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VOR TESTS WITH 50-KC FREQUENCY SEPARATION

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by

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SUMMARY

This report presents the results of tests conducted by the Civil Aeronautics Administration Technical Development Center to determine the interference between two VOR facilities operating 50 kilocycles apart when using two navigation receivers having different selectivity characteristics. These tests indicate that the amount of interference between two VOR's having a frequency separation of 50 kilocycles will be affected by the geographic separation of the ground stations, the altitude of the aircraft, and the receiver selectivity. The maximum altitude flown during these tests was 15,000 feet.

INTRODUCTION

The continuing increase in the number of VOR installations in the United States has resulted in a decrease in the usable distance range of some VOR facilities because of the interference that occurs when two facilities operating on the same frequency do not have sufficient geographical separation. The problem becomes more acute as more aircraft fly at higher altitudes.

At present the VOR channel frequency separation is 100 kilocycles (kc). It has been proposed that the separation be reduced to 50 kc. This report presents the results of tests conducted during March 1956, at the Technical Development Center (TDC) to determine the feasibility of reducing the VOR channel frequency separation.

RECEIVING EQUIPMENT

A Collins 51X1 communication receiver was modified for VOR reception and used in these tests. A two-stage resistance-capacitor (RC) filter was connected in the automatic-volume-control (AVC) circuit of the receiver to eliminate errors caused by feedback of the 30-cycles-per-second (cps) signal to the radio-frequency (r-f) and intermediate-frequency (i-f) stages. Also, a shielded lead was connected to the detector circuit for the purpose of feeding the detected signal to the audio circuit of a conventional Collins 51R3 navigation receiver.

LABORATORY TESTS

The course sensitivity characteristics of the modified 51X1 receiver and a 51R3 receiver are shown in Fig. 1. Figures 2, 3, and 4 show the selectivity characteristics of the modified 51X1 receiver for no modulation, 50 per cent amplitude modulation at 1,000 cps, and 50 per cent amplitude modulation at 10 kc, respectively. For these tests, the AVC voltage was maintained constant and the frequency and output level of a Boonton Type 211 signal generator were varied.

Figure 5 shows the interference characteristics of the modified 51X1 receiver for two VOR signals having different frequency separations. This is plotted as the decibel ratio of the undesired to the desired signal, which produces a course deviation indicator (CDI) error of plus or minus 1°. To obtain these data, two Type 479S-211 test generators were connected in parallel across the input of the modified 51X1 receiver. The output of one generator was maintained constant at 118.00 Mc at a level of 10 microvolts, and the frequency and output of the second generator were varied to produce a plus or minus 1.0° course variation in the indicated bearing produced by the signal from the first generator. In order to obtain the maximum indicated error, the power supply for one Type 479S generator was obtained from an oscillator-amplifier unit, the frequency of which was adjusted to approximately 59.7 cps. The normal wiggle-filter damping in the CDI circuit was reduced to obtain a maximum indicated error. A General Radio Type 1213-1 crystal oscillator served as a radio frequency standard. Figure 6 shows the interference characteristic when the frequency was adjusted to 118.05 Mc. The interference characteristic of a 51R3 receiver when tested under similar conditions is shown in Fig. 7.

FLIGHT TESTS

Since the lowest frequency channel of the 51X1 receiver is 118.00 Mc, it was necessary to conduct the interference tests outside of the VOR frequency band. The Tilden, Ind., experimental VOR was adjusted to operate at 118.00 Mc, and a portable TVOR unit located at Arcola, Ill., (100 miles west of Tilden) was adjusted to operate at 118.05 Mc. Both stations were adjusted to 50 watts output. The Tilden VOR was operated from a commercial 60-cps power supply and the portable TVOR was operated from a gasoline engine generator unit at a frequency of approximately 59.7 cps.

Figures 8 and 9 show the results of the flight tests when both VOR's were operating at 50-kc separation and using the modified 51X1 receiver. Flights were made at various altitudes on a course between the two stations. The average useful range of each station was approximately 80 per cent of the distance from either station. A variation of plus or minus 1.0° in the indicated visual course of the desired station, caused by the interfering station, was used as a measure of the usable distance range between the two VOR's. Simultaneously, during these flights a 51R2 receiver was in operation and tuned to 118.00 Mc. The useful range for each station when using this receiver was found to be approximately 30 per cent of the distance from either station.

In order to compare 50-kc separation with 100-kc separation when using a normal 51R3 receiver, similar flight tests were conducted with the

Tilden VOR operating at 115.7 Mc and the commissioned Covington, Ky. (CVG), VOR operating at a frequency of 115.6 Mc, 106 miles from Tilden. Both stations were operated at an output power of approximately 150 watts Figures 10 and 11 show the results obtained during these flight tests. The average useful range of each station was approximately 94 per cent of the distance from either station.

DISCUSSION

During the laboratory and flight tests with 50-kc frequency separation, there was evidence that the harmonics of the 9,96-kc subcarrier signal caused a derrogation in the expected selectivity characteristics of the system. It was indicated that, by reducing the harmonics of the 9 96-kc signal radiated from VOR stations, the results obtained using a Type 51X1 receiver for 50-kc VOR separation would be similar to the results using a 51R3 receiver and 100-kc VOR separation. There was no evidence that reducing the harmonics of the 9,96-kc signal would improve the interference characteristics of a 51R3 receiver for a 100-kc VOR separation.

CONCLUSIONS

1. The useful range of adjacent VOR stations, operating at a frequency separation of 50 kc, was extended from approximately 30 per cent of the spacing between stations when using a conventional Collins 51R3 receiver to approximately 80 per cent of the spacing between stations by using a modified Collins 51X1 receiver.

2. A receiver having a selectivity characteristic similar to the modified Collins Type 51X1, but with improved sensitivity and a better AVC, should be a satisfactory VOR receiver, should the VOR channeling be changed from 100-kc to 50-kc separation

3. With a reduction in the harmonics of the 9.96-kc signal at VOR stations operating at a 50-kc separation and by using improved receivers similar to the Collins 51X1, the results obtained should be similar to the results obtained with a Collins 51R3 at a 100-kc separation.

4. The allocation of frequency channels on a 50-kc basis is a technical solution to the problem of making more VOR and ILS channels available. This would increase the number of channels from 100 to 200 in the 108- to 118-Mc band. This solution requires the use of narrow-band receivers with characteristics equivalent to the Collins 51X1 receiver.

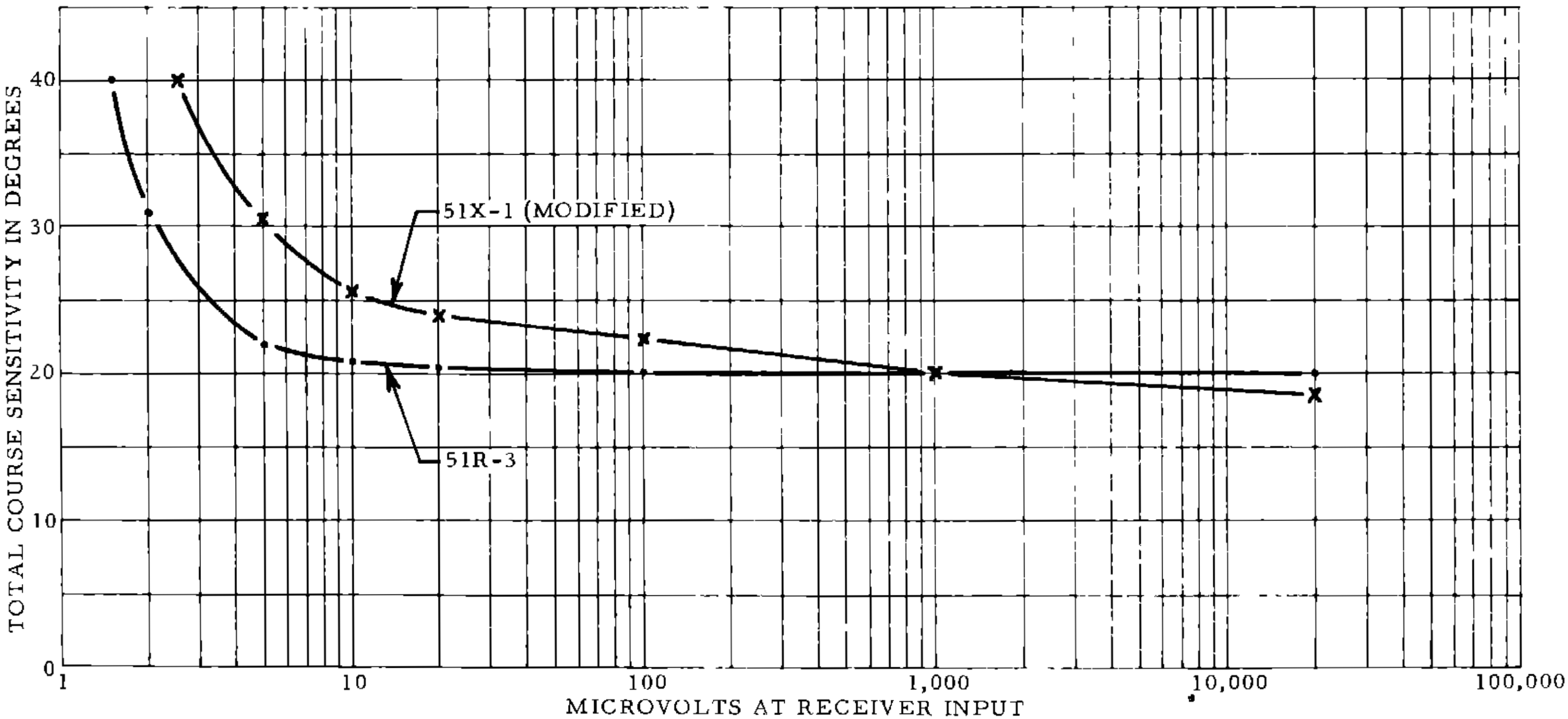

FIG 1 COURSE SENSITIVITY CHARACTERISTICS OF 51R-3 AND 51X-1 (MODIFIED) RECEIVERS

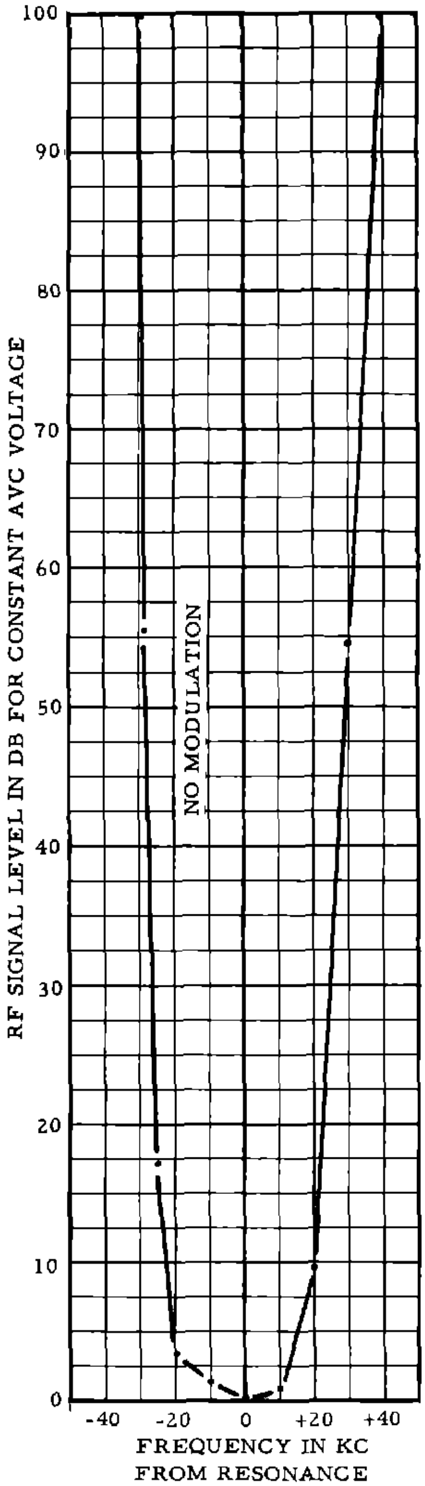

FIG 2 SELECTIVITY CURVE OF MODIFIED 51X-1

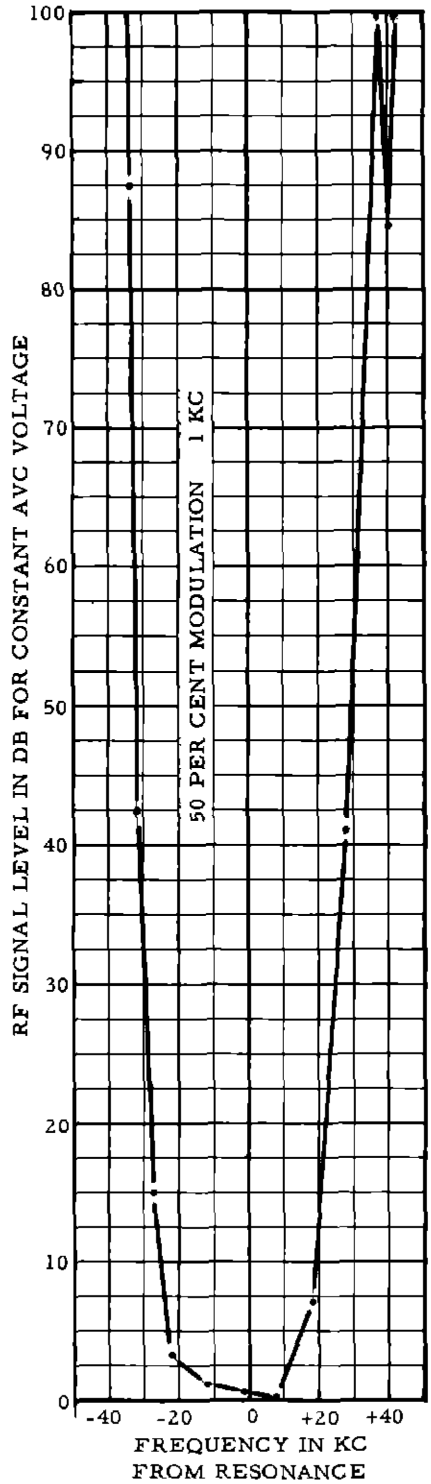

FIG 3 SELECTIVITY CURVE OF MODIFIED 51X-1

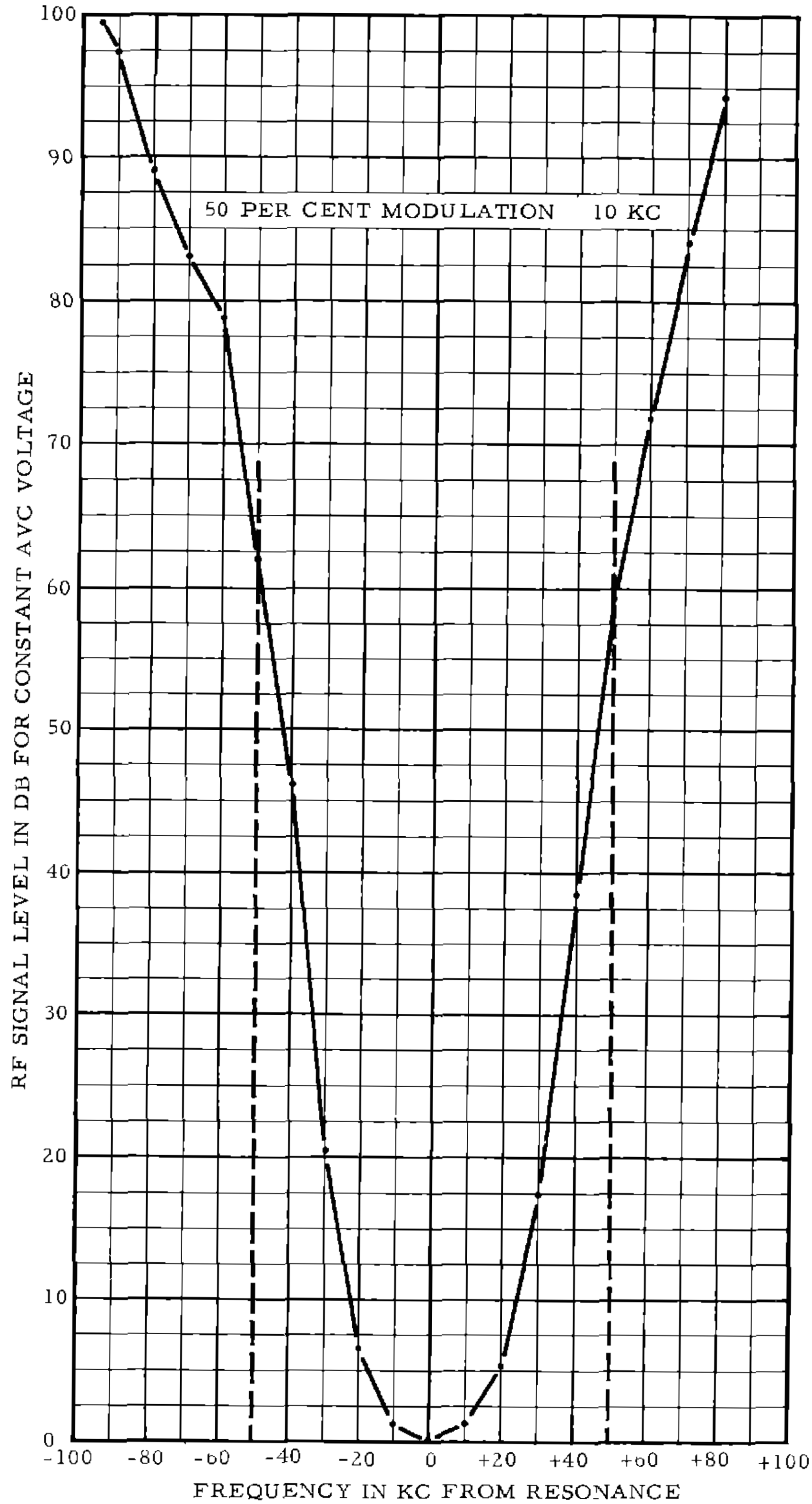

FIG 4 SELECTIVITY CURVE OF MODIFIED 51X-1

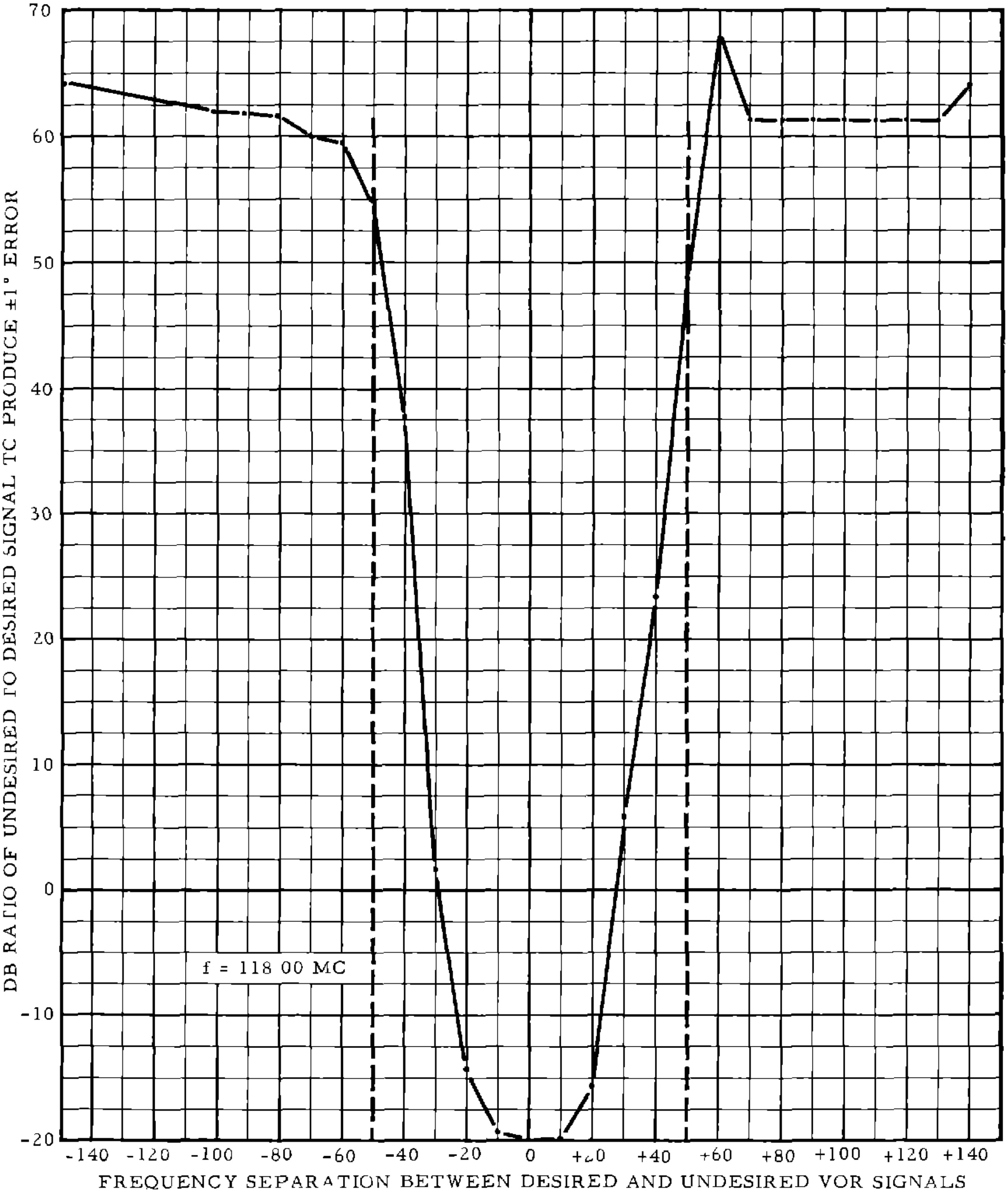

FIG 5 INTERFERENCE CHARACTERISTICS OF MODIFIED 51X-1

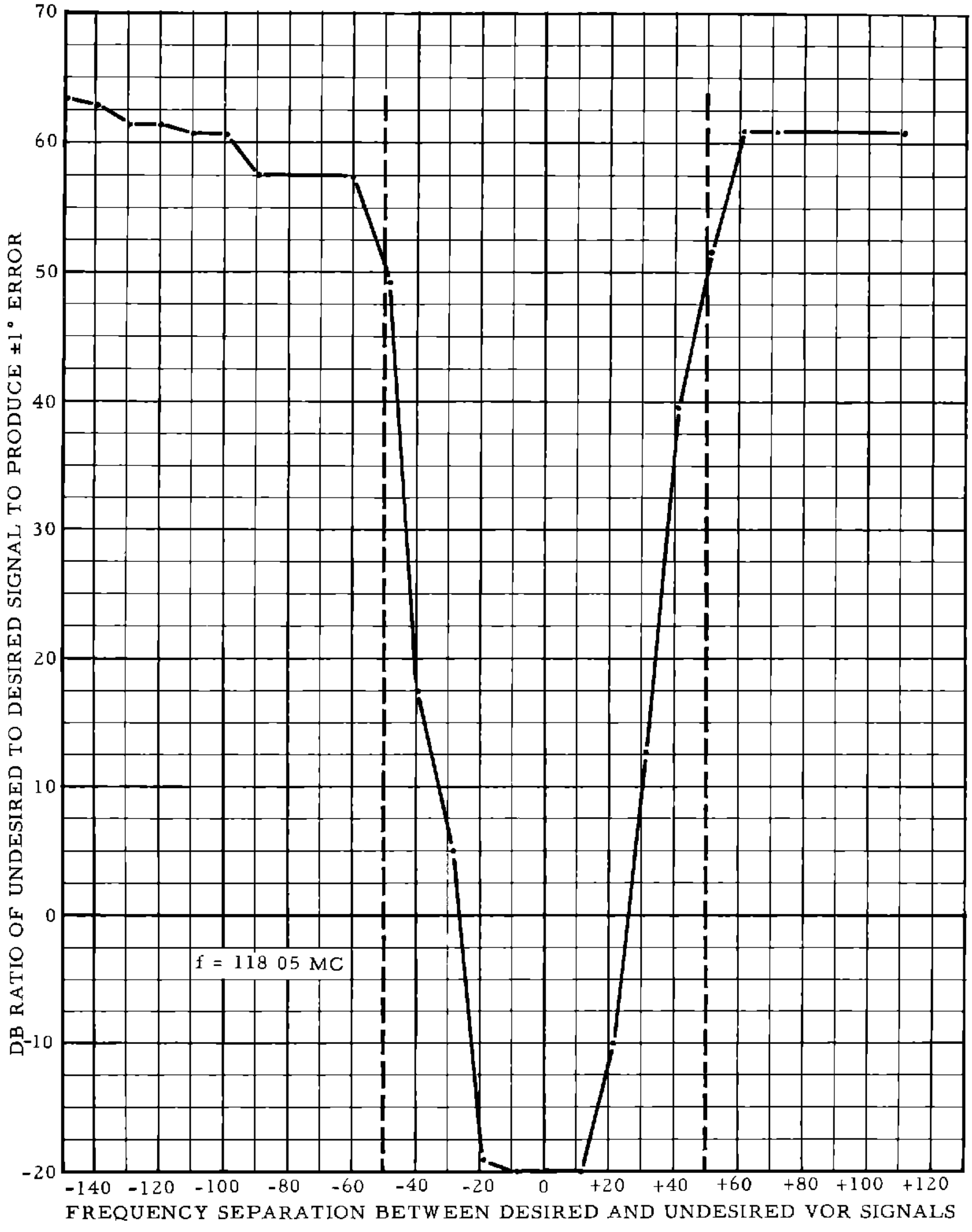

FIG 6 INTERFERENCE CHARACTERISTICS OF MODIFIED 51X-1

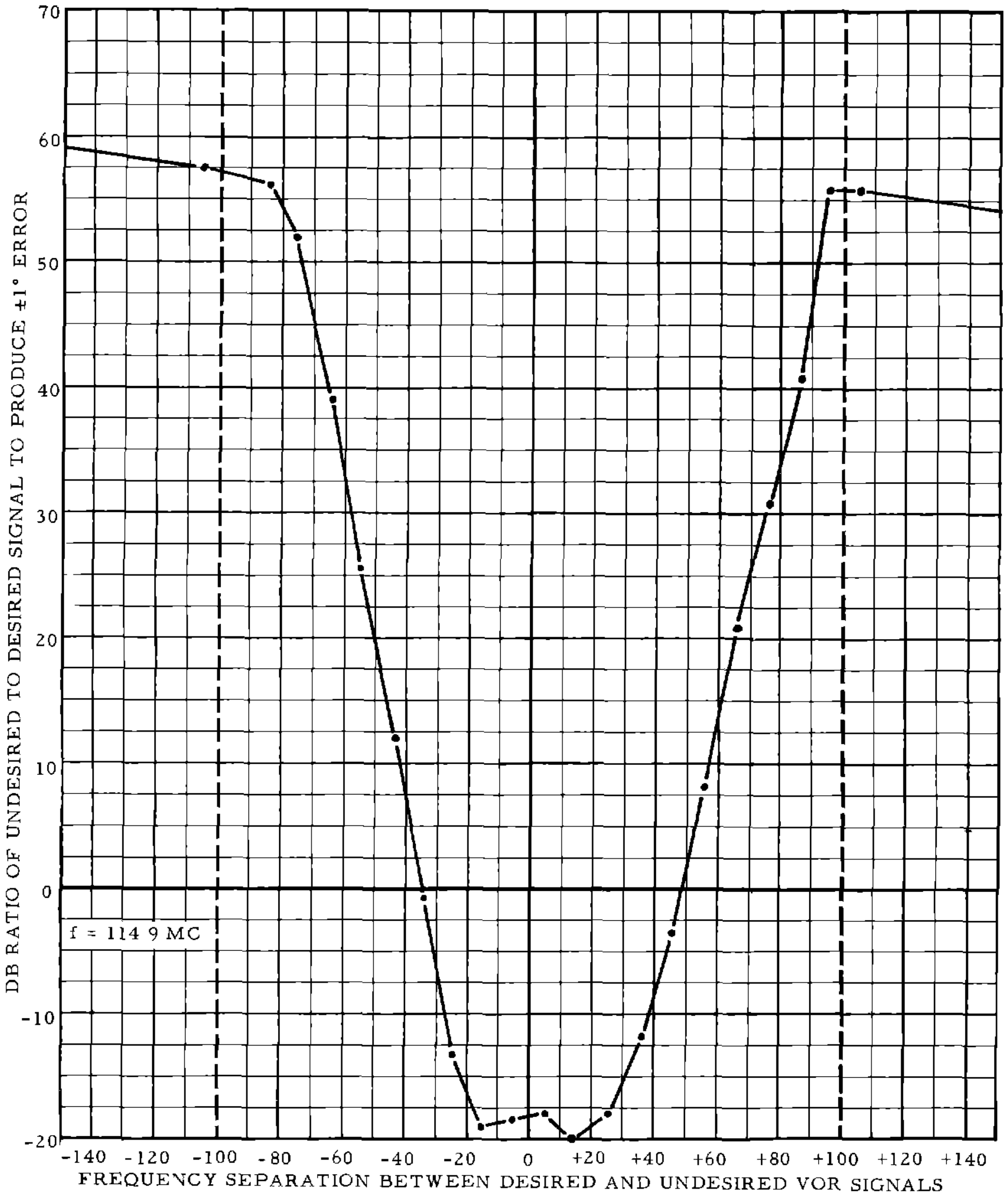

FIG 7 INTERFERENCE CHARACTERISTICS OF 51R-3

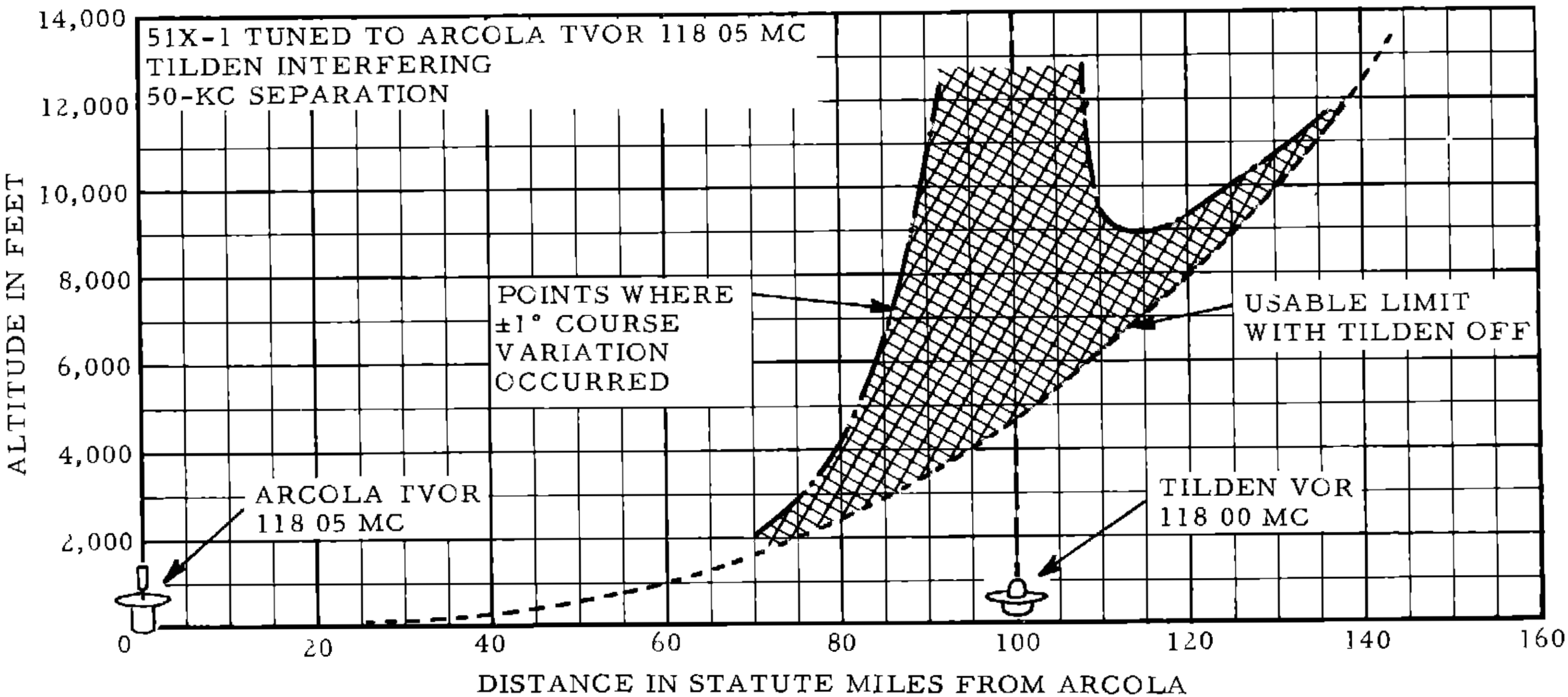

FIG 8 FLIGHT TESTS OF COLLINS 51X-1

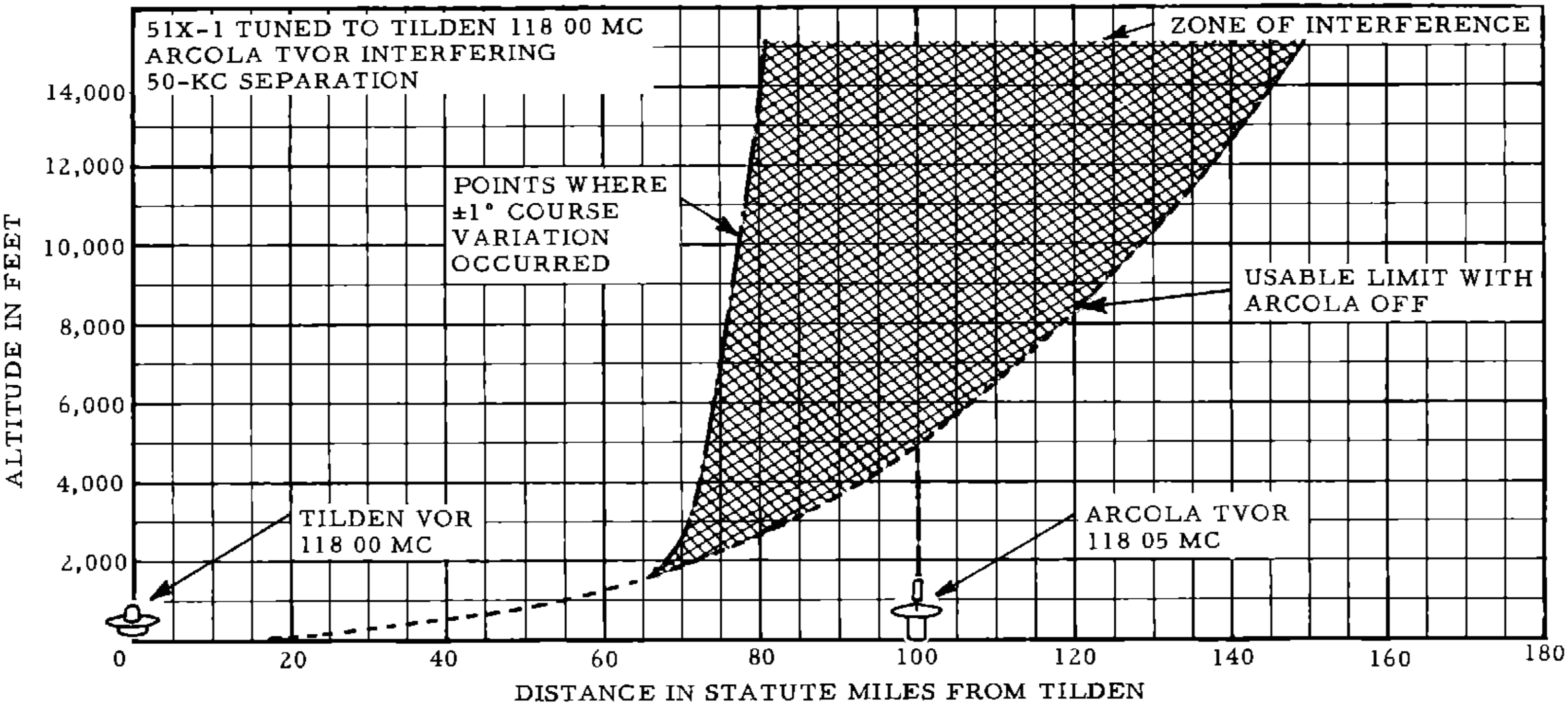

FIG 9 FLIGHT TESTS OF COLLINS 51X-1

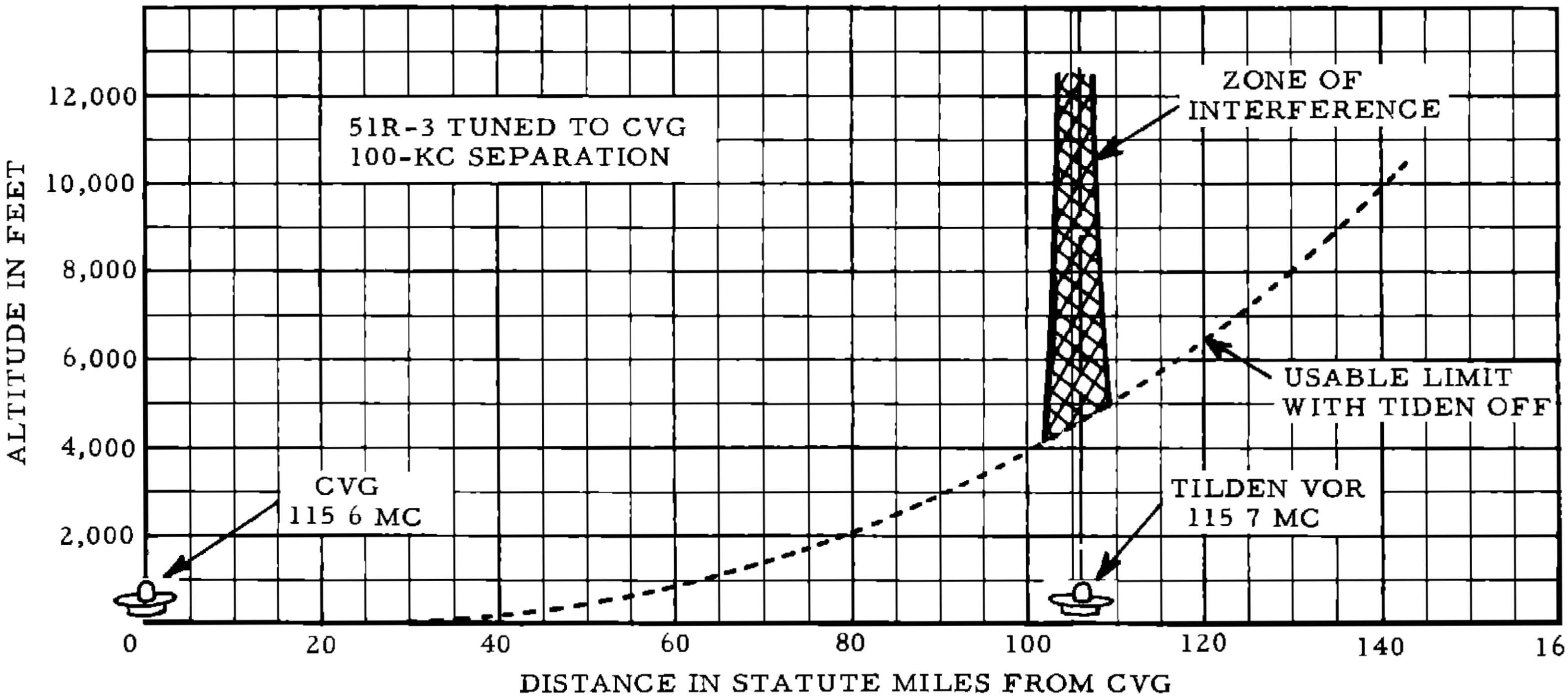

FIG 10 FLIGHT TESTS OF COLLINS 51R-3

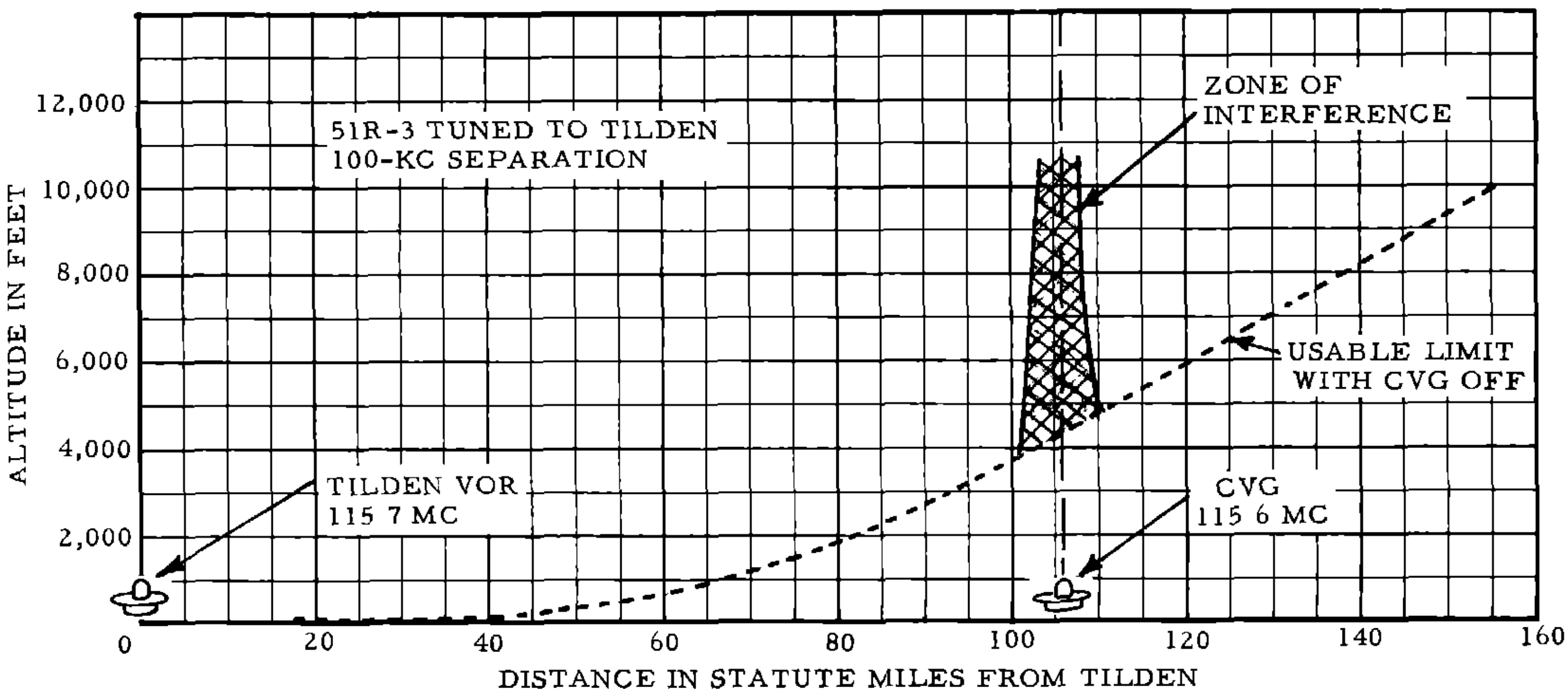

FIG 11 FLIGHT TESTS OF COLLINS 51R-3