer—center arm to coil</td>
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<td>2</td>
<td>RF Primary shunt</td>
<td>RF Primary shunt</td>
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<tr>
<td>3</td>
<td>Antenna and ground rheostat shunt</td>
<td>Antenna and ground rheostat shunt</td>
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<td>4</td>
<td>Untuned Antenna potentiometer—2000 ohm grid resistor must be connected between terminals No. 1 and No. 3</td>
<td>Untuned Antenna potentiometer—center terminal to ground</td>
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<tr>
<td>5</td>
<td>RF Primary Potentiometer—center terminal to plate</td>
<td>RF Primary Potentiometer—center terminal to plate</td>
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<td>6</td>
<td>Antenna Cathode Potentiometer</td>
<td>Antenna Cathode Potentiometer</td>
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<td>7</td>
<td>With Switch.</td>
<td>With Switch.</td>
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<td>8</td>
<td>Cathode series resistor</td>
<td>RI-202</td>
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<td>9</td>
<td>75,000 ohm RF Primary shunt</td>
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<td>With Switch.</td>
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<td>RF Secondary shunt</td>
<td>RF Secondary shunt</td>
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<td>RF Secondary potentiometer—center arm to grid</td>
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<td>RF Secondary potentiometer—center arm to shield</td>
<td>AF Secondary potentiometer—center arm to grid</td>
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<td>18</td>
<td>Antenna potentiometer and Cathode series resistor</td>
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<td>19</td>
<td>Antenna potentiometer and screen grid potentiometer</td>
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<td>22</td>
<td>Tone Control unit (rheostat and condenser with leads)</td>
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ELECTRAD INC.

BASIC CIRCUITS
For Which Electrad
Replacement Volume
Controls Are Designed

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ELECTRAD INC.

ELECTRAD VOLUME CONTROLS ARE AVAILABLE FOR THE FOLLOWING RECEIVERS

(Important Note—All controls listed below must be used only in circuit indicated)

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<td>AC-7 Control B</td>
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<td>AC-9 Control C</td>
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<td>Krell RECEIVER</td>
<td>AC-9 Control D</td>
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☆ Value of R of Circuit No. 15

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<th>RECEIVERS</th>
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<tr>
<td>Acme</td>
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<td>Bosch</td>
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<td>Bush &amp; Lane</td>
<td>Model 12</td>
<td>10000 ohms</td>
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<td>RCA</td>
<td>Models 44, 46, 47</td>
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</table>
MODEL 79
also 99 and 109

VOLTAGE READINGS AT TUBE SOCKETS

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<tr>
<td>1</td>
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<td>225</td>
<td>94</td>
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<td>94</td>
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<td>Detector</td>
<td>120</td>
<td>-</td>
<td>20*</td>
<td>2.1</td>
</tr>
<tr>
<td>6-7</td>
<td>Power Tubes</td>
<td>225</td>
<td>215</td>
<td>16.5*</td>
<td>2.8</td>
</tr>
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</table>

VOLUME CONTROL AT MAXIMUM

2.5V To all heaters

2.5V To 247 Fil.

<table>
<thead>
<tr>
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VOLUME CONTROL AT MINIMUM

2.5V To 247 Fil.

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<td>16.5*</td>
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</table>
Can You Service Every Set Accurately • Quickly • Profitably?

These two Jewell Service Instruments provide Every facility for servicing all modern receivers

The Pattern 444 Set Analyzer

1. Tests easily, quickly every circuit in all receivers. Direct tests of all variable-mu and pentode circuits.
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1928

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3—Pigtails are tinned copper, molded into the caps, not soldered or strapped—thus insuring positive contact and proof against noise caused by faulty connection.

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[Diagram showing radio components and connections]
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Ever since the appearance of the commercial radio broadcast receiver as a household necessity, the Radio Service Man has been an essential factor in the radio trade; and, as the complexity of electrical and mechanical design in receivers increases, an ever-higher standard of qualifications in the Service Man becomes necessary.

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To give Service Men such a standing, it is obviously necessary that they must prove themselves entitled to it; any Service Man who can pass the examination necessary to demonstrate his qualifications will be elected as a member and a card will be issued to him under the seal of this Association, which will attest his ability and prove his identity.

The terms of the examination have been drawn up in co-operation with a group of the best-known radio manufacturers, as well as the foremost radio educational institutions.

We shall not attempt to grade the members into different classes. A candidate will be adjudged as either passing or not passing. If the school examining the papers passes the prospective member as satisfactory, we shall issue to him an identification card with his photograph.

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- Grafton-Graham Company (Mansfield), Mansfield, Ohio. Mr. L. B. G. Wilkinson, Service Mgr.
- C. C. Grigsby-Grunow Company, Los Angeles, Calif. Mr. J. M. Griggsby, Service Mgr.
- The Crosley Radio Corporation, Cincinnati, O. Mr. C. C. Grigsby, Service Mgr.
- RCA-Victor Company, Inc., Camden, N. J. Mr. H. C. Grobb, Vice-President.
- Stewart-Warner Corporation, Chicago, Ill. Mr. W. C. Wessel, Service Mgr.

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- East Bay Radio Institute, Oakland, Calif. Mr. C. T. Tokeshi, Director.
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The Problems of the Service Man
General Methods of Analyzing Trouble
General Description of Modern Receivers
The Need for a Radio Set Analyzer
What to Expect from an Analyzer

CHAPTER 2
The Analyzer
The Fundamental Requirements of an Analyzer
The Switches or Push Buttons
The Ammeter
Multiscale Ammeters
The Shunt and Its Calibration
The D.C. Voltmeter
The Multiscale D.C. Voltmeter
The Multiplier and Its Calibration
The O.C. Voltmeter
The Design of a Simple Analyzer

CHAPTER 3
Trouble Shooting with the Analyzer
Classification of Trouble—
(1) External to the receiver;
(2) In the receiver proper:
(a) Mechanical troubles;
(b) Electrical troubles.
Detailed Analysis of Electrical Troubles—
(1) Tube testing;
(2) Localizing trouble:
(a) By past experience;
(b) By actual test of circuit.
(3) Interpretation of analyzer readings;
(4) Tube charts (use of);
(5) Circuit diagrams (use of);
(6) Testing the power unit;
(7) The use of the analyzer in testing individual units.
Additional Features and Uses of the Analyzer—
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- Service Men's data
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<table>
<thead>
<tr>
<th>FILTER BLOCKS</th>
<th>FIXED RESISTORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Standard of the Industry Built to specification</td>
<td>Wire-wound Tubular Flat Strip—Flexible Grid Leaks</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BY-PASS CONDENSERS</th>
<th>VARIABLE RESISTORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>In stock in all usual capacities</td>
<td>Carbon Volume Controls Wire-wound Volume Controls Rheostats—Potentiometers</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>UNCASED PAPER CONDENSER SECTIONS</th>
<th>TRANSFORMERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>For repair work</td>
<td>Audio Transformers Power Transformers Standard Choke Units</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ELECTROLYTIC CONDENSERS</th>
<th>COIL WINDINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>In single, double and triple units</td>
<td>All types of coils, except radio frequency, built to specification</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MICA CONDENSERS</th>
<th>MAGNET WIRE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postage Stamp Type Large Molded Small Molded</td>
<td>Enamelled Wire Sizes, 18 to 42—in case lots</td>
</tr>
</tbody>
</table>

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MODELS
94, 11, 12 and 101, 112, 122

POWER UNIT
MODELS
90, 11, 12 and 101, 112, 122

VOLTAGE READINGS AT SOCKETS USING WESTON 547 ANALYZER
Line Voltage 115. Fuse in 120 Volt Clips.

<table>
<thead>
<tr>
<th>TYPE</th>
<th>POSITION</th>
<th>PLATE VOLTS</th>
<th>GRID VOLTS</th>
<th>SCREEN VOLTS</th>
<th>NORMAL PLATE</th>
<th>GRID TEST</th>
</tr>
</thead>
<tbody>
<tr>
<td>224</td>
<td>1st R.F.</td>
<td>2.3</td>
<td>185</td>
<td>3.25</td>
<td>90</td>
<td>4</td>
</tr>
<tr>
<td>224</td>
<td>2nd R.F.</td>
<td>2.3</td>
<td>185</td>
<td>3.4</td>
<td>90</td>
<td>4</td>
</tr>
<tr>
<td>224</td>
<td>3rd R.F.</td>
<td>2.3</td>
<td>185</td>
<td>3.3</td>
<td>90</td>
<td>4</td>
</tr>
<tr>
<td>224</td>
<td>Det.</td>
<td>2.3</td>
<td>90</td>
<td>3</td>
<td>30</td>
<td>.25</td>
</tr>
<tr>
<td>227</td>
<td>1st A.F.</td>
<td>2.3</td>
<td>170</td>
<td>12</td>
<td>—</td>
<td>6</td>
</tr>
<tr>
<td>245</td>
<td>P.P.</td>
<td>2.3</td>
<td>245</td>
<td>50</td>
<td>—</td>
<td>28</td>
</tr>
<tr>
<td>245</td>
<td>P.P.</td>
<td>2.3</td>
<td>245</td>
<td>50</td>
<td>—</td>
<td>28</td>
</tr>
</tbody>
</table>
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EVEN since the advent of radio, the summer months have been a time for radio people to enjoy the company of their radio service men. This means that the average radio service man and his helper have plenty of leisure time to spend with their families during the summer months.

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<table>
<thead>
<tr>
<th>SIZE</th>
<th>COLOR</th>
<th>USED FOR</th>
</tr>
</thead>
<tbody>
<tr>
<td># 20</td>
<td>RED</td>
<td>180 V.F. PLATE LEAD.</td>
</tr>
<tr>
<td># 20</td>
<td>WHITE</td>
<td>+250 FILTER CHOKE.</td>
</tr>
<tr>
<td># 20</td>
<td>YELLOW</td>
<td>AUDIO CATHODES.</td>
</tr>
<tr>
<td># 20</td>
<td>SLATE</td>
<td>Screens &amp; Cathodes: F.K.</td>
</tr>
<tr>
<td># 20</td>
<td>BLACK</td>
<td>Audio Grid Leads, Grid Comm.</td>
</tr>
<tr>
<td># 1A</td>
<td>BLUE</td>
<td>Power Filts., Pilot Light</td>
</tr>
<tr>
<td># 1A</td>
<td>BLACK</td>
<td>226-227 Filaments.</td>
</tr>
<tr>
<td># 20</td>
<td>BROWN</td>
<td>Slate, 224 Det. Screen.</td>
</tr>
</tbody>
</table>

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Often, the trade name of a set is known by the user of this book but the name of the manufacturer not known.

In searching for diagrams, if the particular diagram you desire cannot be found, be sure to look through the Miscellaneous section at the end of this index. If it is not listed there look through the Trade Name Index; this gives the name of the manufacturer for each trade name.

Since all diagrams are listed in the index in alphabetical order in accordance with the manufacturers' names, it is absolutely necessary to know the name of the manufacturer before a particular diagram can be found.

In the supplements are included diagrams for which we have received requests. Wherever the diagrams that have been requested are not included in one set of supplements, they will appear in the set published after we receive them. Many diagrams of obsolete sets are difficult to obtain, but we are using every possible effort to procure them.

We wish to express our thanks to the many subscribers who have taken such extreme interest in the Manual, and especially to those who have voluntarily submitted diagrams for publication in the supplements.

—The Publishers.

A

A. C. DAYTON CO.
XL-20; XL-25; XL-30 77
XL-61; AC-66 78
AC-63; AC-65 79
XL-3; Navigator, Navigator Power P. 80
XL-10; XL-70 80.
XL-60; XL-30 A.C. 80B.

ACME ELECTRIC CO.
Model S.G. 88; AC-7 81

ALL-AMERICAN MOHAWK CORP.
6 and 8 tube A.C. "1926-27" 85
Power Pack 82
Lyric models 60, 61, 62, 65 and 66 82
Lyric models 80, 83, 84, 85, 86, 88 82
70, 73 and 75; No. 90 chassis, 60 cycle 83
No. 90 chassis 25 cycle; No. 96 chassis, 60 cycle 84
Mohawk one dial battery

A. C. 226-227 85
Model D. Lyric Receivers 84A*
Model 44; Model H 84B*
All American Lyric B-94 85
Model K 138
Model P 139
Model 90 Chassis, 60 130
Model 90 Chassis, 64 130
Model 90 Speaker and plug 131
Model 96 Chassis, 60 131
Model S-8 Lyric 132
Model S-7 Lyric 133
Model J Lyric 134
Model S-6 Lyric 135
Model B-7 Battery 136
Model C-6 Lyric 136
Model DC Lyric 137

AMERICAN BOSCH MAGNETO CORP.
16 Amborada; 27 Amborada; 46 The Little Six; 57 & 87 86
Cruiser, Royal Cruiser and Imperial Cruiser, model 33 battery sets 87
Models 66, 76, and 76L 88
the Cruiser; Models 66AC, 96, 116, 136 88
for A.C.; Model 107 88
for A.C.; Model 126 88
for A.C.; Model 146, 166, 176, 46-A.C. 88
Model 96 D.C. receiver; 88
Model 58, 59 90A*
Model 61, 62 90B*
Model 60 Volume Control Receiver 90C*
Model 5 90D*
Model 60 and 61 (Automatic Volume Control) 90E*
Model 62—D. C. 90F*
Model 63—D. C. 90G*
Models 78 and 74 140
Model 20 141
Model 80 and 84 142

ALLIED ENGINEERING INSTITUTE
(See Television Section)

Bosch Motor Car receiver 81
Model 38, 39 81
Model 61, 62 81
Model 60 Volume Control Receiver 90C*
Model 5 90D*
Model 60 and 61 (Automatic Volume Control) 90E*
Model 62—D. C. 90F*
Model 63—D. C. 90G*
Models 78 and 74 140
Model 20 141
Model 80 and 84 142

AMERICAN TRANSFORMER COMPANY
De-Luxe Recording Amplifier 143
Pick-Up Matching Circuit 143
PP-281 144
PP-250 144
PP-245A 145
Hum Reduction Chart 145

Circuits listed in italic type are in the 1931 issue of the Manual. Circuits listed in italic type, with the page number followed by an asterisk*, are in the supplements to the 1931 Manual.
BEEDE ELECTRICAL INSTRUMENT CO.
(See Test Equipment Section)

BELMONT RADIO CORPORATION

Series 40 .......................... 178
Models 45, 46 ........................ 179
Series 50 .......................... 180
Models 65, 66 ........................ 181
Model 70 Super ..................... 182

BRANDS PRODUCTS CORPORATION

AC Set and power unit 183
AC Set and power unit, 25 cycles .... 184
6 Tube DC .......................... 185
6 tube AC, 60 and 25 cycles ......... 186
Models B-11, B-12, .................. 187
Branded ......................... 188
Model 25 ......................... 189
Model K-54 (210 power tube) ....... 190
Model K-38 ......................... 191
Model K-42 ......................... 191
Model K-48 ......................... 192
Models K-60, 62 ..................... 193
Models K-70, 72 ..................... 194
Models K-80, 82 ..................... 195
Models K-90, 92 ..................... 196
"B" Socket power unit ................. 197
Columbia Electric Phonograph ....... 197
Columbia 960 ....................... 198
Columbia C-9 ...................... 199

BREMER-TULLY MFG. CO.

B-T Counterphase 6; Counterphase 8; 6-40 power converter ............... 106
6-40 circuit diagram .............. 107
7-70 and 7-71 .................... 108
(Also see Brunswick Corp.)

AUTOMOBILE RADIO CORP.

TR-100; NR-109 .................. 75

AZTEC RADIO COMPANY

5-Tube Pentode .................... 177

B

B-180 Form B; B-133; .......... 23
B; BW or B Model ............... 104B*
Model A .......................... 104B
Socket "A" supply ................ 23
6-180 Form A .................... 26

BRUNSWICK-BALKE COLLENDER-COMPANY

Model X-1102 ..................... 199
Model RPA 5 (AP058) (with potentiometer) .................. 200
Models 14, 21 SPU .............. 201
Models 14, 21 ..................... 202
Models 11, 12, 16 ............... 203
Model 10 ......................... 204
Models 14, 21, 31 ............... 206
Models 17, 24, 26 ............... 207

CANADIAN MARCONI CO.

Type XIV D.V. .................. 360
Type Units, Types XV, XVI, XVII, XVIII A. C.; Power Unit ....... 361
Models X, XII .................. 370A
Models XI, XII .................. 370B
Models V, VII .................... 370C
Models XII, XIII power ......... 370D

CIRCUITS listed in italic type are in the 1931 issue of the Manual. Circuits listed in italic type, with the page number followed by an asterisk*, are in the supplements to the 1931 Manual.
CROSLEY RADIO CORPORATION

Models XJ and XL... 210
Models 20, 21, 22... 210
Model 706... 211
Rosario... 211
Models 92, 28, 121, 121-1 Series B... 212
Model 92... 212
Model 77... 212
Models 104, 105, 106... 213
Power Converter... 213
Models 104R and 105R Power Converter... 213
Models 122, 123... 214
Model 124... 215
Speaker 497 and 903A... 215
Speaker 278, 306J, and 306M... 215
AC-7 and AC-7C... 130
Models 3B and 3C... 121
Crosley Deluxe... 212
Tuner B-255... 212
F. A. D. ANDREA, INC.

Model 248, revised... 231
Model 250... 231
Model 271A... 232
Era model 224 screen炎炎炎炎... 142B
Era model 225... 142B
Era model 226... 142B
Era model 227... 142B
EMERSON RADIO & PHONOGRAPH CORP.

Model F... 155

F. A. D. ANDREA, INC.

Pfaff 10, 11, 30 and 31... 768c
-60 cy.: 102, 117, 302, 312-25 cy.: 16, 17, and...
Models 30, 40 and 48; Models 30N, 40N and 48N; Model 50 — 162
Model 130 — Model NR215
NR400, English long
and short wave set — 163
Model 457 Power Unit;
Model NR60DC — 164
Model 905 A.C., Model
NR-93 A.C. — 470 — 165
Model NR83; Model S2
Model 800
Models NR80, NR-3 — 166A
Models NR78, NR-3 A — 166B

CHAS. FRESHMAN CO.,
INC.

J. E. models 21 and 22;
J. E. models 31 and 32 — 167
QD-165; Model N — 168
Model G; Model G power
pack; Model G with
GoQ-5 power supply — 169
Earl model 41; Freshman
model N with N 60
power supply — 170
New and improved Master-
piece; Equaphase
Combination K and K-605
QD-165 — 172
Q-31 and Q-216; Q-2
and 2N-605 — 173
21AC and 22AC: 3Q-15
and 3Q-16 — 174
Model 121; Model 21
D.E.; Earl models 33,
31 and 24 D.C. — 175
32 and 32 AC; 31 AC
and 32-AC and Earl
33-AC; 41AC — 176
Models "G" 2N-12 — 176A

G

GAROD RADIO CO.

Model EA — 188D

GENERAL ELECTRIC COMPANY

Model E-52 Phono
Model H-51-R; H-71-R
Model H-51-R; H-71-R
Motor contactor adj-
justment — 239
Model T-41 — 240
Model T-12 — 241
Model H-32 — 242
Model K-62 — 243
H-31 — 266A
H-21 — 266B
H-31 — 266C
General Electric Models
G.E. Jr. No. S-22; G.E.
Motor No. S-22 A; C;
S-42 — 266G
Models H-31, H-31 and
H-71 — 266H

GRAYBAR ELECTRIC
COMPANY

Model 8 — 247
Model 311 — 389
900 — 266B
900 — 266C
Model 312 — 266D
Graybar No. 8 Midget. — 266G
Graybar Models 705, 770;
6 AC — 266H

GRAY & DANIELSON
MFG. CO.

Rember R-14, Infradyne. — 220F
Sargent-Rayment, 1927 — 220F

A. H. GREBE & CO.

R.F. Amplifier type RORN
"13" Regenerative Re-
ceiver; Short Wave type
CR-19: Short Wave
Model CR-6 — 186
Type MU-1: Broadcast Receiver — 187
Super Synchrophase type
SK-4: Super Synchroc
Phase AC — 188
Super Synchrophase type
SK-4 — 188A
B & C Socket power type
071 B SuperSynchro
phase; Type AH-1 — 188B
Models SK-4 DC, AH-1. — 188C

GRIGSBY-GRUNOW
COMPANY

Model 20 — 248
Model 30 — 249
Model 15 — 250
Model 160 — 250
Model 50 power unit — 251
Model 60 — 252
Model 160 — 253
Model 90B — 254
Model 110 auto radio — 255
Model 120 — 257
Majestic Models 60-707 — 190
7BP3 Power Unit — 190
Models 90, 91, and 92;
9P3 Power Unit; 9P6
Power Unit; Model 70B
chassis in 72 Set — 191
Model 100; 90-B — 192
Model 100-B; 180 and
181
7P6 and 7P3 Power Units
(old wiring) 7P6 and
7P3 Power Units — 193
BP-4 and BP3 Power Unit;
P.U. System in 130-A
Super Screen Grid Grid
Section — 194
Super Screen Grid chas-
is in model 130-A; in
Model 230-A — 196
Majestic Jr. eliminators; 23
Majestic Models 30; 51
and 52 Supers — 192B

CULBRENSAN COMPANY

Model 60-68 — 258
Model 269-In-Line — 258
Model 724, 8-Tube — 258

H

HAMMARLUND MFG. CO.

HI-Q 30 A.C. — 51
HI-Q 31 A.C. — 51
Hammarlund - Roberts
HI-Q 365C
HI-Q 5; HI-Q Six
HI-Q 6; HI-Q Six Power Supply — 196
HI-Q 30, battery model 356D
Z-4 Commander — 365D

HATRY & YOUNG, Inc.

Short Wave: 6 — 188D

HICKOK ELECTRICAL
INSTRUMENT CO.
(See Test Equipment
Section)

HIGH FREQUENCY
LABORATORIES

Mastertone Super-10, 1931
Mastertone, 1929 Model
and Next-In-Line — 192B
Charles Hoodwin Company

World Wide 1 tube: 267
Low Power Transmitter: 267
Aero "Transmitter": 268
Metropolitan Four, International A.C./D.C., 15-30 Watt Transmitter: 196K
1929-1930 Auto Radio, Aero S. W. Converter, Aero L-Power Transmitter: 267
Aero Seven, Aero Short Wave Adapters for A.C. and batteries: 196M
Aero "Trio" A.C. Three, Aeroyne D.C. Six: 196N
Aero 1931 Model, Aero 1931 Auto Radio: 196O

Horn Radio Company

Model 15: 488D
Model 59: 265
Model 49: 266
Models 69-69: 584
Models 79, 99, 109: 584

Howard Radio Company

Model SG-A: 196A
Model 8 Green Diamond: (4 tubes): 196B
Model SG-B Midget: 196C
Model SG-C: 196D
Model SG-B: 259
Model H: 260
Model O: 261
Model AVH: 262
Model 60 Phonograph Combination: 263
Model 135 AC: 264

Insuline Corporation of America

AC Broadcast and Long Wave Combination: 269
110 Volt DC Midget: 270
DC Broadcast and Long Wave: 270
Midget: 220 DC: 271
110 Volt AC Midget: 271
Insullette and Mascot, BC and LW: 272
Insullette and Mascot, AC: 272
A.C. Short Wave Set: 340

Jenkins and Adair, Inc.

Model 62 Midget: 354

Jewell Electrical Instrument Co.

(See Test Equipment Section)

Keller-Fuller Manufacturing Co.

Model 20: 279
Model 70: 280
Model 120: 281
Radiote Model: 14F: 355
Model Fifty: 328B

Kellogg Switchboard and Supply Co.

6 Tube Set 507 and 508: A.C. 7-tube set inductance tuned; "A" chassis: 510, 511, 514, 516-8 tubes: 198
Power Unit K-50 for sets: 324, 325, 357, 528; Chassis: "B" 515, 519, 521; 523 and 526 with power unit No. 245: 200
Wave Master, RFL: 201
Models 533, 534: 535, 536: 200A

Colin B. Kennedy Company

Model 50: 282
Model 28, 36, 88, 40: 282
Model 26: 283
Model 34 SW: 284
Model 42: 285
Model 52: 285
Model 54 Super-het SW: 286
Converter: 286
Model 60: 286
Model 28L: 110: 220: 202
Model 6 type 420: Models 515 type 430 and 431: 203
Cortet D. C.; Type 435
Model 20 type 440: 204
Model 522 and 523: 204
Model 10: 205
Model 20: 205
Kennedy Model: 206B

Combination: 2064A
Royal 80: 204A
Models 30 and 32: 204B

King Mfg. Corporation

Model 218: 287
Model 10K1 Neutrodyne: 287
Neutrodyne: 30 T.R.F.: 287
61 T.R.F.: 287
Model E and 80A: 287
Model 80: 287
Model 81: 287
Model F: 287
Model 82 and power pack: 287
Model J: 209
Model H: 209
Model 97: 98
King Monarch: 210
Model G: 210
Power pack uniting King, Roy, Imperial and Monarch: 211
Model PP: 220E

Kolster Radio, Inc.

Model K-60, K-62: 288
Model K-70, K-72: 289
Model K-80, K-82: 290
Model K-90, K-92: 291
ColumbiA type 930: 291
Kolster 6K: 292
Kolster 6-tube receiver: 292
7 tube A.C. set (Brandes): 293
Kolster 8A-B-C: 294
7B: 294
K-44, K-43: 295
K-45: 296
BrandeS B10, B15: 296
K-22, K-27 and 7 tube A.C. set (Brandes): 296
Columbia: 297
Kolster 6A-B-C: 298
Model K-90, K-92: 299
Model K-60, K-62: 300
Model K-70, K-72: 300
Model K-80, K-82: 300
Model K-90, K-92: 300
Columbia: 301
Kolster 6K: 302
Kolster 6-tube receiver: 302
7 tube A.C. set (Brandes): 303
BrandeS B10, B15: 303
K-22, K-27 and 7 tube A.C. set (Brandes): 304
K-45: 305
K-45: 306
K-46: 307
K-47: 308
K-48: 309
K-49: 310
Power supply and amplifier unit No. 245: 311
Tuning chassis for 7 tube sets used in K-21, K-23, K-24 and K-28: 312
Tuning chassis used in K-24: 313
Tuning chassis: 510, 511, 514, 516-8 tubes: 314
Power Unit K-50 for sets: 324, 325, 357, 528; Chassis: "B" 515, 519, 521; 523 and 526 with power unit No. 245: 317
Wave Master, RFL-7: 318
Models 533, 534: 319
Models 533, 534: 320A

Lang Radio Company

Model BD6 DC: 292
Model M-T AC: 292
Model J-7 DC: 292
Model BA-6 AC: 292
Model E-9 DC: 293
Model R-8 DC: 293

C. R. Leutz, Inc.

Trans-Oceans; "Seven Seas" console: 333

Lincoln Radio Corporation

Model 31: 337
Lincoln DC-8: 338C

Long Radio Co.

Cardinal Model 70: 108D

Majestic

(See Grigsby-Gruno Co.)

Master Radio Mfg. Co., Ltd.

Model Master Model 424: 335

MeMillan Radio Co.

Series 900, A.C. power set: 210

Midwest Radio Corporation

Model AC-9: 560
Model Unisneue 5: 552
Model RF and Detector: 552
Ultra 6, Ultra 7: 554
Unisneue 8: 556
Model Ultra 8 battery: 558
Model AC-11: 560
Model AC-9: 562

Mills Phonograph Co.

Mills phonograph: 218B
Phonograph diagrams with extra speakers: 218D

Montgomery Ward & Co.

Model 20W and 62-520: 296
Model 49: 296
Model 26P and 26PX: 297
Model 26-360: 297
Model 26-367: 297
Model 1111 and 811: 298
Model 111X and 811X: 298
Model 1355 and 1955: 298
Model 62-1040: 299
Models Commander and Cavalier: 299
Model 181, 60 cycle: 300
Model 181, 25 cycle: 300
5 tubes S.G. battery sets Nos. 1522 & 1566: 300
(Wells Gardner): 7 tube A.C. S.G. sets Nos. 2822, 2827, 2856, 2877, (U. S. Radi & Television Co.): 218M

Motorola (Galvin Mfg. Corp.)

Auto Receiver: 294

MULTICOUPLER (Amy, Aces and King)

Riser Circuits for Multi-coupler installation: 295

Circuits listed in italic type are in the 1931 issue of the Manual. Circuits listed in italic type, with the page number followed by an asterisk, are in the supplements to the 1931 Manual.
### NATIONAL CARBON CO., INC.

Eveready models 1, 2, and 3; series 30... 220
Eveready series 30, 30-C, and 40... 221
Models 20, 21... 220E

### NATIONAL COMPANY Inc.

Model BD Official... 301
One Tube Reflex... 301
B.D. Transformer Co. .301
Models SW-3; SW-4... 220A
Models MB-29, MB-30... 220B
Models SW-1 and Special Television Receiver... 220C
Automatic Receiver... 220D

### NATIONAL COMPANY

Screen Grid Model 80... 300
Model 50 and 50A... 300
Transiste (3)... 307
BATTERY CHarts... 308
Model 30... 309
Model 35... 310
Philco Resistor and Condenser data... 76D
Oscillator circuits for 173... 76E
Philco Model 40; Model 41... 222
Model 65; Model 76... 223
Model 77 & 774; 86 & 87... 224
Model 87... 225
96 & 96-A: 296 & 296-A... 226
Models 511, 512, 513
513, 514, 515, 531
511, 517; Model 95... 227
"A" & "B" Eliminators...
"DB" & "B" part of "DAB" socket... 226
180 volt B and B part... 226
AB-623, AB-643, AB-663, AB-683, AB-693, AB-943
Philco Set Model 65:
"Baby Grand" 20 & 204
Sockets: "A" supply... 226B
AB-656 & AB-652... 226B
Models 92, 95, 95E
96A, 96E, 296A, 296E
Models 111 and 111A... 226C
Models 220 and 220-A... 226C
Models 211 and 211-A... 226C
Philco Model 30... 226C
Models 56 and 46-E... 226C
Models 111 and 111-A... 226H
Models 112 and 112-A... 226H
Models 119 and 119-A... 226H
Philco Model 70 and 70-A... 226H
Models 90 and 90-A... 226H
Model Series 3... 230F

### PECORIO AIRIO, Inc.

Model AC-144-5... 311
Model AC-534-S... 312
Model DC-273... 313
Model AC-447M... 313
Model AC-547... 314
Model AC-547-A... 314
Model AC-546-7... 315
Model 724... 316
Model 727 DC... 317
Model 734-7... 318
Model DC-627-8... 319
Model AC-746-7M... 320
AC-24-45... 321
De WALD Model 1C... 324
Pierce Airio DeWald D.C... 632
Pierce Airio DeWald D.C... 358B

### PACE ELECTRIC COMPANY, Inc.

Both connections film reproducer... 308, 309
Disc and film reproducer... 308, 309

### PFCSTYLE PRODUCTS

Co.
Models 54 and 50 AC... 290F

### PILOT RADIO & TUBE CORP.

5 Tube TRF Midget... 321
Model SW Converter... 321
Model DC Super-het 320... 322
Model DC 7 tube 120 volts... 323
PEG; K-113 power amplifier; Pilotsite Electric Speaker; Super Wasp... 228
Pilot Automotive Radio...
Grimes 110 volt D.C.
New Yorker; Twin S.G.
K-106; K-108; S.G. -105
A.C. Super Wasp... 354
Pilot Midget Super Wasp... 354
Philco Models... 356
Philco Model 35... 356
220A... 356
220C... 356
226A... 356
B-623, AB-643, AB-663, AB-683, AB-693, AB-943
DAB... 226
"A" & "B" Eliminators... 226
"DB" & "B" part of "DAB" socket... 226
180 volt B and B part... 226
AB-623, AB-643, AB-663, AB-683, AB-693, AB-943
Philco Set Model 65:
"Baby Grand" 20 & 204
Sockets: "A" supply... 226B
AB-656 & AB-652... 226B
Models 92, 95, 95E
96A, 96E, 296A, 296E
Models 111 and 111A... 226C
Models 220 and 220-A... 226C
Models 211 and 211-A... 226C
Philco Model 30... 226C
Models 56 and 46-E... 226C
Models 111 and 111-A... 226H
Models 112 and 112-A... 226H
Models 119 and 119-A... 226H
Philco Model 70 and 70-A... 226H
Models 90 and 90-A... 226H
Model Series 3... 230F

### PHILADELPHIA STORAGE BATTERY COMPANY

Model BD Official... 301
One Tube Reflex... 301
B.D. Transformer Co. .301
Models SW-3; SW-4... 220A
Models MB-29, MB-30... 220B
Models SW-1 and Special Television Receiver... 220C
Automatic Receiver... 220D

### N. R. I.

(See Television Section)

### NATIONAL TRANSFORMER CO.

Midget Six... 359F
Screen Grid 8... 359F

### OZARKA, INC.

Model 92AC... 302
Model 95 WDI... 302
Models S-7; S-8; S-A... 358G
Models 89, 90... 358H
Model 78 and Viking 92 AC... 358I

### PRIESS RADIO CO.

Models R and C nine-in-line super... 357

### RADIO PRODUCTS CO.

(See Test Equipment Section)

### RADIO TECHNIC LABORATORY

Television Receiver... 455D

### RADIO RECEPTOR, Inc.

Model C Announcer... 352
Model CAM3... 352
Model R80-81 Control Panel... 358
Time Clock Control Panel... 358
Model PMA2... 354
Model PMA254-R... 354
Model PFPX250A... 354
Model PFPX254P (variation)... 354
Model PFPX254 (variation)... 354
Model PMA-1... 356
Model PMA-1... 357
Model PMA-1 AX2... 358
Model H-1 Amplifier... 358
Model PMA-1 AX-1... 359
Model P-50-W... 359
Model P-50-W... 359
Model RXPX171... 359
Model FX-245... 359
Model MM-3PMX3... 361
Model PFPX245... 361
Model PFPX245... 362
Model PFPX245... 362
Model PSA-2 control panel... 382
Model AR-3 Receiver... 382

Circuits listed in italic type are in the 1931 issue of the Manual. Circuits listed in italic type, with the page number followed by an asterisk, are in the supplements to the 1931 Manual.
Radiola 42
Radiola
RCA 82
Audio
RCA R-80266A
Radiola 44; Models 3 &
Brunswick
Radiola 66

READRITE WORKERS
(See Test Equipment
Section)

REMELER COMPANY Ltd.
Model 21
Model 15

53 K Superheterodyne
Cameo Model 14

ROBERTSON-DAVIS CO.
Model 600-610
Model 9A TRF
Model 235
Model 40
Model 51M-52
Model 620-740-750 DC
Model 30-B. 630
Model 15
Model 686 Amplifier
Model 9G Receiver
Model 117 B Amplifier
Model 728 B Amplifier
Models 30 (chassis, 60
Lowboy, 95 Highway
and 75 Concert Grand
720 A.C.
S.M. 690 Public Address
System)
33-A power supply (25
& 60 cy.), 1929 9-tube
S.G. superheterodyne.268A
Model 34 - A; Model
35-A
Silver Marshall Super
with Model 36A Chas-
ris and 32A Power
Pack
722 Band Selector 7. SM.
712 Tuner, 724 A.C.
Receiver
68D A
Model 714 Superhetero-
dyne; Models 37, 38
and 39
Models 30-B, 630

S

SAMSON ELECTRIC
COMPANY
Model PAM9
Model PAM16N
Model PAM17M
Model PAM5
Model PAM 16
Model PAM 17
Model PAM 26
Model PAM 19
Model PAM MIKI

SCOTT TRANSFORMER
CO.
All-Wave Super-Hetero-
dyne

SEARS, ROEBUCK & CO.
Sivertons Models F, G,
H, I; same as King
Silverstone F, FF, G, H,
I

SHORT WAVE AND TELE-
VISION LABORATORY
 Baird Television
Receiver

SILVER MARSHALL Inc.
Model 782-16 Midget...
Model 30-A
Model 725 DC
Model SMD-1 Super...
Model 728 SW
Model A
Model 716 Receiver
Model 683 Amplifier

Model SM 684
Amplifier
Model 692
Model 709 SW adapter
Model D
Model F
Model 686 Amplifier...
Model G Receiver
Model 679B Amplifier
Model 738 Converter
Model 737 AC S.W.
Model 732 B Amplifier
Model 729 Amplifier...
Models 30 (chassis, 60
Lowboy, 95 Highway
and 75 Concert Grand
720 A.C.
S.M. 690 Public Address
System)
33-A power supply (25
& 60 cy.), 1929 9-tube
S.G. superheterodyne.268A
Model 34 - A; Model
35-A
Silver Marshall Super
with Model 36A Chas-
ris and 32A Power
Pack
722 Band Selector 7. SM.
712 Tuner, 724 A.C.
Receiver
68D A
Model 714 Superhetero-
dyne; Models 37, 38
and 39
Models 30-B, 630

SIMPLEX RADIO
COMPANY
Model H
Model K

SONORA PHONOGRAPH
CO., INC.
Model 2RF-25
3 RP and 4R
3 RP
7 P
B-31 (25 cycle); Phonog-
raph automatic stop.274
Models E-AC, A-36.268D A

SPARKS WITHINGTON
COMPANY
Models 564, 570, 740,
750
Model AR-19
Models 6 and 9 TRF
Model 103-578 En-
semble
Model 107 Serial 6502
and up...
Model 410-420 DC
Model 974-870
Model 790-610 DC
Model 10 Super-Hetero-
dyne
Model 31
Model 51M-52
Model 40
Model 30
Model 29
Model 236
Model 9A TRF
Model 410-420
Model 600-610

Models 25 and 60
Super
Model 591-593
Sparkon Model 39; 89A.273
49; 9-301
931 and 101 D.C.
6-26; 6-16; A.C. 62-63
A.C. 89-99
3-26, 5-15; Model 110-281
Sparkon 931 A.C.
Equations Model 369;280C
Sparkon 301 A.C.280D

SPEED INDICATOR
Stroboscope discs

SPIEGEL, MAY, STERN
CO., "Melrose"—same as Apex
41

SPLITT DORF ELECTRIC
MFG. CO.
R-200; PAD-4 ABBEY
(with volume con-
trol)
A.C.
Model 171
Inherently Elec-
Model 24. A
Model Spuitoff Model M5, R.V.
693
Model M-6: R-100

STAIRS-WINTERS CO.
Television Receiver

STANDARD RADIO CORP.
A. C. Model 29

STEINTE RADIO
COMPANY
Model 20 Chassis...
Model 15 Chassis...
Model 26 Receiver
Model 28 Receiver
Model 28 Receiver...
30-4 & 102-A
991, 992, 993, 105 &
261 & 262
Model 40 power pack...
Power Pack Models 40C-
60-120C
10 No. 10 Screen Grid Chas-
is in Models 70, 80
95

STENODE CORPORATION
OF AMERICA
Steren Receiver

STERLING MFG.
COMPANY
Miniature Receiver...
5DGA Receiver
(See Test Equipment
Section Also)
4 No. 4 speaker; No. 4
power unit and speaker

Circuits listed in italic type are in the 1931 issue of the Manual. Circuits listed in italic type, with the page number followed by an asterisk*, are in the supplements to the 1931 Manual.
SUPREME INSTRUMENT CORPORATION
Model 31 436
Model 42 439

STUDEBAKER LABORATORIES

TELEPHONE MAIN TENANCE CO.
Telmaco P-1 338

TEMPLE CORPORATION
8-60, 8-80, 8-90 301
8-61, 8-81, 8-91 302

TELEPHONE MAIN TENDACE CO.

TRANSFORMER CORPORATION OF AMERICA
Model 40 456 & 457
Model AC 94 458
Model 25-94 458
Model AC-94, 25-94 460
Model 70 Clarion 460
Model 70 Clarion 461
Model 61 Clarion 461
Model 61 and 70 462
Model 40 463
Model 90 464
Model 80 465
Model 83 Clarion 466
Model 92 Clarion 467
Clarion AC-33, AC--35 25, 51-25, 53-25, 53-288
Clarion Fr. Model 60, 335
Clarion Series 90, Models AC-90, AC-91, 25-90 and 25-91 328A*

TRAV-LER MFG. CO.
Model AC SG DX 451
Model K 452
Model S Super 453
Trav-Jette 454
Model DC SG 455
Model SG AVG Super 255 455
Model 6 & 7; D.C. & AC power packs .332

U NITED AIR CLEANER CO.

W ESTERN ELECTRICAL CORP.

WEBSTER ELECTRICAL CORP.
Model 6013 Power Amplifier 496
Model 35TA Amplifier 496
2-Stage PO. Amplifier, Code 6005; 6025-JD Amplifier 1304*
3-Stage PO. Amplifier: 6030—JE & B-37-50 Amplifier 334B*

WELLS GARDNER & CO.

WESTARK RADIO STORES
Knight Model 8/9 324B*

WESTINGHOUSE ELECTRIC & MFG. CO.
Model WRA 511, 512 & 513
Model WR-8, R diagram 514
Model WR-8 diagram 515
Model WR-8 Power Unit 516
Model WR-8 Receiver Assembly 517
Model WR-8 Receiver Assembly 518
Model WR-8, R Power Unit 519
Model WR-10 520
Model WR-10 521, 522, 523
Model WR-14 525
Model WR-6-R and WR-7-R 526
Model WR-6-R and WR-7-R Receiver Assembly 527
Power Unit 528
Remote Control Connections 529
Model W R 266A* 266A*
Model W R 266B* 266B*
Westinghouse No. WR-10 266C*
Westinghouse model 266C*
Westinghouse WR-8 & WR-8R 266H*

WESTON ELECTRICAL INSTRUMENT CORP.
(See Test Equipment Section)

Circuits listed in italic type are in the 1931 issue of the Manual. Circuits listed in bold type, with the page number followed by an asterisk*, are in the supplements to the 1931 Manual.
<table>
<thead>
<tr>
<th>Service Manual</th>
<th>Question Coupon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name:</td>
<td>Address:</td>
</tr>
<tr>
<td>This coupon is good for one question.</td>
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