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# PERFORMANCE TESTS OF THE LEAR VHF OMNIRECEIVER

FOR LIMITED DISTRIBUTION

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# PERFORMANCE TESTS OF THE LEAR VHF OMNIRECEIVER

The purpose of this report is to present the results of tests conducted at the Technical Development and Evaluation Center, of the Lear, Inc. VHF omnireceiver.

The equipment tested is shown in Fig. 1 and consists of the following units:

Model LR5B VHF receiver, Serial No. 65G9
Model LCP-5 Omnipack, Serial No. 417H9
Model LDP-5 Omniscope
Model VCA-2 Filter Amplifier, Serial No. 2J9
Model VC1X Cross Pointer Indicator

This equipment provides visual indications of omnirange and instrument landing localizer courses and aural reception of modulated signals. The receiver is tunable over the frequency range of 108 to 127 Mc. Omnirange and phase comparison localizer indications are presented on a cathode-ray type indicator and the tone localizer indications are presented by means of a left-right needle type indicator. The receiver unit also contains provisions for a VHF transmitter. No tests of the transmitter were made.

The following test equipments were used during the tests.

Boonton Radio Corp. Type 211A VHF Signal Generator with
Boonton Radio Corp. Type 505A 6 db Attenuator
Collins Radio Co. 479S Audio Signal Generator
Daven Co. Type OP-182 Power Output Meter
Hewlett-Packard Co. Type 200B Audio Oscillator
General Radio Wave Analyzer, Type 736A

The following conditions were maintained during all tests, unless otherwise stated.

Battery Voltage - 13.25 v. dc
Audio Output Load - 3 ohms
Signal Generator Attenuator Setting - 1,000 microvolts with 53 ohm 6 db attenuator connected between signal generator and receiver
Modulation - 30 per cent of 1,000 cps for audio measurements and 30 per cent of 30 cps plus 30 per cent of frequency modulated 9,960 cps for omnirange measurements.
Signal-to-Noise Ratio - 4·1 in power
Temperature - Approximately 25 degrees C.

The following test results were obtained:

## Sensitivity

| Frequency Mc | Microvolts Radio-Frequency Input for 4:1 Signal-to-Noise Power Ratio |
|---|---|
| 110 | 5.3 |
| 115 | 5.4 |
| 120 | 5.3 |
| 126 | 5.0 |

The volume control and signal level were adjusted to provide an audio output of 50 milliwatts and 4 1 signal-to-noise ratio simultaneously.

## Dial Calibration Error

| Receiver Dial Reading Mc | Boonton 211A Signal Generator Frequency Mc | Calibration Error Mc |
|---|---|---|
| 110.55 | 110.10 | +0.45 |
| 115.30 | 114.90 | +0.40 |
| 124.15 | 123.86 | +0.29 |

## Selectivity

| Radio-Frequency Input Microvolts | Ratio of Off-Resonance Input to Resonance Input db | Signal Generator Frequency Variation in kc for Constant Audio Level | | Bandwidth kc |
|---|---|---|---|---|
| | | Above Resonance | Below Resonance | |
| 3.0 | 0 | 0 | 0 | 0 |
| 6.0 | 6 | + 60 | -60 | 120 |
| 7.5 | 8 | + 70 | -70 | 140 |
| 15.0 | 14 | + 90 | -100 | 190 |
| 30.0 | 20 | + 105 | -130 | 235 |
| 60.0 | 26 | + 120 | -140 | 260 |
| 150.0 | 34 | + 140 | -190 | 330 |
| 300.0 | 40 | + 155 | -210 | 365 |
| 3,000.0 | 60 | + 220 | -285 | 505 |
| 30,000.0 | 80 | + 290 | -365 | 655 |

The receiver was tuned to 117.9 Mc during this test. Volume control and radio-frequency input were adjusted for 4·1 signal-to-noise ratio at resonance.

## Automatic Volume Control Action

| Radio-Frequency Level Microvolts | Audio Level (10-Minute Warm-Up) db | Audio Level (10-Minute Warm-Up) mw | Audio Level (45-Minute Warm-Up) db | Audio Level (45-Minute Warm-Up) mw |
|---|---|---|---|---|
| 2 | 5.7 | 3.7 | 1.0 | 1.2 |
| 5 | 10.5 | 11.0 | 3.0 | 2.0 |
| 10 | 16.6 | 46.0 | 9.5 | 9.0 |
| 15 | 18.5 | 70.0 | 13.4 | 22.0 |
| 30 | 20.0 | 100.0 | 19.2 | 85.0 |
| 50 | 21.3 | 135.0 | 21.1 | 130.0 |
| 100 | 22.1 | 165.0 | 22.3 | 175.0 |
| 500 | 23.2 | 210.0 | 23.6 | 230.0 |
| 1,000 | 23.8 | 240.0 | 24.1 | 260.0 |
| 5,000 | 24.8 | 300.0 | 25.1 | 320.0 |
| 10,000 | 25.3 | 340.0 | 25.6 | 360.0 |
| 50,000 | 27.0 | 500.0 | 27.0 | 500.0 |
| 100,000 | 28.2 | 650.0 | 28.2 | 650.0 |

## Harmonic Distortion

| Power Output Watts | Audio Frequency Distortion - Per cent of Fundamental: Second Harmonic | Third Harmonic | Fourth Harmonic | Resultant Distortion |
|---|---|---|---|---|
| 3.0 (Maximum) | 2 | 20 | 1 | 20.2 |
| 2.0 | 2 | 2 | Very Small | 2.8 |

Modulation was 30 per cent at 400 cps.

## Audio Output from Vibrator Noise

| Power Output from 30 Per Cent Modulation at 400 cps - Watts | Frequency of Audio Output Due to Vibrator - cps | Audio Output Due to Vibrator - mw |
|---|---|---|
| *3.0 | 110 | 132 |
| | 220 | 660 |
| | 440 | 330 |

*Volume control set for maximum audio output.

## Fidelity

| Modulation Frequency - cps | Audio Output mw | Audio Output db |
|---|---|---|
| 30 | 5.2 | -20.0 |
| 60 | 8.2 | -18.5 |
| 100 | 14.0 | -15.5 |
| 150 | 50.0 | -12.0 |
| 200 | 110.0 | -6.5 |
| 400 | 370.0 | -1.4 |
| 600 | 475.0 | -0.2 |
| 1,000 | 500.0 | 0.0 |
| 1,500 | 400.0 | -1.0 |
| 2,000 | 300.0 | -2.1 |
| 3,500 | 120.0 | -4.2 |
| 5,000 | 50.0 | -10.0 |
| 10,000 | 7.5 | -18.0 |

30 per cent modulation was maintained at all modulation frequencies. The volume control was adjusted to obtain 500 mw output when the modulation frequency was 1,000 cps.

## Undesired Responses

All undesired responses, including that at image frequency, were 60 db, or more, below the desired response at resonance.

## Sensitivity and Frequency Stability versus Temperature and Battery Voltage

| Temperature Degrees C | Battery Voltage v. dc | Sensitivity Microvolts for 4:1 Signal-to Noise Power Ratio | Frequency Drift - Mc From 115.1 Mc |
|---|---|---|---|
| +25 | 12.5 | 5.0 | -0.03 |
| | 13.5 | 5.0 | 0.0 |
| | 14.5 | 5.0 | -0.015 |
| +40 | 12.5 | 5.0 | -0.080 |
| | 13.5 | 5.0 | -0.065 |
| | 14.5 | 5.0 | -0.074 |
| +60 | 12.5 | 3.0 | -0.195 |
| | 13.5 | 4.5 | -0.180 |
| | 14.5 | 5.0 | -0.190 |

Sensitivity and Frequency Stability versus Temperature and Battery Voltage (continued)

| Temperature Degrees C | Battery Voltage v. dc | Sensitivity Microvolts for 4:1 Signal-to-Noise Power Ratio | Frequency Drift - Mc From 115.1 Mc |
|---|---|---|---|
| +23 | 12.5 | 4.5 | --- |
| | 13.5 | 5.0 | **00 |
| | 14.5 | 5.8 | --- |
| 0 | 12.5 | 5.8 | -0.015 |
| | 13.5 | 5.5 | -0.01 |
| | 14.5 | 5.8 | -0.01 |
| -20 | 12.5 | *30.0 | -0.070 |
| | 13.5 | *58.0 | -0.070 |
| | 14.5 | *40.0 | -0.065 |
| +22 | 12.5 | 5.5 | -0.070 |
| | 13.5 | 5.8 | -0.040 |
| | 14.5 | 5.8 | -0.060 |

*The apparent low sensitivity at the ambient temperature of -20 degrees C was due to vibrator noise.

**The receiver frequency dial setting was slightly different for the cold than for the heat test since the two tests were not made consecutively.

Omnibearing Accuracy versus Temperature

| Omniscope Reading | Bearing Error - Degrees +25 Degs. C | +40 Degs. C | +60 Degs. C | +23 Degs. C | 0 Degs. C | -20 Degs. C | +22 Degs. C |
|---|---|---|---|---|---|---|---|
| 0 | -1.1 | +1.9 | +4.3 | -1.6 | -6.8 | -6.7 | -2.5 |
| 30 | +0.7 | +3.3 | +4.9 | +0.5 | -5.8 | -5.6 | -0.6 |
| 60 | +1.4 | +4.0 | +5.6 | +1.4 | -4.0 | -3.5 | +0.5 |
| 90 | +3.9 | +5.9 | +9.3 | +2.9 | -1.7 | -2.5 | +3.7 |
| 120 | +4.5 | +6.8 | +11.0 | +3.2 | -1.4 | -1.8 | +3.2 |
| 150 | +4.3 | +7.6 | +10.0 | +2.0 | -5.0 | -4.6 | +2.8 |
| 180 | +3.5 | +5.5 | +7.5 | +1.1 | -4.9 | -5.7 | +1.2 |
| 210 | +3.3 | +5.7 | +6.5 | +2.7 | -4.1 | -4.3 | +0.6 |
| 240 | +1.6 | +3.7 | +5.0 | +0.3 | -3.7 | -2.4 | -0.5 |
| 270 | +0.7 | +3.2 | +6.5 | +0.2 | -3.0 | -1.7 | -1.6 |
| 300 | +0.3 | +1.8 | +7.2 | -1.2 | -5.9 | -2.0 | -2.2 |
| 330 | -1 7 | +1.7 | +4.6 | -2.2 | -7.5 | -8.0 | -3.6 |
| 360 | -1.1 | +1.5 | +4.0 | -1.5 | -6.6 | -6.8 | -2.9 |

The omniscope trace diameter decreased one-half inch when the battery voltage was varied from 14.5 to 12.5 v. dc.

At +40 degrees C the trace diameter was one-fourth inch less than normal. The trace was adjusted to normal diameter before readings were taken.

At +60 degrees C the trace diameter was one-half inch smaller than normal. The trace was readjusted to normal diameter before readings were taken.

At -20 degrees C the trace had an oval shape and the largest diameter was 0.5 inch greater than normal. The trace size was readjusted to normal at +23 degrees C before the low temperature test was started.

Bearing Variation with Change in Radio-Frequency Level

| Radio-Frequency Input Level Microvolts | Bearing Variation - Degrees | | | |
|---|---|---|---|---|
| | Pip at 0 Degs. | Pip at 90 Degs. | Pip at 180 Degs. | Pip at 270 Degs. |
| 10 | -4.6 | -2.9 | +2.4 | +1.2 |
| 20 | +1.1 | +1.8 | +2.6 | +3.5 |
| 50 | +1.2 | +1.9 | +1.6 | +2.1 |
| 100 | +0.3 | +1.2 | +1.7 | +1.6 |
| 500 | +0.3 | +0.1 | +0.3 | 0.0 |
| *1,000 | 0.0 | 0.0 | 0.0 | 0.0 |
| 10,000 | +0.9 | +1.7 | +1.4 | +0.9 |
| 100,000 | +2.0 | +2.7 | +2.3 | +1.7 |

*Signal level of 1,000 microvolts used as reference level.

No pip was visible on the circular trace when the signal level was less than six microvolts.

Tone Localizer Course Sensitivity and Centering versus Radio-Frequency Input Level

| Radio-Frequency Level Microvolts | Deviation Indicator Deflection - Dots | |
|---|---|---|
| | Four db Ratio of 90 and 150 cps Modulation | 20 Per Cent Modulation of Both 90 and 150 cps |
| 20 | 1.0 | 0.0 |
| 23 | 1.5 | 0.0 |
| 35 | 2.0 | 0.0 |
| 200 | 2.5 | 0.0 |
| 1,000 | *3.0 | 0.0 |
| 21,000 | 3.5 | 0.0 |
| 100,000 | 4.0 | 0.0 |

*Tone localizer sensitivity control adjusted to provide deflection of three dots for radio-frequency input of 1,000 microvolts.

Tone Localizer Course Sensitivity and Centering versus Battery Voltage

| Battery Voltage v. dc | Deviation Indicator Deflection - Dots | |
|---|---|---|
| | Four db Ratio of 90 and 150 cps Modulation | 20 Per Cent Modulation of Both 90 and 150 cps. |
| 11.0 | 1.8 | 0.0 |
| 12.0 | 2.2 | 0.0 |
| 13.0 | 2.8 | 0.0 |
| 13.5 | 3.0 | 0.0 |
| 14.0 | 3.2 | 0.0 |

Phase Comparison Localizer Performance

Detailed measurements of phase comparison localizer performance could not be made because of the type of presentation. The presentation is such that the pip appears at approximately 180 degrees on the omniscope when the aircraft is to the left of the runway and at approximately zero degrees when the aircraft is to the right of the runway. No pip is visible when the aircraft is on course. Course sensitivity measurements could not be made since neither the position nor the size of the pip changes linearly with change in variable phase modulation percentage.


FIG.1 LEAR INC. VHF OMNIRECEIVER