Receiver Circuit Analysis

All receivers are built around the vacuum tube used as amplifier, detector, rectifier or oscillator. Whenever an open or short occurs in the filament, plate, grid or screen-grid circuit of a vacuum tube, it will have a definite effect upon the voltage and current readings obtained at these different tube elements with an analyzer.

The analyzer is designed to indicate the variations caused by such opens or shorts, and thus enables the service man to determine in which tube circuit the abnormal condition exists. Having done this the analyzer has done all that it is possible for an instrument to do. It now remains for the service man to decide (by analytic reasoning based on previous experience and thought on trouble shooting problems) in which portion of that particular tube's circuits the trouble is.

On the following pages will be found 4 fundamental, schematic diagrams of the complete filament, grid and screen-grid circuits for:

1. Filament type triodes and screen-grid tubes.
2. Heater-cathode type triodes and screen-grid tubes.
3. Filament type pentodes (voltage or power amplifiers).
4. Heater-cathode type pentodes (voltage or power amplifiers).

The various circuits are numbered as:

Example:

1 = grid return from grid of tubes to negative C in grid circuit.

2 = plate circuit from positive B on voltage divider to plate of tube.

On a following page will be found a chart listing the effects noted (as compared to the normal readings) when the various circuits or parts are open or shorted. By the use of this chart, knowing what normal conditions are, and how the abnormal conditions compare with them, it is possible for a service man to narrow his tracing of the suspected tube circuit, down to the testing of one or two of the parts of that circuit.

Diagrams No. 1 and No. 2 apply equally as well to triodes of the filament and cathode-heater types by omitting circuit No. 13 and condenser No. 7 which apply to screen-grid types only.

It will be noted that circuit No. 14 in diagrams No. 3 and No. 4 applies only to a pentode. It represents the connection between the suppressor grid (located between the space charge or screen-grid and plate) and the cathode, or to a point in the circuit whose potential is more negative than the cathode. Since the suppressor grid serves the same purpose (i. e., to practically eliminate the effects of secondary emission) whether the tube be a radio-frequency pentode, such as the 57, or whether it be a power-output pentode, such as the 47, diagrams No. 3 and No. 4 apply equally as well to both types of tubes. The effects upon normal voltage readings when this circuit opens are listed under circuit No. 14 on the following chart. In certain tube types, such as the 47, circuit No. 14 is made within the tube, as indicated by the dotted lines in Fig. 3. An open in this internal connection will cause the same analyzer readings as those noted under circuit No. 14 in the accompanying chart.

Diagram No. 4 applies to triple-grid amplifiers, such as the 89, when used as a pentode power amplifier. When this tube is used as a class A or B amplifier, it would then be classified as a triode, and in this case diagram No. 2 would apply. For information on the operation and connections of the grids of a triple-grid amplifier when used in class A or B amplifier circuits, refer to the set manufacturer's service notes.

Example:

If it is found that the readings at one tube socket show E_{c1} = above normal, I_b = o, E_b = o, E_{kf} = above normal; referring to the chart we see that when this condition exists it indicates a short in No. 6—(the plate bypass condenser)—when its return is connected to positive side of grid-bias resistor No. 4, or it indicates an open in the cathode circuit through conductor No. 3 or grid-bias resistor No. 4.

The meaning of the symbols used in the reference chart are as follows:—

E_{c1} = Grid voltage or control grid on S. G. tubes.	S = Shorted.
	L = Leaking.
E_{kf} = Cathode voltage on cathode heater tube.	Op = Open.
	O = Zero voltage or current.
E_b = Plate voltage.	Lo = Below normal.
E_{c2} = Screen grid voltage.	Hi = Above normal.
E_{c3} = Suppressor grid voltage.	Nor = Normal.
I_b = Plate current.	F = Fluctuating.

Note: In servicing modern receivers it is extremely desirable that the service man use the set manufacturer's service notes. These will be found to be of great assistance in locating troubles and applying the correct remedy. Most radio set manufacturers will gladly furnish responsible service men with service notes on any model of their receivers upon a written request to the manufacturer's service department.

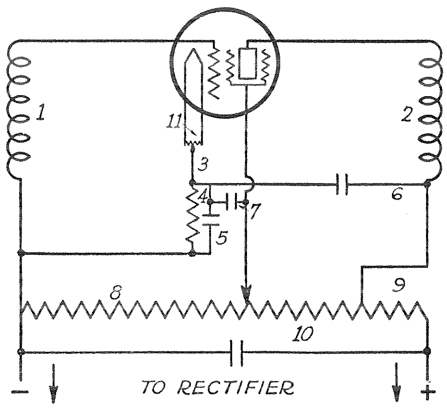


Fig. 1

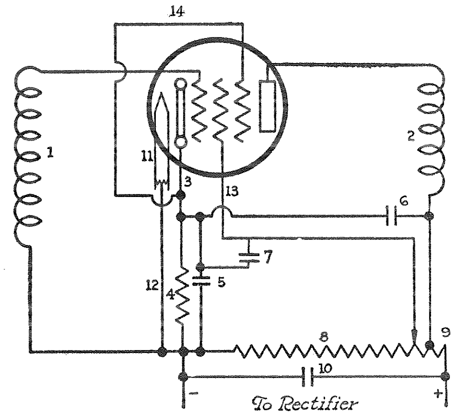


Fig. 4

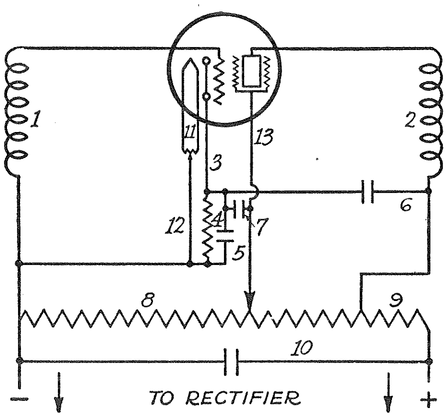


Fig. 2

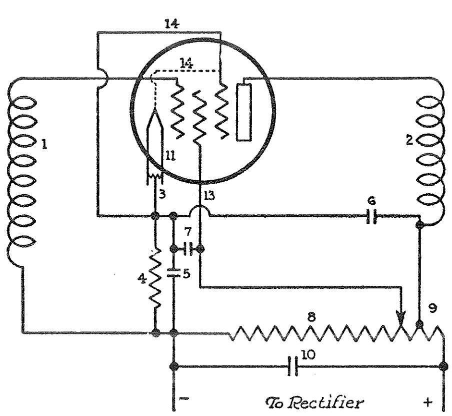


Fig. 3

Circuit No.	Condition	E_{c1}	E_{c2}	I_{c2}	I_b	E_b	E_{kf}	E_{c3}
1	Op	O	Lo	Hi	Hi	Lo	Hi	
* 2	Op	O	Nor	Hi	O	O	O	
† 3	Op	Hi	O	O	O	O	Hi	
4	Op	Hi	O	O	O	O	Hi	
5	S	O	Lo	Hi	Hi	Lo	O	
5	L	F or Lo	Nor	Nor	F or Hi	F or Lo	F or Lo	
5	Op	Nor	Nor	Nor	Nor	Nor	Nor	
‡ 6	S	Hi	O	O	O	O	Hi	
6	L	F or Hi	F or Lo	F or Lo	F or Lo	F or Lo	F or Hi	
6	Op	Nor	Nor	Nor	Nor	Nor	Nor	
‡ 7	S	Hi	O	O	O	Lo	Hi	
7	L	F or Hi	F or Lo	F or Lo	F or Lo	F or Lo	F or Hi	
7	Op	Nor	Nor	Nor	Nor	Nor	Nor	
8	Op	Hi	Hi	Hi	Hi	Hi	Hi	
9	Op	O	O	O	O	O	O	
10	S	O	O	O	O	O	O	
11	Op	Nor	Nor	Nor	Nor	Nor	Nor	Hum
12	Op	Nor	Nor	Nor	Nor	Nor	O	Hum
13	Op	O	O	O	O	Hi	O	
14	Op	Nor	Nor	Hi	Lo	Nor	Nor	Hi

Exceptions:

*E_{c1} = O when Individual Bias Resistor.
E_{c1} = Lo when Common Bias Resistor, or S. G. Tube.
†E_{c1} & E_{kf} = Hi when Individual Bias Resistor.
E_{c1} & E_{kf} = Lo when Common Bias Resistor.
‡E_{c1} & E_{kf} = O when condenser return is to neg. end No. 4 or Neg. Rectifier.

RCA VICTOR

BULL'S - EYE SOCKET - VOLTAGE CHARTS FOR NEW "OCTAL" METAL TUBE SOCKETS

AS USED IN

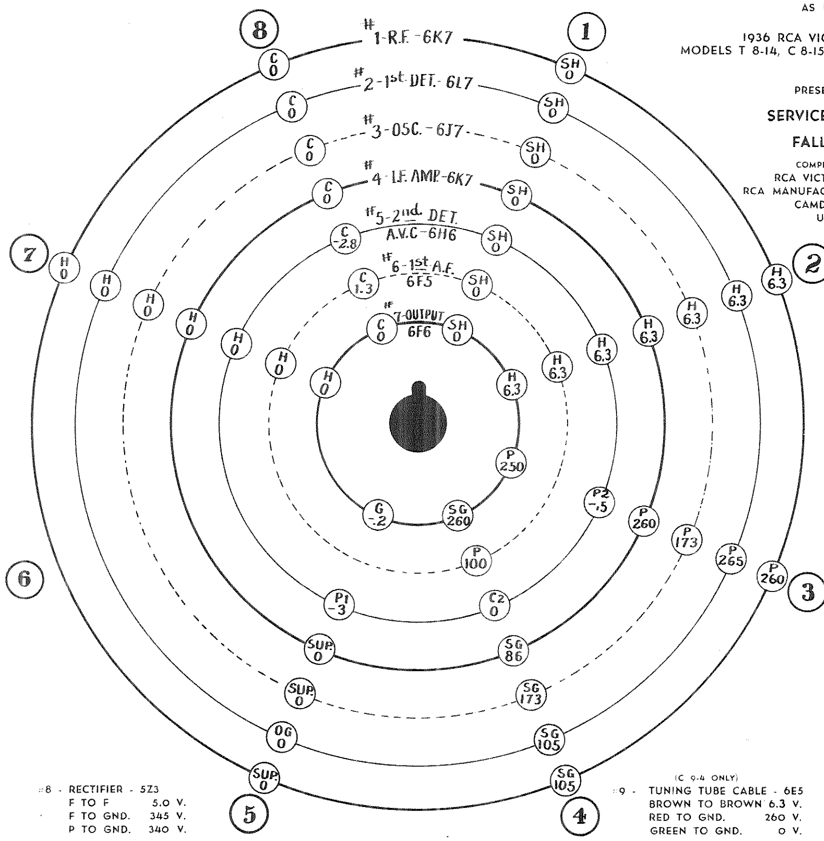
1936 RCA VICTOR RECEIVERS
MODELS T 8-14, C 8-15, C 9-4, T 10-1 AND C 11-1

PRESENTED AT

SERVICE MEETING

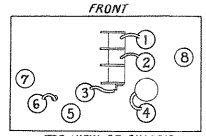
FALL - 1935

COMPLIMENTS OF
RCA VICTOR DIVISION,
RCA MANUFACTURING CO., INC.,
CAMDEN, N. J.
U. S. A.

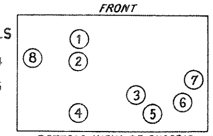


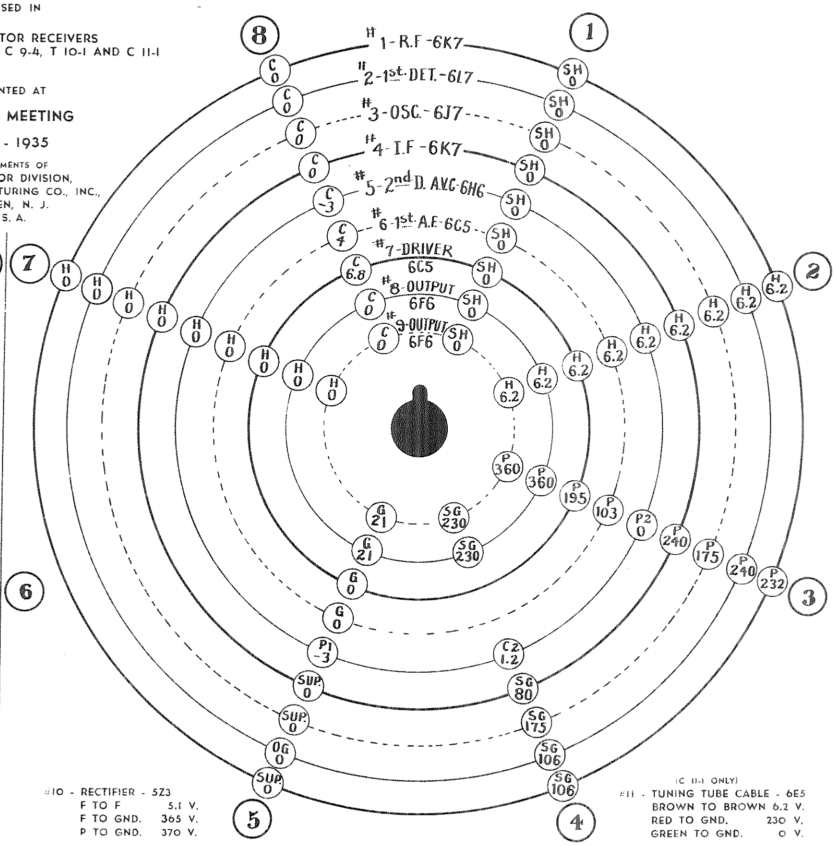
#8 - RECTIFIER - 5Z3
F TO F 5.0 V.
F TO GND. 345 V.
P TO GND. 340 V.

#9 - (C 9-4 ONLY) TUNING TUBE CABLE - 6E5
BROWN TO BROWN 6.3 V.
RED TO GND. 260 V.
GREEN TO GND. 0 V.



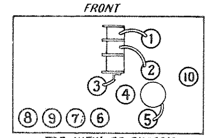
MODELS
T 8-14
C 8-15
C 9-4



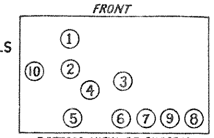


#10 - RECTIFIER - 5Z3
F TO F 5.1 V.
F TO GND. 365 V.
P TO GND. 370 V.

#11 - (C 11-1 ONLY) TUNING TUBE CABLE - 6E5
BROWN TO BROWN 6.2 V.
RED TO GND. 230 V.
GREEN TO GND. 0 V.



MODELS
T 10-1
C 11-1



PROCEDURE: Place chassis with bottom up, speaker connected, all tubes in place, range switch on Band "A", dial setting at low-frequency end of Band "A", NO station tuned in, volume control setting optional. Select socket by referring to "under chassis view". Locate Pin #1, which is the first pin clockwise from the aligning lug; then continue in a clockwise direction for the remaining pins, comparing voltage readings obtained with those on the chart. All readings are positive with respect to chassis (ground) unless indicated by a negative (-) sign. All d-c readings taken with a 1000 ohms-per-volt voltmeter. Screen voltages measured on 250 volt range. Power supply - 115 volts, 60 cycles.

INSTRUCTIONS: Each bull's-eye represents the under-chassis socket terminals for the receiver models indicated. Each large circle represents the particular socket-pin layout for which it is labeled. The small outer circles indicate the pin numbers. The upper and lower designations in each small circle, on the large circles, indicate respectively; PIN CONNECTION and PIN VOLTAGE TO GROUND. All heater voltages and plate-to-ground rectifier voltages are a-c; all other voltages are d-c. At the lower left are voltages for the rectifier tube; at the lower right, voltages for the tuning-tube cable.

RCA VICTOR

BULL'S - EYE SOCKET - VOLTAGE CHARTS FOR NEW "OCTAL" METAL TUBE SOCKETS

AS USED IN

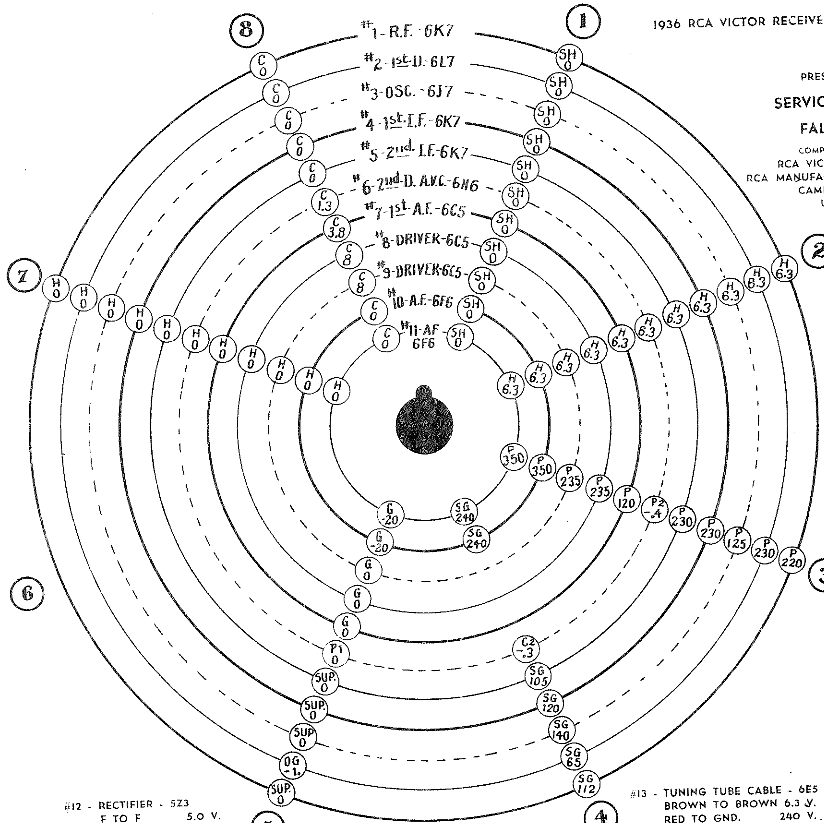
1936 RCA VICTOR RECEIVERS: MODELS C 13-2 AND C 15-3.

PRESENTED AT

SERVICE MEETING

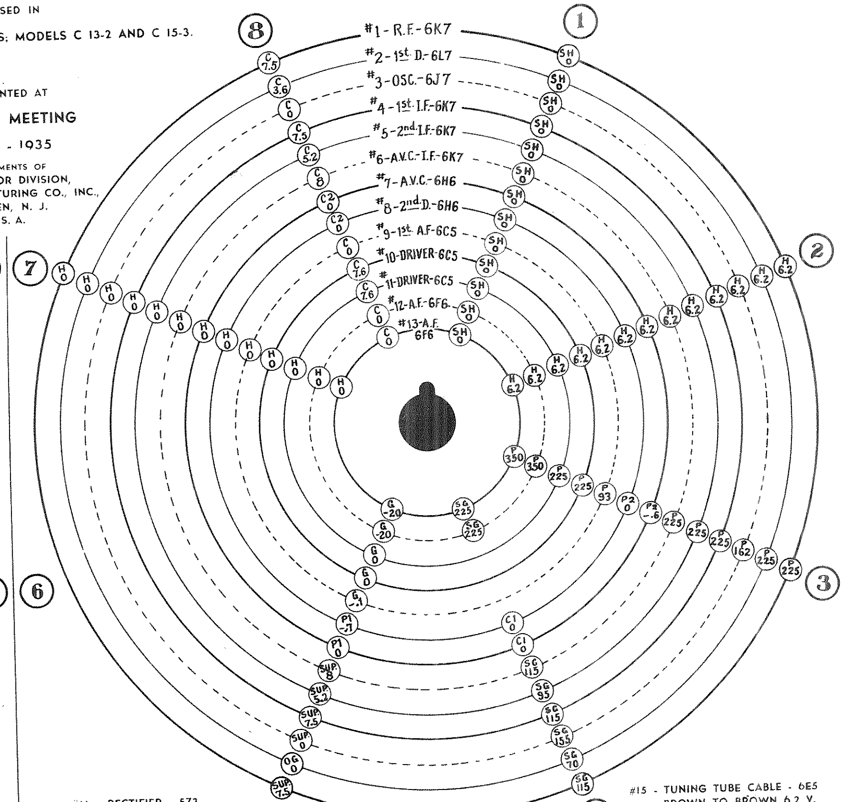
FALL - 1935

COMPLIMENTS OF
RCA VICTOR DIVISION,
RCA MANUFACTURING CO., INC.,
CAMDEN, N. J.
U. S. A.



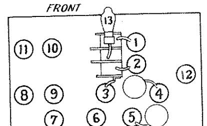
#12 - RECTIFIER - 5Z3
F TO F 5.0 V.
F TO GND. 360 V.
P TO GND. 360 V.

#13 - TUNING TUBE CABLE - 6E5
BROWN TO BROWN 6.3 V.
RED TO GND. 240 V.
GREEN TO GND. 0 V.



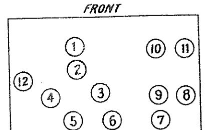
#14 - RECTIFIER - 5Z3
F TO F 4.9 V.
F TO GND. 355 V.
P TO GND. 360 V.

#15 - TUNING TUBE CABLE - 6E5
BROWN TO BROWN 6.2 V.
RED TO GND. 225 V.
GREEN TO GND. 0 V.

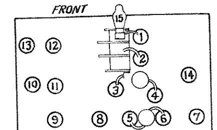


TOP VIEW OF CHASSIS

MODEL C 13-2

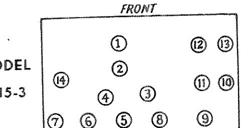


BOTTOM VIEW OF CHASSIS



TOP VIEW OF CHASSIS

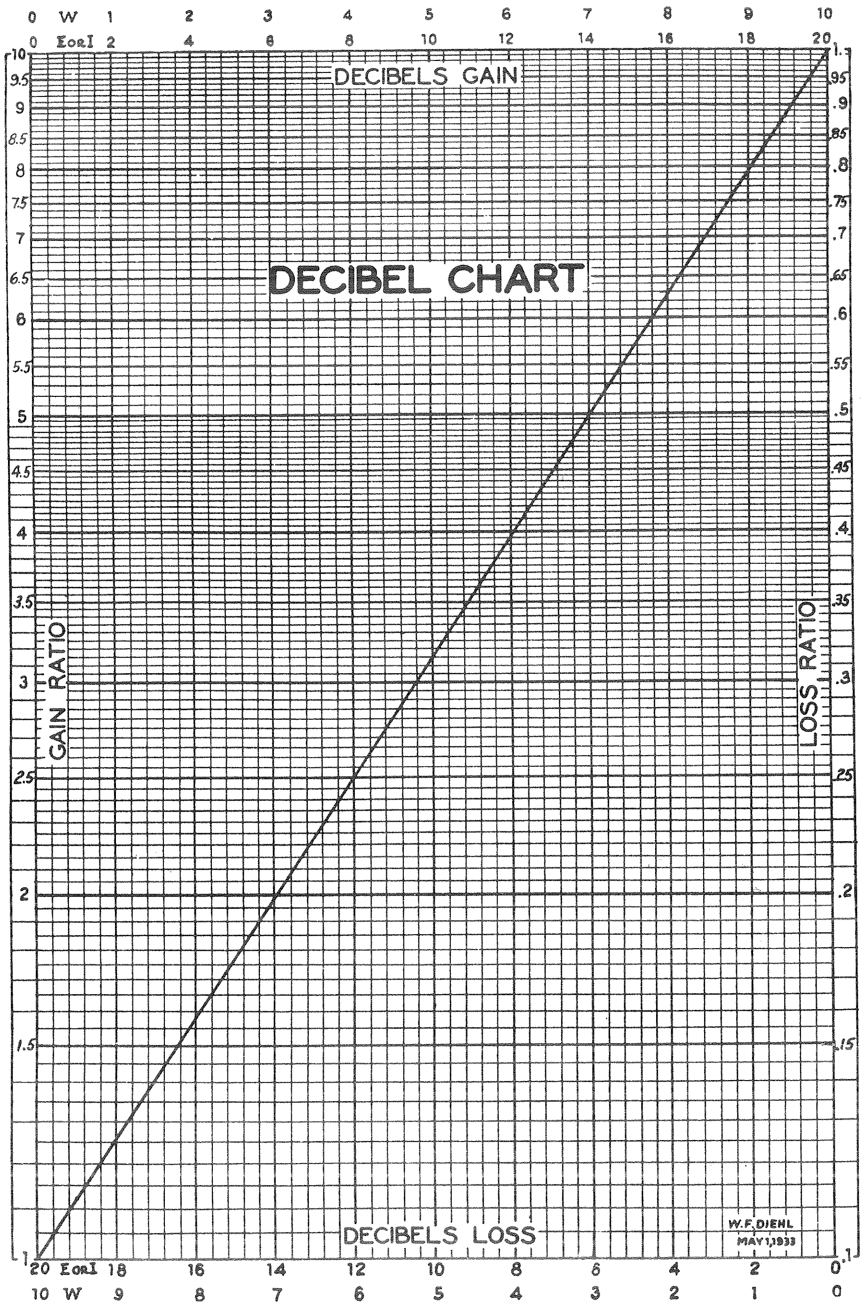
MODEL C 15-3



BOTTOM VIEW OF CHASSIS

INSTRUCTIONS: Each bull's-eye represents the under-chassis socket terminals for the receiver models indicated. Each large circle represents the particular socket-pin layout for which it is labeled. The small outer circles indicate the pin numbers. The upper and lower designations in each small circle, on the large circles, indicate respectively; PIN CONNECTION and PIN VOLTAGE TO GROUND. All heater voltages and plate-to-ground rectifier voltages are a-c; all other voltages are d-c. At the lower left are voltages for the rectifier tube; at the lower right, voltages for the tuning-tube cable.

PROCEDURE: Place chassis with bottom up, speaker connected, all tubes in place, range switch on Band "A", dial setting at low-frequency end of Band "A", NO station tuned in, volume control setting optional. Select socket by referring to "under chassis view". Locate Pin #1, which is the first pin clockwise from the aligning lug; then continue in a clockwise direction for the remaining pins, comparing voltage readings obtained with those on the chart. All readings are positive with respect to chassis (ground) unless indicated by a negative (-) sign. All d-c readings taken with a 1000 ohms-per-volt voltmeter. Screen voltages measured on 250 volt range. Power supply - 115 volts, 60 cycles.



The Decibel

The decibel (db) 1/10 of the "bel" is a logarithmic unit which may be properly used to express power ratios and power levels only. It is the exact equivalent of the term "Transmission Unit" (TU) which is now obsolete, and is most useful for expressing the relation of the power output to the power input of devices in a communication system, since the overall power gain of the system may be readily obtained by adding algebraically the db gain of the individual devices comprising the entire network or system. When the power output is greater than the power input, the device acts as a repeater or amplifier and there results a transmission gain. When the power output is less than the power input, the device acts as an attenuator and there results a transmission loss.

The number of decibels (N db) by which two amounts of power differ may be expressed as follows:

$N\,db = 10 \log_{10} \frac{P_0}{P_i}$ where P_0 = power output and P_i = power input. If voltage instead of power is used, then

$$N\,db = 20 \log_{10} \frac{E_0}{E_i} + 10 \log_{10} \frac{Z_i}{Z_0} + 10 \log_{10} \frac{\cos_0 \theta}{\cos_i \theta}$$

For current instead of voltage

$$N\,db = 20 \log_{10} \frac{I_0}{I_i} + 10 \log_{10} \frac{Z_0}{Z_i} + 10 \log_{10} \frac{\cos_0 \theta}{\cos_i \theta}$$

Where I_0, E_0, Z_0, $\cos_0 \theta$ = the output, current, voltage, impedance and power factor respectively and I_i, E_i, Z_i, $\cos_i \theta$ = the input current, voltage, impedance, and power factor respectively.

In order to save considerable time in solving the equations the chart shown herewith has been prepared.

Instructions for Using the Decibel Chart

Assume the power output of a device is twice the power input. The power output being greater than the power input, the quantity 2 is located on the left of the chart, on the "Gain Ratio" Scale. Where the horizontal 2 line joins the diagonal line, the gain in dbs is located at the top of the chart opposite the column marked "W." In this example the gain is found to be 3 db. If the ratio were 20 instead of 2, then 10 db would be added, making a total of 13 db. If the power output were less than the input, the ratio would be found on the scale marked "Loss Ratio" and the number of dbs (negative) would be located at the bottom of the chart as indicated on the "DECIBELS LOSS" scale opposite the column marked "W." For example, a loss ratio of 0.50 corresponds to a loss of 3 dbs. A loss ratio of .050 would correspond to a loss of 13 dbs.

When voltage or current is used instead of power, the chart is used in a similar manner with the exception that the scales marked "E or I" are used instead of the scale "W." In this case, when the gain or loss ratio is outside the range of the chart, it is necessary to add 20 db for each power of 10 for power gains, and add minus 20 db for each negative power of 10 for power loss. In using the final complete formula, the number of decibels should first be determined for the voltage or current ratio, then the correction for the impedance mismatch determined from the chart by assuming the impedance ratio to be a power ratio. If a correction is still required for power factor, this can also be obtained from the chart by assuming the power factor ratio to be a power ratio.

NOTE: As the ear is a non-linear device the minimum change in intensity perceptible by the average human ear is not a constant, three (3) db as is generally stated, but varies from one-half (.50) db to eight (8) db depending on the intensity, the frequency and the waveform of the sound. I Ithe sound is very loud, eighty (80) db above threshold, then the ear is approximately uniformly sensitive to a change in intensity as small as one-half (.50) db over the entire frequency range of 30 cycles to 10,000 cycles. However, if the sound is of very low intensity, five (5) db above threshold, then the ear is only sensitive to a minimum change of eight (8) db at low frequencies, three (3) db at medium frequencies and eight (8) db at high frequencies.

CHART OF FREQUENCY OR IMPEDANCE
VS.
INDUCTANCE AND CAPACITY

The Chart shown below provides a quick method of determining several unknown factors when one or more are known. The Chart covers a very wide range, namely, from 10 micro-henries to 100 henries inductance, 10 cycles to 50.000 kilocycles, .1 ohm to 10 megohms and 1 micro-microfarad to 10 microfarads. If, for example, one wishes to know the capacitance to use with a 10 henry inductor to have it resonate at 50 cycles, it can be readily seen that it would be a 1 mfd. capacitor. This is determined by finding the intersection of the vertical line representing 10 henries and the oblique line representing 50 cycles. The intersection occurs at the horizontal line representing 1 mfd. The other oblique line at this intersection represents the impedance at this frequency. This is approximately 3000 ohms.