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AVIATION RADIO DIRECTION FINDERS AND NON-DIRECTIONAL BEACONS: PRINCIPLES OF OPERATION AND THEIR IMPORTANCE IN AVIATION

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Abstract

This paper examines the role of aircraft radio direction finders and non-directional beacons (NDBs) in ensuring safe and accurate air navigation. Two categories of radio direction finding systems are considered: airborne and ground-based systems, including their classification and operational purpose. The operational principles of non-directional beacons are analyzed, with emphasis on their operating modes ("Homing" and "Communication") and key system components such as the tone generator and call-sign keying unit. The study also discusses NDB types, coverage areas, and their application in approach and en-route navigation. Particular attention is given to signal transmission principles, identification procedures, and voice communication functionality within the system.

Keywords: Radio direction finders; Automatic Direction Finders (ADF); Non-Directional Beacons (NDB); Radio beacon bearing (RBB); NDB coverage area; "Homing" mode; "Communication" mode; GTG generator; Amplitude modulation

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Introduction

Aviation radio direction finders and non-directional beacons play a key role in ensuring the safety and accuracy of air navigation. These systems make it possible to effectively determine the position of aircraft, provide communication between pilots and air traffic controllers, and are also used in search and rescue operations. Radio direction finders, which are divided into airborne and ground-based types, help guide aircraft toward radio stations and track their movement in the air. Non-directional beacons (NDBs), including approach and standalone types, provide essential navigation data and serve as an important tool in air traffic management. The operating modes of NDBs, such as "Homing" and "Communication," determine the method of transmitting signals and voice messages, which is crucial for maintaining reliable communication and accuracy in aviation operations.

MAIN PART

1. Radio Direction Finders: Types and Functions

Aviation radio direction finders are devices used to determine the direction to a source of radio waves. The process by which this is achieved is called radio direction finding.

There are two types of radio direction finders: airborne and ground-based.

1.1. Airborne Radio Direction Finders

Airborne radio direction finders are known as Automatic Direction Finders (ADF). These devices are divided into two types depending on the frequency range:

- Medium-frequency ADFs are designed for direction finding of ground-based non-directional beacons (NDBs), determining the direction relative to the longitudinal axis of the aircraft. This angle is called the radio beacon bearing (RBB). They can also be used for direction finding of broadcasting radio stations.
- Ultra-high-frequency ADFs are used for direction finding of emergency radio transmitters from aircraft that have crashed or made forced landings. These radio

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direction finders are installed on aircraft and helicopters involved in search and rescue operations.

1.2. Ground-Based Radio Direction Finders (RDF)

Ground-based radio direction finders (RDF) are used to determine the bearing of VHF radio transmissions from aircraft operating in transmission mode. These devices assist air traffic controllers in distinguishing aircraft among multiple targets displayed on radar screens and in maintaining radio communication with the crew. Previously, shortwave (HF) radio direction finders were used in aviation, which could transmit the aircraft's position upon request from the crew [1].

2. Non-Directional Beacons (NDB): Types and Coverage Areas

Non-directional beacons (NDBs), also referred to as locator beacons, are ground-based radio transmitting stations that use omnidirectional antennas. These radio stations are of key importance in aviation navigation, providing information necessary for performing navigation tasks (**Fig. 1.1**).

Fig. 1.1. External View of Non-Directional Beacons

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On aeronautical charts, non-directional beacons (NDBs) are depicted using concentric circles of varying diameters, next to which a rectangle (data box) is usually placed, containing the information necessary for the use of the beacon in navigation. Knowing the coordinates of an NDB, the flight crew can navigate toward the station, determine the moment of passing over it, establish the aircraft's position using the intersection of bearings from several NDBs, and monitor maneuvers during the approach phase (**Fig. 1.2**).

Fig. 1.2. Designation of PRS on the chart**.**

Depending on their purpose and installation location, non-directional beacons (NDBs) are divided into two types:

- **Approach (aerodrome) NDBs**-installed at an airfield along the runway centerline. They enable pilots to perform precise maneuvers during the approach phase. For example, in the **non-precision approach system "OSP"** (used at aerodromes of the former USSR), approach NDBs were located at a distance of **4000 ± 200 m** (for the outer NDB) and **1100 ± 150 m** (for the inner NDB) from the runway threshold. In addition to these radio stations, **marker beacons** were installed, forming the **outer marker (OM)** and **inner marker (IM)** beacons. When NDBs are used as part of a **radio beacon landing system**, they are installed together with outer and middle marker beacons.

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- **En-route (standalone) NDBs**-these are radio stations used for various navigation tasks not directly related to landing. They can be installed in different locations and assist in navigation, for example, in determining an aircraft's position by the intersection of bearings from several beacons.

Each NDB is assigned an **identification signal (call sign)**, which is transmitted using **Morse code**. Call signs for outer NDBs consist of two letters, while those for inner NDBs consist of one letter. In other cases, call signs may consist of three letters.

For radio range stations (PRS), a specific coverage area is established, which represents a region of space in which the error in measuring the course bearing of the radio station (KUR) does not exceed the permissible value (±5°). The coverage area depends on the type of station:

- For long-range PRS (DPRS), the coverage radius is 150 km.
- For short-range PRS (BPRS), it is 50 km.

Separate PRS (OPRS) are divided into two types:

1.Off-aerodrome OPRS-installed at locations marking the entry and exit points of air corridors or at turning points of air routes. Off-aerodrome OPRS may operate together with marker beacons (MRM). Their coverage area is at least 150 km.

2.Aerodrome OPRS-installed at an aerodrome along the extension of the runway centerline at a distance of 3800 to 4200 m from the runway threshold. Installation is also permitted to the side of the extended centerline or near the runway.

In the event of failure of onboard communication systems, the air traffic control (ATC) controller may transmit voice messages via the DPRS station or an aerodrome OPRS. These messages can be heard by the pilot if the aircraft headset is connected to the output of the automatic direction finder receiver (ADF) [2].

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3.Modes and operating principle of PRS

The operating mode of a radio range station is determined by the method of transmitting identification signals or voice messages. The following operating modes are distinguished:

- "Beacon" mode (A1 and A2)-in this mode, the station transmits identification signals.
- "Communication" mode- the station transmits voice messages from the air traffic control (ATC) controller.

In "Beacon" mode, identification signals may be transmitted in different formats. Figure 3.1 shows a simplified block diagram of the PRS, and Figure 3.2 shows timing diagrams that explain the operation of the PRS in different modes.

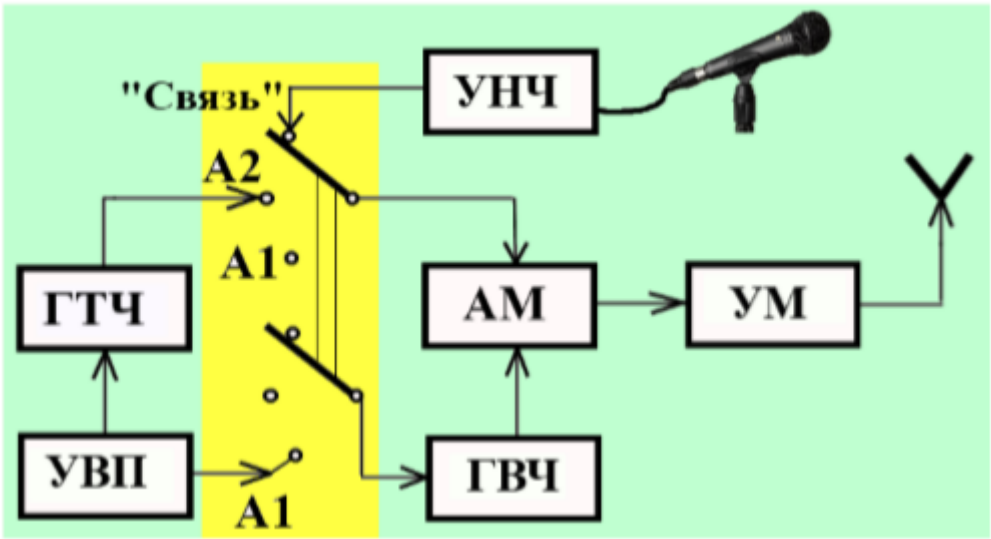

Figure 3.1 Simplified block diagram of PRS

In "Beacon" mode ("A2"), the output of the tone frequency generator (TFG) carries an audio-frequency voltage of 1020 ± 50 Hz or 400 ± 25 Hz.

The operation of the TFG generator is controlled by the call sign generating unit (CSGU), which switches the power supply to the TFG generator in accordance

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with the PRS call signs. The amplitude modulator (AM) performs amplitude modulation of the oscillations of the high-frequency generator (HFG) using signals from the TFG generator. From the output of the power amplifier (PA), high frequency amplitude-modulated oscillations are fed to the PRS antenna

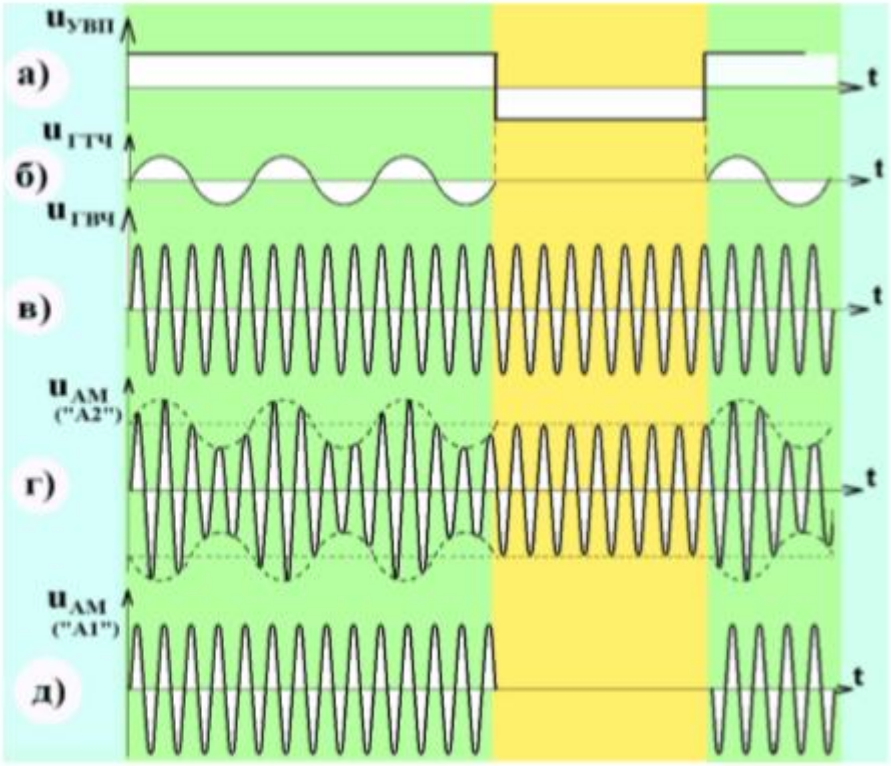

Figure 3.2 Timing diagrams of PRS signals

To ensure operation of the PRS at higher power and greater range, the “Beacon” mode (“A1”) is used. In this mode, the CSGU again switches the operation of the HFG according to the PRS call signs. As a result, unmodulated oscillations with interruptions in the carrier frequency are fed to the antenna. In such oscillations, amplitude modulation is absent, which means that no sound will be heard in the headphones when receiving these signals. To make the call signs audible, internal

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amplitude modulation is used in the ADF receiver. For this purpose, the "CW–AM" switch on the ADF control panel should be set to the "CW" position.

In "Communication" mode, modulation is carried out by an amplified low-frequency voltage coming from the ATC controller's microphone. This allows the pilot to listen to the controller's messages through the headphones connected to the output of the radio compass receiver [3].

Conclusion

Aircraft radio direction finders and radio range stations (PRS) are essential components for ensuring safety and accuracy in aviation navigation. These systems enable effective determination of aircraft positions, maintain communication between pilots and air traffic controllers, and also play a key role in search and rescue operations.

Radio direction finders, which are divided into airborne and ground-based types, provide accurate bearing to radio stations, helping to track aircraft positions and manage their movement in airspace. Radio range stations (PRS), including aerodrome and separate types, play an important role in navigation by providing precise data to pilots during approach and other maneuvers.

PRS operating modes such as "Beacon" and "Communication" determine the method of signal and voice message transmission, which is critically important for communication reliability and navigation accuracy, especially in emergency situations. The TFG generator and amplitude modulator are the main components that ensure signal transmission and proper operation of radio stations over long distances.

In the future, with the development of technology, radio direction finding systems and PRS will continue to improve, increasing their range, accuracy, and reliability. Despite new technologies, these systems will remain an important part of aviation infrastructure, ensuring safety and accuracy of air traffic.

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References

1. Mikhailov, V. N. Radio Direction Finders in Aviation-Moscow: Transport, 2014.
2. Gromov, I. S. Fundamentals of Aviation Navigation: textbook-Moscow: Transport, 2012.
3. Shevchenko, I. I. "Aircraft Radio Direction Finders and Radio Navigation Systems-Moscow: Mashinostroenie, 2016.