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NAVY DEPARTMENT

BUREAU OF ENGINEERING

REPORT ON

TEST OF RCA VICTOR GENERAL PURPOSE RECEIVER

(RCA Victor Drawing S813295,

Range 1380 - 29500 KC)

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON,D.C.

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Date of Test: Tests conducted from 13 October 1933 to 20 November 1933.

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AUTHORIZATION:

1. The test of this equipment was authorized in Bureau of Engineering letter S67/46(9-16-W8) of 19 September 1933 under Problem R5-7.

PURPOSE OF TESTS:

2. The examination and test of RCA Victor general purpose receiver, (RCA Victor drawing E213895), to determine its performance and chararacteristics. The Bureau of Engineering designated, in reference (a), that this receiver be subjected to tests similar to those to which the DeForest Model RRH-11 receiver was subjected as reported by reference (b).

REFERENCES:

3. (a) BuEng letter S67/46(9-16-W8) of 19 September 1933.

(b) Naval Research Laboratory Report RE 271 dated 27 July 1933.

EQUIPMENT UNDER TEST:

4. Subject receiver, manufactured by the RCA Victor Company, Inc., Camden, New Jersey, is of the double detection, or superheterodyne type, having an autodyne circuit with oscillating first detector, and a combination second detector, i-f oscillator and automatic volume control, for which purpose a duplex-diode pentode is used. The receiver employs a total of six tubes, and is battery operated. The frequency range is 1380 to 29,500 kilocycles, which is covered in six bands by the use of a tap switch, which changes the taps on the secondary tuning inductance in the R.F. and first detector stages. The R.F. and detector circuits are ganged, and tuning is accomplished with a single dial. Other controls on the panel consist of a frequency vernier which operates in conjunction with the tuning dial; an antenna trimmer to compensate for changes in R.F. tuning due to operation of coupling control; a control to regulate antenna coupling; a switch to change from broad to sharp tuning; a sensitivity control, which, with the A.V.C. control off, regulates the bias on the grids of the tubes in the i-f stages, and with the A.V.C. control on, operates on the audio amplifier to control the output level, an on and off switch which controls that circuit of the combination A.V.C.-detector oscillator tube which functions as an oscillator; an on and off switch for A.V.C.; an on and off switch for power; one phone jack for phone output and one for line output. The front panel measures 8.75" x 20", and the case is 11" deep.

The input circuit consists of an antenna coil electromagnetically coupled to the secondary tuning inductance in the grid circuit of the r-f amplifier through an electrostatic shield. This is a double coil with the two sections in parallel, there being two secondaries, one of which is used with the three lower frequency bands, and the other with the three higher frequency bands, the change over being controlled by the tap switch.

There are three binding posts, two to the ends of the primary coils, and the center one to ground, the center of the coils being grounded when used with a transmission line.

One stage of r-f amplification is followed by an oscillating first detector which autodynes the incoming signal to produce an intermediate frequency of 19 kcs.

The plate circuit of this tube is coupled by means of an auto transformer to the grid of the first i-f tube, there being a band pass filter also in this grid circuit. The first i-f stage is coupled to the second i-f stage also by auto transformer. Then follows the combination detector, oscillator, automatic volume control which is a duplex-diode pentode, type 6B7. The control grid of this tube is tuned to the i-f oscillator frequency, the screen grid serving as the anode, which is inductively coupled back to the grid tuning inductance. This oscillating component is electron coupled to the plate circuit, which plate is conductively coupled to the plate of the last i-f tube, and the beat frequency produced thereby is inductively coupled to the diode circuit which functions as a half wave rectifier. The two diodes are tied together with respect to the A-C component, but the second diode acts independently for the A.V.C. feature, the rectified current being divided between the two diodes. From one diode this current returns to the cathode through the secondary coupling inductance and a load resistor, and from the other through a resistor, the potential drop across which changes the bias on the grids of the two i-f tubes, as the current varies with the received signal.

The potential drop across the load resistor in the first diode circuit is used to energize the grid of the audio amplifier.

In the plate circuit of the single audio stage is an output transformer with a split secondary designed for 'line' and 'phones' load.

With the A.V.C. switch in the 'off' position the volume control resistor operates to regulate the bias on the grids of the i-f tubes. When in the 'on' position the volume control resistor operates as a shunt across the primary of the output transformer to control the output level, at the same time the grids of the i-f tubes assume their normal bias for full gain, the bias being increased as the signal becomes strong enough to increase the IR drop across the resistor in the A.V.C. diode circuit. With the CW switch in the 'off' position, the screen grid circuit of the 6B7 tube is opened thus eliminating the i-f oscillator. When in the 'on' position, the screen grid circuit is closed. When on 'Broad' tuning, the capacitors around the auto transformer and band pass filter inductances between the two i-f stages are disconnected. When on 'sharp' tuning, both inductances are tapped to decrease their value, and the capacitors connected; a resistor also being placed in shunt to the secondary coupling inductance in the diode circuits.

The tubes employed in addition to the type 6B7 above mentioned are one each type 39 pentodes for first r-f and two intermediate stages, one type 36 tetrode for first detector-oscillator and one type 89 pentode for power amplifier. Condenser and grid leak are used in the first detector, and fixed grid bias for the r-f and a-f grids are obtained by the use of resistors in the cathode circuits.

METHOD OF CONDUCTING TESTS:

5. A model LC-1 standard signal generator was used to supply all input test r-f voltages; an audio oscillator, General Radio type 513-B, to supply audio frequency test voltages; an output meter, General Radio type 483-C, resistance 20,000 ohms, to measure outputs, and a General Electric cathode-ray oscillograph type HC-10-A1 to study the operation of the automatic volume control, and its time constant.

For the purpose of these tests, the following definitions are applicable:

Standard output is 5 milliwatts, or 10 volts across 20,000 ohms.

Sensitivity is shown as the microvolts input through 300 ohms resistance for standard output with gain adjustment for a noise level of not over 0.5 volt. With a noise level of 0.5 volt and signal output of 10 volts across 20,000 ohms, the voltage ratio is 20 to 1 while the power ratio is 400 to 1. It is believed that under ordinary operating conditions, a much smaller ratio is tolerated, and any decrease of this ratio increases the sensitivity, since the noise is reduced by reducing the gain.

In a receiver where the sensitivity is of the order of 5 to 10 microvolts, the internal receiver noise does not generally control the output noise level, this being governed by the noise pick-up of the collector system.

Selectivity is shown as the ratio of input for standard output, at percentages of frequency above or below resonant frequency, to input for standard output at resonant frequency.

Primary image frequency is defined as any input frequency other than that for which the signal frequency circuits are resonated, whose fundamental frequency, combined with the fundamental frequency of the first oscillator, will produce the fundamental frequency for which the i-f stages are resonated, no discrimination being made here between the two closely related frequencies producing a-f beats on opposite side of zero beat.

Secondary image frequency is defined as any other frequency which, when combined with the fundamental frequency or harmonics of the first oscillator, will produce a beat frequency to which the i-f system will respond, this resultant being usually a frequency of which the i-f fundamental is a harmonic.

Audio characteristics are shown as the attenuation in decibels above and below a reference level, which is taken as the voltage gain of the audio amplifier at 1000 cycles.

All receiver input voltages are applied through 300 ohms resistance.

Test for interaction between receivers is made with the input terminals of two receivers connected directly to the same antenna.

The following tests were made:

(a) Sensitivity, CW input, Broad and sharp tuning.

(b) Sensitivity, MCW input, Broad and sharp tuning.

(c) Selectivity, MCW, Input, Broad and sharp tuning.

(d) Audio amplifier characteristics.

(e) Resonant overload, A.V.C. off.

(f) Resonant overload, A.V.C. on.

(g) Maximum noise level.

(h) Image response, primary and secondary.

(i) Response of i-f system to frequencies other than the fundamental i-f frequency.

(j) Interaction between receivers.

(k) Study of operation of automatic volume control and its time constant.

RESULT OF TESTS:

6. (a) Sensitivity. Prior to taking sensitivity measurements with CW input, it was found that with the CW oscillator on, but no signal input to receiver, and the volume control reduced to minimum gain the output meter indicated 3 volts, with zero reading when the oscillator was shut off. It was found that the center of each of the two secondary windings in the output transformer is grounded, and that by placing a .01 mfd capacity around one half of the secondary winding for the 'phones' output, the circuit was tuned to the oscillator frequency, and acted as a trap to eliminate the undesired CW output, no attenuation of output being noted as a result of its use.

Sensitivity, with gain adjustment for 0.5 noise, and with both CW input and CW modulated 30% at 1000 cycles input each for broad and sharp tuning, is shown on plates 1 to 4 inclusive.

(b) Selectivity, with CW input modulated 30% at 1000 cycles, taken with the CW oscillator off, and gain adjustment for 0.5 volt noise is shown for both broad and sharp tuning on Plates 5 to 36, inclusive.

It will be noted that each curve shows a peak in addition to the resonance peak, which is that of the image response, removed about 38 kilocycles from resonance, the intermediate frequency being 19 kilocycles. The image response is about equal to the signal response, being produced when the autodyne first detector is tuned on the opposite side of zero beat.

When tuning off resonance on the side toward zero beat, and usually at a point where the input required for standard output is between 100 and 1000 times that required at resonance, the output becomes unstable, with a tendency to block, until the curve begins to approach the point of maximum image response. Due to the response to non-resonant signals over practically all of the band between resonance and maximum image response, the actual selectivity must be considered between the curves away from resonance on the one side and away from maximum image response on the other.

To account for the above mentioned instability with high inputs, and tendency to block when approaching zero beat, it is believed that this is due to secondary image response, the autodyne detector producing beat frequencies of the order of two to nine kilocycles, of which the intermediate frequency is a harmonic, and to which the intermediate system would respond. On plate 6 are shown the various fluctuations that occur as a result of this response.

Selectivity, with a resonant frequency of 1935 KC is shown on a large scale at and near the peak of the curve, for inputs up to ten times that at resonance, on plate 37 for broad tuning, and on plate 38 for sharp tuning. It will be noted on plate 38 that the selectivity is great enough to cut the side bands, the second peak occuring one kilocycle off resonance, or the resonant frequency plus the frequency of modulation.

(d) The audio amplifier characteristics are shown on Plate 41, with the voltage gain at 1000 cycles given as 17.7, audio frequency voltage being applied to the coupling condenser from the diode circuit of type 6B7 combination oscillator-detector-AVC tube, with the equivalent resistance of the diode inserted, this resistance being determined to be 5,000 ohms. Standard output was used.

(e) Resonant overload curves, taken at 7700 KC, and with both CW and CW modulated 30% at 1000 cycles input, for broad and sharp tuning are shown on plates 42 to 45 inclusive, automatic volume control off.

(f) Resonant overload curves, taken at 7700 KC, and with both CW and CW modulated 30% at 1000 cycles input, for broad and sharp tuning, are shown on plates 46 to 49 inclusive, automatic volume control on. These are taken at several output level settings, to show the effectiveness of the automatic volume control.

(g) Maximum noise level, with CW oscillator on and off, with broad tuning, is shown on Plate 50.

Maximum noise level, with CW oscillator off, and with sharp tuning, is shown on Plate 51.

Maximum noise level, with CW oscillator on, and with sharp tuning, is shown on Plate 52.

(h) Primary image response is noted on the opposite side of zero beat, and about 38 kilocycles removed from the signal, the autodyne detector producing an intermediate frequency beat note of 19 kilocycles which is of about the same strength as the signal response.

With the receiver resonated at 2000 KC, response was noted when the signal generator was adjusted to any frequency of which the resonant frequency was a harmonic, response being obtained on either side of zero beat as outlined above. This is believed to be more a characteristic of the signal generator, as response to signal generator frequency harmonics is obtained on receivers of various types.

Secondary image response was noted only as described under selectivity test ( ), where the autodyne detector produced a beat frequency of which the intermediate frequency of 19 kilocycles is a harmonic, and to which the intermediate systems will respond.

(i) To determine what frequencies the i-f system would accept, a signal CW modulated 30% at 1000 cycles was applied to the grid of the combination first detector and oscillator tube, the grid tuning inductance being shorted out to stop oscillations in this tube, and the result is shown in the form of a selectivity curve for the i-f system, for sharp tuning on plate 39, and for broad tuning on Plate 40. It will be noted that the curve for broad tuning is based on resonance at 15.5 KC where slightly less input was required for standard signal output, however the curve between 15.5 KC and 19 KC is practically flat.

(j) To determine the interaction between receivers, subject receiver was connected to the same antenna with a Hammerlund Comet "Pro", and resonated to set up a frequency of 2000 KC from the first oscillator.

From the Comet "Pro" outputs noted were as follows:

Frequency	Volts Output, across 20,000 ohms
2000	20
4000	1.5
6000	-
8000	-
10000	1.5

(k) By coupling the output of the receiver to the deflection terminals of a cathode-ray oscillograph, the action of the automatic volume control was observed, by viewing the deflected beam on the fluorescent screen, the oscillograph functioning as a voltmeter without lag.

It was noted that when the signal was suddenly increased, the output voltage remained constant, there being no perceptible lag in the action of the volume control in regulating the grid bias to compensate for the increased signal. However, when signal was suddenly decreased, there was a very noticeable lag in the action of the control. The output voltage would instantaneously drop to a low level, and it would require a period of approximately one second for the grids to assume their normal value, and for the output voltage to resume its normal level. By regulation of the resistor in the audio system, which is connected when the AVC switch is 'on', the maximum output can be set at any desired level, but with a corresponding decrease in output with lower signal input, as is shown on Plates 46 to 49 inclusive.

CONCLUSIONS:

7. The usable sensitivity of this receiver is very good, the input required for standard output of 5 milliwatts averaging 8.7 microvolts, varying from 4.3 to 21 microvolts, for CW signals. For MCW signals, the input required for standard output averages 18 microvolts, varying from 11.3 to 30 microvolts. These measurements are based on a noise output of .0125 milliwatts.

The selectivity is very good except for the lack of selectivity over a band of 38 kilocycles between the resonant signal and image response. On the side away from the image response, the slope of the curve is very sharp, showing an attenuation of 60 DB's on a voltage basis at 1.85% off resonance at the lowest frequency, and an attenuation of 60 DB's at 0.1% in the highest frequency band. The same attenuation, however, on the other side of resonance, due to the intervening poor selectivity band between resonance and image response, is at 3.7% for the lower frequency, and 0.3% for the higher frequency.

Resonant overload curves show that the receiver will handle outputs satisfactorily up to 400 milliwatts.

There is considerable interaction between receivers from the first oscillator frequency, but only slight interaction from its harmonics.

With the single tuning control and band change switch, tuning and frequency shift are facilitated.

The noise level is readily controlled and stable operation is obtained.