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INVESTIGATION OF INTERFERENCE WITH LAFAYETTE VHF OMNIRANGE

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By
David S. Crippen

Radio Development Division
Technical Development
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CIVIL AERONAUTICS ADMINISTRATION
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During a flight check of the Lafayette, Indiana, VHF omnirange, personnel of the Third Region observed erratic indications of the course-deviation indicator and flag alarm when the aircraft was flown over Crawfordsville, Indiana. The interference area had a radius of approximately six miles and was centered over Crawfordsville. Intense heterodyning and whistles in the receiver audio output were also reported. Crawfordsville is located 23 miles south of the Lafayette omnirange facility.

The problem was referred to the Technical Development and Evaluation Center for investigation. Several flights were made over Crawfordsville using several different types of receivers. The interference was present when any of the different types of receivers were used Erratic visual indications were observed and whistles and noise were heard when the aircraft was within the interference area.

At first it was believed that the interference was due to the inherent undesired response characteristics of the receivers and the high level of the signal radiated from the Crawfordsville FM station. The Crawfordsville FM station, WFMU, operates at 102.9 Mc with an effective radiated power of 13,000 w. The Lafayette omnirange operates on a frequency of 113 5 Mc.

Laboratory measurements of the undesired response characteristics of one type receiver showed that the interference could be the fault of the receiver if the level of the WFMU 102.9 Mc signal at the receiver antenna input terminals was 0.2 v or greater, and if the level of the desired signal was ten microvolts or less. A flight was then made to measure the level of the signals from WFMU and the Lafayette omnirange. It was found that the signal level was 0.1 v from WFMU and 50 microvolts from Lafayette at an altitude of 1,000 feet above WFMU. A Measurements Corp. Model 56 UHF radio noise and field strength meter was used and connected to an aircraft V type omnirange receiving antenna. The flight measurements indicated that the signal levels were not such as to cause interference.

It was decided to search for signals in the vicinity of 113.5 Mc. A flight was made over Crawfordsville with the Lafayette omnirange off the air. Signals in the frequency range of 113.2 to 113.9 Mc having magnitudes up to 80 microvolts were observed 1,000 feet above the ground. At an altitude of 5,000 feet, signals as great as 23 microvolts in the frequency range of 113.2 to 113.9 Mc were measured.

When the omnirange was turned on the visual indications were erratic and aural interference consisting of whistles and noise was heard when the omnirange receiver was tuned to 113 2 113.6, 113 7, 113.8, and 113.9 Mc Occasionally, garbled WFMU modulation could be heard.

In view of the fact that the signals heard during the flight were modulated, it was believed that they were being radiated from WFMU. This information was referred to the Station Director, WFMU, with a request for a check of the station transmitter The Station Director engaged Mr Martin Williams, Consulting Engineer, to make the investigation. Mr Williams reported that no signal in the frequency range of 112.6 to 114.5 Mc was present in the transmitter output. The observations were made using an RCA Model WX-1A field intensity meter with the receiving antenna located a few feet from the transmitter tank and antenna coupling coil. Mr. Williams then mounted the field strength meter in a car to determine whether signals at 113.5 Mc were being radiated from other sources in Crawfordsville. A 50 microvolt-per-meter signal at 113.5 Mc was found just outside the transmitter building. This signal was present even though all the transmitting equipment was temporarily disabled. Further investigation showed that the source of the signal was a Montgomery Ward Model 94-HA-1529 household receiver which was tuned to WFMU, and which was located approximately one mile north of the transmitter. Modulation which was the same as that of the transmitter signal was heard when the field strength meter antenna was 20 to 25 feet from the receiver. The modulation was of low percentage, but the audio output of the field strength meter was sufficiently intelligible for positive identification of the signal. Other Montgomery Ward receivers of the same model and of another model were checked and all receivers radiated signals of large magnitude at or near 113.5 Mc.

The oscillator frequency of household receivers made by several different manufacturers is 10.7 Mc higher than the frequency of the signal to which the receiver is tuned. When these receivers are tuned to the WFMU signal at 102.9 Mc, the oscillator frequency is 113.6 Mc. However, the oscillator frequency will be 113.5 Mc if the intermediate amplifier frequency is 10 6 Mc or if the receiver is tuned to 102.8 Mc. Slight mistuning of the receivers is to be expected. The signal level of WFMU in the vicinity of Crawfordsville is very high, and it is possible that some of the receivers could be tuned anywhere in the frequency range of 102.5 to 103.3 Mc. The oscillator frequency would vary from 113.2 to 114.0 Mc.

A trip was made to Crawfordsville by Technical Development and Evaluation Center personnel to confirm the report made by Mr. Williams. The Montgomery Ward Warehouse was visited, and observations were made before the station started operation for the day. The Measurements Corp. Model 56 UHF radio noise and field strength meter

was used for these measurements. The receiver in the warehouse was turned on, and a field strength of 530 microvolts per meter at approximately 113.5 Mc was observed for a receiver frequency dial setting of 102.9 Mc. The field strength meter dipole antenna was approximately 175 feet from the receiver. The field strength did not change when WFMU was put on the air. A weak audio signal was heard in the field strength meter audio output when the receiver volume control was adjusted for maximum audio output. No modulation was evident when the volume control was adjusted to minimum position. A signal strength of 12,000 microvolts per meter was measured when the dipole was placed 15 feet from the receiver.

It was found that other receivers at other locations in Crawfordsville were radiating signals at approximately 113.5 Mc. The table below lists the types of receivers involved and strength of the signals radiated. In each case the signal disappeared when the receiver was turned off.

Type of Receiver	Distance from Receiver (feet)	Signal Strength uv/m
Montgomery Ward Model 94-HA-1529	40	7,000
Montgomery Ward Model 94-HA-1529	50	12,000
RCA Model 8R71	60	19,000

None of the above receivers have rf amplifier stages. The power cord was used as the antenna.

Two other types of household receivers were investigated in Indianapolis, and the following results were obtained

Type of Receiver	Type of Antenna	Distance from Receiver (feet)	Tuned Frequency (Mc)	Oscillator Frequency (Mc)	Signal Strength (uv/m)
Bendix Model 95M9U	Internal	60	94.7	105 4	420
Admiral Model 4H145	Double X Outside	12	94.7	84	70,000
Admiral Model 4H145	Double X Outside	2,640	94.7	84	7

Heterodyne interference and erratic visual indications were observed during a flight in the vicinity of Brazil, Putnamville, and Greencastle, Indiana. The aircraft omnirange receiver was tuned to the Lafayette VOR.

It is evident that radiation of signals of large magnitudes may be expected from the oscillators of many different types of receivers. It is expected that more cases of interference will be found in the future due to the increasing use of omnirange facilities and to the increasing number of FM stations. Interference does not occur over many cities and towns because the frequency of the receiver oscillators does not happen to approximate the frequency of the Federal Airways VHF facilities in those areas.

It is reported that Montgomery Ward has distributed over 500 receivers in the Crawfordsville area. Many other types of receivers operating in this area also are capable of causing interference. Assuming that the if of the majority of commercial receivers in the Lafayette VOR service area will continue to be 10.7 Mc, the interference may be reduced by changing the operating frequency of either the Crawfordsville FM station or the Lafayette omnirange transmitter at least plus or minus 0.5 Mc. If the Crawfordsville frequency is changed, the new frequency should be such that the household receiver oscillator frequency will not be within 0.5 Mc of any of the following navigation facilities.

Location of Facility	Type of Facility	Frequency in Mc
Lafayette, Ind	VOR	113.5
Fort Wayne, Ind.	VOR	114 6
Terre Haute, Ind.	VOR	115.3
Indianapolis, Ind.	VOR	116.3
Indianapolis, Ind.	VOR (Experimental)	114.1
Indianapolis, Ind	VOR (Experimental)	113.9
Indianapolis, Ind.	Runway Localizer	109.9
Indianapolis, Ind.	Runway Localizer (Phase Comparison)	108.3
Indianapolis, Ind.	Runway Localizer (Experimental)	108.9
Indianapolis, Ind.	Runway Localizer (Directional)	109.1

If the Lafayette frequency is changed, the choice of frequency should be such as to avoid interference with all the omnirange facilities listed above, in addition to those operating in this geographical area.

Some types of receivers may have if other than 10.7 Mc, and the oscillator frequencies of those receivers must be considered when a new VOR operating frequency is selected.

Consideration should be given to encouraging manufacturers to build future FM receivers with local oscillator frequencies outside of the aviation band of 108 to 132 Mc.