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IDENTIFICATION OF LF/MF NON-DIRECTIONAL RADIO BEACONS UTILIZING FREQUENCY MODULATION (F_1)

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FOREWORD

The information contained in this circular concerns a proposed method of identifying LF/MF Non-Directional Radio Beacons and LF/MF Radio Broadcasting Stations by utilizing frequency modulation (F_1) techniques for conveying the identity in such a manner that certain difficulties experienced with existing A_1 and A_2/A_2 methods of identification are eliminated.

The material was submitted to the Fourth Session of the Communications Division of ICAO by the Government of France. The Division recommended that the material should be disseminated to States for their information and for the purpose of encouraging an operational evaluation of the proposed method of identification.

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CHAPTER I

IDENTIFICATION OF NON-DIRECTIONAL BEACONS

SUMMARY

1.1 Problem of Radio Beacon Identification

Historical

ICAO Doc 2553 - COT 26 (Section IV - paragraph 5.2) recommended that all non-directional beacons use A_0/A_2 emission in order that the carrier should never be interrupted during transmission of identification since interruption of the carrier causes the automatic direction finder to drift during the periods of interruption, particularly in cases of interference. (With an A_1 system, the ADF tends to align itself with the azimuth of the interfering station during the keying periods.)

In accordance with these provisions, during 1948 a certain number of beacons equipped with modulators (mainly American transmitters) were set up on A_0/A_2 in the European and African Region by the French authorities. It was not long before complaints were received from airlines (TAI), particularly those operating over the Sahara area. In effect, the A_0/A_2 system advocated by ICAO has certain disadvantages. These are as follows:

- a) Considerable bandwidth required (2 to 3 kc/s). The A_0/A_2 system transmitters which are provided in this instance utilize grid modulation only, which does not modulate the carrier sufficiently. Satisfactory A_0/A_2 operation requires a depth of modulation corresponding to at least 80%.

b) It is difficult to read the identification signal owing to the insufficient depth of modulation at long distances and when there is interference. This is very inconvenient when long range beacons are used for short distance navigation with an ADF, as well as for long distance navigation with manual D/F.

c) The addition of a modulator capable of providing sufficient depth practically doubles the cost of the equipment and the power requirements of a beacon of given range. This is out of the question for radio beacons which are to be operated in desert areas.

For low power beacons and marker beacons the complexity and increase in operating costs of A_0/A_2 system equipment is also a factor for consideration.

Following these comments which were presented by France to the ICAO preparatory Meeting on the MF Geneva Plan which came into force on 15 March 1950, it was accepted that medium and long range beacons in the EUMED Region would continue to operate on A_1 . Moreover Annex 10 only provides a Standard regarding A_0/A_2 type emission for locators.

Therefore it appears that, as no fully satisfactory solution has yet been adopted, the problem of radio beacon identification still exists.

1.2 Identification of Broadcasting Stations

It is well known that, for "en-route" navigation, Broadcasting Stations are often used as beacons in conjunction with an ADF. However, this method, although very interesting, is not to be recommended in the present circumstances, owing to the difficulty involved in identification of these stations.

During the last war, the Germans used to interrupt their broadcasts to transmit identification signals.

In 1941 the American authorities on their side investigated a more discrete method of identification. This research, interrupted by the war, was resumed in 1946, and in 1948 the American "AERONAUTICAL RADIO INC" tested a method involving modification of the ADF equipment. (See Chapter V.)

The Broadcasting carrier wave was modulated at a very low frequency (40 c/s.) and at a very low percentage (5%). When received, the 40 c/s. signal operated a 1000 c/s. oscillator. As a result of complaints from listeners it became necessary to reduce the percentage of 5% to 3%. With that, the device ceased to be of any value as the identification could only be received over short distances and the principle was abandoned.

It appears today that a solution can be adopted, which solves both the problem of beacon identification without interrupting the carrier and that of identification of broadcasting stations. This is frequency shift modulation or F_1 modulation.

1.3 F_1 Modulated Beacons

This system consists in shifting the frequency of the radiated carrier about one hundred cycles at the identification keying rate. (See Chapter II.)

The advantages of this type of modulation are as follows:

- a) reduced frequency spectrum space required;
- b) no interruption of the carrier during identification keying;
- c) possibility of transmitting a signal inaudible to Broadcast listeners but which can be used by navigators for identification purposes.

If such a method of identification could be applied to all European stations with an exclusive frequency, then it would be possible to ensure full coverage by powerful non-directional beacons suitable for en-route navigation. The aerodrome beacons could then be reduced in power so as to yield a range of 50 nms for final homing. This system is particularly valuable in view of the complete deadlock we are facing in the EUMED Region with regard to the LF/MF part of the radio frequency spectrum.

Nevertheless there is a serious obstacle to the immediate application of this system on an international basis; most ADF receivers are equipped with a heterotone device for reception of A_1 , consequently reception of F_1 signals is not possible.

However, certain airlines, and Air France in particular, have envisaged, for other reasons, the addition of a BFO to the ADF, which permits F_1 modulation to be received.

Furthermore, the latest American Bendix ARN6 and RCA AVR21 automatic direction finders are equipped with a BFO on the antenna and D/F positions.

Therefore it appears that a recommendation to modify ADF equipment would not give rise to serious objections.

In any case, one cannot compare the minor nature of the proposed modification (addition of a BFO costing about 20,000 francs) with that involved in the adoption of the equipment described by the American ARINC, had it been adopted.

CHAPTER II

STUDY OF AN MF FREQUENCY SHIFT MASTER OSCILLATOR, FOR F₁ RADIO BEACON IDENTIFICATION

WORKING PRINCIPLE

2.1 Standard crystal oscillator with frequency shift

In the oscillator schematic diagram in Fig. 1, it can be seen that the frequency of oscillation of crystal Q is a function of the value C of capacities CV_1 and CV_2 .

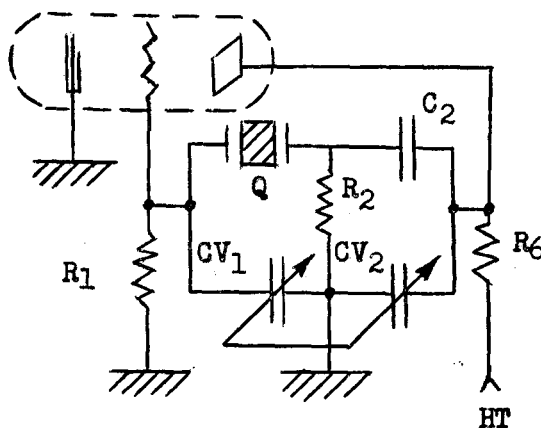


Fig. 1