

1937

## Instrument - Not Blind Flying

Herbert W. Anderson

Follow this and additional works at: <https://scholar.smu.edu/jalc>

---

### Recommended Citation

Herbert W. Anderson, *Instrument - Not Blind Flying*, 8 J. Air L. & Com. 191 (1937)  
<https://scholar.smu.edu/jalc/vol8/iss2/2>

This Article is brought to you for free and open access by the Law Journals at SMU Scholar. It has been accepted for inclusion in Journal of Air Law and Commerce by an authorized administrator of SMU Scholar. For more information, please visit <http://digitalrepository.smu.edu>.

## INSTRUMENT—NOT BLIND FLYING\*

HERBERT W. ANDERSON†

When a person is lost and wandering aimlessly in circles, perhaps through a dense forest or in desert land, his sense of direction is gone because he has no natural way of determining direction other than by visual reference to familiar objects. We lack what might be termed a "compass" in our minds. We may become lost directionally on the ground or lost in all directions in the air. Airplane pilots flying in fog or clouds are in what appears to be a gray globular mass where all sense of direction is lost. They not only must maintain the desired direction horizontally, but are required to keep the airplane in the proper attitudes longitudinally and laterally. That the pilot is incapable of doing this without special instruments has been proved in many tests both in flight and on the ground. Majors Ocker and Crane<sup>1</sup> have made extensive research on this subject, even demonstrating that blindfolded birds, when launched into the air, fluttered helplessly, and failed utterly in their attempts to maintain flight.

In the inner ear we have semi-circular canals which are tubes lined with delicate nerves and filled with liquid. These give us our "sense of balance." Without this device it is likely that we would be unable to stand or walk in the dark. This mechanism does not, however, enable us to fly without visual reference to the ground. The forces of acceleration and deceleration and the centrifugal forces encountered in flight are many times greater than those experienced while walking or standing. As a result the pilot must depend on visual reference to the ground for his "air-balance sense" or employ instruments that substitute outside visual reference.

---

\* This is the first of a series of articles to be published in the JOURNAL OF AIR LAW on the use of radio and other instruments in air navigation. With the increasing importance of instruments in air navigation and public attention on "blind" flying, lawyer and layman alike, if uninitiated, are confronted with the necessity for a non-technical explanation of a highly technical subject matter. This article, which was prepared by the author at the request and under the supervision of the Editor-in-Chief, is intended to serve that purpose and to furnish the basic information for any further research deemed necessary. The JOURNAL OF AIR LAW is fortunate to have secured the services of the author whose training, qualifications and long experience in instructing, fit him pre-eminently for the task assigned.—[Ed. note.]

† District Advisor, Bureau of Air Commerce, United States Department of Commerce, Chicago, Illinois. Engaged in aviation since 1921, with a total of 5,000 hours of flying time to date. Formerly: Co-pilot, National Air Transport; Pilot, Century Airlines; Pilot, Ford Freight Lines; Instrument Flying Instructor and Pilot, Trans-American Airlines (later merged with American Airlines); First Pilot, American Airlines. Holder of all ratings for all types of land airplanes, including S.A.T.R., Instructor's and Night Flying Instructor's ratings.

1. Ocker and Crane, *Blind Flight in Theory and Practice*.

Properly executed turns evoke no sensation of turning. It is even possible to execute some acrobatic maneuvers in flying without receiving, through the sense of balance, a true impression of what is taking place. The fluid in the ear in these cases remains in its normal position due to centrifugal force. Since the fluid does not change its position, no sensation of change of the plane's attitude is received.

The "sense of balance" is further complicated by other forces coming into play in flying which tend to give false impressions. Rapid acceleration gives an impression of leaning backward. Rapid deceleration gives an impression of leaning forward. The reader may try a simple experiment on the vagaries of the balance mechanism by gazing upward at a spot on the ceiling of a room and then turning around, eight or ten times to the right.

Upon stopping, close the eyes—notice that the sense of balance causes an impression of turning to the left although no turn is being made. The physiological and psychological phases of the inability of a pilot to maintain equilibrium through his balance sense while flying in fog or clouds are many.

That the pilot must be equipped with the proper instruments and proper training in their use in order to fly successfully without any visual reference to the ground has been proved. It is believed that many of the early transoceanic flights ended in tragedy because of such deficiency. Lindbergh was one of those who paid much attention to this problem. The Spirit of St. Louis was so designed that it was difficult for the pilot to fly other than by instruments. It had no direct forward visibility except through a periscope. Its design might be likened to having an automobile windshield occupied and covered with the instrument panel. A pilot, today, untrained in instrument flying would find it a most difficult machine to fly over land even in clear weather.

The development of the instruments themselves marks a long period of experiment. Part of the early experiments were concerned with indicating devices that were operated by gravity. Some of these were spirit levels in various shapes and combinations; others were pendulum devices. They were unsuccessful because the centrifugal forces in actual flight gave erroneous readings similar to the sensations received by the pilot through his sense of balance. A slight gain was made in that the instruments could be better controlled as to sensitivity.

The magnetic compass fails as an instrument for indicating turns due to centrifugal and magnetic forces acting on it. When

flying on a course East or West, raising or lowering the plane's nose causes the compass to indicate the start of a turn although no change of direction is made. In making sharp turns from North to South the compass card indicates a turn through East when the turn is actually made through West and indicates a turn through West when the turn is actually made through the East. South of the Equator this takes place on turns away from South. The instability of the compass increases with distance from the Equator until the magnetic poles are reached—there the slightest maneuvers of the plane revolve the compass card through wide arcs.

The behavior of the magnetic compass; while changing direction, made it necessary to seek other solutions.

The mechanics of the gyroscope have long been understood and inventors focussed their attention on this device as a solution because of the gyroscope's stability and reactions. The turn indicator was one of the first gyroscopic instruments to be developed for aviation use. In this instrument the gyroscope is linked with a needle that indicates when a turn is being made to the right or to the left and when a straight course is being maintained. This gives the pilot a definite fix that he can rely upon. By controlling the turn he can correlate the use of his air-speed indicator. When the plane is slowing down (as shown by the air-speed indicator), he is climbing; when it is accelerating, he is diving. By the use of a level, called the bank indicator (a steel ball in a curved, liquid filled tube), he has information as to whether the wings are level when the plane is in straight flight. This information permits sustained flight irrespective of visual reference to the ground.

To further aid him, another flight instrument was added—the rate of climb indicator which shows the rate of ascent or descent in feet per minute. This instrument was needed because the air speed indicator could be relied upon only when the plane was flying faster than its stalling speed and when the power from the engine unit remained practically the same. By correlating the knowledge of the speed with the knowledge of whether the plane was climbing or descending, the pilot's navigation problem was considerably lessened.

These basic instruments still appear on modern transport ships. They are, however, supplemented by the artificial horizon (an instrument showing the true position of the horizon in relation to the airplane), the directional gyro compass (a non-magnetic instrument),

and, in some cases, the gyro, or automatic pilot.<sup>2</sup> These additional gyroscopically activated instruments give definite information, rapidly and accurately at all times, as to the plane's position with relation to the earth's axis.

In taking tests for a scheduled air transport rating (required of all airline pilots carrying mail and passengers) the pilot is not permitted the use of these later gyro instruments. He must demonstrate skill under more difficult conditions. The pilot must fly his test using as flight instruments the compass, rate of climb, air-speed indicator, bank and turn indicator, clock, altimeter and radio only.

In order to secure this rating, a pilot, in addition to his experience requirements,<sup>3</sup> must prove his ability to handle a plane while under a hooded cockpit which blocks out all vision except that of the instruments and controls. He must perform all of the normal maneuvers of flying such as climbs, glides, precision turns to a pre-determined heading, straight and level flights within very strict limits of change of heading and altitude, steep banks and recovery from unusual positions such as stalls, tight spirals, etc. He must also prove his ability to locate himself by the use of his radio, to navigate to the radio range station and then to maneuver for an accurate approach to the airport.

Proficiency is attained through practice in actual flight in a training plane supplemented, in some instances, by the use of a ground training device such as the Link trainer, a patented ground training device simulating flight conditions.<sup>4</sup>

One of the first things the student learns in flying under the hood is that his sense of balance is his enemy rather than his friend because the sensations he receives are inaccurate and may be at variance with his instrument readings. He also learns that trying to visualize the attitudes of the plane in interpreting his instrument readings is a drawback. The pilot must learn to use the controls for the sole purpose of moving the needles on the instrument panel.

During all practice flights, the instructor or "safety pilot" has full outside vision and a complete set of controls and instruments with which he makes landings and take-offs and which are available in emergencies. The student sits in an enclosed cockpit having his vision restricted to the instruments and the airplane controls. The radio receiving set is usually equipped with an inter-cockpit com-

---

2. "Current Practice in Instrument Panel Layout," 27 *Aero Digest*, 1935, Aug. p. 40, Sept. p. 42, Oct. p. 40, Dec. p. 40.

3. See Bureau of Air Commerce Bulletin 7E.

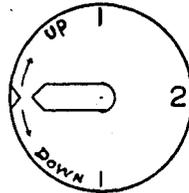
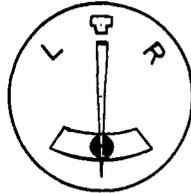
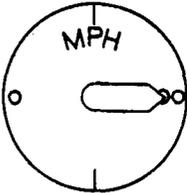
4. 35 *Aviation*, 1936, Sept. pp. 37-38.

FIG. NO. 1.

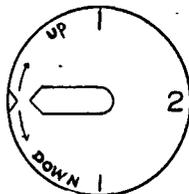
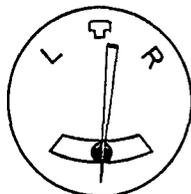
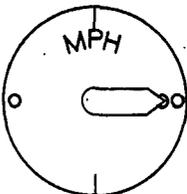
Air Speed

Bank and Turn

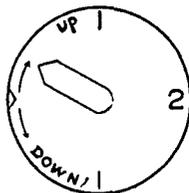
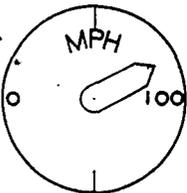
Rate of Climb



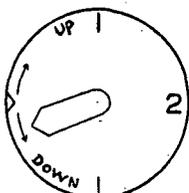
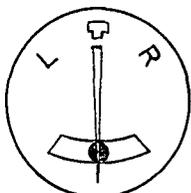
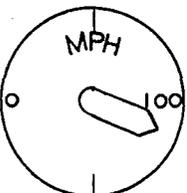
STRAIGHT LEVEL FLIGHT



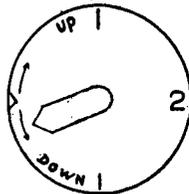
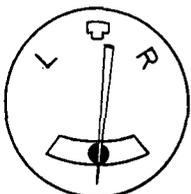
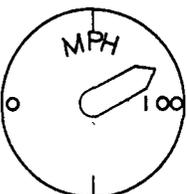
NORMAL RIGHT TURN



STEEP LEFT CLIMBING TURN



GENTLE STRAIGHT DIVE



GLIDING RIGHT TURN

munication system to permit exchange of conversation between student and the instructor and to permit both to listen to the radio signals. If a student has no previous instrument flying experience he most likely will be given a ride with the hood open, enabling him to determine what the instrument readings are in such positions as normal climb, normal glide, etc. A few of these positions are illustrated in Figure No. 1. The hood is then closed and the pilot student instructed in the use of the turn indicator and the other instruments and in the importance of their correlation with the controls themselves rather than with the corresponding attitude of the airplane. Practice is started on turns and straight flying until the student definitely has acquired ability to control the plane in these maneuvers. He then progresses to precision turns, changing direction 90°, 180°, etc. These are executed by using the turn indicator and clock. Turn indicators are usually calibrated so that a turn of 3° per second is made when the turn indicator needle is moved to the right or left a distance equal to its own width and the pilot, in changing direction, calculates on the following basis:

3°	—	1 second
90°	—	30 seconds
180°	—	60 seconds

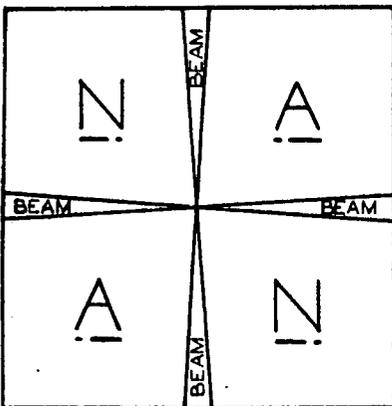
From there the student progresses to making turns from one compass course to another. Should he be flying a course of 90° (East) and should the instructor request a heading of 180° (South), the student would make a turn to the right for 30 seconds, then return his plane to a straight and level flying position until the compass settled down and permitted him to check the change of course. As the work continues the instructor becomes more exacting in the matter of smoothness, accuracy, ability to hold altitude, etc.

The student then progresses to climbing turns, gliding turns, maximum climbs, minimum glides, steep banks, holding an accurate compass course for considerable periods of time, and recovery from unusual positions. In the teaching of recovery from such positions, the instructor first takes the controls and makes at least two turns of a sharp, steep bank to induce vertigo. He then places the plane in some unusual attitude and asks the student to recover to straight level flight as soon as possible. The vertigo induced in the turns often makes the student confused, since his senses indicate continued turning in an opposite direction even though he has resumed level flight as shown by his instruments. This practice

on actual instrument flying continues until the student can definitely demonstrate his ability to perform the required maneuvers with a skill comparable to that which he would exhibit if he were flying visually. Experiments have been successfully conducted wherein a person with no previous flight training was given a complete course of instrument instruction under the hood before he was permitted to fly visually. Results indicated that learning instrument flying was no more of a problem to the novice than learning visual flying.

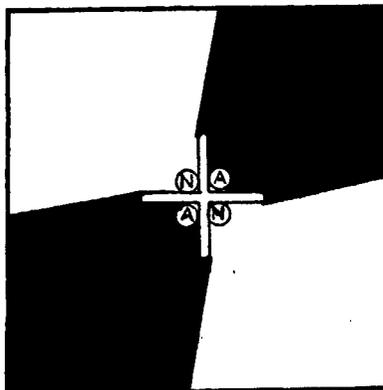
Leaving this stage of air work, the pilot student passes into the subject of Radio Navigation. This is the only means of accurately navigating without visual reference to the ground or sky

Figure No. 2



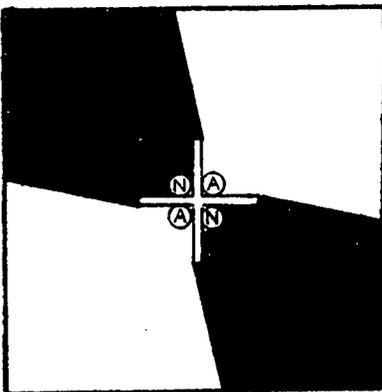
PLAN RADIO RANGE BEACON

Figure No. 3



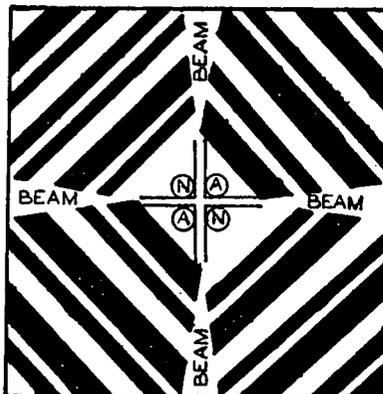
LIGHTS N-N BURNING

Figure No. 4



LIGHTS A-A BURNING

Figure No. 5A



SYNCHRONIZED FLASHES

and which makes possible the practical and safe application of instrument flying to the commercial need of going from here to there.

The system of radio navigation most used in United States aviation today is the Radio Range Beacon—or, by another name, "Radio Beam." It is designed for aircraft use. The radio range beacon transmits radio signals of a pattern that forms four "off-course" zones (Two are "N" quadrants—dash dot — . ; two are "A" quadrants—dot dash . — ). The pattern also forms four "on-course" paths (radio beams). In plan they form a cross. See Figure No. 2.)

An airplane radio receives the signal of the zone it is flying in and will always receive some signal from the station to which it is tuned unless the distance between them is too great (from 40-100 miles or more, depending on the station's power and atmospheric conditions). A nation-wide system of radio range stations makes air navigation possible without sight of sky or land. The "on-course" signals or "beams" are directed along the courses of the principal air routes.<sup>5</sup>

To illustrate the principles of radio navigation and at the same time avoid a highly technical explanation, the behavior of light waves will be used as a medium of explanation. Both radio and light waves travel in patterns of straight lines and so permit the comparison.

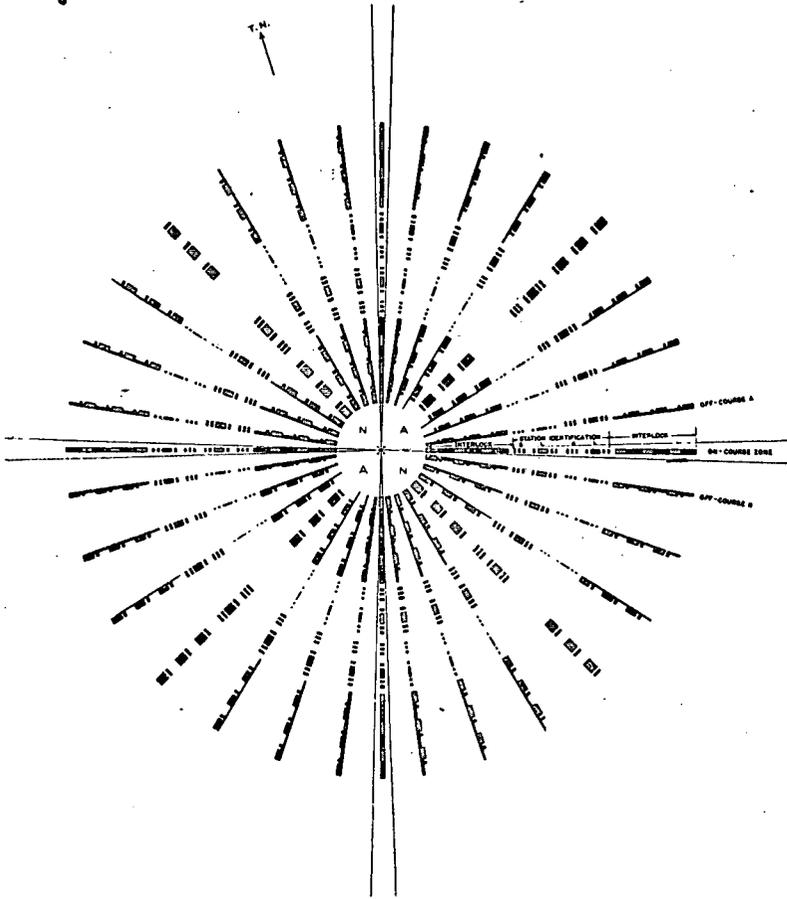
The four light bulbs in Figures No. 3, 4, 5A represent the four transmitting antennae found at radio range stations. The lines separating the four lights are opaque partitions simulating the particular radio antenna design. When lights "NN" are burning and lights "AA" are out, a pattern of light and shadow results as in Figure No. 3. If lights "AA" are burning and lights "NN" are out, a pattern of light and shadow results, as in Figure No. 4. If these two patterns are superimposed as in Figure No. 5A, note that four zones are always in light. The zone always lighted represents the "on course" signals or beams and the areas alternately light and dark, the "A" and "N" quadrants. By synchronizing the intermittent flashes, the four beams can remain in continuous light and a distinctive signal code be transmitted in the "A" and "N" quadrants.

In the radio range beacon, the key of the automatic transmitter synchronizes the radio impulses. The key makes contact

---

5. The Federal Airways System, Aeronautics Bulletin No. 24, July 1, 1935, p. 16.

Figure No 5B

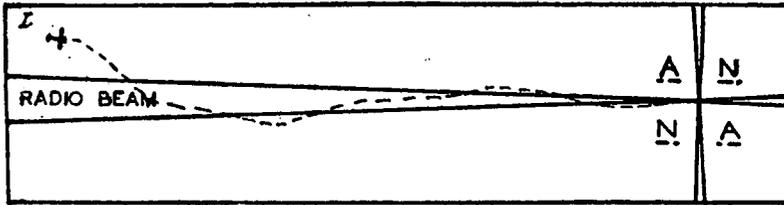


and transmits the dash of the "N" (dash dot — . ) signal over the "N" antenna and the very instant it breaks contact, the dot of the "A" (dot dash . — ) signal is transmitted over the "A" antenna. As this contact is broken, the dot of the "N" signal is sent over the "N" antenna, followed by the transmission of a dash over the "A" antenna. As one antenna set broadcasts, the other is silent. This synchronization provides a continuous note in the "on course" signal zone. Technically the "on-course" signals are not projected, but are due to the placement of the aircraft in a geographical position with respect to the amount of "light" or signalled energy from the NN and AA lights or antennae. Whenever the amount of "light" or signal energy from the two signal sources is equal, the monotone signal formed by the controlled keying of the two signal

sources of energy indicates a known geographical "on-course" signal. Figure No. 5B. To avoid confusing the signals of one radio range station with another, a coded station identification signal is transmitted at regular intervals not exceeding 12 seconds.

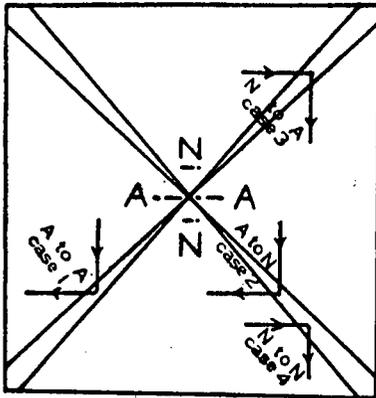
The instrument flying student not only receives an explanation of Radio Range Beacon theory but must familiarize himself with the compass directions of the various beams of the station he is practicing on, the location of the radio station relative to the airport (usually within a 1½ mile radius), and other items intimately connected with the particular station used in practice flights. This familiarization follows the air lines' approved approach or "let-down" procedure, which has previously been worked out by the chief pilot and Bureau air line inspectors. He is not necessarily

Figure No.6



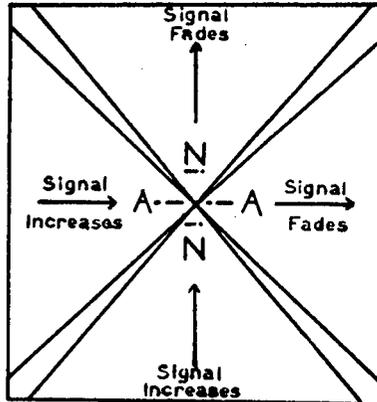
FOLLOWING THE BEAM

Figure No.7



90° ORIENTATION METHOD

Figure No.8



FADEOUT ORIENTATION METHOD

required to remember these headings but it is necessary that he have a plan or "plate" of the approved procedure.

In Radio Beam training, the student is taken out in a direction known to him to work on a designated beam. He is given practice in following this particular beam. He may start out to follow it from position "I" as illustrated in Figure No. 6. Hearing the "A" signal, he would turn to a course that would intercept the "on-course" signal. Upon hearing the "on-course" signal, he would make the necessary correction to head toward the station. Continuing this path until hearing an "off-course" signal (in this case being the "N"), he would then make the necessary correction to again intercept the beam and by so using the radio signals, follow the gradual tapering "on-course" signal zone into the station. As he approached the station there would be a noticeable build-up in the signal strength until the transmitting station itself was reached. There a pronounced surge from a strong signal to a very, very weak signal, back to a strong signal, followed by a gradual fading would be heard. The area of low signal strength is commonly called the "cone of silence" and appears directly over the transmitting station indicating to the pilot his position with respect to it.

After attaining proficiency in following the radio beam and locating the transmitting station, the pilot student is then given instruction in orientation problems. In these he is not permitted to turn the radio on until told to do so by the instructor. Not knowing his location, he is, to all purposes, "lost." When he does turn the radio on he will hear either an "A" signal or an "N" signal. However, he does not know whether it is the signal North of the station or the signal South of the station. To determine which zone he is in, he applies one of several orientation methods which he has studied.

Only two will be mentioned here. One is called the 90° method. (The particular compass headings or courses to be flown while working this type of orientation problem are plotted on the airway map.) In this example the direction of the beams are represented in Figure No. 7. If the student should hear the "A" signal, as in cases No. 1 and 2, he would take a course of South, as shown. Upon reaching the "on-course" signal, he would make a 90° right hand turn. If after making a 90° turn to the right he hears an "N" signal, he came from the East sector and is now in the South "N" sector (case No. 2). If he should hear an "A" after making the 90° right hand turn, he came from the West sector and is back in the West sector (case No. 1). He must now maneuver to get back on the known radio range beam and follow it into the station.

A comparative procedure would be used in the event the "N" signal was the one first heard. (Cases No. 3 and 4.)

Another method of orientation is known as the fade-out system. If, upon turning on the radio, the student should hear an "A" signal, and not know its location with relation to the transmitting station, he would take a course that would be a bisector of either angle formed by the "on-course" headings of the radio beams adjoining the "A" signal quadrants. (These beam headings are given on all maps issued by the Bureau of Air Commerce showing radio aids.) With his receiver volume tuned low, he would fly this course until there was an unquestioned change in the signal strength. If the signals became weaker and weaker, he would know that he was flying away from the station and in this case he would be in the East "A." (See Figure No. 8.) If the signals should increase in strength, he would know that he was approaching the station and would locate himself as being in the West "A." The same procedure would be followed in the "N" sectors. After identifying a particular "A" or "N" quadrant, the student would then seek the "on-course" signal zone and follow it into the station.

During the Scheduled Air Transport Rating (commonly referred to as S.A.T.R.) test, the pilot is required to perform all of his air work before turning on the radio and, as a result, he loses his position relative to the home radio station and is required to work the orientation problem to locate himself. After locating himself and getting on the beam, he follows it to the cone of silence at an altitude of two or three thousand feet, as the Bureau of Air Commerce Inspector may designate. He is then required to go away from the station, intercept a designated beam of the radio range and then to again return to the station but this time at an altitude that will permit him, after again passing the cone of silence, to maneuver to the airport, arriving there at an altitude of approximately 200 feet.

The application of instrument flying and radio navigation to actual airline practice is one that involves many factors other than the technique of maneuvering and navigating the airplane itself.<sup>6</sup> It is in the application of instrument flying that the best judgment of the pilot, dispatcher, and meteorologist are united for maximum performance and safety. Because of adverse weather conditions at the intended destination, instrument flying is sometimes used to take passage to alternate terminals or emergency landing fields. One pilot jokingly referred to his turn and bank indicator as a "turn and go back" indicator. However, this pilot had

---

6. See *W. B. Courtney*, "Is It Safe to Fly?," *Colliers' Magazine*, March 20, 1937. It should be noted, however, that the map in the article referred to does not depict with exactness the location of the air facilities in question.

used his instruments and radio navigation aids many times in completing safe trips that would not have been flown had it been necessary for him to see the ground during the entire flight.

Thunderstorms, rain and snow static, split beams, and other radio phenomena plague the efficiency of radio navigation. Thus research is promoted, experiment and invention continued in further perfecting the Radio Range and development of new methods of Radio Navigation. Fortunately radio waves travel more or less in straight lines which makes it possible to receive them with an airplane antenna having directional characteristics. When such a directional antenna is turned to intercept the radio waves  $90^\circ$  from the maximum strength a "null" is apparent. This "null" or indication is registered on an azimuth<sup>7</sup> indicator from which calculations can be readily made as to the source of signal energy in respect to the magnetic headings of the aircraft. Such system is commonly known as "direction finders" or "radio compass."<sup>8</sup>

Still another system of radio navigation has been used successfully. In this system the aircraft's transmitter radiates energy on a designated frequency (wave-length) while one, two, or possibly three direction finders on the ground are operated to determine the direction of the airplane. Where only one direction finder is employed on the ground it is possible to locate the position of the airplane but only with respect to its bearing from the receiving point. In order to determine both bearing and distance a "fix" is necessary. This "fix" can be ascertained when two or more radio direction finders on the ground separated geographically and operated simultaneously obtain bearings. A line, corresponding to the bearings, from each of these receiving points is projected across a chart, at the intersection of these lines a "fix" is indicated which definitely locates the plane's position. This information is then relayed back to the pilot in terms of his position, which, in the case of domestic operation, is usually associated with known geographical points and in over-water operation is referred to by latitude and longitude.

Honors and credits for the past technical achievements are owed to many: airlines, federal and military agencies, pilots, engineers, and others. Federal airline safety conferences, where individual experience is generously divided, further advance the technique, making it truly instrument—not blind flying.

---

7. The azimuth of a body is the angle made by a vertical plane passing through it and the observer and a plane passing through the earth's axis and the observer.

8. *Frederick W. Lutz*, "The Kruess Radio Compass for Commercial Use," 26 *Aero Digest*, Feb., 1935, p. 50. "Radio Compass," 35 *Aviation*, May, 1936, p. 24.

See also *Max Karant*, "Airlines Adopt Homing Devices," 20 *Popular Aviation*, April, 1937, p. 39.