DIVERSITY COMMUNICATION RECEIVER

TYPE DR-89

INSTRUCTIONS

Manufactured by
RCA VICTOR DIVISION
of
RADIO CORPORATION OF AMERICA
Camden, New Jersey, U. S. A.

IB-25955-1

ADDENDA

JUNE 1944

MODEL DR-89
For IB-25955-1

INSTALLATION INSTRUCTIONS

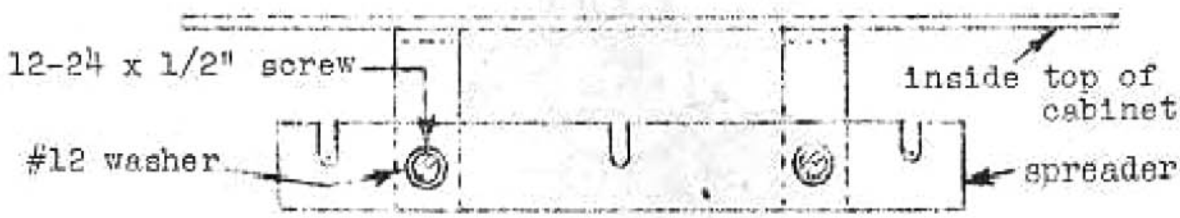
Antenna Panel

Assemble Antenna Panel in space at top front of cabinet with six #12-24 screws supplied, using holes in rack and brackets.

Power Distribution Box

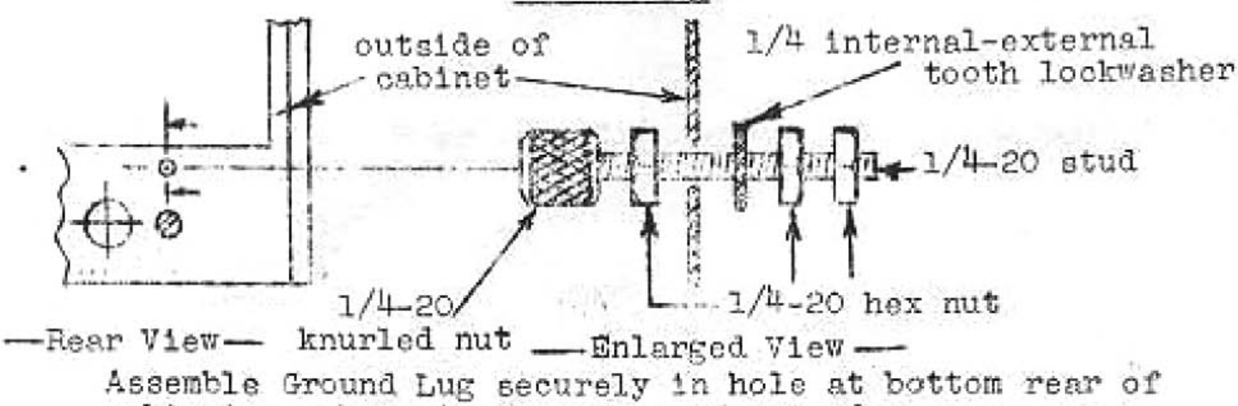
Assemble Power Distribution Box inside lower rear flange of Cabinet with three #6-32 x 1/2 lg. screws supplied, using drilled holes in rear of Cabinet

Spreader Panel



Assemble Spreader to brackets inside top rear of cabinet with two #12-24 x 1/2 lg. screws and two #12 washers supplied, using tapped holes in brackets.

Ground Lug



Assemble Ground Lug securely in hole at bottom rear of cabinet as shown to provide good ground.

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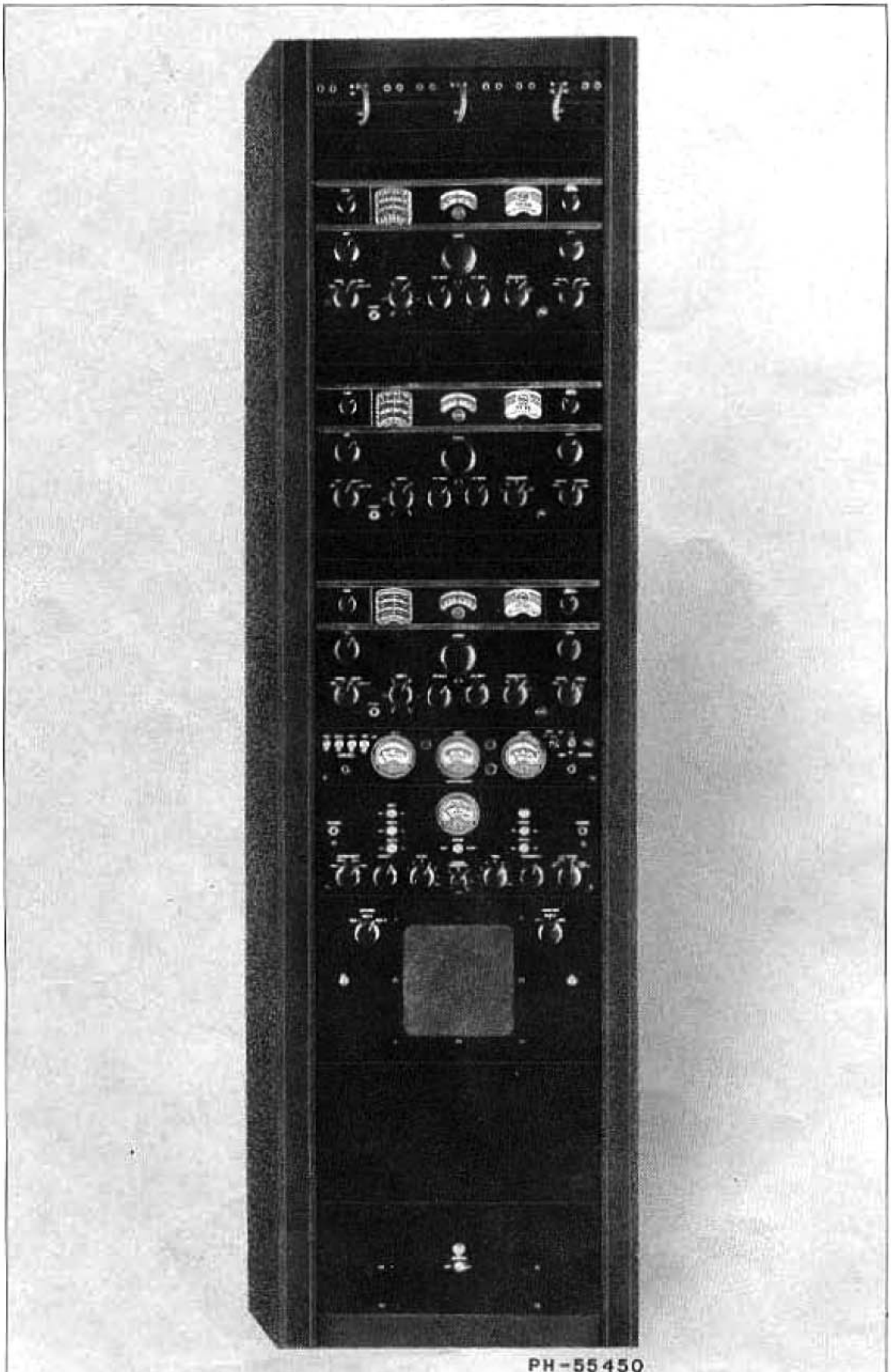

Frontispiece—The DR-89 Diversity Receiver

SECTION I

TECHNICAL SUMMARY

Electrical Characteristics

Frequency Range—Total 6 Bands	535 to 32,000 kc.
Band 1	535 to 1,600 kc.
Band 2	1,570 to 4,550 kc.
Band 3	4,450 to 12,150 kc.
Band 4	11,900 to 16,600 kc.
Band 5	16,100 to 22,700 kc.
Band 6	22,000 to 32,000 kc.
Maximum Undistorted Output (Tone Keyer and Combining Unit)	12 milliwatts
Maximum Undistorted Output (Receiver Amplifier)	2.5 watts approximately
Output Impedance—Tone Keyer	600 ohms
Output Impedance—Receiver	2.5 ohms and 600 ohms
Power Supply Rating	100-117, 117-135, 135-165, 190-230, 200-260 volts, 50/60 cycles a-c
Power Requirement	450 watts

Mechanical Specifications

Overall Dimensions	Approximately 22" wide x 84" high x 21" deep
Total Weight	Approximately 650 lbs.

Tube Complement

a. Each Component Receiver Unit

R-F and I-F Amplifiers	5 RCA 6SG7
1st Detector (converter)	1 RCA 6SA7
Oscillator	1 RCA 6J5
2nd Detector	1 RCA 6H6
Noise Limiter	1 RCA 6H6
A-F Amplifier	1 RCA 6SJ7
Power Amplifier	1 RCA 6K6-GT
Beat Frequency Oscillator	1 RCA 6J5
Rectifier	1 RCA 5Y3-GT/G
Voltage Regulator	1 RCA VR150-30

b. Tone Keyer Unit

D-C Amplifier Limiter	1 RCA 6SL7-GT
D-C Amplifier Limiter and Line Amplifier	1 RCA 6SN7-GT
Keyed Amplifier	1 RCA 6SL7-GT
Oscillator	1 RCA 6SL7-GT
Phone Noise Limiter	1 RCA 6H6
Power Rectifier	1 RCA 5Y3-GT/G
Voltage Regulator	1 RCA VR150-30
Voltage Regulator	1 RCA VR75-30

c. Monitoring Unit

I-F Amplifiers	2 RCA 6SG7
A.V.C.	1 RCA 6H6
A-F Ampifier	1 RCA 6SJ7
Detector and Beat Frequency Oscillator	1 RCA 6SN7-GT

d. Monitoring Unit Power Supply

Power Rectifier	1 RCA 5Y3-GT/G
Voltage Regulator	1 RCA VR150-30

SECTION II

INTRODUCTION

The DR-89 Diversity Receiver is designed for reception of either continuous wave or modulated carrier signals with frequencies between 535 and 32,000 kilocycles. Three complete radio receivers together with a Tone Keyer, Monitoring Unit, Monitor Power Supply, and a Loudspeaker Assembly are mounted on a single rack. The Tone Keyer electronically selects the strongest output signal of the three individual receiver units and suppresses the output of the other two. Output of the complete Diversity Receiver may be taken from the Tone Keyer or from any one of the three component radio receivers, all of which are terminated with suitable impedances to match either a transmission line, loudspeaker or headphones. Voltage tap switches are provided to permit operation of all units of the receiver with power supplies in the two ranges of 100 to 165 and 190 to 260 volts 50/60 cycle alternating current. For operation of the complete receiver 450 watts are required.

Theory of Diversity Reception

The term "fading" as used in this instruction book is employed to denote variations in signal strength over periods of from several minutes duration to variations of only a fraction of a second. It is not to be construed as referring to the slow hour to hour, day to night, day to day or seasonal variations in signal strength.

It is generally agreed that signal fading is caused by the fact that radio waves propagated from a transmitter may travel over two or more paths between transmitting and receiving antennas. Differences in the physical length of these paths cause the several signals arriving at a receiving antenna to have varied phase relationships. This variation in phase will result in either complete or partial addition or cancellation of signal potential.

The exact length of the distance traveled by the signal is principally controlled by three major factors. These are:

1. Distance between transmitting and receiving antennas.
2. Frequency of the transmitted signal.
3. The instantaneous height of the Kennelly-Heaviside layers above the earth's surface.

The first two of the factors are constant, but continuously changing ionospheric conditions make the third a variable.

Referring to Figure 1, the distance covered by the radio waves traveling over the two paths between the transmitter and receiver may be considered as equal to n wavelengths of the transmitted frequency. Assuming n to be equal to a whole number, the distance traveled over path "A" would then equal $n\lambda$. Considering this path only, if n were increased to $n + 1$, a constant signal would go through a complete cycle of phase shift with respect to a fixed receiving antenna.

If two or more signals are received from a single transmitter as in Figure 1, and the distances that they travel are equal to $n\lambda$ and $(n + x)\lambda$,

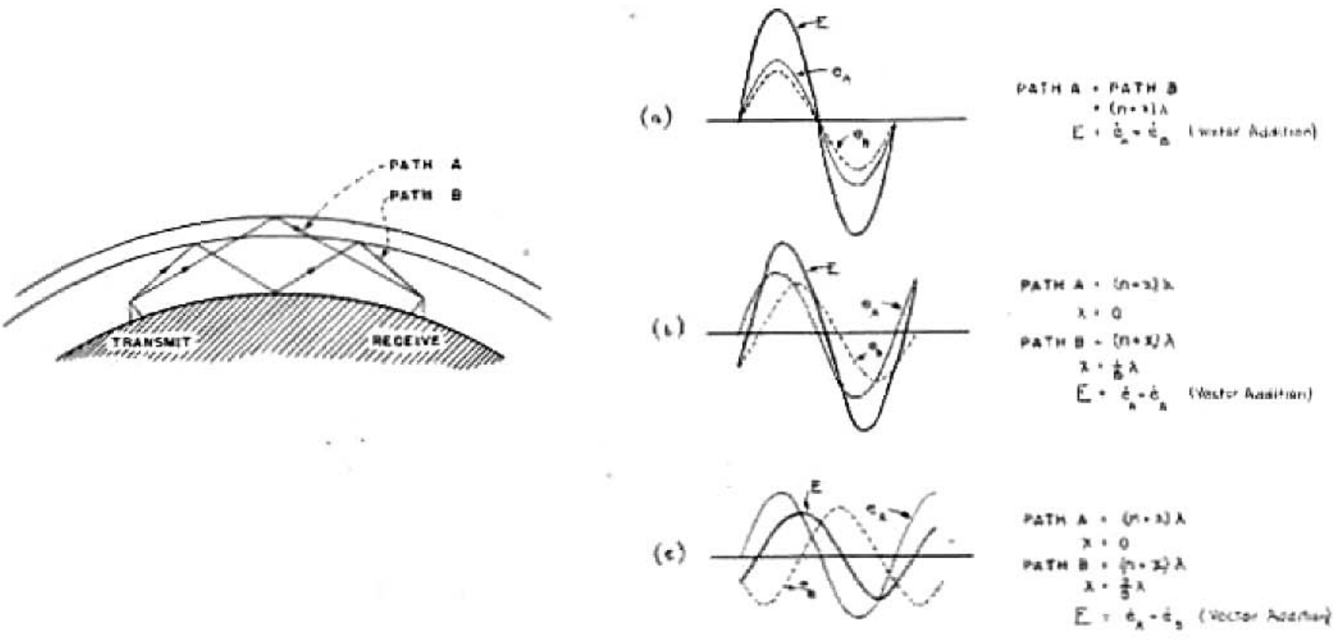

Figure 1—Reflected Waves

they will induce a total voltage E in the receiving antenna equal to $\dot{e}_A + \dot{e}_B$. See Figure 1a. As the value of x approaches $\frac{1}{2}$ (which will cause a 180° phase variation), the sum of the two voltages will approach zero. Differences in distance will cause unequal attenuation, therefore, the two signals will not be equal in value and will not suffer complete cancellation. It is obvious that through the range limited by n and $n + 1$, values between n and $n + \frac{1}{4}$ and also those between $n + \frac{3}{4}$ and $n + 1$ will produce a total voltage E which will be greater than either e_A or e_B (see Figure 1b). Likewise, values between $n + \frac{1}{4}$ and $n + \frac{3}{4}$ will produce a total voltage E that will be less than either e_A or e_B (see Figure 1c).

The space diversity system of reception eliminates the possibility of cancellation by locating an antenna in such a position that the distance covered by signals cannot equal null points regardless of the value of $(n + x)\lambda$. This is done by erecting three antennas at the vertices of an equilateral triangle with each side of the triangle equal in length to several wavelengths. Signals may originate from any direction in a complete circle around the center point of such a triangle. The signal from each antenna is fed to a separate radio receiver and the rectified outputs are applied to a common load. This automatically selects the strongest of the three signals and suppresses the other two. Thus, the output will have the best signal to noise ratio for any combination of operating conditions. It is important to note that the final output of the Diversity Receiver is derived from the voltage induced on one antenna only. The outputs of the individual component receivers which are derived from the several antennas are not combined.

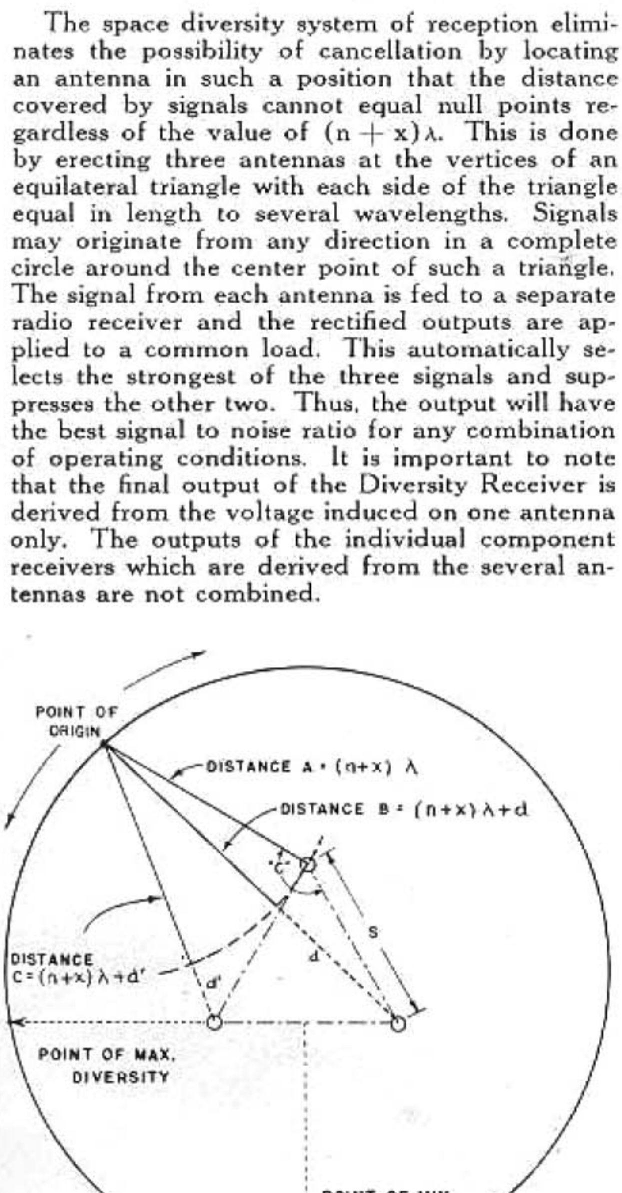

Figure 2—Diversity Reception

Referring to Figure 2, as the point of origin is rotated, it is noted that if distance A is equal to $(n + x)\lambda$, then distance b will be equal to $(n + x)\lambda + d$ and distance c will be equal to $(n + x)\lambda + d^1$.

As the antennas form an equilateral triangle,
Distance $A = (n + x)\lambda$
Distance $B = \sqrt{S^2 + [(n + x)\lambda]^2 - 2S\,(n + x)\lambda\,\cos C}$
where S = spacing between antennas
and $(n + x)\lambda$ = distance between transmitter and antenna A.

Extension d which is equal to Distance B – Distance A will then be a function of S. Distance C, which may be calculated from the same formula will then become a secondary function of the prime function S. Therefore, for any value of n or S, distance A can never equal **both** Distance B and Distance C, and the signal paths to each antenna **must** vary in phase relationship.

Maximum diversity will be obtained when the point of origin of the transmitted signal is in the same plane as any two of the antennas. Minimum diversity will be when the point of origin is at right angles with one of these planes as d will then be equal to d^1 and only two points will bear varied phase relationship.

For optimum performance on the usual communication channels, a spacing of approximately 1,000 feet between antennas is recommended. If, however, this amount of area is not available, excellent diversity action can be obtained at smaller separations.

Spacing the antennas less than this distance would result in greater probability of fading in transmission at lower frequencies due to the lesser diversity. Spacings greater than this distance would entail attenuation in the transmission lines that would negate the possible benefits. For maximum signal strength, the individual antennas in the array should be directed with respect to the transmitter azimuth.

Diversity Communication Receiver Type DR-89

The Block Diagram, Figure 3, illustrates the functions of the several components of the Diversity Communication Receiver Type DR-89. A signal is received simultaneously on the three antenna and radio receiver units. The Monitoring Unit, which is connected to the I-F sections of all three receivers, may be used at any time during operation. Depending on the setting of the control switches on the Tone Keyer Unit, the signal may be taken from the diode rectifier of the receivers and presented to the common load in the Tone Keyer or returned to the audio amplifying section of the originating receiver. When a signal is returned to the originating receiver, the receiver functions as a single unit. When one or more signals are fed to the common load the strongest is selected and is amplified in the Tone Keyer circuits. The output of the Tone Keyer may be either taken directly through the 600-ohm output termnial or may be further amplified by the audio amplifying sections of any one of the component receivers in operation. Selection is made by means of the Speaker switch on the Loudspeaker Assembly.

The operation and functioning of each of the components of the complete unit will be discussed separately in later sections of this instruction book.

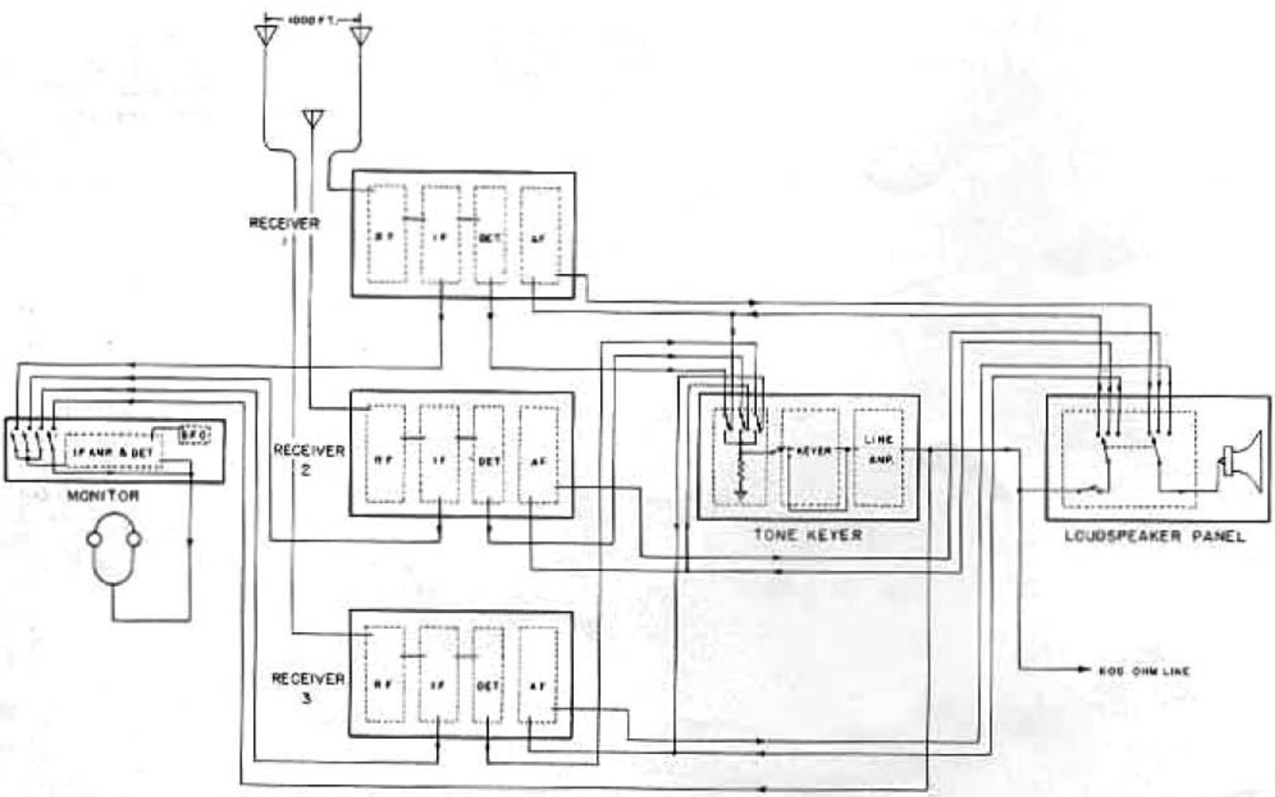

Figure 3—DR-89 Functional Block Diagram

SECTION III

EQUIPMENT

The equipment supplied is mounted on a completely enclosed rack and consists of the components listed in Table I.

TABLE I—COMPONENT PARTS

Quantity	Description	Approx. Weight per Unit	Type Designation
3	Diversity Radio Receivers	98 lbs.	MI-17104
1	Tone Keyer Unit TK43	26 lbs.	MI-17106
1	Monitoring Unit	11 lbs.	MI-17144
1	Monitoring Unit Power Supply	18 lbs.	MI-17157
1	Speaker Unit and Panel Assembly	12 lbs.	MI-17143
1	Cabinet Rack and Panels Assembly*	275 lbs.	MI-17105
1	Set of Interconnecting Cables		MI-17142
1	Instruction Book		I.B. 25955-1

* Includes Antenna Connecting Panel.

All components are shipped complete with the required tubes. Additional equipment that will be required for operation includes a complete diversity antenna system, a separately fused a-c power supply, and a set of high impedance headphones. Headphones MI-5803-6 are recommended.

A complete set of spare parts is available as MI-17819. Vacuum tubes are not included in the spare parts group.

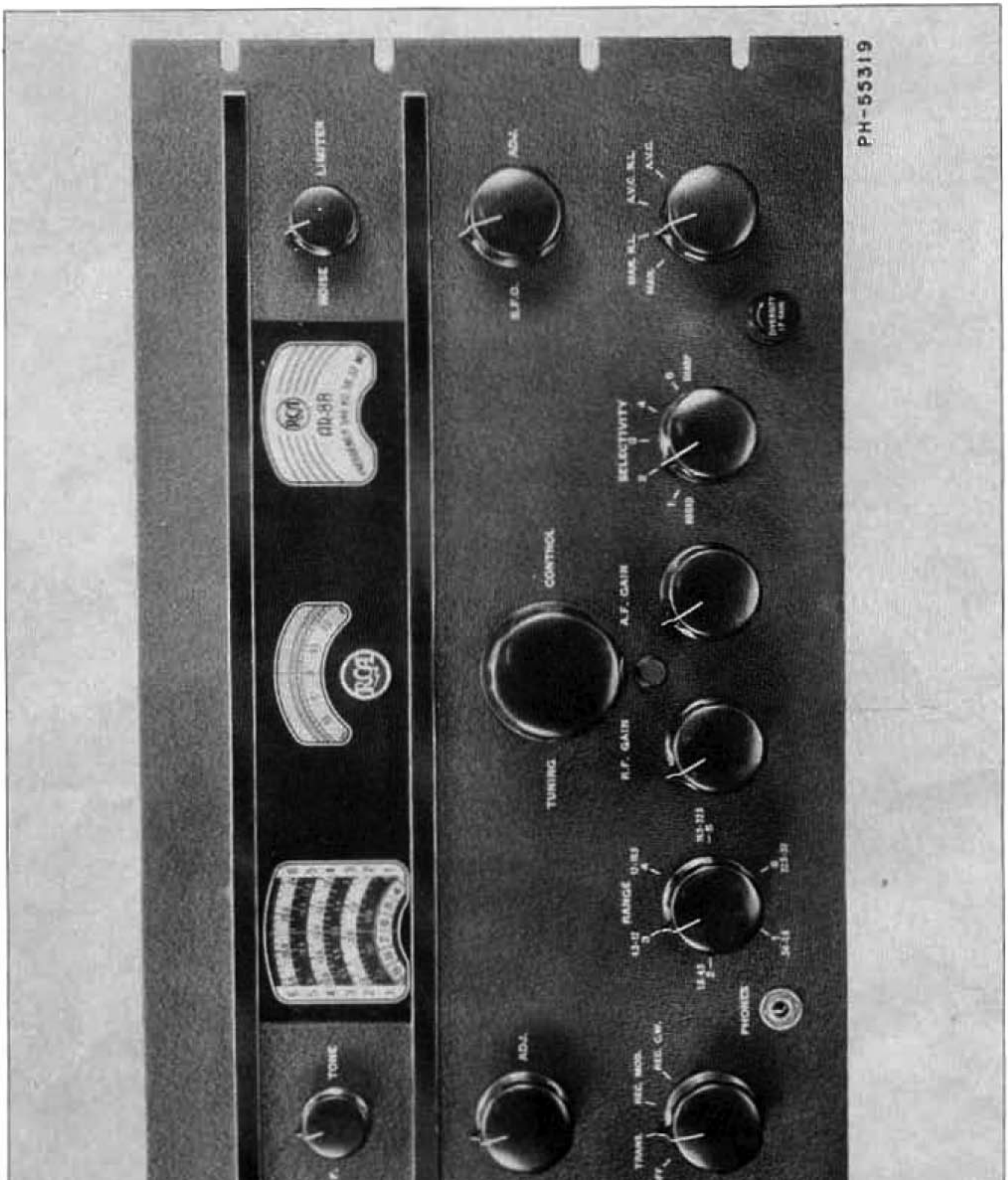

Figure 4—Component Radio Receiver—Front Panel

SECTION IV

COMPONENT RECEIVERS

a. **Introduction.**

The three component receivers used in each DR-89 Diversity Communication Receiver are complete, self-contained units and are capable of high quality reception when used individually. In the design of the unit, great care has been taken in order to secure high standards of sensitivity, selectivity, stability and reliability.

The sensitivity of this receiver is limited only by the tube noise originating in the first tube and its associated circuits. A large part of this noise is due to "shot" effect in the first amplifier tube and thermal agitation in the first tuned circuit. A signal to be intelligible must produce a voltage on the grid of an order of magnitude, the same as or greater than these inherent noise voltages. An efficient coupling system between the antenna and the first r-f tube of the receiver is of great importance. This has been the subject of considerable development, and the system used on this receiver gives optimum coupling with antenna or transmission line impedances of 200 ohms, over the entire frequency range of the receiver, except on the broadcast band. This band utilizes a low frequency primary which resonates at a frequency well below the band when connected to a 200 mmf. antenna.

Selectivity in a radio receiver is necessarily a compromise with fidelity of the reproduced signal. The unit is designed to have five degrees of selectivity, three of which include a crystal filter. To insure good frequency stability, rugged construction of parts and wiring in the high frequency oscillator circuit have been included in the design. These factors together with electronic voltage stabilization of the oscillator plate supply, temperature compensation, and proper oscillator excitation, provide a high degree of stability.

b. **The Unit as an Individual Receiver.**

The receiver covers short wave, standard broadcast, and CW service; its principal use is for short wave communications. It is designed to withstand severe climatic and line voltage variations without appreciable impairment of performance. Its features include:

Mechanical Band Spread with Single Control for ease of tuning a previously logged station.

Automatic Noise Limiter which automatically limits interference to a percentage of modulation determined by the setting of a NOISE LIMITER Control.

Continuously variable Tone Control.

Antenna trimmer for circuit alignment.

Crystal filter for ultra-sharp selectivity when required.

Exceptionally good oscillator stability through normal variations in line voltage.

Two Tuned R-F Stages ahead of the 1st Detector insure high image ratio on all bands.

Twelve Tuned I-F Circuits giving a very high degree of selectivity.

Temperature compensated oscillator circuits on all bands.

Ceramic Insulation throughout on gang condenser, sockets, range switch, and selectivity switch.

Tuning Dial Lock to prevent accidental detuning.

c. **Circuit Description.**

The circuit is shown schematically in Figure 19. It consists of two stages of r-f amplification, first detector, first heterodyne oscillator; three stages of i-f amplification, second detector, noise limiter, second heterodyne oscillator, a-f amplifier stage, output power stage, and power supply system.

INPUT COUPLING—The antenna coupling system is designed to provide optimum coupling from a 200-ohm transmission line, except in the broadcast band. The first tuned circuit is provided with a trimmer condenser which is adjustable from the front panel. This insures a proper antenna circuit alignment for most antenna impedances.

For the standard broadcast band, conventional antenna and ground connections should be used.

The antenna terminal board on the rear of the chassis is provided with three terminals (see Figure 19), two of which may be joined together with a link. When a single wire antenna is used, the link should be closed and the antenna connected to "A." If a ground is used, connection should be made to "G." If a transmission line or balanced input is used, the "link" should be opened and the line connected to terminal "A" and the center terminal.

R-F AMPLIFIER—The R-F Amplifier is designed to provide ample selectivity ahead of the first detector for minimizing cross modulation and the blocking effect of strong interfering signals and for obtaining a high degree of image signal suppression. The amplification is adjusted to provide optimum signal-to-noise ratio by making noise contributions of circuits following the first tube negligible in comparison with the noise contributed by the first r-f grid circuit. Each tuned circuit in a receiver contributes some noise voltage, but by making the gain of the first tube high, noise contributed by succeeding circuits is unimportant.

BAND SPREAD—The mechanical spread with single control knob enables the operator to quickly tune a previously logged station. The log scale on the main dial and the separate vernier dial provide for exact logging and tuning.

FIRST HETERODYNE OSCILLATOR — The first heterodyne oscillator is aligned to track with the R-F Amplifier at 455 kc. higher than the signal frequency, thus producing a 455 kc. intermediate frequency in the first detector plate circuit which is amplified further in the i-f stages. The oscillator anode voltage is controlled by an RCA VR150-30 regulator tube to provide maximum frequency stability under conditions of variations in power supply voltage.

INTERMEDIATE FREQUENCY CRYSTAL FILTER—The first detector plate circuit is tuned to the intermediate frequency and a balanced link circuit is used to couple the first detector plate and first i-f grid circuits. A 455 kc. crystal is connected in one arm of the link circuit and a neutralizing capacitor is connected in the other. The impedances of the coils in the link circuit are designed so that the crystal selectivity characteristic is not impractically sharp. The band width at two times resonant input may be adjusted to 400 cycles, 1,500 cycles, or 3,000 cycles. For this adjustment see "Operation."

INTERMEDIATE FREQUENCY AMPLIFIER—Three stages of i-f amplification are used; RCA-6SG7 tubes are used in all stages and an RCA-6H6 tube is used for A.V.C. and second detector. The first i-f transformer has a tuned primary and secondary and is coupled through the crystal filter link. The second and third i-f transformers are composed of four tuned circuits each. These circuits are varied in coupling by the selectivity switch. The fourth i-f transformer has two tuned circuits.

The third i-f stage is not connected to the A.V.C. nor to the manual volume control so that a good A.V.C. characteristic with little overload distortion is obtained. This also permits the CW oscillator to be coupled to the grid circuit of this stage, giving a comparatively high detector excitation voltage with small electrical coupling to the oscillator circuit.

SECOND HETERODYNE OSCILLATOR—The second heterodyne (CW) oscillator is a triode RCA-6J5 tube, which is electrostatically coupled to the final i-f stage. A panel control is provided to permit variation of the frequency of the heterodyne oscillator and resultant audio beat note. Particular care has been taken in the design of the circuit constants to minimize oscillator harmonics.

AUTOMATIC VOLUME CONTROL—A.V.C. voltage is obtained from the second detector, an RCA-6H6 tube. A variable delay is obtained depending on the setting of the r-f gain control. The second heterodyne (CW) oscillator excitation voltage is maintained at a slightly lower value than the A.V.C. diode bias voltage so that it will not decrease the sensitivity of the receiver.

MANUAL VOLUME CONTROLS—Three manual volume controls are provided; an audio gain control which is employed when the A.V.C. is in use to obtain the desired output level, an i-f gain control which is used only when the receiver is operated in diversity, and an r-f gain control.

NOISE LIMITER—The noise limiter circuit utilizes an RCA-6H6 tube and limits the noise interference to 100% modulation and to continuously lower percentages down to any modulation whatsoever, determined by the setting of the NOISE LIMITER control.

A NOISE LIMITER switch in conjunction with A.V.C. provides for use of the noise limiter on CW or on modulated reception when interference is present.

OUTPUT TUBE—The RCA 6K6GT output tube is resistance coupled from the a-f amplifier, an RCA 6SJ7 tube, and operates into an output transformer which has taps for matching a 2.5 or 600-ohm load, or headphones. The headphones winding is designed so that a maximum of approximately 10 milliwatts of power may be delivered to 20,000-ohm phones. Terminals are provided on the rear apron for the 2.5 and 600-ohm impedances. The output from the 600-ohm winding is fed directly to the 600-ohm terminals, neither of which is grounded and may be used to feed a balanced 600-ohm line. The output from the 2.5-ohm tap is fed to the 2.5-ohm terminals through a two-position jack mounted on the panel. With the phone plug inserted into the jack in the first position, the phones are in parallel with the 2.5-ohm output and both are on. When the plug is pushed into the second position, the phones are connected to the phone winding and the 2.5-ohm output is cut off from the rear terminals. If no load is connected to the 2.5- or 600-ohm output terminals headphones should always be used in the second position; as under this condition a load resistor is shunted across the 2.5-ohm tap to maintain impedance matching of the system.

POWER PACK—The power pack mounted on the receiver chassis consists of a power transformer, rectifier tube RCA-5Y3GT, and filter. A tap switch is provided on the rear apron for changing the power transformer voltage tap. (See Figures 14 and 19.) The voltage for which the switch is set may be read directly on the switch.

SHIELDING—Interstage shielding is provided to insure stability under all operating conditions and to minimize oscillator radiation. Complete external shielding prevents coupling to any portion of the circuit except through the antenna circuit.

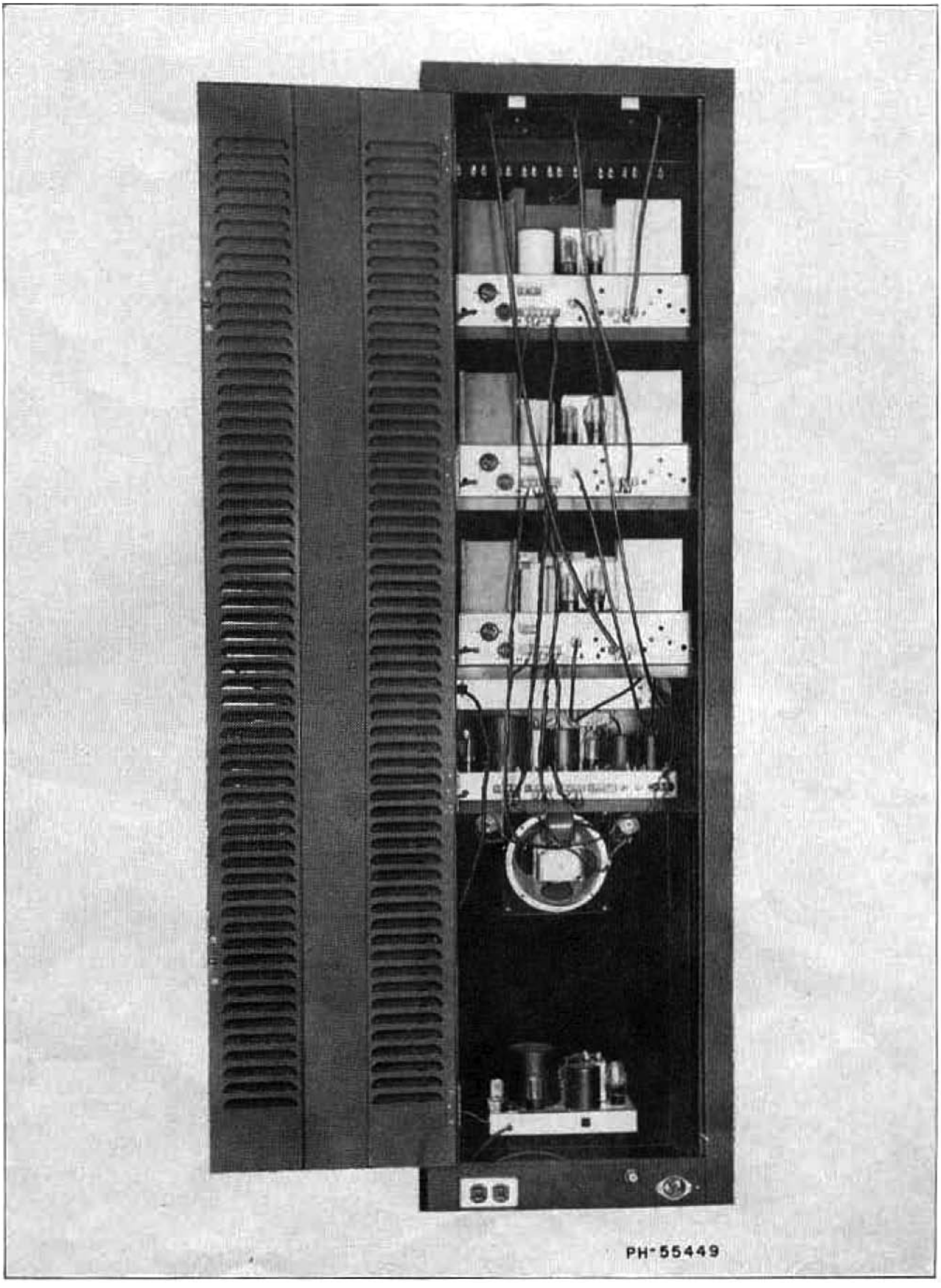

Figure 11—*DR-89 Diversity Receiver—Rear View*

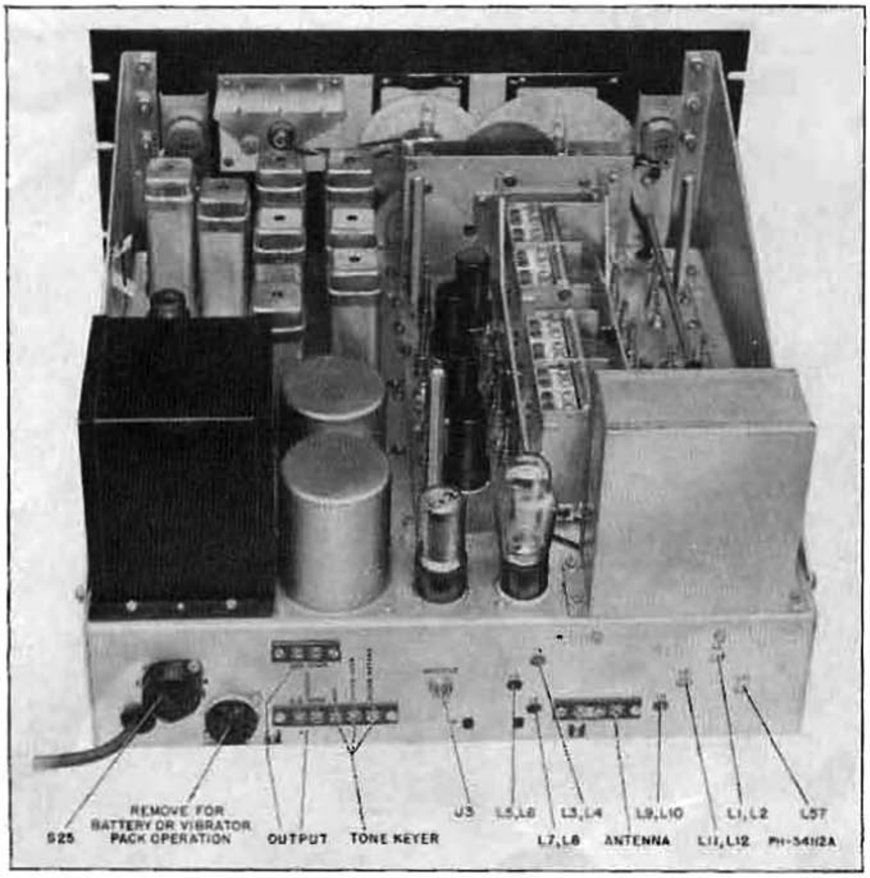

Figure 14—Component Receiver—Chassis Rear View

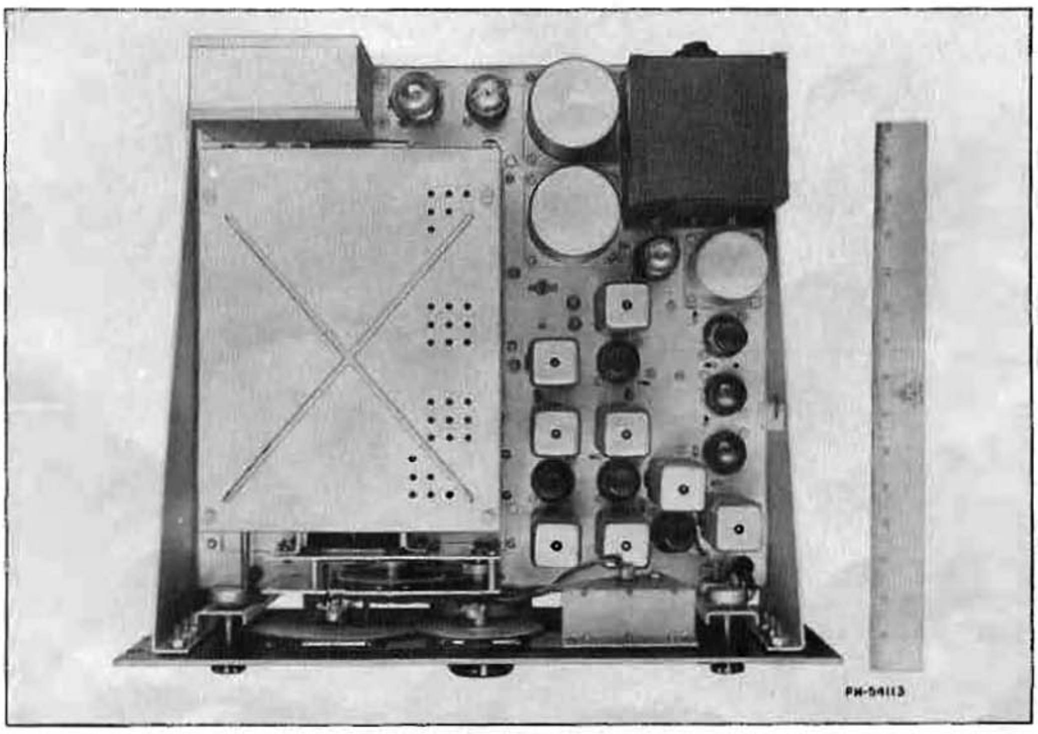

Figure 15—Component Receiver—Chassis Top View