AVIATION COMMUNICATION SYSTEMS

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For each study step, read the assigned pages first at your usual speed, then reread slowly one or more times. Finish with one quick reading to fix the important facts firmly in your mind. Study each other step in this same way.

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AVIATION COMMUNICATION SYSTEMS

The Importance of Radio to Aviation Communications

TODAY the airplane is man's greatest accomplishment in transportation. Modern aviation permits travel to any part of the world at speeds that would have been unbelievable only a generation ago.

It is not surprising that such a space-commanding form of transport as the airplane should ally itself with an equally space-commanding form of communication. Radio is the nerve network that ties together the far-flung operations of a modern airline into a smoothly efficient, safe transport system. Without it, scheduled air transport would be haphazard and uncertain, if not altogether impossible. In recognition of the importance of radio communication, all transport planes are required by law to carry certain specified radio equipment. A pilot has at his finger tips all the resources of a vast, co-ordinated system of ground radio stations, whose facilities are dedicated solely to safety of flight.

Radio carries the voice of authority to pilots throughout the length of every civil airway, warning them of changing weather, advising them of field conditions and traffic along the airway, and directing them to traffic-safe altitudes or to emergency landings.

Radio range stations outline the airways with a network of directional "beams," providing course guidance in "instrument-flying" weather. Radio "marker-beacons" located along the beams provide frequent position checks.

Radio instrument-landing systems help bring aircraft safely down through fog and cloud conditions that would otherwise prevent landing.

Radio direction-finders, or "radio-compasses," both ground and aircraft installations, are still another important radio aid to air navigation.

This Lesson, the first of a series dealing with aviation radio, is intended to show you how radio is used to promote the safety and efficiency of flight. We shall give you a preview of the operation of both government and private radio systems, discussing their purposes, how and by whom they are used, and how they affect airline and private flying. Complete technical descriptions of the receivers and transmitters used in aviation services will be given in later Lessons.

AVIATION COMMUNICATIONS

In the relatively few years that have elapsed since the first airlines began, the industry has made enormous strides toward improving the *reliability* of air transport. Much of this progress is attributable to improved communications. Experience has shown that aircraft in flight must rely on radio as the only practical means of communication with the ground, and that contact with the ground is vital to safety of flight. An aircraft communications system must meet the following basic requirements:

(1) It must keep aircraft in flight advised of weather conditions existing and expected, so that flight-planning may be continued *after* take-off.

(2) It must provide radio course guidance under conditions of low ceilings and reduced visibility.

These needs are met by a co-operative, nation-wide system of government radio stations operated by the C.A.A. (Civil Aeronautics Administration) and ground stations operated by each airline company along its own route. Trans-oceanic airlines use the same radio navigational aids as are used on ships—radio beacons and loran; these aids are maintained by the U. S. and foreign governments.

C.A.A. Radio Facilities. The Civil Aeronautics Administration operates a vast, country-wide net of radio weather-beacon stations (radio "range" stations) and airways traffic control stations, linked by teletype circuits and radio channels. At or near airports having the required activity to justify C.A.A. aids, are traffic control towers and radio instrument-landing systems. Radio marker beacons of various types are provided to identify distinctive features on the airway, such as intersections of radio range courses, changes in terrain, control zone boundaries, and the "cone of silence" of a radio range.

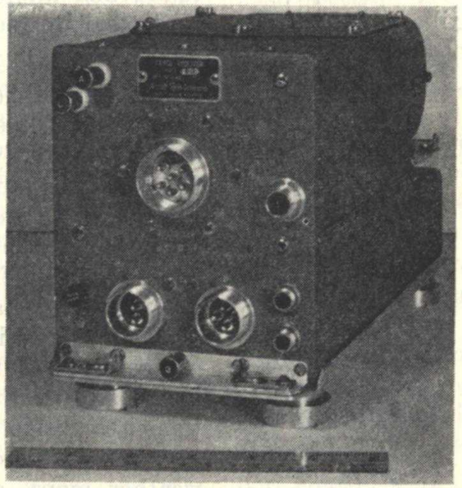
Courtesy C.A.A.

This is one of the Airway Traffic Control centers, operated by the C. A. A., that exert control over all scheduled flights along the country's airways. At the left in the picture is the Flight Progress Board, on which a detailed, continuous record of each flight is kept. Teletype receiving equipment is visible at the right.

Airline Company Ground Stations. Operating in close co-operation with the government services are the privately owned radio facilities of each airline. The importance attached to radio communication by airline operators is illustrated by the amount and modernity of the ground radio equipment installed at airline terminals. Transmitting and receiving equipment capable of maintaining two-way radiotelephone communication on several frequencies with aircraft and other ground stations is provided at each airport; in addition, point-to-point radiotelegraph service is provided between major terminals, dispatch centers and divisional points. Most companies operate one or more large radio maintenance bases—usually at overhaul points—to keep the transmitting equipment within the frequency tolerances specified by the Federal Communications Commission.

Aircraft Radio Installations. To make full and efficient use of ground radio facilities, the airplane must be equipped with special-purpose radio receivers and transmitters. A typical commercial aircraft installation consists of the following units:

(a) A transmitter capable of transmitting on the company radio frequencies and on the government-calling frequencies.



Courtesy Aircraft Radio Corp.

A typical range receiver used aboard aircraft. It operates in the low-frequency range spectrum (190-550 kc.). Notice how compact it is (the ruler in the foreground is six inches long).

The transmitter is equipped with crystal-controlled tuning units for each of these frequencies, and frequency selection is accomplished by a simple switching operation.

(b) A receiver capable of receiving on the assigned company frequencies; since it need operate only on these fixed frequencies, it is also equipped with crystal tuning units, and tuning is accomplished by switching in the desired unit.

(c) A receiver capable of receiving low-frequency radio range and beacon signals, and one to receive VHF omni-range signals. The low-frequency receiver is known as the "beacon" receiver, and is usually tuned over the 200-400 kilocycle band. The omni-range receiver operates over the 108.3-mc. to 118-mc. band.

(d) In addition to the minimum equipment listed above, most transport planes are equipped with an auxiliary beacon receiver, a v.h.f. marker beacon receiver, and a radio-compass receiver. The radio-compass receiver is usually tunable over both the range band (200-400 kilocycles) and the standard broadcast band (550 to 1500 kilocycles). With the radio-compass, the pilot can "home" on any simultaneous range, H facility, or broadcast station whose location is known, or may plot his position by taking bearings on two or more stations.

Aircraft radio equipment is characterized by ruggedness and simplicity of operation. It is usually remotely controlled from control units located in the cockpit; the control units incorporate only the necessary volume, tuning, and switching controls. The radio equipment is usually powered by dynamotors, which are operated from a standard 12- or 24-volt aircraft storage battery.

AIR TRAFFIC RULES

The C.A.A. has established air traffic rules for both clear-weather (contact) and bad-weather (instrument) flying, and has specified minimum "ceiling" and visibility conditions for take-off and landing, day or night. These minimums may differ for different airports, depending upon the local terrain, airport facilities, etc.

When the weather is clear, a pilot can navigate "contact" by visual observation of landmarks or light beacons, and continual direction from the ground is not necessary; however, certain general air traffic rules, such as airport landing and take-off control, apply at all times. But when flying "on instruments," a pilot is directed into certain air lanes at specified altitudes, and all plane movements are controlled by radio from the ground.

Flight Plan. Preparation for flight begins some time before take-off—in fact, with airlines it is a continuous process. Hourly weather reports from weather-reporting stations along the airway, and regional forecasts prepared by the U. S. Weather Bureau, are taken from the teletype and studied by dispatchers and meteorologists. The dispatcher checks the estimated load, maximum permissible fuel load, weather and field conditions, condition of equipment, etc. Company meteorologists prepare weather maps, analyze the weather trend along the airline route, and prepare "flight forecasts" containing predictions of winds aloft, air conditions, probable icing conditions at various altitudes, and local weather conditions to be expected at various airport terminals. From this mass of information, supplemented by a "briefing session" with the dispatcher and meteorologist, the pilot computes his flight plan on a form provided for that purpose. The flight plan includes the following information:

(1) Estimated departure time, estimated times over check points and between scheduled stops.

(2) Altitudes and type of flight (contact or instrument).

(3) Alternate airports (to be used in case weather conditions prevent landing at regularly scheduled terminals).

(4) Total amount of fuel aboard and estimated amounts used en route.

(5) Cruising speed.

A flight plan must be submitted for every proposed flight, whether private, scheduled airline, or military. Scheduled airline flights are "cleared" by both the company dispatchers and C.A.A. Airways Traffic Control; other flights are cleared only by the C.A.A. However, any change in flight plan after departure, for any type of flight, must be approved by the C.A.A. Airways Traffic Control.

Air Traffic Control

In addition to general air traffic rules and safety regulations, the C.A.A. has established a system of traffic control to cope with the recent tremendous increase in air traffic. This system provides complete, centralized control of all air traffic by air traffic "controllers," stationed at airport control towers and at traffic control centers along the airways. Two-way radiotelephone communication enables these controllers to contact any aircraft within the station's control zone.

Air traffic control starts at the airport, where it is called airport traffic control, and extends along the airways, where it is known as airways traffic control. Control towers at the airport direct traffic in the immediate vicinity of the field (within a 25 to 30 mile radius), and airways traffic control centers regulate traffic along the airways.

THE CONTROL TOWER

An airport control tower is responsible for issuing information and instructions to aircraft on or in the vicinity of the field—departing, approaching, landing, or taxiing. These instructions are transmitted almost entirely on VHF (118 to 135 mc.). About 99% of control tower traffic is on VHF.

The information transmitted includes everything essential to safe handling of aircraft in airport traffic, including such information as wind direction and velocity, weather, take-off, landing and taxiing instructions—in short, what to do and when to do it.

Airport traffic control is primarily concerned with preventing collisions, both in the air and on the ground, and with expediting traffic into and out of the airport. Flights approaching the airport are "cleared to the tower" when they approach the airport control zone limits, and the control tower directs their movements from that time until they pull up to the loading ramp on the ground. In contact weather the landing instructions are routine; however, if several flights simultaneously approach an airport "on instruments" the control problem becomes more complex. The flights must then be "stacked up"—that is, directed to circle at specified altitudes—and allowed to land in turn.

Each controller in a tower performs a given set of duties. Each set of duties is assigned a position designation—usually A, B, or C, since the control tower team usually consists of three men. In the event that the control tower team consists of less than three, the duties of the extra position must be shared.

Controller A instructs pilots by radio when and where to taxi and take off; in other words, he handles ground traffic on the airport.

Controller B assists controller A and also operates the airport interphone system and records all messages received on that system.

Controller C handles approaching and landing aircraft, telling them when and where to land.

The term "operator" as applied to the man handling the microphone, and "recorder" as applied to the controller logging messages and posting plane movements on a flight progress board, have also come into general use. Also, if the control tower team consists of more than three men, "assistant controllers" work as "calculators," posting movements of aircraft flying at upper levels (probably not landing), and "controllers" handle aircraft flying at lower levels.

Control tower operating is exacting work, demanding constant vigilance and cool, quick thinking in emergencies. When an aircraft is taxiing, for example, the pilot's vision is somewhat restricted, and, because of the speed of air traffic, possible collision situations develop rapidly. It is the duty of the control tower to anticipate these situations and to act quickly to prevent accidents.

Control Tower Transmitters. The typical airport control tower transmitter is a low-power (50- to 100-watt), radiotelephone transmitter capable of reliable transmission within a radius of 25 to 30 miles, on frequencies between 230 and 500 kilocycles (or 130 megacycles). It is usually powered by a 100-120-volt, 60-cycle a.c. source.

The transmitter is crystal-controlled (allowable frequency deviation ±0.01%), and the audio equipment is capable of 100% modulation of the carrier. Tuning meters are provided so that the transmitter may be adjusted without using external meters or tuning devices. No control equipment other than a "press-to-talk" microphone is needed to operate the transmitter.

Control Tower Receiver. A typical control tower receiver is a four-band superheterodyne with frequency bands of 150-410 kc. (long-wave), 530-1800 kc. (standard broadcast), 1800-6400 kc. (medium-wave), and 6400-23,000 kc. (short-wave). At least four sets are necessary, because control towers must continuously "guard" at least four frequencies: These are: the frequencies assigned for general calling, to airlines, to military aircraft, and to itinerant aircraft. Therefore, at least four, and sometimes as many as six or seven, loudspeakers are mounted in the control tower. Many times calls are received on several or all of these speakers simultaneously, and close attention—and considerable practice—is required to differentiate between them. The receiver installation is usually housed at some distance from the control tower, and one or more technicians are always in the receiver room.

THE AIRWAYS TRAFFIC CONTROL CENTER

It is important to distinguish between airport and airway traffic control. Airport control is localized to small zones around airports (25 to 30 miles radius); airway traffic control extends along the airways. Once clear of the airport control zone, a pilot contacts ATC, and the center assumes

control of his movements along the airway.

The control center may be located at an airport or fifteen to twenty miles away from the airport, along an airway. If located at a large "hub" air terminal, its control may extend along all the airways that converge at the hub.

The control center is responsible for issuing information and instructions to pilots of aircraft under its control to prevent collisions between aircraft flying "on instruments" and to minimize delays to scheduled aircraft operation. If an aircraft is operating under contact flight rules, it is the pilot's responsibility to avoid collision with other aircraft.

Airways traffic control prevents collisions along an airway by establishing safe traffic separation—vertically, horizontally, and in time. In effect, it assigns to each aircraft a reserved air space (which moves with the plane) about 30 miles long (10 minutes flying time at 180 miles per hour), 5 miles wide (one-half the width of a civil airway), and 1000 feet high (the minimum allowable vertical separation when the visibility is less than one mile).

The C.A.A. has established standard air traffic control procedures for the guidance of traffic control personnel; however, if instances arise in which air traffic can be more efficiently or safely controlled by deviating from these standards, it is the responsibility of control personnel to exercise their best judgment in each individual instance.

C.A.A. control centers issue traffic information by radiotelephone to aircraft under their control as follows:

(a) To an air carrier (airline) aircraft unless the airline operator has advised the center that issuing traffic information to its aircraft is unnecessary.

(b) To any aircraft upon request.

(c) To any aircraft being operated in weather conditions bordering between contact and instrument flight rules, and when, in the judgment of the control-

Courtesy C.A.A.

An assistant controller posting information on the Flight Progress Board of an Airways Traffic Control center.

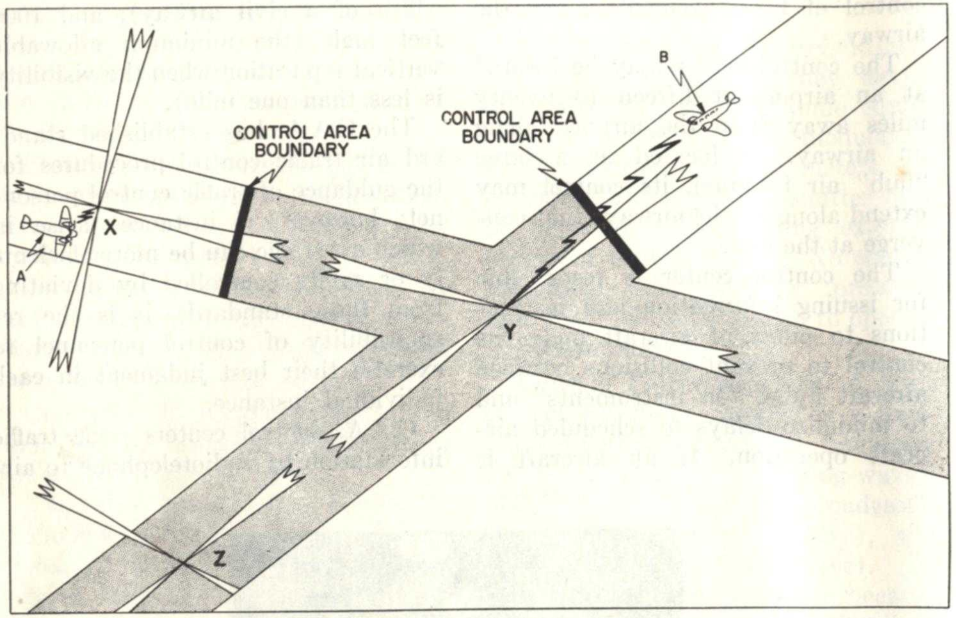


FIG. 1. Aircraft leaving one control area and entering another must be cleared by radio before entry. The communication station issuing the clearance may be in either control area.

ler, traffic information is necessary to prevent the possibility of collision.

CLEARANCES

After preparing his flight plan, an airline pilot receives two clearances before taking off. The first is a company clearance or release, issued by the flight dispatcher. This clearance is based on such factors as equipment, crew, weather conditions, fuel load, and field conditions. A typical company clearance includes the following information:

(a) Company flight designation.
(b) Points between which cleared (via intermediate stops).
(c) Type of flight (contact or instrument).
(d) Minimum fuel load.
(e) Alternate airports (if instrument flight).
(f) Dispatcher's signature.

The second clearance is the airway traffic control clearance; it is concerned only with *traffic conditions*.

Traffic clearances (flight plan approval), traffic control instructions (flight plan amendments), and traffic information are broadcast by radiotelephone from a control center, and are worded in accordance with standard phraseology to avoid error. Traffic clearances must conform to the following standard form:

(a) Flight identification.
(b) Clearance (points to and from which cleared).
(c) Approved altitude, approach, or departure instructions.
(d) Special instructions (holding instructions, etc.).
(e) Message delivery information and/or cancellation time, if required.

A traffic clearance always covers a specified and limited portion of the control area of the center issuing the clearance; the clearance limits depend upon existing traffic conditions, the nature of the flight, and other relevant factors. The point to which an aircraft is cleared is termed a "clearance limit," normally either a point of intended landing (range station, tower or airport), a reporting point (fix or holding point), a boundary point of a control area, or "above 14,500 feet" or "below 3500 feet." In some cases a complete flight may be approved by issuing one clearance—"flight plan approved."

Clearance Transmission. A control center clears an aircraft from clearance limit to clearance limit by issuing the text of its traffic clearance to the appropriate communications agency at least five minutes before the aircraft is due to arrive over or depart from the point to which it was last cleared.

An example of a clearance from a control area boundary is illustrated in Fig. 1. Plane A has previously been cleared to the control area boundary by another center. A clearance is then furnished to communication station X for delivery to plane A at the time that plane A is estimated to pass over X.

In the case of plane B, the clearance is delivered by communication station Y *before* plane B enters the control area. Note that in both cases the aircraft are cleared before entering the control area.

Although the traffic control center is required to deliver the clearance to the appropriate communications agency, it is the pilot's responsibility to obtain the required flight plan approval. The following responsibilities are clearly set forth:

1. The airway traffic control center is responsible for issuing the necessary clearances and for delivering them to appropriate communications agencies.
2. Air carrier operators (airline dispatchers or radio personnel) are responsible for delivering ATC clearances to the pilot, or, if unable to make delivery, for notifying ATC of non-delivery within five minutes of the expected delivery time.
3. The pilot is responsible for obtaining the proper flight plan approval. This responsibility cannot be waived except in emergencies.

The control area allocated to each control center is indicated on airway traffic control area maps regularly issued by the C.A.A.

C.A.A. Aeronautical Communication Net

In addition to airport control towers and airway traffic control centers, the C. A. A. maintains a net of radio stations known as "aeronautical communication stations." While controllers at airports and traffic centers are busy regulating aircraft flight movements, a constant stream of weather data is relayed by teletype along this net of stations and broadcast to planes in flight. The net includes range and beacon stations, weather reporting stations, and point-to-point radio stations of various types. In many cases several of these facilities are combined and housed together as one station. Operator-employees at these stations are known as "communicators."

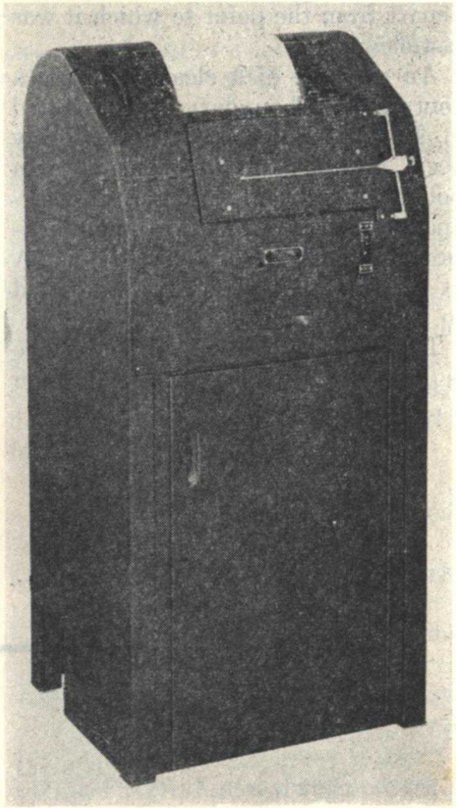
Since a communications system cannot be understood unless the function of each component is known, let us consider briefly each of these facilities. More complete technical discussions will be included in future Lessons.

WEATHER REPORTING

Handling weather message traffic is one of the most important services in aviation communications. At every airport and airways station, weather instruments are read periodically, local weather conditions observed carefully, and a message composed (coded in standard weather symbols) describing the local weather. At large air centers the weather observer is an employee of the United States Weather Bureau; he is usually a trained meteorologist who draws weather maps from the reports received from smaller airways stations and makes regional weather forecasts. At intermediate and emergency fields, the C.A.A. communicator also acts as weather observer. He compiles the weather data, sends it along the airway by teletype or radio, and broadcasts it to planes in flight.

TELETYPE CIRCUITS

To effect rapid sequence collection of weather information, and to insure a minimum delay between the time of observation and the time of transmittal of such information to aircraft, the C.A.A. maintains a teletype system



Courtesy Teletype Corp.

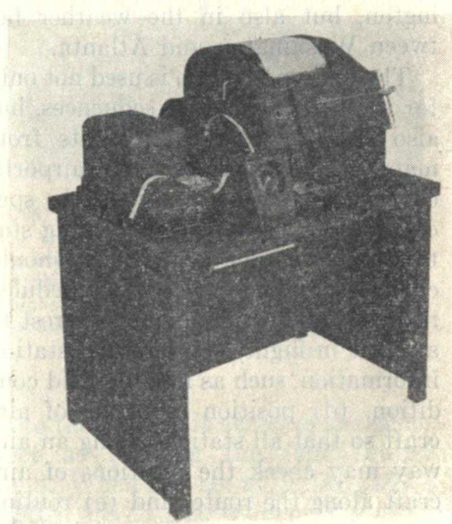
A model 15 receiving teletype printer used in C. A. A. communications. This basic model is used in several different cabinets.

that link the weather reporting stations with the aeronautical communications stations. This teletype service is also installed at airports, making weather information available to pilots prior to departure. After take-off, a pilot may ascertain changes in weather conditions along his flight route by listening to the airways weather broadcasts.

The teletypewriter lines are leased from the American Telephone and Telegraph Company, but the equipment is owned and maintained by C.A.A. Both manual and automatic teletype machines are in use. The automatic teletype uses perforated tape, which is cut on a special "perforator" machine having a typewriter keyboard. The tape can be cut at any speed, just as easily as a message is typed. The prepared tape is fed to the automatic teletypewriter at about 75 words per minute and the message appears typed on a tape or page in the receiving machine.

The C.A.A. teletype network is divided into chains of stations along the principal airways, so that a given station need handle only the weather information applying to the airway on which it is located. Manually operated teletype machines are used at such stations. Every hour, all the stations on a teletype chain report, in sequence, the weather information collected by the local weather observer.

Let us follow a typical weather report sequence, say along the Washington-Atlanta route. At a given time, the Washington operator originates the sequence by typing the current weather observation on the teletypewriter. Simultaneously, the message is received on all machines in the chain. When he has finished, the Washington operator rings a signal bell, informing the Quantico (next station on the sequence) operator that the circuit is clear for his report. The Quantico operator reports immediately; his report also appears simultaneously on all machines immediately after the Washington report. Quantico is followed in turn by Richmond, South Boston, Greensboro, Charlotte, Spartanburg, Anderson, Jefferson, and Atlanta, in that order. When the Atlanta operator has finished, a detailed account of the weather along the Washington-Atlanta airway is before the operators at each of the stations, including the aeronautical communication stations at Washington, Richmond, Greensboro, Spartanburg, and Atlanta. These stations then immediately broadcast the information to aircraft in flight.



Courtesy Teletype Corp.

A model 19 teletypewriter assembly in use by the C. A. A. This equipment consists of a printing unit, a transmitter unit, and a model 14 transmitter-distributor. This last is a device that automatically and simultaneously transmits teletype signals to the various circuits in a network.

At the terminal airports (Washington, for example), both manual and automatic teletypewriters are used The sequence messages typed on the manual machines along the route automatically cut the transmission tape for the automatic machine, which then transmits the complete sequence—automatically and at high speed—to other major air terminals such as New York, Chicago, Kansas City, etc. Such widespread dissemination of weather information is required for the preparation of weather maps and also because of the length of flight of many airliners. The pilot of an airplane leaving New York for Atlanta, for example, is interested not only in the weather from New York to Washington, but also in the weather between Washington and Atlanta.

The teletype system is used not only for the hourly weather sequences, but also for (a) weather forecasts from many of the larger terminal airports, covering 4- to 6-hour periods, (b) special reports by weather reporting stations if weather conditions should change sufficiently between scheduled reports to be of immediate interest to aircraft in flight, (c) terminal station information, such as landing field condition, (d) position reporting of aircraft so that all stations along an airway may check the positions of aircraft along the route, and (e) routine government messages essential to the efficient operation of the entire communications system.

THE SMRA RADIOBEACON TRANSMITTER

The transmitter installed at most C.A.A. airways communications stations performs a dual service; it broadcasts weather information to aircraft in flight and also transmits the radio range (course-guidance) signals.

This type of transmitter is called the simultaneous radio-range beacon (SMRA) transmitter. It transmits the range signals and provides for simultaneous voice broadcasts without interrupting the range signals.

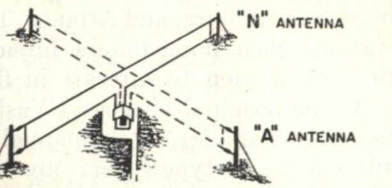


FIG. 2. This crossed-loop antenna system is used by range stations that transmit radiotelegraph signals only.

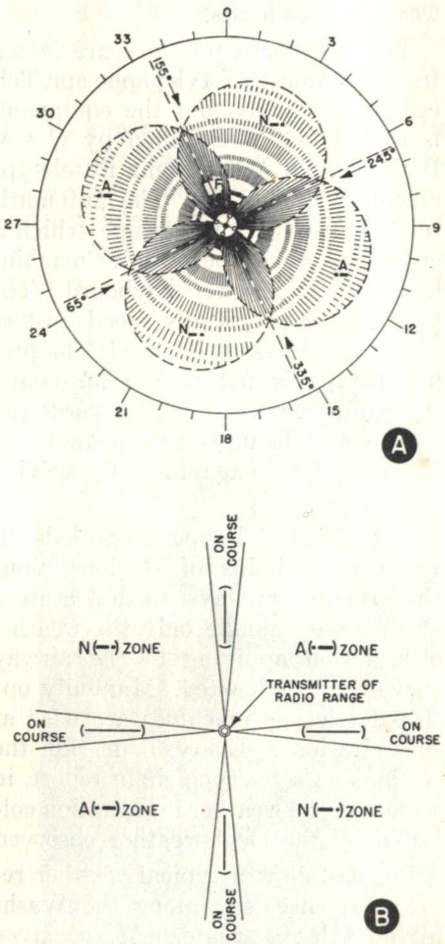


FIG. 3. The field pattern formed by the crossed-loop antenna of Fig. 2 is shown in part A. Notice that the pattern of one antenna forms a figure 8 in which the signal "A" is heard, and the other forms a similar figure 8, at right angles to the first one, in which the signal "N" is heard. In the areas in which these two patterns overlap, these signals blend to form a steady 1020-cycle hum. Thus, four areas are formed in which a steady hum is heard; these areas form the "beams" of the station, which are shown in part B.

Range stations that transmit only radiotelegraph range signals use a crossed loop antenna system (Fig. 2); the field pattern of this system, and the four "beams" formed, are shown in Fig. 3.

Simultaneous transmission of voice and range signals is accomplished by using four vertical radiators, disposed at the corners of a square, to transmit the range signals, and a fifth vertical radiator, centrally located, to transmit the voice signals. The antenna arrangement is shown in Fig. 4. The transmitter is equipped with two independent RF channels—both crystal-controlled—that differ in frequency by 1020 cycles. The continuous carrier output of one channel (about 400 watts) is fed to the central radiator and the RF output of the second channel (about 275 watts) is fed alternately to diagonally opposite pairs of towers (Adcock antenna systems). At the transmitter is a device called a goniometer, which is used for changing courses if necessary. By changing the phase relationships of the signals fed to the towers, it achieves the same effect as rotating the four towers would. When it is set at 0°, 90°, 180°, or 270°, one diagonally opposite set of towers radiates an A signal (dot-dash), and the other pair radiates an N signal (dash-dot.) The A and N signals are interlocked so that if they are received with equal intensity, a steady 1020-cycle "on course" signal is heard. On one side of the "on course" leg the N signal predominates, and on the other side the A signal is heard. Directly above the range station is a region in which the signals cancel, because the pairs of towers are opposite in phase. This region is known as the "cone of silence" (see Fig. 5).

When a voice broadcast is made, the RF input to the central radiator is modulated by the speech frequencies; interference between the speech and the 1020-cycle course signals is pre-

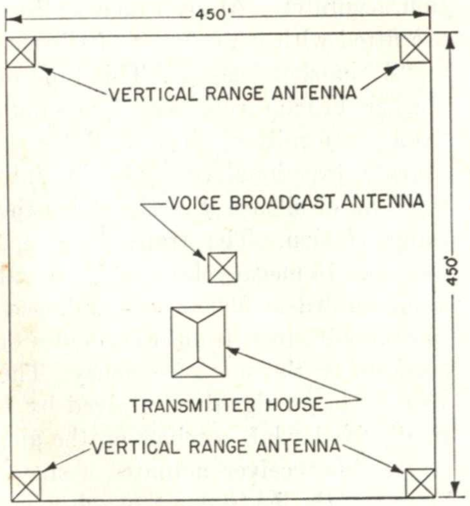


FIG. 4. This is the arrangement of antennas used in range stations that transmit voice as well as code signals.

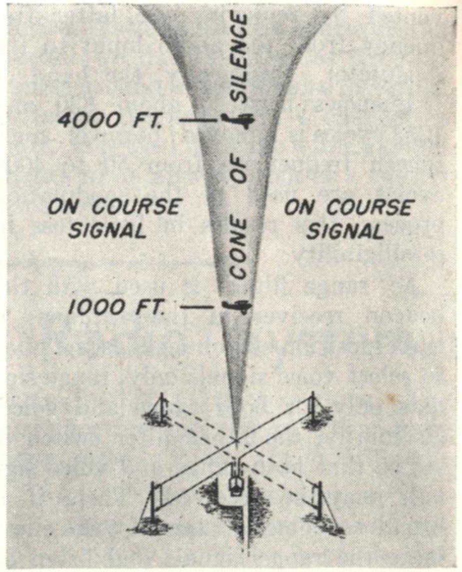


FIG. 5. The signals fade out directly over a range station, producing a "cone of silence." At relatively low altitudes, this cone shows a pilot the location of the station fairly well. At higher altitudes, however, the cone becomes so broad that it gives only a general indication of where the station is.

vented by removing the latter frequency from the audio input to the modulator. Practically, the band of frequencies between about 830 and 1252 cycles is removed; however, since speech frequencies from 50 to 4000 cycles are used in the modulation process, this results in little loss in intelligibility.

A "range filter" is used with the beacon receiver in the airplane; a three-position switch enables the pilot to select voice signals only, range signals only, or both range and voice. Ordinarily, the range filter switch is set so that both range and voice signals may be received. Then, if a broadcast comes on, the pilot can eliminate the range signals and listen to the broadcast, eliminate the broadcast and listen to the range, or listen to both range signals and broadcast simultaneously. Under ordinary atmospheric conditions, the simultaneous signals can be received satisfactorily on an ordinary receiver not equipped with a filter. By concentrating on either the voice signals or the range signals, the pilot can listen to either one, just as a broadcast listener hears both music and the words of an announcer at the same time.

A typical SMRA station consists of a transmitter house containing the transmitter, goniometer (for adjusting the orientation of the radio range course legs), and the control equipment. The antenna system consists of five 125-foot steel towers, fed by coaxial transmission lines from the transmitter. The four outside steel towers are located at the corners of a square having sides about 450 feet long. If the station is near an airport, the extended center-line of the most frequently used runway usually coincides with one of the diagonals of the square. The transmitter house is located near the central tower.

Airway weather broadcasts can be reliably received up to approximately 100 miles from a radio-range station, depending on atmospheric conditions. The nearest station should be used to avoid interference, since, because of the limited frequency band and the number of range stations, stations only 400 miles apart may operate within 6 kilocycles of each other. Also, weather broadcast schedules are so arranged that it is rarely necessary for a pilot to listen to a distant station for weather information pertaining to his flight route.

The technical details of C.A.A. ground station equipment will be more fully discussed in a later Lesson.

MARKER BEACONS

The width of the "cone of silence" above a range station is about 700 feet for each 1000 feet of altitude; therefore, at high altitudes, the "cone of silence" of a range station is so broad that it is hard to locate the station accurately. Many range stations are fitted with v.h.f. "cone of silence" or "Z" marker beacons. This type of marker beacon consists of a small, fixed transmitter that radiates a sharply directional vertical beam into the cone of silence directly above the range station. The transmitter operates at 75 megacycles, and its signal is modulated at 3000 cycles unkeyed, to differentiate it from other types of markers on the same frequency. The vertical beam signal is received by a small, fixed v.h.f. receiver on the aircraft; this receiver actuates a signal lamp on the instrument panel when the airplane flies through the beam.

Another type of high-frequency marker beacon is the "fan" marker, so called because of the shape of the cross-section of its vertical beam. This type of marker beacon also operates on 75 megacycles modulated at 3000 cycles, but it is keyed. The keying indicates its location. One dash indicates that it is the first course east of north, two dashes indicates the next course around in a clockwise direction, 3 dashes the next, and 4 dashes the next. It is used to define a line at right angles to an airway, such as a control zone boundary.

Airline Company Radio System

The purpose of an air transport company is to "transport merchandise, mail, and passengers, for hire." It differs from other common carriers only in that air is the transport medium, rather than land or sea; therefore, an airline company must assume the same obligations as any other public transport company. Its air routes must be flown on schedule, and the schedule must be maintained without avoidable loss of life or cargo. The speed of air transport and the added complexities of three-dimensional navigation over the two-dimensional systems of rail and sea make the operating requirements even more rigid. Reliable company communication is vital, if these requirements are to be met.

The C.A.A. radio facilities are for the specific purpose of safeguarding life; the company radio facilities serve both to increase the safety of flight and to make possible the high degree of organization that enables an airline to function efficiently. The company radio system coordinates the activities of flight dispatchers, pilots, meteorologists, station managers, and operations and traffic personnel, and keeps the entire airline advised of the progress of each flight.

TYPES OF STATIONS

The Federal Communications Commission has classified all types of stations in the aviation service. The classification applying to airline company radio stations are as follows:

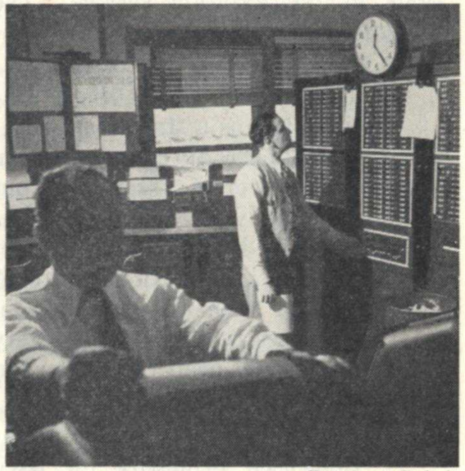
(a) The term "aeronautical station" means a station used primarily for radio communication with aircraft stations, but which may also carry on a limited fixed service with other aeronautical stations in connection with the handling of messages relative to the safety of life and property in the air.

(b) The term "aeronautical point-to-point station" means a station used primarily for fixed service in connection with the relay of messages destined for or orginating on aircraft and relating solely to the actual needs of the licensee.

(c) The term "aircraft station" means a radio station on board an aircraft.

Company radiotelephone stations are, in general, "aeronautical stations," since they are used primarily for communication with aircraft. However, they may also be used to transmit information relative to the safety of flight to other aeronautical ground stations. Such operational information may be weather information, dispatch traffic pertaining to the departure, arrival, or position of flights, or radioed clearance and flight orders from the company dispatcher to airline stations or aircraft in flight.

Radiotelegraph service is, in general, "point-to-point," since radiotelegraph channels are used primarily for traffic not directly relating to the safety of flight, but relating "solely to the actual needs of the licensee." Such traffic may be company business messages, such as traffic forecasts to advise personnel throughout the



Courtesy C.A.A.

A view of part of the Airways Communications Center at La Guardia Field, N. Y.

airline of probable operations for the coming day, reservation request messages, etc.

AERONAUTICAL RADIO, INC.

Most of the privately owned airline radio stations are controlled by Aeronautical Radio, Inc., a non-profit organization set up by the airline companies to coordinate their individual radio systems and to act as an intermediary between the companies and the Federal Radio Commission and other government agencies. Although the radio equipment is owned by the airline company and maintained and operated by company personnel, the stations are leased to Aeronautical Radio. All frequency assignments and licenses for aeronautical stations and aeronautical point-to-point stations are granted by the Federal Communications Commission to Aeronautical Radio, Inc., which then assigns frequencies to the airline companies on a chain basis. Aircraft station licenses, however, are issued directly to the airline company by the Federal Communications Commission.

Aeronautical Radio is responsible to the Federal Communications Commission for the legal operation of all aeronautical stations under its jurisdiction and issues instructions regarding station operation to the airline companies. In case of conflict or interference between stations of different airline companies, Aeronautical Radio decides what changes are necessary.

Aeronautical Radio, Inc., is at present licensed to operate more than 300 aeronautical stations for radio-telephone operation. More than 100 of these stations are also licensed for radiotelegraph (C.W.) operation as aeronautical point-to-point stations. Transport companies hold several hundred licenses for aircraft stations; many other stations of this type are operated by private flyers and government activities.

Frequencies. Because of the propagation characteristics of radio waves in the 2900-6600 kilocycle aviation radio-frequency band, a single frequency, in general, is insufficient to maintain reliable communication throughout the twenty-four hours. Frequencies at the lower end of the band are more satisfactory during the darkness hours and frequencies near the upper limit of the band are better during daylight. Two frequencies—known as "day" and "night" frequencies—are therefore assigned to each airline, or to each division of each

airline. For example, Northwest Airlines route between Chicago and Seattle is divided into two divisions, which have the "day" and "night" frequency assignments given below.

	East Div'n.	West Div'n.
DAY	5377.5 kc.	4917.5 kc.
NIGHT	3005 kc.	2994 kc.

In addition, four C.W. frequencies in the band from 2644 kilocycles to 10,965 kilocycles are also provided. The C.W. frequencies are common to all stations on the airline equipped for radiotelegraph operation.

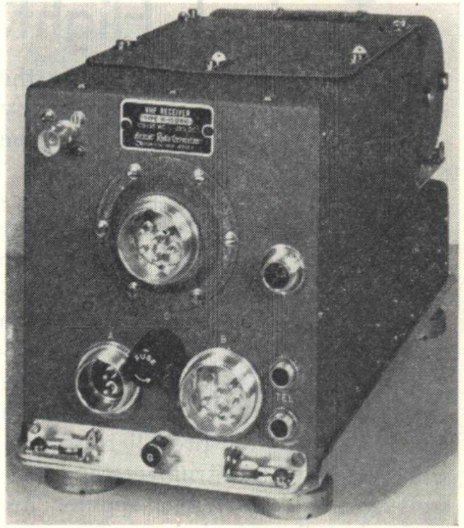
TYPICAL GROUND STATION

A typical airline ground station consists of a 1000-watt, multi-channel, crystal - controlled radiotelephone transmitter, a 400-watt, multi-channel, crystal-controlled radiotelegraph transmitter, a set of remotely controlled, fixed-frequency receivers, a set of manually operated auxiliary stand-by receivers, and a beacon monitoring receiver that can be tuned over the 200-400 kilocycle range- and beacon-frequency band. Many airlines operate VHF receivers tuned to approach control frequencies.

Transmitter frequency changing is automatic; frequency selection is made with a selector switch or dial-control system. The transmitter is provided with a dummy antenna for test purposes and for working aircraft on the ground.

The main receivers (highly selective superheterodynes) are tuned with crystal oscillators to the airline operating frequencies.

All transmitter and receiver controls are mounted on a central control panel known as an "operating position," which is designed to permit complete operation of the equipment with a minimum number of controls. The transmitter controls, for example, may be only a frequency selection control, a switch to throw the dummy antenna in or out, a control to switch from phone to C.W. transmission, and, of course, a switch to turn on the transmitter carrier. This last is usually a "press-to-talk" switch; it may be either a switch on the microphone or a foot-treadle switch. The foot-treadle is more convenient, since it permits the operator to keep both



Courtesy Aircraft Radio Corp.

A typical airborne tunable v. h. f. communications receiver. It is tuned by remote control (notice that there are no tuning controls on the panel of the set).

hands free while operating. The receiver controls need be only a set of preselector switches, a vernier tuning control, a beat oscillator switch (for C.W. reception), a volume control, and an a.v.c. switch. Some sets may also be provided with inter-channel noise suppression systems, or other operating refinements.

The transmitters may each be equipped with tuning units for both radiotelephone and radiotelegraph frequencies, so that in case of breakdown of one transmitter, communication can be maintained (both phone and C.W.) with the remaining transmitter.

In addition to the radio equipment, one or more teletypes may also be installed in or near the radio room so that C.A.A. weather sequences, plane position reports and flight plans, range and beacon operating notices, etc., may be obtained as soon as they are put on the teletype circuit by the C.A.A.

A wind direction and velocity indicator and an altimeter are also placed conveniently near the operating position.

Typical Flight of an Airliner

Let us see how radio fits into the complexity of airline operation by studying a typical, scheduled airline flight.

An airplane in flight is a live, dynamic craft. Uninterrupted power must be delivered to its propellers to sustain it in flight and many instruments must function accurately to navigate it safely. Therefore, the history of a flight actually begins long before take-off. The plane is cleaned and inspected from propellers to tail-wheel; the flight instruments and controls are checked; the engines are "revved up" and their performance carefully noted. A thorough pre-flight preparation of the airplane by the ground crew is most important—nothing is omitted and nothing is glossed over.

PRE-FLIGHT RADIO CHECK

Radio men play an important part in readying an airliner for flight. The operator or technician making the pre-flight radio inspection, whether a licensed operator or not, is known as a radio mechanic. He is required to submit a written report on the condition of the entire radio installation; each airline has its own maintenance forms for this purpose. No discretion is permitted as to what is and what is not to be inspected; ALL equipment is checked in a manner proved by airline experience to be necessary.

The inspection is made well in advance of the scheduled flight time so that the work may be unhurried and thorough; sometimes it is started as soon as the plane has landed from a previous run. A brief of a typical inspection procedure is given below. Note the detail and completeness of the inspection. CARE is the essence of preventive maintenance.

Fixed Antennas: Check condition of wire, joint of lead wire, connection at lead-out insulator, tightness and condition of insulator, fastenings and attachments to fuselage or masts, spring attachments, and strain insulators. Clean all insulators.

Storage Batteries: Storage batteries are checked by mechanic personnel. The battery must be in good condition and all connections must be tight.

Electrical Control Units: Check box mountings, cover fastenings, shield connections, fuses and fuse clips, switch action, volume control operation, and all electrical connections.

Mechanical Control Units: Check mountings, flexible shaft connections, tuning crank action, dial calibration, and bonding.

Frequency Shift: Check mechanical action, fastenings, and connections to receiver and transmitter. When shifting from one frequency to another, make sure that the receiver and transmitter are shifted to the position desired.

Headsets: Check the sensitivity of each earphone, tightness of phone caps and diaphragm, condition of head-band, and cord and plug condition.

Jack Boxes: Check mountings, cover fastenings, jack mounting, connections, ground, shielding, connections to box.

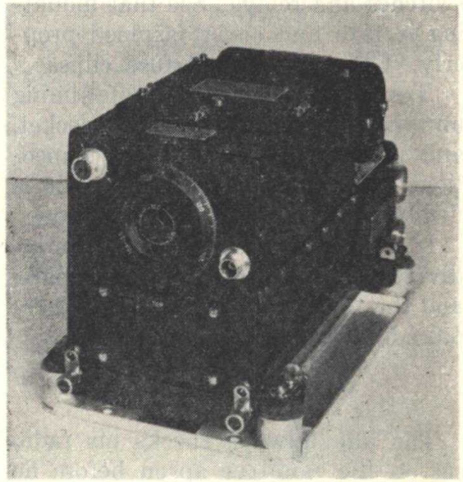
Microphones: Check push-button switch action, modulation ability, case and cord condition, connections, plug condition. Check microphone holder condition and mounting.

Output Control Switch Boxes. Check mountings, moisture shield, action of switches, switch mounting, connections, ground, shielding connections to box.

Power Units: Check mount and fastenings to mount, plug-lock connections, jack, lock and connections, condition of flexible shielding, fuses, action of solenoid switch and dynamotors, mounting of parts on the unit. Check of voltage, electrical noise, etc., will be determined by receiver and transmitter inspection.

Company Receiver: An operating check of the receiver is made by listening on both day and night frequencies. Volume control action, dynamotor noise, ignition, generator or vibration noises, and frequency shift action are observed at this time. Check mountings, fastening in mount, plug connections, antenna connection, bonding on mount, frequency shift, cover fastening, and flexible shielding connections. See that tubes and crystal units are firmly seated in their sockets, that tube shields are tight, and that grid clips are fastened. Oscillator, detector, and antenna tuning should be properly adjusted.

Beacon Receiver: Make an operating check of the receiver by tuning in a number of radio range stations. Check the volume control action, tuning, dynamotor noise, ignition, generator, or vibration noises. Check mounting, fastening in mount, plug connections, antenna connection, antenna transfer switch, bonding on mount and bonding of flexible shafting, drive and connection to receiver and shafting, cover fastening and shielding. See that the tubes are seated firmly in their sockets, that grid clips are fastened, that tube shields are tight, and that airport relay is operating properly. Antenna trimmer condenser should be properly adjusted.



Courtesy Aircraft Radio Corp.

This is a tunable v. h. f. receiver used aboard aircraft for navigation. Notice the dynamotor power supply (the cylindrical object at the top rear).

Auxiliary Receiver: Make an operating check of the auxiliary receiver by tuning in stations of various frequencies in the band. Observe volume control action, tuning, noise from ignition, generator, or vibration.

Transmitter: Make an operating check of the transmitter by communicating with one of the ground stations.

Take meter readings of the circuits on both day and night frequency to check tube condition and circuit tuning. Check mounting, fastening in mount, plug connections, antenna connection and frequency shift action. See that crystals and tubes are firmly in sockets, that output coils are firmly in clips, that the relay action is proper, that cover is fastened.

Terminal Boxes: Inspect wiring and tightness of terminals, jacks, switches and relays. See that mounting is firm and cover fastened properly. Check fuses and fuse clips.

Tuning Unit: If a separate tuning unit is used, check the unit, socket, and mounting. See that all connections are tight and that the unit is firmly plugged into the socket.

If trouble is experienced with an individual unit, it is replaced by a spare, and the faulty unit is checked and repaired in the maintenance shop.

THE FLIGHT

The pilot always checks his radio set on the ramp or apron before he taxis out to the runway for take-off, even though the results of the inspection are noted on the maintenance form. The radio check is entered in the radio log of the station worked, to certify that the radio equipment was in operating condition just before take-off.

The plane has already taken on gas and oil; it now takes on mail and baggage, food for the flight, the stewardess or steward, and passengers. The pilot has the proper clearances and everything is in readiness for flight. Let us follow a typical flight—say a United Airlines flight (number 15) from Chicago to Cleveland.

When flight time arrives, the pilot contacts the Chicago control tower and says, "United fifteen to Chicago tower. Over."

The tower controller replies, "Chicago tower to United fifteen. You are cleared to runway six. Wind north twelve. Altimeter three zero three four. Time zero nine five six."

The pilot sets his altimeter, and taxis to runway number six. He then swings the ship into take-off position on the runway, sets his brakes, and warms up and tries out his engines. When satisfied, he asks his crew on the interphone if they are all set for the take-off and again calls the tower. This time he hears: "United fifteen. Cleared to Cleveland."

Now, to follow the flight en route, turn to Fig. 6. This figure shows the radio ranges and stations on the Chicago-Cleveland airway. Notice that there are four ranges to be followed in this flight — the Chicago range, the Goshen range, the Toledo range, and the Cleveland range. In addition, there are fan marker beacons at McCool and Vermilion that provide general position checks on the radio range courses. The figures beside the shaded range arrows indicate the magnetic course that the aircraft must fly to stay on the range beam.

After taking off from the Chicago airport, the pilot tunes his beacon receiver to 350 kilocycles, the frequency of the Chicago radio range, and follows a magnetic course of 152° (approximately south-southeast). When he is on the proper course, he hears the solid "on course" signal, with the Chicago range identifying signal CHI (—.—. .... ..) repeated at 30-second intervals.

Should the craft get off course to the northeast, the continuous tone would gradually break up and the pilot would hear the off-course signal A (.—). Should the craft get off the course to the southwest, the N signal (—.) would be heard.

Throughout the flight, the co-pilot, or first officer, monitors the company chain frequency to receive any calls from company ground stations, and either he or the pilot transmits position reports to company ground stations at intervals. For example, shortly after take-off, the co-pilot might transmit a position report as follows: "United fifteen to Chicago, reached cruising altitude at ten twelve, south leg of the Chicago range."

After the flight has been under way approximately 15 minutes, the course is changed to 90° (due east) and the beacon receiver is tuned to 320 kilocycles. On this frequency the radio range at Goshen is heard, and the pilot can keep on course by listening to the signals from this station. If the plane drifts to the north, he hears the letter N; if it drifts south, he hears the letter A. On course, he hears the Goshen range identifying signal GSH (——. ... .).

The plane continues on its course until it arrives over the Goshen station; the range signal strength increases as the station is approached until it is necessary for the pilot to reduce the volume frequently so that it will not be uncomfortably loud.

After the plane passes over the Goshen station, a reversal takes place in the course signals. West of Goshen the N signal was to the north of the course; after passing over Goshen the N signal is found to the south of the course. As the plane passes immediately over the radio range antenna system, there is a complete fade-out of the range signals because of the cone of silence directly over the range antenna system.

About 170 miles past Goshen, the beacon receiver is tuned to the frequency of the Toledo range, 239 kc. The identifying signal for this range is TOL (— ——— .—..). Again the off-course signals change

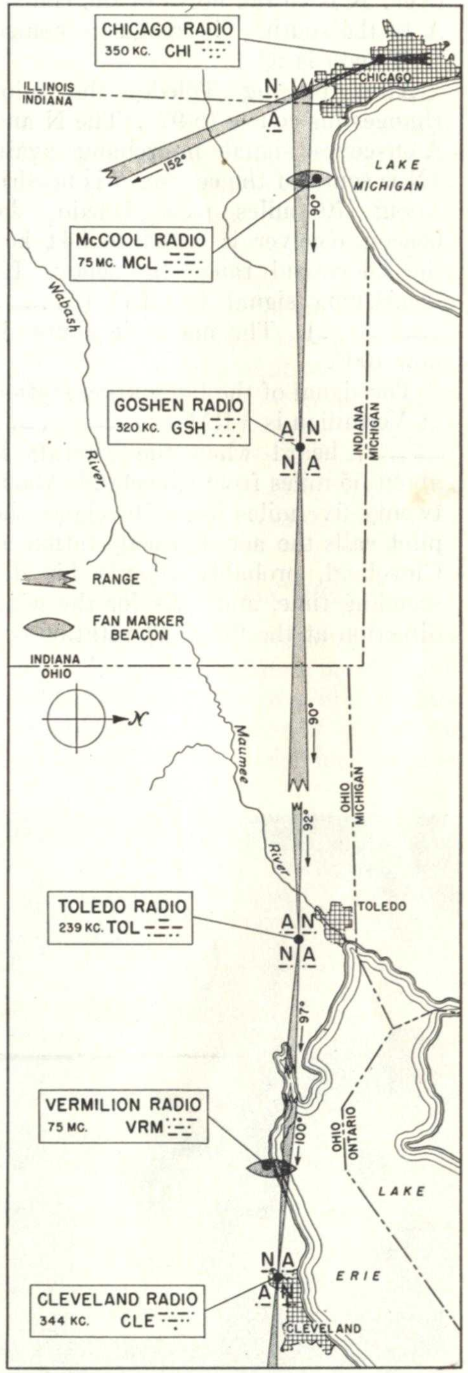


FIG. 6. The principal ranges and markers on the air route between Chicago and Cleveland. Four different beams must be followed to make this flight.

over: N is to the north of the course, A to the south. The magnetic course to Toledo is 92°.

After passing Toledo, the pilot changes his course to 97°. The N and A off-course signals interchange again (N is south of the course, A is north). About 70 miles past Toledo, the beacon receiver is tuned to 344 kc., the Cleveland range frequency. Its identifying signal is CLE (—.—. .—.. .). The magnetic course is now 100°.

The signal of the fan marker station at Vermilion is VRM (...— .—. ——), heard when the aircraft is about 55 miles from Cleveland. About twenty-five miles from Cleveland, the pilot calls the aeronautical station at Cleveland, probably reports his descending time, and asks for the wind direction at the field. The station operator gives him the exact wind direction and velocity, barometer reading, field condition, nature and location of any obstructions, information regarding other planes on the field or in the air near the field, and any other information that may be of value. The pilot then calls the airport traffic control tower and asks for permission to land. From that time until the plane is on the field, the pilot follows the instructions of the traffic control officer.

Safely down, there is a quick turnaround check of all working radio parts if it is an intermediate landing, and a complete inspection and test if it is the end of the run. In either event, the pilot makes a report on the performance of the radio during the flight on the maintenance form that accompanies the flight.

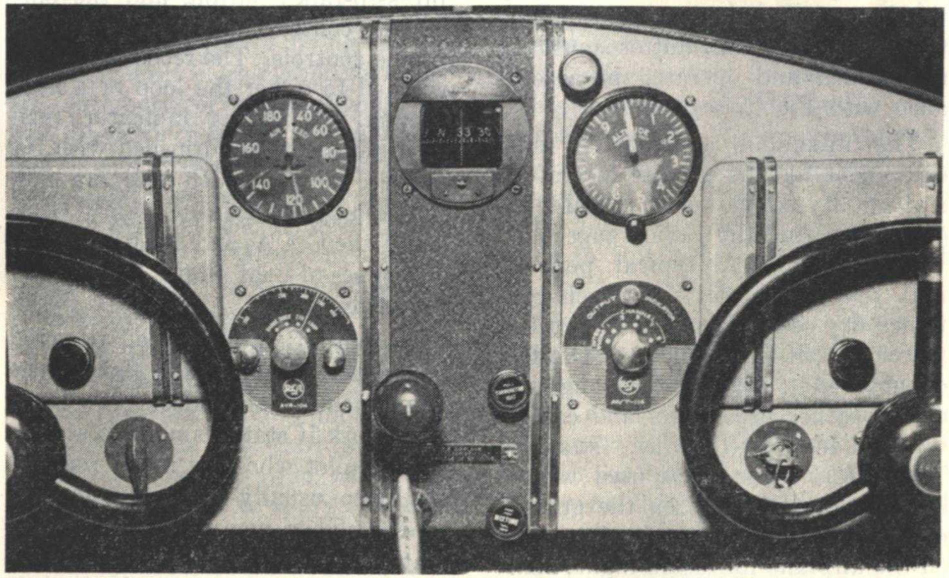
The Itinerant Flyer and Radio

Private (itinerant) flying differs considerably from airline flying; therefore the radio requirements of the private plane differ from those of the airliner. Although at inactive airports, the private flyer can take off when he chooses, when there is a control tower, he is subject to the same instructions from the control tower as a commercial aircraft. Radio equipment is becoming more necessary for the private pilot, and many private planes are now equipped with navigational and communication sets. Most small aircraft are prepared for the installation of radio equipment by the manufacturer; many are sold completely radio-equipped. Private flyers may use both the government and privately owned aviation radio facilities.

The itinerant pilot is not restricted to flying along an established airway; he may fly "cross-country," or directly to his destination, if he wishes. He is entitled to use the C.A.A. radio facilities without charge and may communicate with privately owned Aeronautical Radio stations for a small fee. With as little equipment as a receiver, he can use the radio ranges and receive weather broadcasts; a light, simple transmitter enables him to communicate with the C.A.A. aeronautical stations, airline ground stations, and airport control towers. Many private planes are also equipped with a radio-compass for "homing" and direction-finding purposes.

ITINERANT RECEIVERS

The regulations governing the use of radio by private pilots are few and simple. Anyone can own and operate an aircraft radio receiver, either for navigation or for receiving weather



Courtesy RCA Engineering Products Department

Compact, light radio equipment is used in private planes. This illustration shows an RCA AVT-114 transmitter (at right, beneath altimeter) and AVR-104 receiver (at left, beneath airspeed indicator) installed in an Ercoupe.

broadcasts and airport control tower instructions. The receiver is perhaps the most important single piece of radio equipment that could be installed in a private airplane.

A directional loop antenna may be used with the receiver without special permit. With a single receiver and a directional loop, the pilot can both hear a radio signal and determine from which direction it is coming, thus further simplifying navigation. If the receiver covers the broadcast frequencies (550 to 1500 kilocycles), bearings may be taken on these stations as well as on range stations. Since even the most simple loop antenna is electrostatically shielded, its static pick-up is much less than that of the usual unshielded antenna. In addition to direction-finding, therefore, the loop antenna may also be used to reduce static—an important feature in bad weather flying.

If the private plane is equipped with a transmitter, both the transmitter and its operator must be licensed by the Federal Communications Commission, and the transmitter must be maintained and operated in accordance with F.C.C. regulations.

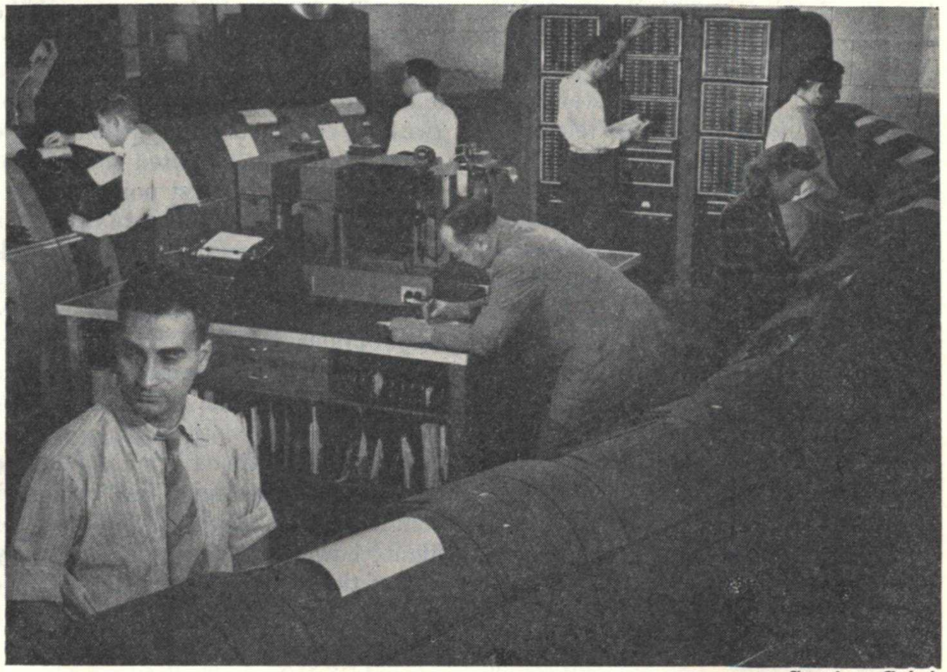
The minimum amount of radio equipment for the private aircraft is a small, dry-cell powered, portable receiver covering the radio range band (200-400 kc.). A typical portable unit operates either from self-contained dry cells or from an a.c. or d.c. power line; it is tunable over two frequency bands, 150-400 kc. (range signals, weather broadcasts and control towers) and 550-1550 kc. (standard broadcast). It may be used with a built-in loop antenna on the ground, or may be switched to a fixed antenna on the airplane for use in flight; similarly, it is equipped with both a built-in loudspeaker and a headphone jack. A typical unit measures only 8½" by 12" by 6", and weighs 12½ pounds, including batteries capable of operating it for 100 hours.

Dry-cell powered radio equipment, both transmitters and receivers, is deservedly popular with private pilots, since it is inexpensive, easy to install, and does not drain the ship's battery or require generators. Such equipment, if well engineered, is sufficient for the private pilot's normal communication needs.

ITINERANT TRANSMITTERS

The transmitter used with this receiver provides a 100% voice-modulated signal or a 100-cycle MCW telegraph signal with a power output of slightly more than 16 watts. The transmitter is crystal-controlled at 3023.5 kilocycles, and another crystal may be substituted in flight for operation on any frequency from 2900-6500 kilocycles. Operation is simple; for example, the only transmitter operating control is the microphone "press-to-talk" button, and the only receiver controls are the tuning and volume controls. The receiver may be switched to either the loop or a fixed antenna. A bearing indicator (azimuth indicator) is furnished with the receiver. Several such sets are now approved by the Aviation Safety Division of the C.A.A. and are installed in some types of light planes at the manufacturing plant.

The output of a dry-cell powered transmitter is ample for short-range communication, and sufficient for long-range work if static is not too severe. For the pilot who flies in all weather (and who usually has a larger airplane), higher powered radio equipment is recommended. These units are basically the same as the dry-cell powered types, but are somewhat larger, operate from a standard 12-



Courtesy C.A.A.

Teletypewriter equipment in use at the Washington National Airport.

volt aircraft battery, and use a special power unit. Larger private planes approaching airline aircraft in performance and type of flying may be equipped with more elaborate receivers, automatic or semi-automatic radio direction finders, and powerful, multi-band transmitters. Some private pilots also install ultra-high frequency marker beacon receivers, radio altimeters, instrument landing equipment, and carry a small battery receiver for emergency use.

HOW THE ITINERANT WORKS GROUND STATIONS

The itinerant plane equipped with a transmitter is a licensed non-scheduled aircraft radio station, and certain rules and regulations apply to the use of frequencies licensed to Aeronautical Radio by such aircraft. The regulations are intended to insure maximum protection of life and property and to minimize radio interference on these chain airline frequencies.

Any call from a non-scheduled aircraft station on a chain frequency indicates that the frequency is being used under proper license, and the call is promptly answered by the aeronautical station. Before transmitting the call, a non-scheduled aircraft station should first tune his receiver to the chain frequency on which he intends to transmit to make sure that the channel is clear.

Aeronautical stations receiving flight plans from itinerant aircraft forward the flight plans to Airways Traffic Control, or to an airport control tower or C.A.A. communications station, preferably to a control center. The aeronautical station would receive a flight plan only if none of the C.A.A. stations are located at the itinerant's point of departure.

Aeronautical Radio requires that private aircraft operators give two hours prior notice of intent to use Aeronautical Radio station facilities. Normally, the private flyer will notify the nearest aeronautical station in person, or by messenger or telephone. Private aircraft may use aeronautical station frequencies only to contact Aeronautical Radio ground stations. These frequencies may not be used to communicate with other classes of stations.

Itinerant aircraft use the radio facilities of Aeronautical Radio stations in the same way as a scheduled airline flight. They report over the same check points or radio fixes, and, having initiated a reporting schedule, will not, under normal conditions, cancel the reporting schedule before landing. Aeronautical Radio stations report the positions of itinerant aircraft to Airways Traffic Control as soon as the position reports are received. Itinerants initiating a reporting schedule and failing to complete the series of two-way contacts will ordinarily be charged for the expected number of contacts up to the first point of landing, unless a reasonable explanation is made. On airways on which no check points or radio fixes have been established (beyond the jurisdiction of Airways Traffic Control), or off the airways, the normal number of contacts is determined by the time interval assigned between contacts.

All contacts are as brief as possible and the messages must be "business" communications necessary to safety of flight; however, in case of emergency any of the regulations restricting traffic may be suspended.

Special Frequencies and Procedures

MISCELLANEOUS CALLING AND WORKING FREQUENCIES

333 kilocycles. General calling frequency for aircraft stations operating outside the North American continent on trans-oceanic flights.

375 kilocycles. International direction-finding frequency for use outside the continental United States.

457 kilocycles. Working frequency exclusively for aircraft on sea flights desiring an intermediate frequency.

500 kilocycles. International calling and distress frequency for ships and aircraft over the seas. (8280 kc. is also used for this.)

1638 kilocycles. Air navigation frequency for aeronautical stations, scheduled and non-scheduled aircraft.

3023.5 kilocycles. National aircraft calling and working frequency for use by non-scheduled aircraft. The use of this frequency is restricted to communications pertaining solely to aircraft operation and the protection of life and property.

3117.5 kilocycles. National aircraft calling and working frequency for aircraft that normally fly regularly scheduled routes. This frequency is used in accordance with the following conditions:

Miscellaneous Maritime Frequencies. Calling and working frequencies of ship stations may also be assigned to aircraft stations, or ship stations, when aircraft are in flight over the seas.

SPECIAL RADIO PROCEDURES

Flying is not like other forms of travel; therefore certain procedure signals are required.

The letters P A N by radiotelegraphy or radiotelephony are sent out from an airplane immediately preceding an impending forced landing—not an impending crash landing. In other words, when a pilot wishes to give notice of damage to the plane that compels the aircraft to land without requiring immediate assistance, these letters are sent.

The *distress* call that should be sent from an airplane by radiotelephone is *mayday*. This was originally adapted from the French "m'aidez," meaning "help me." This should always be followed by the name or number of the plane or the call letters of the plane. If time permits, the approximate position of the plane should follow this broadcast distress signal phrased in regard to what can be seen. As an example, "mayday mayday mayday trip nine over heavy timber beacon light dead ahead about five miles turning back turning back will try to make Platte Canyon one engine out."

The distress signal in radiotelegraphy everywhere consists of the letters SOS. This means that the airplane sending this signal is in grave and imminent danger and requests immediate assistance. A message should immediately follow this call containing the name or number of the aircraft, its position, the nature of its danger or distress, and the kind of assistance needed. Airplanes usually attempt to include the line of action contemplated by the pilot in the impending emergency by saying "jumping" or "bailing out" and the significance of these brief messages is readily understood by anyone receiving them. Any station hearing a distress signal must first listen and NOT commence transmitting until it seems fairly certain that the distress transmission is complete; then immediately take proper action unless some other station broadcasts acknowledgment and announces that it will take action. The proper action indicated is the securing of a promise by competent authority that help of a suitable nature will be dispatched to the scene of the expected crash. (Note that the radiotelegraph distress signals are sent on 500 kc., which is the international calling and distress wave. The radiophone distress call "mayday" is sent on the frequency being used, not necessarily on 500 kc.)

The *urgent signal* consists of several repetitions of a group of X's sent before the call letter of the station called: Example, XXX XXX XFO de KFM. This would be sent by telegraph to station Oakland by plane K.F.M. when the plane has a very urgent message to transmit concerning the safety of the plane or some other plane that he has in sight. The urgent signal has priority over all other signals except those of distress. All other planes stop transmitting and listen, after hearing this signal, whether they are addressed or not.

The *safety signal* consists of the letter T formed in a group of three. well-spaced, followed by the word de (from) and the call signal of the station sending it. It indicates that the sending station will immediately transmit a storm warning or message concerning the safety of navigation.

A pilot may order a distress signal

sent at any time that he considers life and property to be in danger. If an airplane is following a maritime route, its transmitter must be adjusted to 500 kc. The order of priority of communication in mobile services is as follows:

1. Distress calls, distress messages, distress traffic.

2. Communications preceded by an urgent signal.

3. Communications preceded by the safety signal.

4. Communications relative to radio-compass bearings.

5. All other communications.

Lesson Questions

Be sure to number your Answer Sheet 55RC-1.

Place your Student Number on *every* Answer Sheet.

Most students want to know their grade as soon as possible, so they mail their set of answers immediately. Others, knowing they will finish the next Lesson within a few days, send in two sets of answers at a time. Either practice is acceptable to us. However, don't hold your answers too long; you may lose them. Don't hold answers to send in more than two sets at a time or you may run out of Lessons before new ones can reach you.

1. To what aircraft does an airport control tower issue information and instructions?
2. What control organization operated by the C.A.A. directs the movements of an aircraft in flight along an airway?
3. What method of communication is used to send weather information from weather reporting stations to aeronautical communications stations?
4. Does an SMRA transmitter (a) broadcast weather information, (b) transmit radio range signals, or (c) do both at the same time?
5. What is the name of the v.h.f. beacon transmitter that sends a sharply directional vertical beam into the cone of silence above a range station?
6. Is the radio equipment of a commercial airliner carefully checked before the start of every flight or only at periodic intervals?
7. May private flyers use (a) government aviation radio facilities, (b) privately owned facilities, (c) both, or (d) neither?
8. Is a license required to own and operate an aircraft radio receiver?
9. What are the international calling and distress frequencies for ships and aircraft over the seas?
10. What is the radiotelephone distress call?

EACH DAY COUNTS

Each day of our life offers its own reward for work well done, its own chance for happiness. These rewards may seem small, and these chances may seem petty in comparison with the big things we see ahead. As a result, many of us pass by these daily rewards and daily opportunities, never recognizing that the final goal, the shining prize in the distance, is just a sum of all these little rewards we must win as we go along.

J. E. Smith