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INTERFERENCE BETWEEN VHF NAVIGATION RECEIVERS

By

David S. Crippen and W. L. Seibert
Electronics Division

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INTERFERENCE BETWEEN VHF NAVIGATION RECEIVERS

SUMMARY

This report presents the results of tests conducted at the Technical Development and Evaluation Center of the Civil Aeronautics Administration to determine the interference between two navigation receivers installed in the same aircraft. It was found that considerable interference may exist when two navigation receivers are connected to the same antenna. The use of separate antennas reduces the interference. It was also found that the interfering signals may be coupled from one receiver to another by the interconnecting wiring in the aircraft.

INTRODUCTION

When two navigation receivers are installed in an aircraft, it is possible that signals generated in one receiver can interfere with signals received by the second. Measurements were made to determine the magnitude and frequency of signals at the antenna circuit of one navigation receiver when the signals are generated by oscillators in a second navigation receiver connected to the same antenna or to a separate one. The level of interfering signals that are coupled by the interconnecting wiring of one receiver to that of a second was also measured in one aircraft.

The tests were made on Types 51R-1 and 51R-2 receivers manufactured by Collins Radio Company and on the Type MN-85BA receiver manufactured by Bendix Radio Division of Bendix Aviation Corporation. Only one of each type of receiver was used.

TESTS AND RESULTS

The two receivers were operated simultaneously, and the antenna receptacles were connected by two lengths of RG-8/U transmission line and a radio-frequency phaser, as shown in Fig 1. The phaser is identical with those used in the very-high-frequency (VHF) omnirange transmitter antenna change-over and phasing unit and is equivalent to a 53-ohm transmission line having a length which can be varied by moving a slider. The slider position was varied to obtain maximum and minimum interference signal levels at the antenna input circuit of the first receiver for each frequency-selector setting of the second receiver. Since the electrical length variation of the phaser is

limited to approximately 90 degrees, it was often necessary to substitute different lengths of RG-8/U transmission line to obtain the maximum or minimum interference level.

A direct-current (dc) milliammeter connected in the cathode circuit of the first radio-frequency amplifier stage of the indicating receiver was used to indicate cathode-current changes due to the interfering signals. The cathode-current readings were converted to equivalent signal input microvolts by connecting a Boonton Type 211-A VHF signal generator to the receiver through a 53-ohm, 6-decibel (db) attenuator pad and by adjusting the signal-generator attenuator to produce identical cathode-current readings. The readings of the attenuator dial in microvolts were recorded as interfering signal levels. The signal generator was tuned for maximum receiver response in each case so that the readings recorded represent equivalent value of the interfering signal at the resonant frequency of the indicating receiver.

Primary consideration was given to interfering signals in the band 108 to 122 megacycles (Mc). Interference from the Bendix MN-85BA receiver may be expected whenever the frequency-selector setting is 6.9 or 7.0 Mc higher than that of the indicating receiver. The first mixer injection frequency is 6.95 Mc lower than the frequency to which the receiver is tuned. Thus, interference in the 108- to 122-Mc frequency band is possible when the selector setting is from 114.9 to 129.0 Mc. When the phaser was adjusted for maximum interference, the average level of the interfering signal was equivalent to seven microvolts. When the phaser was adjusted for minimum interference, the equivalent level was two microvolts. The maximum equivalent level was ten microvolts. The indicating receiver was also a Bendix receiver. Similar results were obtained when a Collins 51R-2 receiver was used as the indicating device. The same tests were made using an Aircraft Radio Corporation Type 15A receiver as the indicating device. This receiver was tuned for maximum response, and the interfering signal level varied from 40 to 80 microvolts.

Interfering signals from the Collins navigation receiver were measured in the same manner. The results shown in Table I were obtained when receivers 51R-1 Serial No 228 and 51R-2 Serial No 43 were used as interference sources and receiver 51R-2

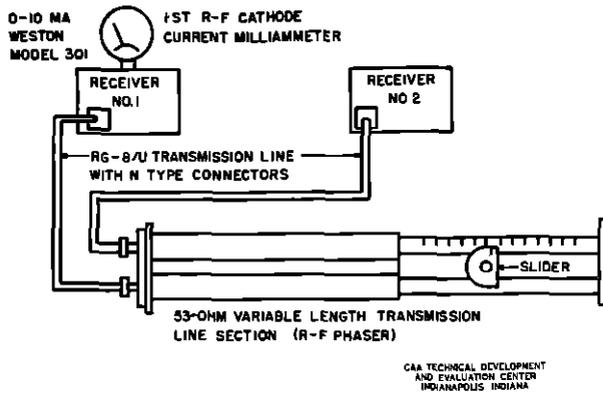


Fig 1 Equipment and Connections Used to Measure Interference Levels When Receivers Were Connected by Variable Length Transmission Line

Serial No. 41 was used to indicate the interference level. In the following, the receiver used to indicate the frequency and level of the interfering signal is designated No 1 receiver and that one in which the interfering signal is generated is the No. 2 receiver. The frequency-selector settings of the No 1 receiver shown in the first column of Table I represent the approximate frequencies of the interfering signals. The figures in the second column of this table represent the frequency ranges or intervals of No 2 receiver-selector settings that cause interference. For example, if the frequency-selector setting of receiver No 2 is between 128.0 and 129.9 Mc, inclusive, a signal at 108.5 Mc will be received by No 1 receiver. A 114.1-Mc signal will be received by No. 1 receiver when No 2 receiver is tuned to 108.0, 110.0, 112.0 Mc, and at each even and integral frequency up to and including 134.0 Mc.

The interference level ranges shown in Table I, columns 3 and 4 represent maximum and minimum values obtained by adjusting the length of the transmission line between the receivers. Column 5 indicates the source of the interference from within the receiver. The levels also vary somewhat with No 2 frequency-selector setting, and this variation is included. Since the transmission-line lengths in an aircraft installation are fixed, the interference levels at some frequencies may approach maximum values and the levels at other frequencies will have minimum or intermediate values.

It was found that the maximum or minimum interference levels measured at a particular frequency could be approximated when both receivers were connected to the

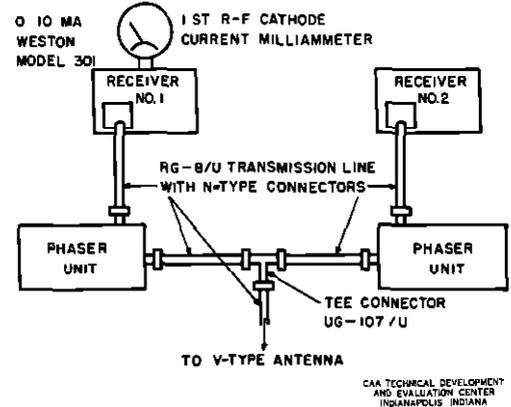


Fig 2 Equipment and Connections Used to Measure Interference Levels When Both Receivers Were Connected to the Same Antenna

same antenna as in Fig. 2. This was done either by adjustment of the phasers or by substitution of different lengths of RG-8/U transmission line connecting each receiver to the UG-107A/U Tee connector at the end of the transmission line from the antenna.

The use of separate antennas reduced but did not entirely eliminate interference, because some signals were also radiated from wiring associated with the receivers. Measurements made in airplane N-182, a DC-3 aircraft having two Collins installations, showed that the equivalent of a 12-microvolt signal can be transferred from one receiver to another through interconnecting wiring in the aircraft. The frequency-selector setting of No 1 receiver was 110.5 Mc, and the No. 2 receiver setting was 130 Mc. Shielded 50-ohm resistors were connected to the receiver transmission-line receptacles.

Table II shows the attenuation of the interfering signals measured when using separate antennas as in Fig. 3. The values given are approximate and vary with types of antennas, their location on the aircraft, and the length of the transmission lines. The Boonton 211-A VHF signal generator was substituted for receiver No 2 to eliminate the effects of radiation from leads connecting the receiver to the frequency-control unit, the omnibearing selector, the omnibearing indicator, the accessory unit, and the course deviation indicator. The measurements were made using two V-type antennas mounted on pedestals and located on the roof of the laboratory. In receiver No 1, the radio-frequency cathode current for a reference signal level of 2 microvolts was established

TABLE I
INTERFERENCE BETWEEN
PARALLEL-CONNECTED COLLINS 51R-1 AND 51R-2 RECEIVERS

Interference Detector No 1 Receiver 51R-2 No 41 Frequency Selector (megacycles)	Interference Source One of Two No 2 Receivers 51R-1 No. 228 or 51R-2 No 43 Frequency Selector (megacycles)	Interference Level Ranges Measured at No 1 Receiver		Source of Interference From Within No. 2 Receiver***
		Interference Source 51R-1 No 228 (microvolts)	Interference Source 51R-2 No 43 (microvolts)	
108 5	128 0, 128 1, etc , to 129.9	900-2700	225-780	A
110 5	130 0, 130.1, etc , to 131 9	450-2700	225-780	A
112 5	132.0, 132.1, etc , to 133 9	800-3500	275-780	A
114.1	108 0, 110 0, etc , to 134 0	0 8 - 4 5	0-2 0**	C
114 5	134 0, 134.1, etc , to 135 9	250-1100	220-650	A
114 8	108 1, 110 1, etc , to 134 1	0 4 - 3 5*	0-2 0**	C
115 5	108 2, 110 2, etc , to 134 2	0 2 - 1 8	0-2 0**	C
116 2	108.3, 110 3, etc , to 134 3	0 4 - 3 5*	0-2 0**	C
116 9	108 4, 110.4, etc , to 134 4	0 8 - 6.3	0-2 0**	C
117 6	108 5, 110 5, etc , to 134 5	0 2 - 4 6	0-2 0**	C
118.0	108 0, 108 1, etc , to 109 9	20-130	3 5 - 95	B
118 3	108 6, 110 6, etc , to 134 6	0 4 - 3 5*	0-2 0**	C
119 0	108 7, 110 7, etc , to 134 7	0 4 - 3 5*	0-2 0**	C
119 7	108 8, 110 8, etc , to 134 8	0 4 - 3 5*	0-2 0**	C
120 4	108 9, 110 9, etc., to 134 9	0 4 - 3 5*	0-2 0**	C
121 1	109 0, 111 0, etc., to 135.0	0 4 - 3 5*	0-2 0**	C
121 8	109 1, 111 1, etc., to 135 1	0 - 0.8	0-2 0**	C

*Average of readings recorded for 114 1, 115.5, 116 9, 117 6, and 121 8 Mc Figures for 114 1, 115 5, 116 9, 117.6, and 121.8 Mc measured with No 2 selector at approximately 108, 116, 124, and 134 Mc.

**These values are not measured values and represent the average of the results of measurements made with No 1 selector setting of 125 3 and 127 4 Mc Corresponding No 2 selector settings were 109 6, 111 6, and so forth, to 135 6 Mc, inclusive, and 109 9, 111 9, and so forth to 135 9 Mc, inclusive

***Source A is the signal injected into the first mixer stage Source B is the fourth harmonic of the first high-frequency multiplier stage, and Source C is the fourteenth harmonic of the low-frequency oscillator

TABLE II
ATTENUATION
OF THE INTERFERING SIGNAL
WITH SEPARATE ANTENNAS

Frequency of Radiated Signal (megacycles)	Distance Between Antennas (feet)	Attenuation Ratio Provided By Separate Antennas
110.5	55	150:1
120.0	55	140:1
136.0	55	400:1
110.5	28	40:1
120.0	28	40:1
136.0	28	130:1
110.5	14	25:1
120.0	14	25:1
136.0	14	100:1
110.5	6	20:1
136.0	6	60:1

by connecting the output of the signal generator to this receiver through a 53-ohm, 6-db attenuator pad. The signal generator was then connected to antenna A through the same attenuator pad, and receiver No. 1 input was connected to antenna B. The level of the signal fed to antenna A from the signal generator was adjusted to provide at receiver No. 1 a signal which was equivalent to the reference level. The attenuation ratio was calculated by dividing the signal-generator attenuator setting by two. Adjustment of the phaser connected in the transmission line to antenna A had very little, if any, effect on the signal at the antenna input circuit of the receiver. Adjustment of the phaser in the transmission line from the receiver to antenna B also had very little, if any, effect at frequencies below 120 Mc. At frequencies above 120 Mc, the amplitude of the signal at the receiver input circuit could be varied as much as two to one by phaser adjustment. The values given in Table II represent average values.

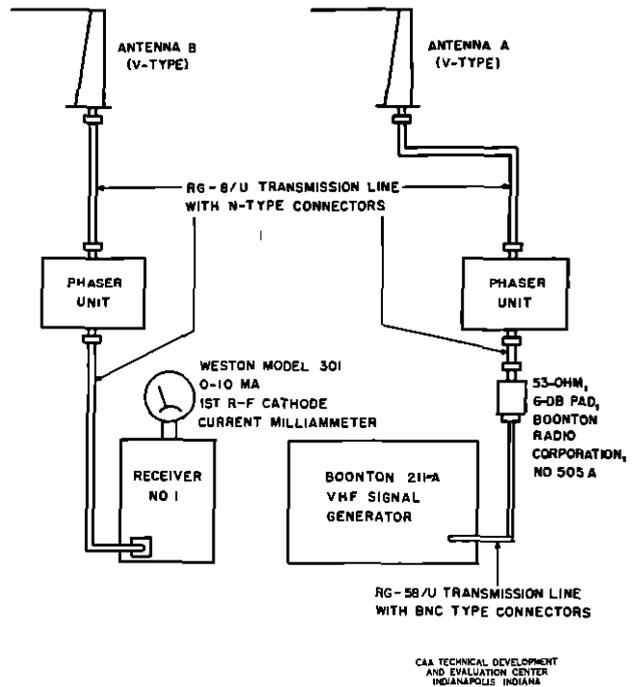


Fig. 3 Equipment and Connections Used to Determine the Level of Signals Fed to Antenna A and Required for Equivalent Two-Microvolt Signal at Receiver No. 1

CONCLUSIONS

It is evident that considerable interference may exist when two Collins navigation receivers, two Bendix navigation receivers, or one of each are operated from the same antenna. The use of separate antennas provides considerable attenuation of the undesired signals, as indicated in Table II. Transfer of undesired signals from one receiver to another by means of interconnecting wiring in the aircraft is also possible. The degree of interference for various combinations of receivers cannot be predicted since the frequency and magnitude of the interfering signals vary, depending upon crystal frequencies and upon factors contributing toward coupling of the signals to the antenna input circuit or to interconnecting wiring.