CIVIL AERONAUTICS AUTHORITY

TECHNICAL DEVELOPMENT DIVISION

REPORT NO. 5

DEVELOPMENT AND USE OF THE AIRPORT ORIENTATOR

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DECEMBER 1938

The author desires to acknowledge the assistance of Mr. Horace Stark in the preparation of the material contained in this report and the editorial help given by Mr. John Easton and Mr. J. M. Farrar of the Technical Development Division of the Civil Aeronautics Authority.

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SUMMARY

Inasmuch as the ordinary effort of instrument flying is increased when the airplane is within the airport area due to the preparations for the approach and landing, it is advisable to afford the pilot some relief, if possible, from this increased effort. The Airport Orientator, an instrument developed by the Bureau of Air Commerce, provides the pilot with the airport and approach information he is trying to formulate in his mind, pictorially represented and held in proper orientation with the ground. In addition, the Orientator provides such information as the proper approach altitudes, location of principal obstructions, etc. This information is vitally necessary but it is difficult for the pilot to continually and accurately bear it in mind and usually necessitates his reference to a manual.

When the traffic situation is placed on a simplified and improved basis, it is logical to believe that the pilot will do better on the glide to the landing, since his mind has not been severely taxed prior to this time. It is hoped that the Airport Orientator will be a welcome and valuable addition to the flight group particularly as it does not add to the number of

instruments whose indications must be observed. That this hope is not too extravagant is evidenced by the statements of the pilots who have used the instrument. The Airport Orientator has successfully passed through a program of testing by pilots of Pennsylvania-Central Airlines and should be available to the public by the time this report is in print.

INTRODUCTION

The Airport Orientator is an invention of Mr. Horace Stark, a pilot for Pennsylvania-Central Airlines, Inc. Many months ago, Mr. Stark submitted his invention to what was then the Development Section of the Bureau of Air Commerce. The invention consisted of the modification of the standard Sperry Directional Gyro so that a map of the airport and its environs was maintained in fixed azimuth relation with the ground and therefore all directions on the map coincided with the corresponding directions on the ground.

As a means of placing before the pilot a pictorial representation of the airport surroundings and characteristics and thereby reducing the pilot's effort of instrumentation it seemed to Bureau officials to offer attractive possibilities.

Accordingly, specifications covering the instrument were drawn up and a contract with the Sperry Gyroscope Company was consummated. Of the development price, one-third was contributed by the inventor and the remainder was paid by the Bureau. The instrument was accepted by the Bureau of Air Commerce on November 18, 1937 and was delivered in December 1937.

PURPOSE

It was for the purpose of relieving the pilot of certain exacting work and placing instrument flying on an improved and simplified basis that development of the Airport Orientator was undertaken.

The problems of instrument approach and landing are made additionally difficult by the time factor involved. The pilot finds himself performing at instrument flying as usual, with the important exception that he is operating at high speed. Together with this, he has several more things to think about in the way of radio markers on the approach and one or two instruments that are used only at this time.

It is probably a safe statement to say that we are in the final stage of development of instrument approach and landing. While no system is exactly perfect at the present time, it seems to sum up the opinion of authorities generally to say that a start should be made, which is to say that we should begin the instrument approach work for this is easier than making instrument landings. Not so many aids are necessary for instrument approach and the procedure is not materially different from that with which pilots are already familiar. Closely analagous procedure is, of course, carried out for the instrument approach as for instrument landings, and it is logical to believe that training in the former would soon eventuate in

landings being made regularly and safely during any condition of ceiling and visibility.

Also of very great importance is the necessity for simplification in coping with traffic congestion around important airports. With the present system when in the vicinity of an airport, it is one thing for a pilot to know his position, heading, course and track, and it is quite another to know all this and its relation to other airplanes in the airport area at the same time. By placing a properly orientated map before the pilot on which he can mentally "spot" the position of other airplanes as reported by the control tower, this complex problem should be simplified. On familiar headings and at certain airports under simple traffic conditions the pilot can form a rough mental picture of the situation without too much thought and loss of time and, in addition, perform the many other duties requisite to the successful completion of the flight. However, there are other occasions when the procedure requires more attention than can safely be spared and the pilot has difficulty in forming the picture at all, as when he is under pressure at a terminal where a problematical situation exists.

A feature of the Airport Orientator card or map, in addition to making the beams visible, which, it will be conceded, is a definite help, is the marking of the points of the compass

thus making it possible to see directly the position of other airplanes as reported by the airport control tower, thereby eliminating any necessity for protracted computational thought on the part of the pilot.

It is also essential that the co-pilot be fully aware of what is taking place when the airplane enters the locality of the airport and from then on until it is on the ground. Frequently the co-pilot does most of the radio work when the airplane is near the terminal, and the pilot is occupied with making preparations for the approach and landing. The co-pilot is usually reluctant to give the airplane's position without first consulting the first pilot, since he is under the latter's command and usually is less experienced. In such instances, the co-pilot is continually interrupting the pilot's outside source of information by asking questions relative to the airplane's present position and the course that will be flown in the next few minutes, which creates an undesirable situation. There is also the possibility of error in position location by failure to determine and report the reciprocal heading of the directional gyro, instead of the indicated heading, when on a straight course to the station. This possibility is not remote inasmuch as after passing the station on a straight course the reverse should be done. The Airport Orientator, however, not only provides the right picture, which

feature is of inestimable value, but it also makes it possible for the co-pilot to give the important information of position to the airport control tower and thus prevent a misdirection of traffic. The point of being able to read off directly the position of the airplane at all times should aid in making it virtually impossible for the pilot or co-pilot to make a mistake.

To recapitulate: Through the use of a map placed before the pilot in proper orientation with the ground, the pilot will be able to effect a worthwhile simplification of some of his problems. This is the purpose of the Airport Orientator. In ensuing sections of this report more information is offered relative to the specific application of the instrument to these problems.

SPECIFICATIONS, OPERATION, AND INSTALLATION

The specifications which were prepared by the Bureau of Air Commerce as a part of the contract with the Sperry Gyroscope Company appear as Appendix I to this report.

The modifications to the standard directional gyro instrument consist of housing the instrument in a special case, to which the pilot has access during flight for the purpose of changing maps (Fig. 1 & 2). The instrument must, of course, carry a map of the territory surrounding the airport at which a low approach is to be made (Fig. 4).

During the map changing operation, suction to the instrument must be interrupted since the case must be normally airtight, so a means for breaking the seal formed between the case and its cover had to be provided which could be operated easily by a pilot wearing gloves. In the instrument furnished, a shut-off valve in the suction line is operated by the same knob as that used to cage the gyroscope. The operation of caging thereby interrupts the suction to the instrument. Provision for breaking the seal between cover and case is provided by a simple rotating clasp having a cam which prys the cover and case apart as it is rotated into the "unlock" position.

The upper bearing of the two in which the gyroscopic element is carried is made inboard so that the spindle which passes therethrough may carry a disc upon which the various maps are placed. These maps are so constructed as to permit their placement on the disc in only one position, i.e., with the southerly direction coinciding with 0° on the directional gyro card. The directional gyro card is unchanged so that the instrument may be used for en route flying in the generally accepted manner.

In the device, a circular map (Fig. 4) is employed. The light blue or shaded sections represent the A quadrants. The colors red, yellow, and green stand for danger, caution, and clear, respectively. That is, the yellow beams, as for example in Fig. 4, signify that directly out from the airport area of, say, 30 miles the elevation of the terrain is somewhat higher than the minimum initial approach level of 1500 feet. The green beams, on the other hand, indicate a clear approach, while the numeral 600 on the south leg of the range indicates the level and the direction in which to make the low approach. The colored extension lines from the runways of the airport signify the relative clearness or obstruction on the approach to these. They also serve as a means of lining up with the proper direction of landing. Red dots on the map mark principal obstructions in the airport area, such as radio towers

and the like. On the rim of the map are the day and night minimums together with the letters representing that station and the altitude of the airport.

An orientator map is made for each terminal en route, as well as for the alternate airports; one cemented to each side of a light aluminum plate, which in turn is directly connected to a disc member on the top of the directional gyro. These maps are placed in the instrument by dropping them down over two locating pins, making it impossible for the map to turn or be inserted improperly. The shaft supporting the disc on which the maps rest extends up through the case of the instrument from the vertical (gimbal) ring. In this manner, the small, light aluminum map plate is made a part of the gyroscope proper, and by being precisely balanced it does not interfere with the normal, regular operation of this sensitive instrument. In effecting the change of maps, the gyroscope is caged in the usual manner, which cuts off the suction in the case and makes it possible to open the lid of the instrument. This also precludes dust or other foreign matter being drawn down in the gyroscope section when exposed.

The appropriate map may be placed in the Airport Orientator at any time, but preferably this should be done early enough so that no time need be lost in doing it while the airplane is in the vicinity of the airport. Moreover, doing

it early eliminates the necessity for interrupting the suction just before use and insures that the instrument is in its most sensitive condition during the time it is being used.

Installation of the Airport Orientator is made directly in front of the pilot and at the height which provides observance of the map on the same angle as the ground some four or five miles ahead of the airplane. In this manner, it is unnecessary for the pilot to make the mental transposition as if the maps rotated vertically in the plane with the instrument panel.

In the designing of a new instrument panel, care should be taken to install the Airport Orientator as nearly in front of the pilot as possible, in order that he may always be in line with the imaginary course of flight, as indicated by this instrument.

A recommended installation comprises the Airport Orientator directly in front of the pilot with his line of view making an angle of about 30° with the plane of the map. The artificial horizon is placed directly above. The airspeed indicator is placed on the same level as the map of the Airport Orientator and to its left. The rate of climb should be similarly positioned to the right of the Airport Orientator map. An altimeter placed to the left and (in the case where the airplane

is so equipped) the radio compass indicator placed to the right of the artificial horizon complete the grouping. This grouping is compact and as close as any obtainable. It should make it possible for the pilot to get the airplane on the approach path and keep it there with a minimum of effort and attention since any of the instruments may be examined without the chance of a change of course taking place unnoticed.

In the case where the airplane is equipped with a glide path indicator, this can be conveniently placed in the position occupied by the compass indicator in the arrangement described above.

A photograph, Fig. 3, shows the installation of the Airport Orientator in a Boeing 247-D.

USE OF THE AIRPORT ORIENTATOR

There is very little that is new which the pilot must learn in using the Airport Orientator.

In the conception of the instrument, it was reasoned that the earth remains stationary, insofar as ordinary flying is concerned, and that the airplane travels over its surface. It followed that if a scaled representation of the earth, in the form of a map, were held fixed by directional gyroscopic means, so that the north point of the map coincided with geographical north, there would result an orientated picture of important objects below the airplane. However, this form of orientation in itself is incomplete, and it was realized that the radio compass or its equivalent would have to be used in conjunction with the Airport Orientator to obtain the results desired.

Therefore, in the use of the instrument it is necessary only to remember that at all times the lines etched on the cover glass represent the heading of the airplane over the ground and that the map is remaining in register with the ground as the airplane turns. Since the radio range station serving the airport is located at the center of the map it is only necessary to know whether the airplane is flying towards or away from the station. This information, of course, cannot be derived from the Airport Orientator but must be obtained from the

range signals or from the radio compass if the pilot has one.

The gyroscope is set by reference to the magnetic compass as usual, which, of course, aligns the north point of the map with geographical north. In this way, the pilot has an exact picture of the location of the radio beams, airways, position of the airport to these, and so forth, and, regardless of the number of times or in what manner the course is changed or at what angle to the airport the airplane is temporarily positioned, this exact picture is held in correct orientation with the ground itself below the airplane.

This feature probably can be more clearly understood by reference to Fig. 5. The center of this illustration, or of the map, coincides with the radio station to which the radio compass is turned. When the hand of the radio compass is centered, for example, the airplane is either traveling directly towards the station on a course as shown through the forward center of the map, or it is traveling directly away from the station along the same course. The parallel lines over the lid of the instrument coincide with the heading of the airplane. This heading will not, in general, coincide with the track.

The position of the airplane in relation to the radio station is read off directly, and not the reciprocal heading, as is the case when only the conventional directional gyro

is used. In other words, the directional gyro card shows north when the airplane is south of the radio station and headed towards the station (contrary to the Airport Orientator), and this reciprocal indication provides a problem when on an off cardinal heading. The lower or forward end of the center line on the glass cover of the Airport Orientator, Fig. 5, indicates the airplane's position in relation to the radio station when a course is being flown directly towards the station. On the other hand, the other end of this center line indicates the course on a direct heading away from the station, and the position of the airplane in relation to the station at that time.

Here is the situation more in detail. The airplane is brought out of the turn at an unfamiliar heading, for instance, at 60 degrees, by use of only the conventional directional gyro. This is indicated on the directional gyro as the numeral 6. At this time, it is necessary to take the reciprocal of this heading, which is 60 plus 180, or 240 degrees, and then subtract 240 from 270 degrees to determine that the airplane is 30° S of W or WSW of the radio station. Furthermore, the position of the airport and its runways have then to be determined. A different procedure than the above can be followed by considering that 6 on the directional gyro is 60 degrees and that this heading is 30 degrees north of east (90 degrees), or a heading of ENE. The reciprocal of such heading is WSW,

or the airplane's position on the straight approach to the station. As previously mentioned, this is not done after passing the station. Therefore, it readily can be seen that it requires thought to do this correctly and consistently, together with flying the airplane and going over other problems incident to the safe completion of the flight, without such a device as the Airport Orientator.

Of particular note is that the above is the case just in localities where there is little or no magnetic variation. It is more difficult to form this picture correctly when on the West coast, where the difference between magnetic north and true north is around 20 degrees.

For illustration purposes a series of figures (Fig. 5 et seq.) is provided marking the course of the airplane in its flight in the vicinity of an airport. These figures, however, should not be confused with the regular type of Airport Orientator map (Fig. 4).

It will be assumed in what follows that a flight is being made from Pittsburgh, Pa. to Washington, D.C. and that the airplane has approached the station at Washington on a straight course (A) from Pittsburgh (Fig. 6). The Airport Orientator was then positioned as in Fig. 5. At B, after passing the station, the course is changed to a left-hand turn which will take the airplane around over the airport and across the point

desired for an initial approach. Note the position of the course lines on the cover of the instrument for position A, Fig. 5, and the position of these in Fig. 6. In Fig. 6, the airplane is shown at a parallel course to the right of the center line; the same is true in Fig. 7, except that the airplane is farther out to the right on the left turn.

The airplane, in this illustration is shown intersecting the northeast leg of the Washington range on a left turn around the station. The Airport Orientator in this instance solves what ordinarily would be a very difficult problem for the pilot to work out in his mind at various points on a circular flight, because, in crossing the beams at unfamiliar angles and on a constant turn, the matter of orientation is quite confusing. With the Airport Orientator, it is not necessary to follow the instrument continually, but merely to see that the airplane does not get turned directly toward the station again and pass over it without the change in course being noticed. Reference in this case is made to the aural loop, and not to the radio compass having a visual indicator. With the latter, one glance at the two instruments tells everything at any time without previous observation or thought to this end.

The solution of the problem of orientation being correctly given, it is merely necessary in this case for the pilot to

know that the station is to his left or to his right, which is indicated by the radio compass, but not directly by the aural loop. It is reasonable, however, that the visual indicator will be used altogether in the near future, thus providing not only a more accurate homing device but, in addition, giving an indication that is unnecessary to interpret. If the airplane approaches the station to the left, for example, the hand of the instrument points left; the reverse to the right. If the airplane passes the station to one side, the instrument continues to give the same reading but responds in a reverse manner to a correction in course. By this is meant that if the hand is somewhat to the left, a correction to the right will cause it to move still farther to the left. The opposite is the case, of course, when approaching the station, since it then works normally.

Fig. 8 illustrates position locating with the visual type radio compass and the Airport Orientator. Here the dotted positions indicate the initial position of the pointer and the solid positions indicate the direction in which the pointer moves in response to the rudder sense indicated. The corresponding positions of the airplane relative to the station are indicated on the Airport Orientator map at the center.

The Airport Orientator is a device that can be used to advantage with a variety of radio equipment, even with a beacon receiver, for in addition to providing a map, aligned to geographical north and showing all the proper approaches and so forth, it also makes it possible to fly a true bisector course for a fadeout. This is accomplished by turning the airplane until the center line over the map cuts the quadrants through the center at an equal angle. Variance of this can be made for wind drift, which in some cases can prove to be of considerable importance.

In order to cover several of the remaining points, it will be assumed that a flight is being made to an off course alternate, from Cleveland, Ohio, to Columbus, Ohio. Upon changing the course from the regular route, the Airport Orientator map for Columbus is selected and placed in position in the instrument. It should take only a moment to make the change of maps and have the Airport Orientator in operation for the flight to the alternate field. Another minute or two should be sufficient time to tune the radio compass to the alternate station, after which the flight crew is free to give attention to ground station reports and to the regular work of instrument flying.

A time check would be taken at the start of the change in course and after flying a short distance, if it is noticed that the airplane has drifted to the left or right of the course.

For example, the amount of drift would be read off the Airport Orientator chart, which is the difference in degrees between the center line on cover and the center of the beam flown on the map. On occasions when there is no drift, this center line and the center of the beam will be in alignment throughout the straight flight to the station.

Correction for drift with the Airport Orientator is accomplished by heading the airplane into the wind, in the usual manner, the required number of degrees. It is easy, without considering what takes place, to have the impression that the directional gyro card has moved in the direction in which rudder is applied, when actually the reverse is true; that is, the airplane moves and the directional gyro card remains stationary. The point is that one should think of this instrument as it really operates, for in so doing the problems of directional flight will unfold as they actually exist.

Fig. 9 illustrates a correction for a northwest wind on the flight from Cleveland to Columbus, Ohio. It is shown by this illustration that the airplane always heads in the same direction as the parallel lines across the top or lid of the Airport Orientator, since the instrument is secured to the airplane and is a part thereof. As soon as this concept is fixed, the many operations of the Airport Orientator will always be clear.

A course compensating for considerable drift (Fig. 9) is rather hard to conceive if the installation of the Airport Orientator is made improperly. The angle BAC represents the crab angle on the flight to Columbus, Ohio. In studying this illustration, it should be clear that the radio compass records to the right on the entire flight to the station, except when the airplane is turned periodically directly towards the station to determine the position in relation to the beam. Of course, if the pilot listens in on the beam this is unnecessary.

At the writing of this report, the aural loop is being used almost exclusively. Therefore, in those cases when it is not known whether the station lies ahead or astern, either due to passing over the station and not being aware of it, or to being lost momentarily due to temporary radio failure, the following simple procedure should be followed to establish the position once more. Fly a course to the left, for only a minute or two when close in to the station, at 90 degrees to the straight course, toward or away from this station. At this temporary heading the Airport Orientator will be positioned as in Fig. 10.

The beams A and B represent the course from Cleveland to Columbus, Ohio, and on south from this latter station. As the Airport Orientator map is now shown, the airplane is flying a

90 degree course to the above course, which indicates that it is either assuming a course along the dotted line on the left of the illustration or along the dotted line on the right. If the airplane were at C, with the station ahead when the detour was started, a course ESE (90 degree turn) would take it to the left to the point where at D a course WSW would be necessary to receive a null again on Columbus. Conversely, if the station were astern a change in course at E would necessitate a course assumed as shown at F, when a null on Columbus was again obtained. The loop azimuth indicator is always kept at zero when employing the Airport Orientator.

To connect the flight illustrations so far, Fig. 9 shows the airplane approaching Columbus correcting for a northwest wind, and Fig. 10 the position of the map upon a 90 degree change in course to the left. Fig. 11 shows the position at D, again in line with the station, and Fig. 12 the position at F, traveling directly away from the station.

The point intended by these illustrations is to make clear the simplicity of arriving at the airplane's position, relative to the station, by use of the Airport Orientator. As can be seen by the illustrations, it is not necessary to resort to setting the directional gyro at zero on the null position of the aural loop, or at any other time. Moreover,

the matter of degrees and variation are eliminated, and, with all this, the pilot has a pictorial reproduction of the exact maneuvers made.

These illustrations should be perfectly clear if it is borne in mind that the Airport Orientator map, which represents the ground inasmuch as it stays aligned with it, always remains stationary, and that the airplane flies over its surface.

The illustrated flight from Cleveland to Columbus, Ohio, has now been brought up to where it will be considered that the pilot is in range of the airport control tower. Assuming that a course is being flown in the N Twilight down the north leg (Fig. 9), let us find out what the pilot can determine by means of the Airport Orientator.

The airport lies adjacent to the radio station directly in the line of flight. The altitude at this point is shown as 816 feet. This marking is to the left of CO (Columbus) near the rim of the map. Directly above this, in smaller figures, is the minimum altitude for letting down on the field. Across the north leg of the beam is the numeral 2000, which represents the minimum initial approach. As mentioned previously, the final approach altitude, in smaller figures above the initial approach figure, also may be shown. In further reference to these minimums, on the other legs of the radio range the proper initial approach from each direction is given.

To the south and slightly to the left on the map a dot is shown, representing an unusually high obstruction, as, for example, a commercial broadcasting station. As the pilot makes his initial approach, all this information can be absorbed and retained with a minimum of effort. When he finally changes his transmitter over to the airport control tower, he will be in a position to request important information, and, in turn, he will be able easily to understand and retain that which is received from the tower. On such an approach as shown, with the ceiling at, say, 1500 feet, visibility 5 miles, the pilot should be able to get under the overcast before arriving over the station, which, traffic permitting, would be advantageous in view of the very high obstruction just beyond the station at about the exact position of coming out of the overcast. On the other hand, if he had to hold 4,000 feet and stay up in the overcast, he could make the best of the situation by determining just where and in what direction, traffic again permitting, he would break out underneath for the approach to the runway.

In this case we will assume that the ground wind is the same as aloft, northwest. The pilot would notice, upon consulting the Airport Orientator map, that the landing is to be made on the shorter of the two diagonal runways. It also would be noticed that this approach is directly against the field

boundaries; and, of course, having no knowledge of the possible obstructions in line with the runway, detailed information pertinent thereto would be requested from the airport control tower. Undoubtedly, the pilot would receive all this, and in addition, information regarding any construction work that might be in progress at that time. Reference to the Airport Orientator would then be equal to viewing the field itself, in studying the particular section.

Of all flight problems, that of traffic around an airport is one of the greatest. To observe the part played by the Airport Orientator in this case it will be assumed, with respect to our illustrated flight, that one airplane is rounding the field, contact, on a left turn, and another is preparing to take off. A third one is approaching from the west at 3000 feet. This typifies an ordinary condition and will illustrate the value of the Airport Orientator.

The pilot in each airplane if equipped with an Airport Orientator has the detailed picture and can follow each change as it occurs. If the airplane on the ground is dispatched without delay, the pilot will regulate his climb so as not to interfere with the airplane coming in from the west, and the east bound pilot into Columbus will in turn be sure not to lose any altitude. The contact airplane would glide in without interruption, which course would be evident to the two remaining

inbound pilots, and the higher of these airplanes, which is the one from Cleveland, would circle the station momentarily while the other airplane, after passing the station, would very likely make a right-hand turn to the runway approach position. This final maneuver by the airplane from the west, as well as all former maneuvers, would be anticipated by the pilot on the southbound flight into Columbus; all of which information is easy for him to assimilate and utilize in his plan. He may then approach and land without confusion, danger of collision, and loss of time.

It is now assumed that the value and the operation of the Airport Orientator are clear. One more point will be cited, however, inasmuch as it is quite important. It is relative to making a low approach to a runway during unfavorable weather conditions, such as is frequently the case at Pittsburgh, Pa., on one of those customary smoky nights when the ceiling is none too high and the visibility is practically zero. It is quite unnecessary to emphasize that this is difficult.

To relate the usual case, the flight progresses to the point where the airplane is over the field, which is reasonably visible from a vertical position. Objects pass quickly at two or three hundred feet, and soon the airplane is off into total darkness once more, where the turn immediately begins at a

fairly sharp rate, since the pilot realizes the value of not losing sight of the airport if possible. Of course, try as he may he usually does get completely away from the field, and on the return, when the airplane is in a glide, finds that the approach is being made at an angle to the intended course, and that there is too much speed and too much altitude.

For the elimination of this troublesome condition, the Civil Aeronautics Authority is installing approach lights at all of the principal airports. Perhaps such work will prove to be one of the most valuable navigational aids. However, in itself it may prove to be somewhat incomplete since when the visibility is really poor, the pilot finds that in using the conventional directional gyro for directional guidance, it is almost impossible to determine when to stop the turn, particularly if this is to take place at an off-cardinal heading, as for example, southwest.

In flying close to the ground at greatly reduced air speed, together with beginning the glide at a certain point, so much attention has to be given to this end that it is extremely difficult to follow the course of the directional gyro card. The card appears to turn quite rapidly and, due to the very small portion visible, it is difficult for the pilot to determine whether an increase or a decrease in figures is

taking place. With the Airport Orientator, the matter of quick thinking or continual observance of the card is unnecessary, as the course is merely changed in the direction to begin the glide similarly to that done during contact flying. This is accomplished in the following manner: Upon passing over an approach light—and only one light need be visible to start the straight approach to the airport—the airplane is turned until the runway to be used, as shown on the Airport Orientator card, parallels the line of flight, as indicated by the position of the cover lines, Fig. 13.

The fundamental value of having the proper inline picture of the airport, the lay of objects within the airport area, together with pertinent information dealing directly with the approach problem, should now be apparent. The next phase of this report deals with the part played by the Airport Orientator in instrument approach work with regard to traffic control. This is treated quite thoroughly as any device that will minimize the thought involved should indeed be welcomed, even if procedures are possible without it.

Although not extensively practiced, the present method of instrument approach at terminals provided with air traffic control permits the entry of several airplanes into the airport area at the same time, when it is possible to separate these by sufficient altitude; weather being the governing factor.

Other airplanes en route to this field are held out over a radio "fix" until the pilots are advised to proceed in.

When the initial approach to an airport has been made, the time necessary for an experienced instrument pilot, familiar with a particular airport, to make the low approach and effect the landing, depends upon the method employed, the altitude to be lost, and the prevailing ceiling and visibility at this point. When an airport is down to its minimum, the average approach time is 15 minutes, or an income of four airplanes an hour.

Due to the keen military interest shown in airways instrument flying within the last year and the considerable number of private pilots who have obtained instrument flying ratings and have equipped their airplanes for this type of flying, so traveled are the airways that air traffic has increased to the point where it is not uncommon on a normal three-hour flight to be held out from airports as much as two hours or more on making approaches at say, three airports. This requires a total of five hours in all for the trip. This type of operation is trying to passengers and pilots alike, and as for the future, as slight as the increase in traffic could be, it will nevertheless present an outstanding problem with present methods. One or more terminals already have reached the saturation point with scheduled flights alone,

which means that during certain periods each additional airplane into one of these airports holds up succeeding airplanes.

With the present practice of low approach, all let-downs to below the overcast are made in one direction. This procedure is largely responsible for our airport traffic delays by the airplane frequently being ten miles or so on the wrong side of the station when ordered in. It is doubtful if this procedure can be practiced in the future in instrument approach and instrument landing operations. The effect of the wind on the extent of runway used, together with the danger incurred in appreciable drift, will call for landings being made in at least four directions at airports where this is possible. A year or two hence when an airplane is ordered to land on instruments, flight will proceed at a minimum safe altitude directly to the point of starting the approach and glide to the airport. This type of approach will be materially aided by the use of some such device as the Airport Orientator.

The future layout for airport approach unquestionably will provide for markers on each beam, as shown on the south leg of the Pittsburgh range in Fig. 14. Not only would such a system designate to the pilot the distance out from the

station, and thereby affect certain final preparations of the flight, but it would permit a course to be flown directly to the point of changing over to instrument landing facilities.

In Fig. 14, the approach or glide to the airport in this instance is made to the southwest. Although the Pittsburgh layout of range courses and location of field to range station is of the simplest possible type, it nevertheless, presents quite a problem in orientation to the pilot in such an instance as illustrated. On the flight illustrated it becomes necessary to angle into the beam south of the marker, and, upon passing over this point, fly northeast to a point considerably past the airport, where a turn would be made into the instrument landing beam and a course assumed down to the airport southwest.

The above maneuver, made on unfamiliar headings, and one of four or more approach maneuvers made at various times at this airport, combined with preparations for instrument approach on the glide, involves considerable thought. To make the approach problem more difficult, however, let it be assumed that the pilot is ordered to circle the range station to await his turn in, and that he receives this order at position A after making several circles of the airport area. At this point, due to the thought requisite in carrying on

periodically a conversation with the control tower and in lowering the circling altitude occasionally to the next thousand foot level, along with a study of possible prevailing icing conditions and attending to other matters incident to proper flight at this time, the pilot may have little or no idea of his position or the layout of the airport problem in general. Inasmuch as the turning maneuver was the primary cause of this confusion, the natural reaction on the part of the pilot would be to stop the turn and thereby make it possible to simplify the problem somewhat. However, the best plan would be to turn the airplane once more in line with the range station and attempt to make out, before passing over it again, the approximate distance from the station and the whole orientation set-up in general, in order that a course could be flown along the line B.

All this requires enough thought to make it impractical with present methods. If only a simple error were made such as misjudging the distance of the airport from the range station which resulted in crossing the approach beam very quickly and unnoticed, a wrong course easily could be flown along the line C, resulting in complete confusion which would necessitate the working out of the problem all over again. With the Airport Orientator and the visual type radio compass,

or automatic direction finder, the problem in any case would present little more effort than that required in contact flight.

The operation of the automatic direction finder with the Airport Orientator is shown in Fig. 15. The operation of the Airport Orientator is shown in connection with the continuously indicating, single pointer type of instrument although the same information as to position may be derived from other types such as the omnidirectional range, utilizing a cathode ray indicator, or the type which uses two pointers. The airplane in the circles in this illustration, over which the hand of the instrument rotates, is the view of the direction finder as seen by the pilot. Once it is tuned on a station, no further work is necessary to determine its direction, since the hand of the instrument always points toward this particular station. In its use with the Airport Orientator, when it is tuned in on the station in the center of the map, it is merely necessary to visualize this angle to the station on the Airport Orientator, or on out from the extremities of the Airport Orientator map, depending on the estimated distance of the airplane from the station. An aid in determining this is the rapidity with which the hand of the direction finder moves when the airplane is traveling on an angle to the station. Since there is no point in flying

a considerable distance out on a parallel with the range station, it should be a relatively simple matter on such a course close in to determine almost immediately the exact spot over which the airplane is then flying, as well as have the proper inline picture given.

In considering the value of the Airport Orientator in the light of the facts presented, it is believed that the instrument can be of value at any airport, even if it is an alternate airport to which the pilot has never been before. Rather, this is in reality a feature of particular importance, for we are coming more and more to the type of flying that calls for the use of alternates.

The larger airlines spend substantial sums of money in having their pilots fly to alternate airports, so that they may familiarize themselves with off-course routes and terminals necessary in the event of impossible weather conditions over their own route with no place to land. It is difficult, however, for these same pilots to carry in mind the pictures of all their alternate airports. They usually have an idea as to the size of the field and its approximate location with reference to the radio station, and they know the course from a point on their own route to this alternate airport; however, they may fail to remember such important points as the altitude of the field and the height and position of principal obstructions in its immediate vicinity. The matter of proper approach, of course,

is another complicating factor in the training, and if this is included, it increases the number of things which the pilot must bear in mind or must straighten out in such an eventuality by reference to the company manual on the way to that airport. This, however, is difficult, for he has neither the time, due to navigational problems and many questions received over the radio from his company stations, nor is he in the frame of mind for the absorption of such details. Nevertheless absorbed they must be, for he cannot proceed directly to the alternate airport and get under the overcast as quickly as possible, trusting to luck that everything will come out all right. It is needless to emphasize that this method is fraught with dangers and that it would be desirable to rectify the condition by simplification of procedures if possible.

When speaking of alternates, reference is made to those airports located at a distance from the regular route, when in effect there are alternates on the course flown. Reference in this instance is not made to the emergency fields en route but to the intermediate terminals, which are passed up on quite a number of the increasingly popular non-stop flights. Pittsburgh, (Fig. 13), incidentally, is such an alternate for American Airlines on its Washington-Chicago non-stop run.

The principal use of the Airport Orientator—orientation around an airport—has been discussed in this report. Although on its initial test run no claim was made for the value of the

Airport Orientator as an en route instrument, many pilots found that it was easier to fly a course through reference to the Airport Orientator map, or card, than to the conventional directional gyro card, since it presented a larger observed object and therefore afforded exaggerated movements.

TESTS

Following the delivery of the Airport Orientator to the Bureau of Air Commerce, arrangements were concluded through Mr. Stark to have it installed in a Boeing 247-D operated by Pennsylvania-Central Airlines and a preliminary description of the instrument was published in the Air Commerce Bulletin of November 15, 1937. Several months of testing under airline conditions of operation followed, the results of which were sufficiently gratifying to the inventor and to the Bureau.

Pilot approval was immediate and practically unanimous. A questionnaire was prepared by the Bureau and was circulated among those pilots who had had an opportunity to become familiar with the instrument. A generous response by the pilots gave force to the conclusion that the instrument represented a worthwhile modification of the standard directional gyro. The questionnaire and the replies of the pilots appear as Appendix II to this report.

Various fears were expressed at the outset that the addition of the map, particularly if this were defective in balance, would have a detrimental effect upon the accuracy of the instrument. In practice, however, the performance of the Airport Orientator was found to be superior to that of many standard directional gyro instruments. Since only one Airport Orientator was in existence, it was impossible to determine

whether there was a real reason for this or whether the gyroscopic element selected for the Orientator happened to be exceptional.

The instrument was then loaned to American Airlines and was installed in their Link Trainer at Newark. Reports on the results of this testing are not yet available but due to Army interest the manufacturer has decided to manufacture enough of the instruments to permit several to be loaned to airlines for test. At present, the instrument is assigned to the Civil Aeronautics Authority's Instrument Training Section at Wayne County Airport, Detroit, Michigan. It was flown by many representative pilots in that Section's Stinson airplane and then installed as a permanent fixture in the Link Trainer operated by the Section.

The instrument is protected by patents which have been issued to Mr. Stark and will be manufactured by the Sperry Gyroscope Company under license.

CONCLUSIONS

From the statements of the pilots who used the Airport Orientator during its extensive testing under airline conditions of operation, the following conclusions are drawn:

1. The Airport Orientator definitely reduces the pilot's effort of visualizing a picture of the airport by providing him with airport and approach information pictorially represented and held in proper orientation with the ground.
2. All of the essential airport and approach information can be placed on the Airport Orientator map.
3. Use of the Airport Orientator is a worthwhile and simple way of providing the pilot with essential information. It does not add to the number of instruments whose indications must be observed.
4. The Airport Orientator is a device which can be used to advantage with a variety of items of radio equipment.
5. The Airport Orientator is of value to both the airline pilot and the private flyer.

6. In airline use, the Airport Orientator is an invaluable complement to the company manual and is applicable to both airports en route and alternate airports.

7. The universal use of the Airport Orientator probably would simplify the problem of traffic control. The two most obvious ways in which it would accomplish this are:

   (a) by enabling the pilot to visualize the location of other airplanes in the vicinity as these are reported to him.

   (b) by reducing the time necessary for the pilot to orient himself after receiving instructions to land.

8. The Airport Orientator, although not designed as such, may be used as an en route instrument, the map being observed instead of the conventional directional gyro card.

9. The Airport Orientator has no misleading or confusing characteristics.

10. Increasing use of the Airport Orientator will bring about the development of the ideal type of map for the instrument and will develop new means by which the instrument will aid the pilot.

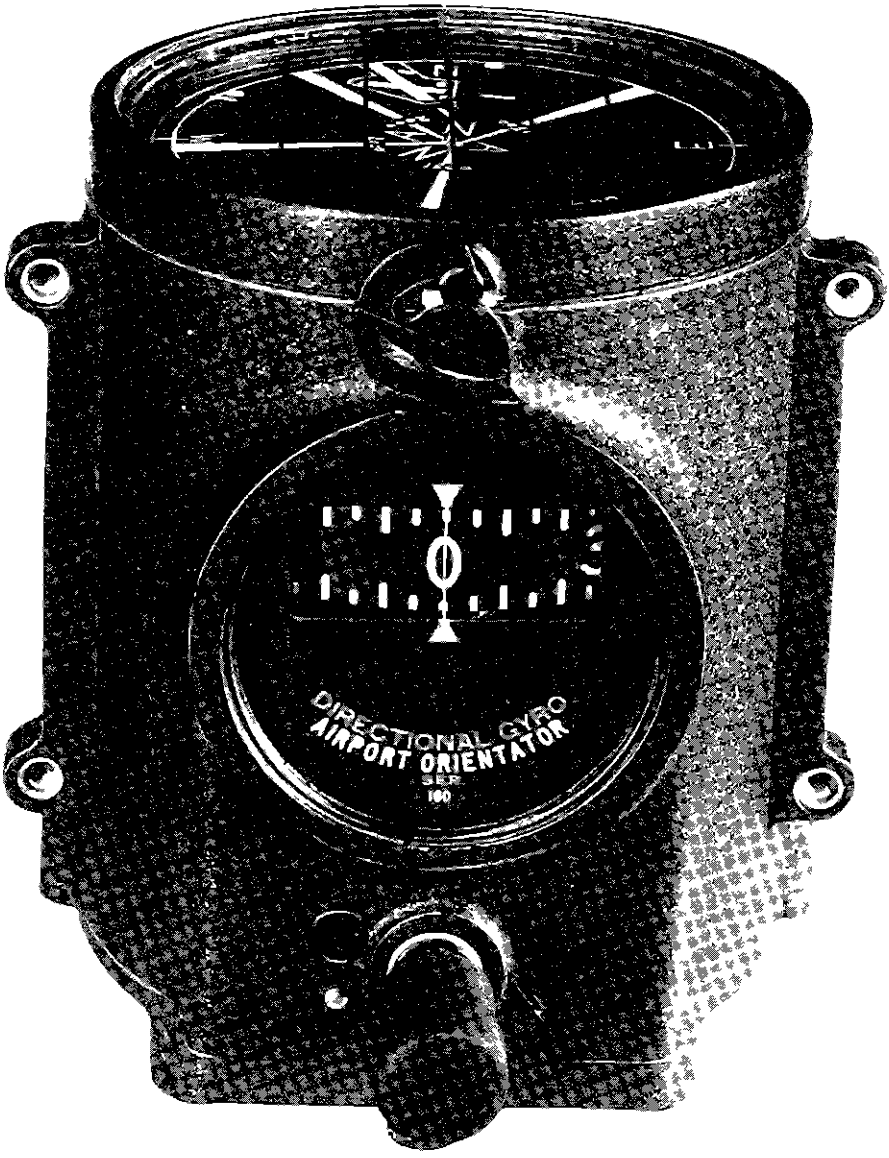

FIG 1

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FIG 2

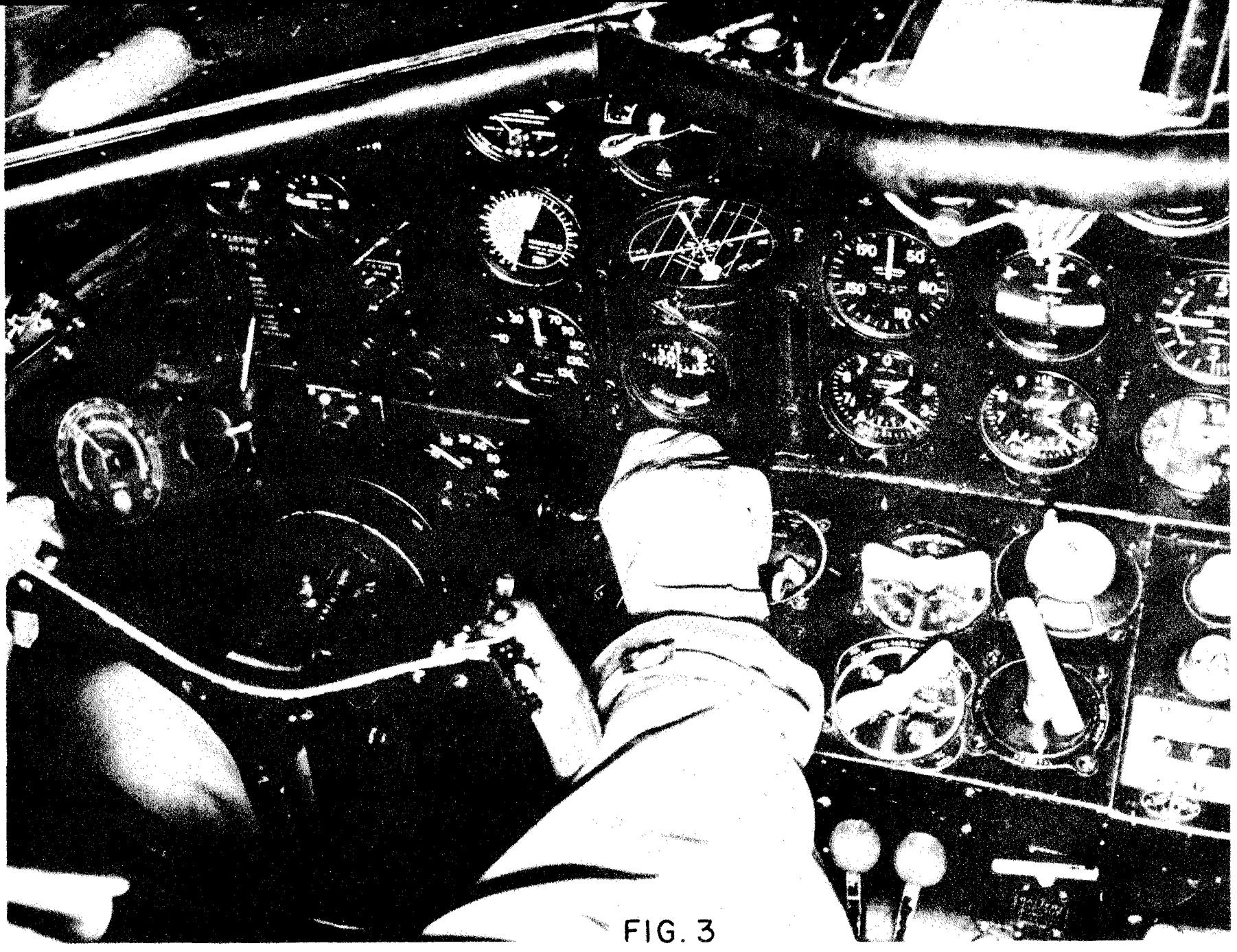

FIG. 3

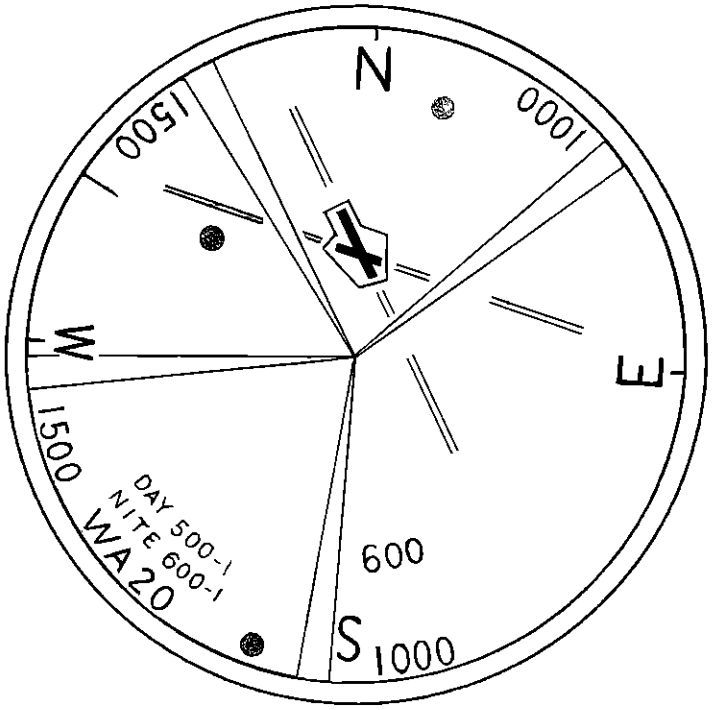

FIG 4

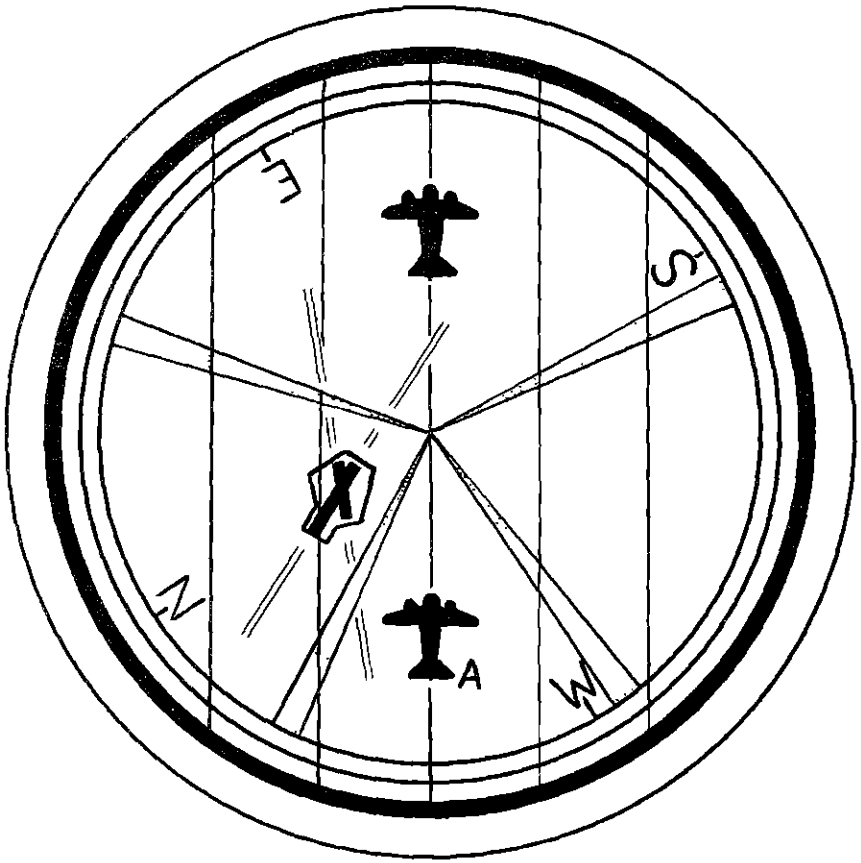

FIG 5

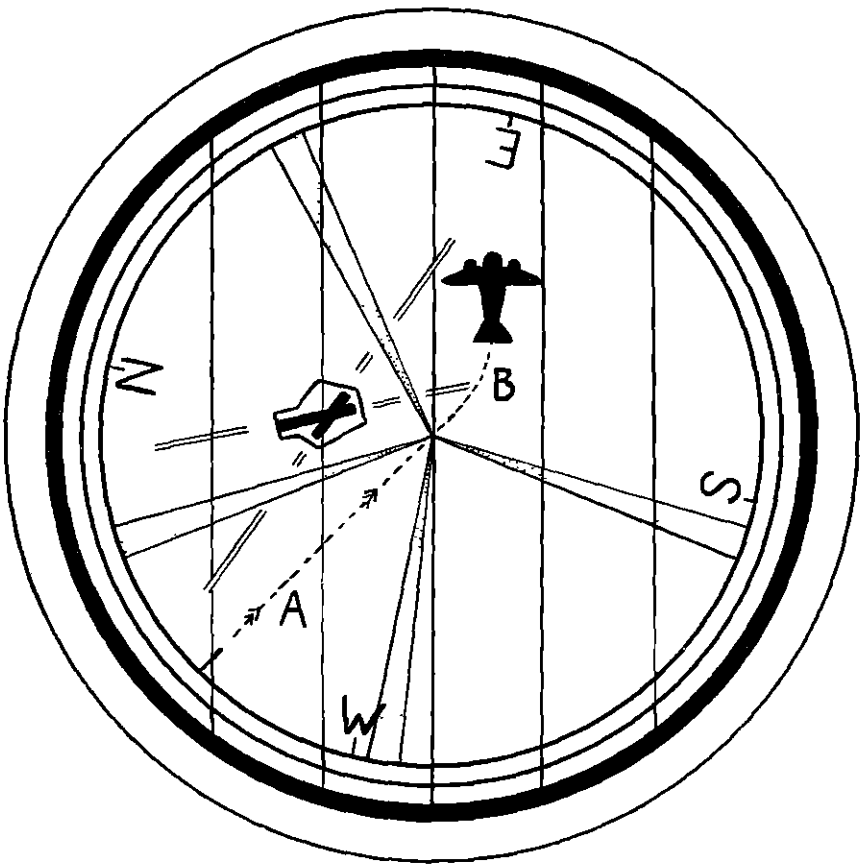

FIG 6

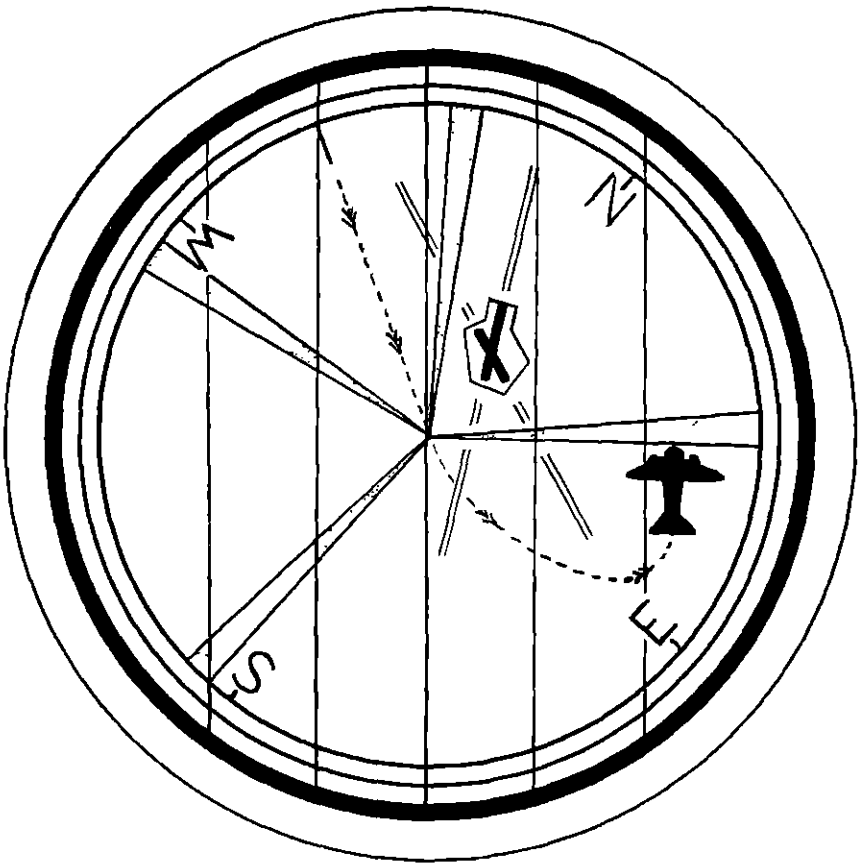

FIG 7

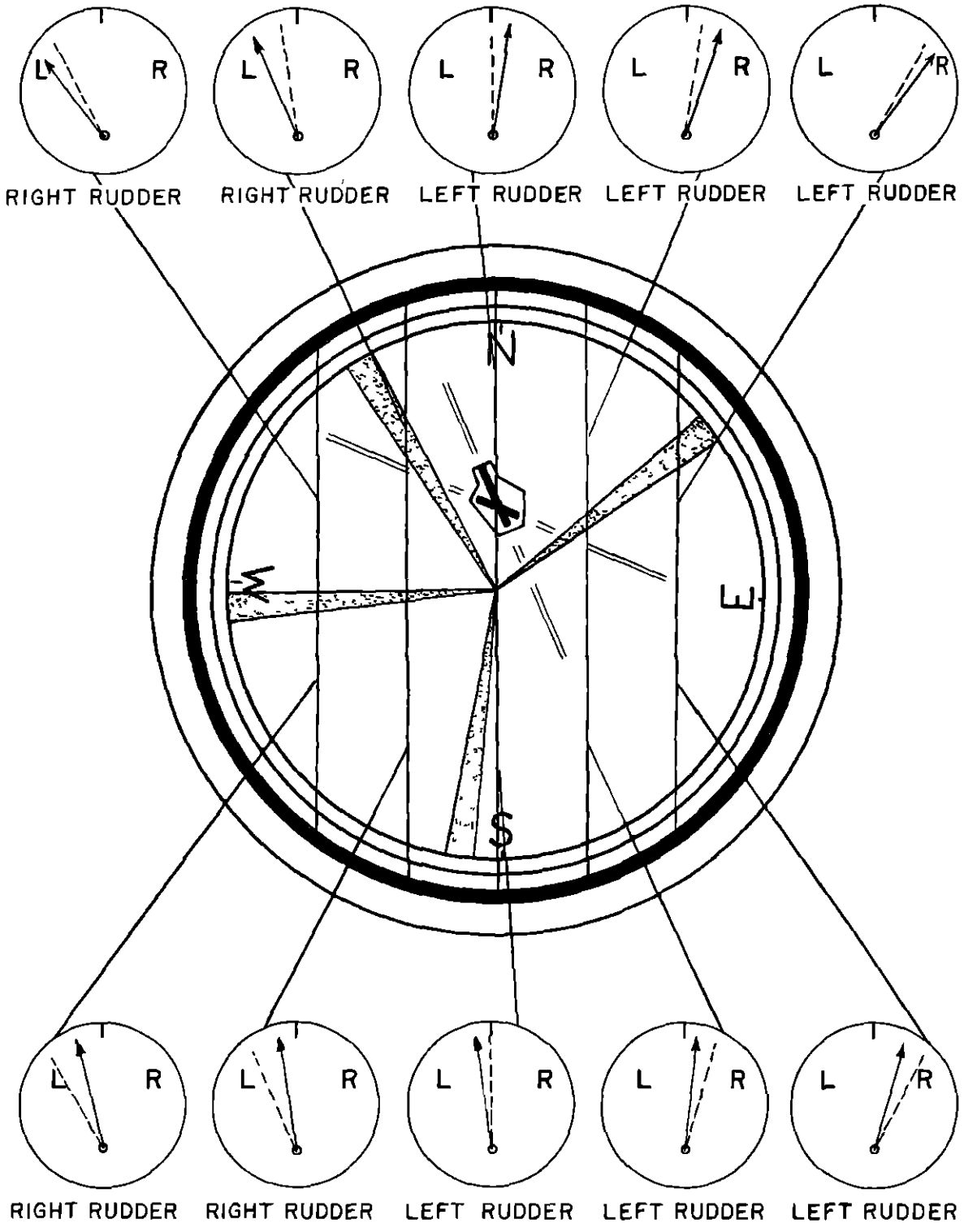
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FIG. 8

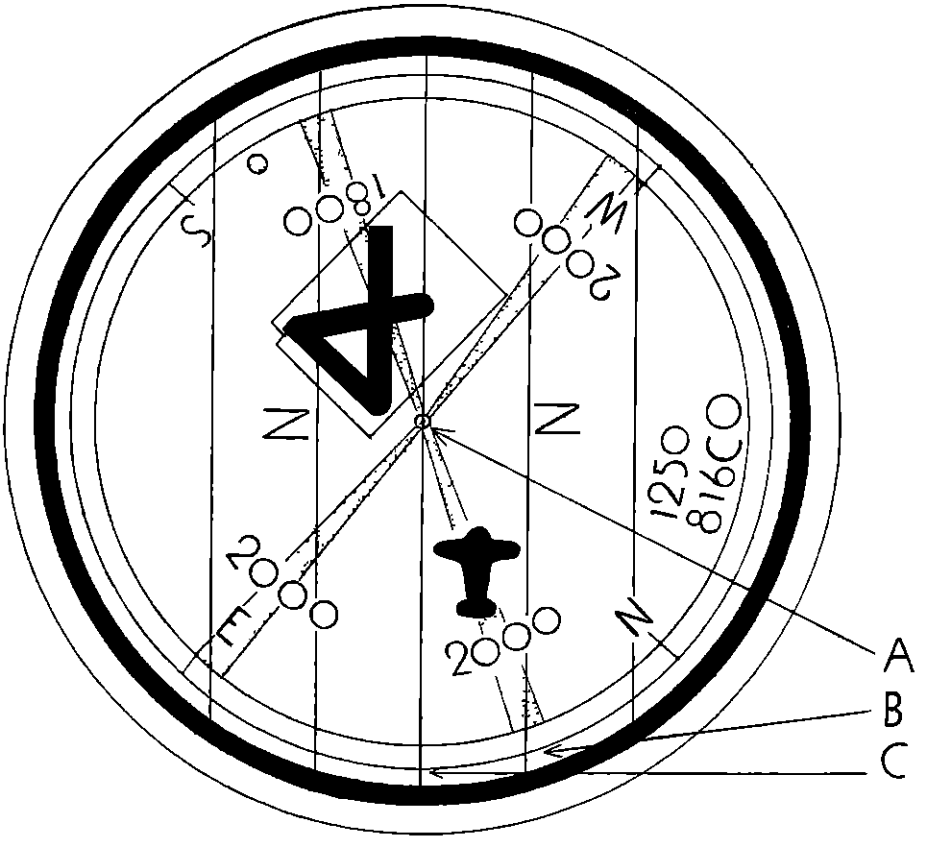

FIG 9

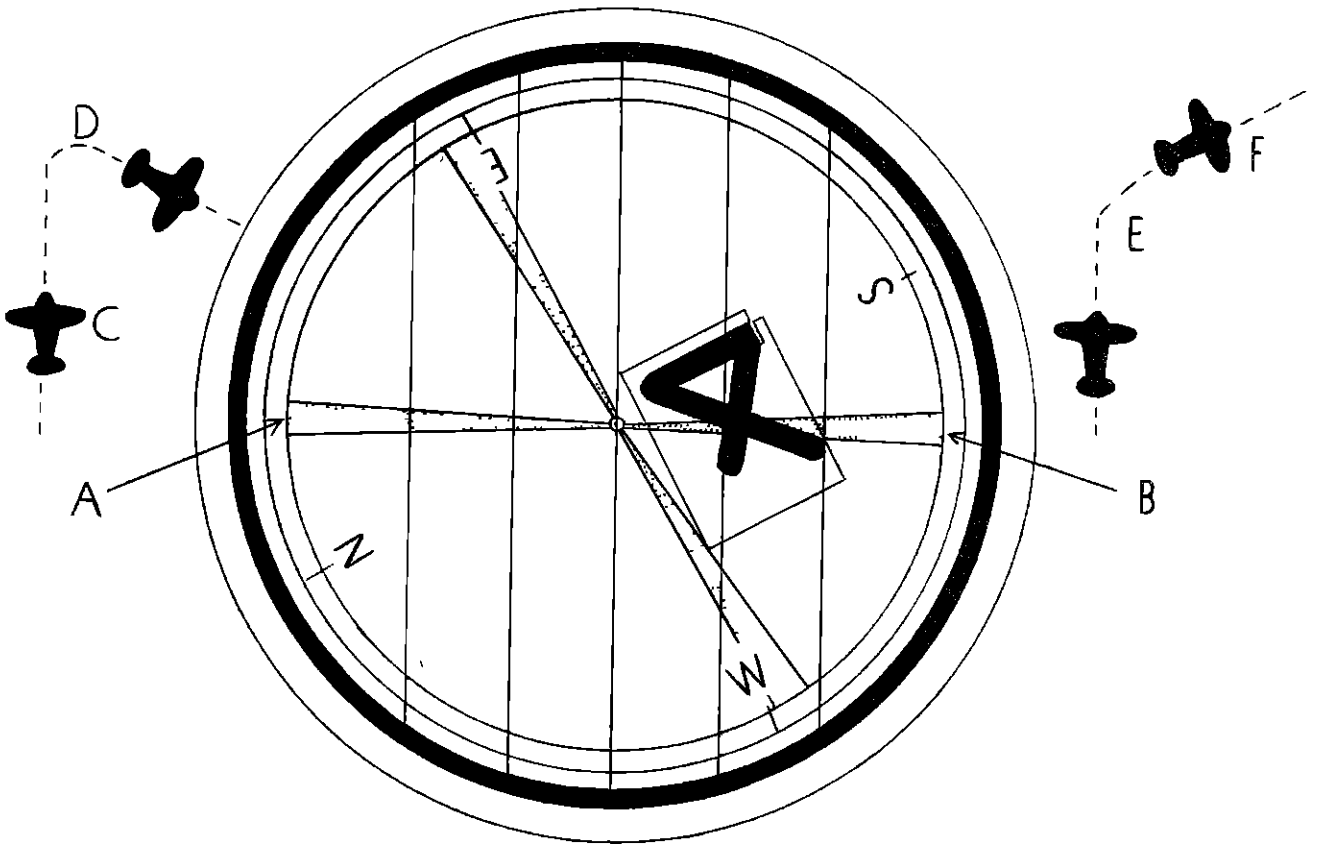

FIG 10

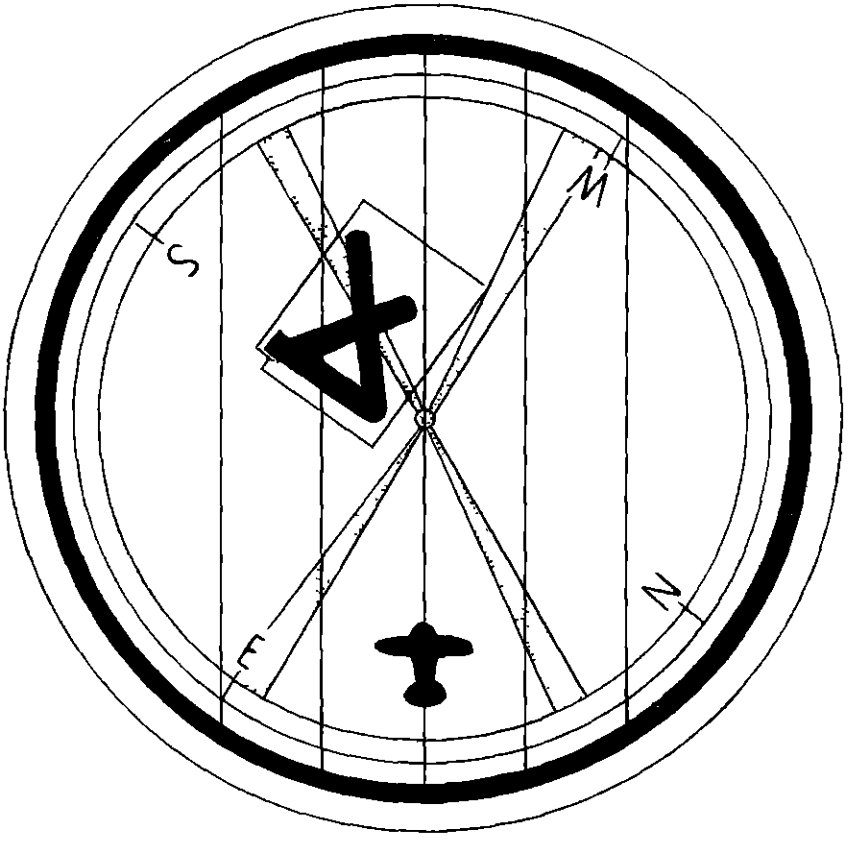

FIG. 11

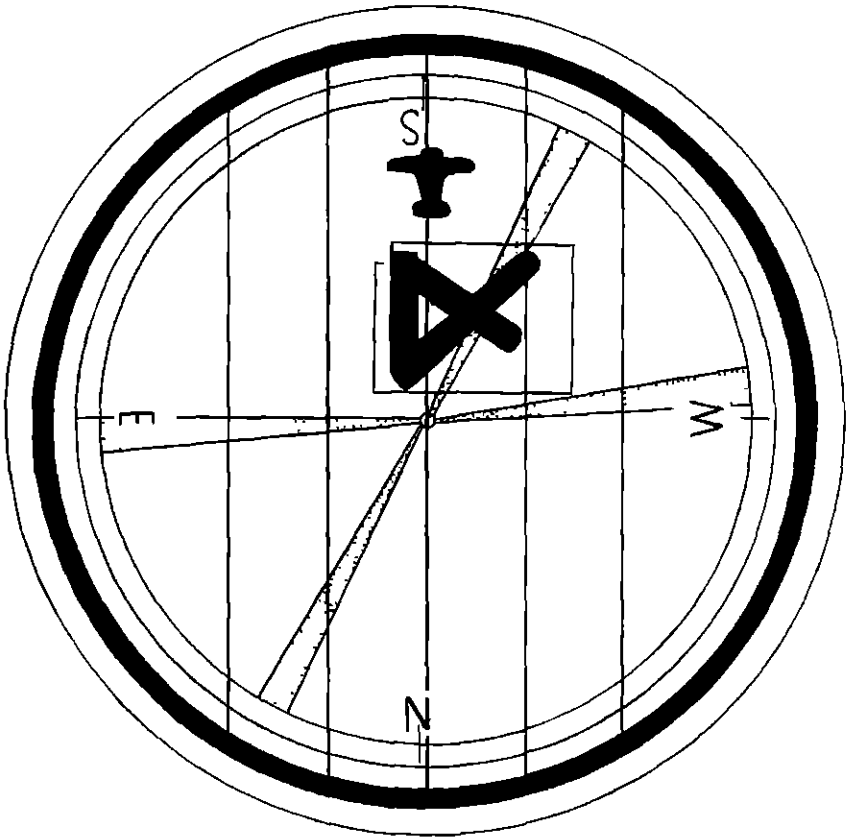

FIG 12

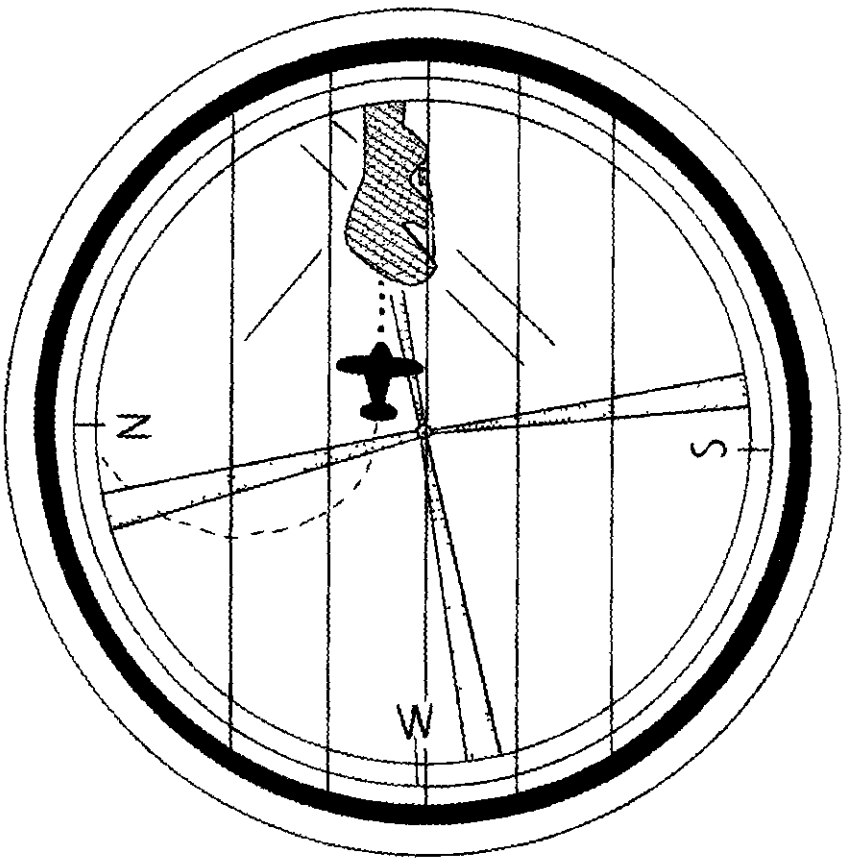

FIG 13

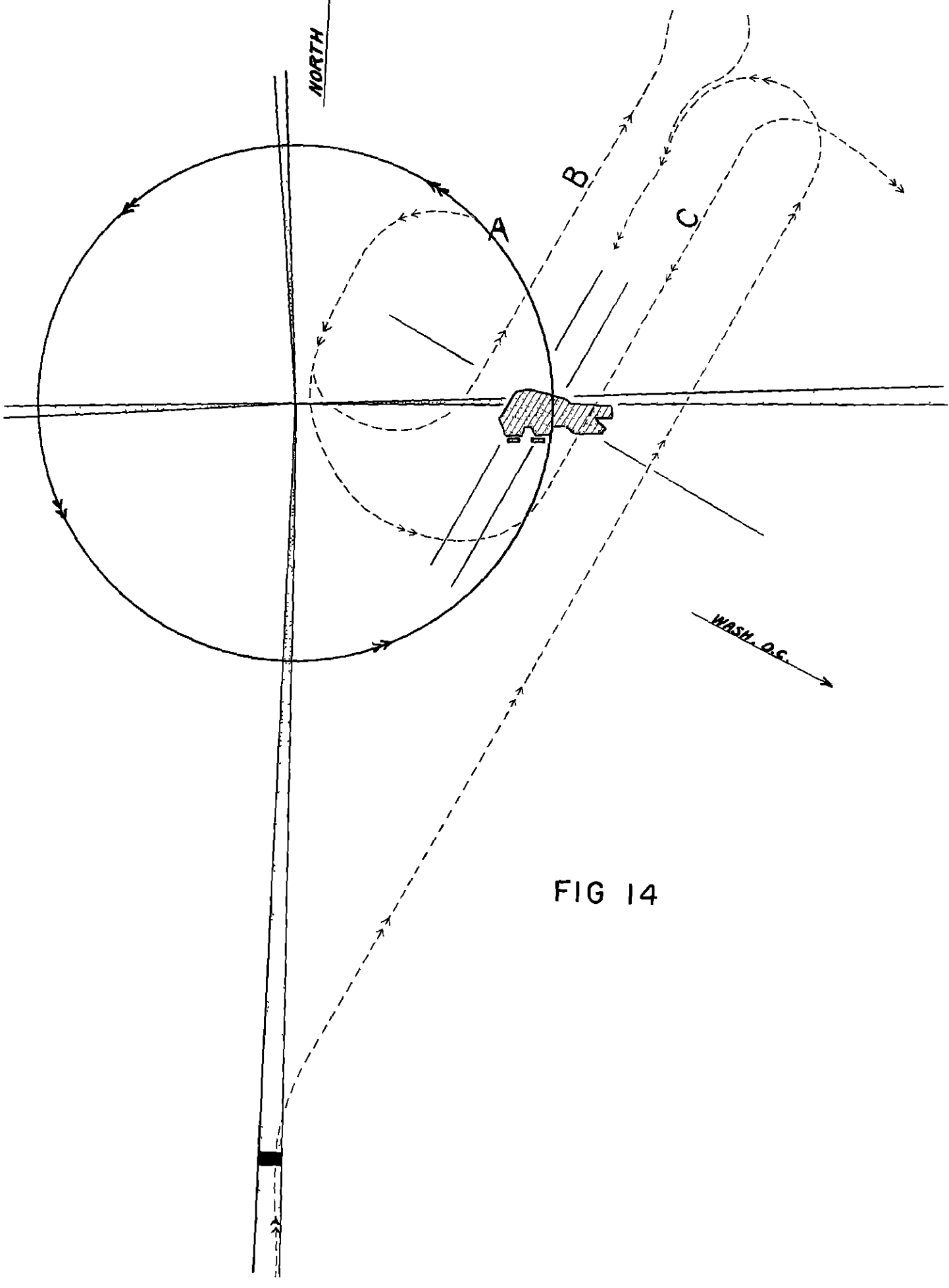

FIG 14

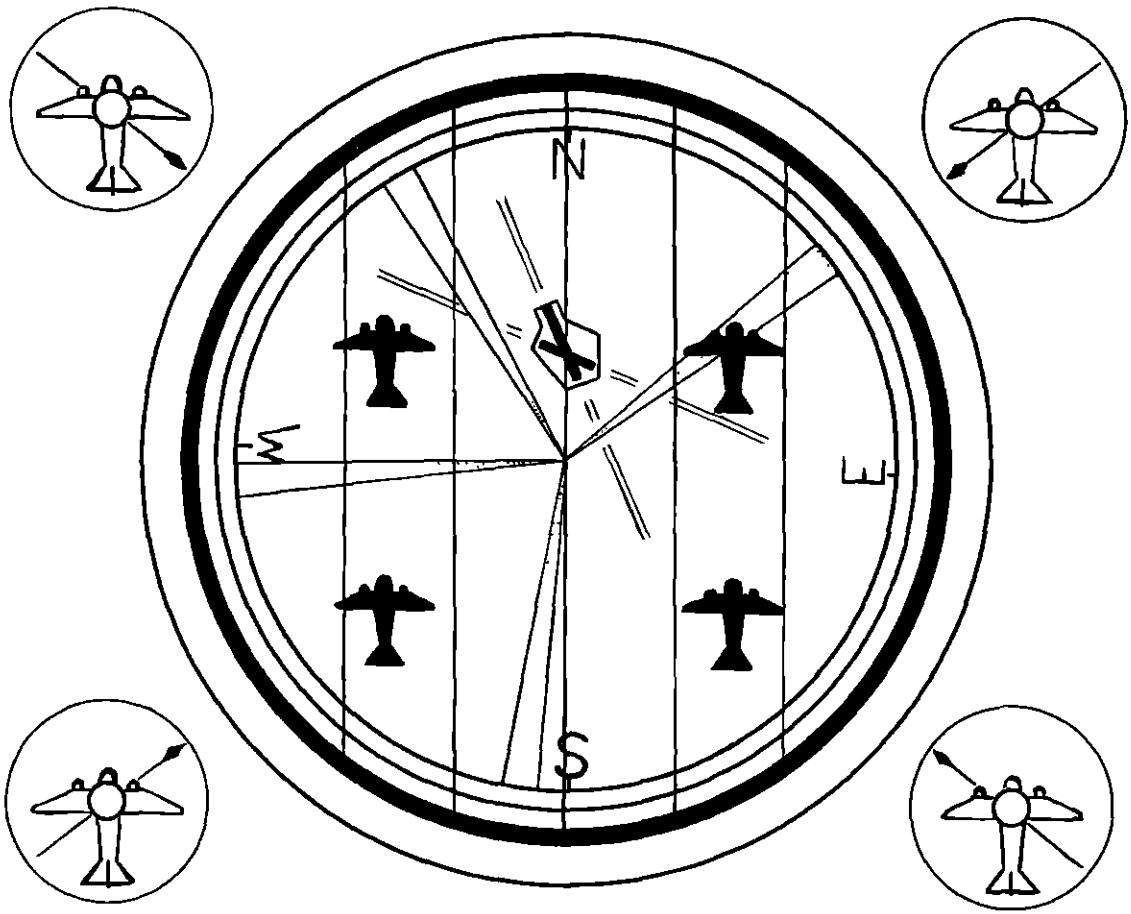

FIG 15

APPENDIX I

Specification BA-268
March 12, 1937.

SPECIFICATIONS FOR AIRPORT ORIENTATOR

These specifications cover an experimental modification of a Directional Gyro which will hereinafter be called an airport orientator.

Section 1. General Description.

The general objective of this instrument is to provide a mounting for a detailed map of an airport and its surroundings, which mounting will automatically rotate the map with respect to the airplane so that the map will remain properly orientated with the airport.

Section 2. Detailed Specifications.

1. The orientator shall be constructed so far as is possible of parts used in the standard form of the directional gyro instrument.

2. The housing of the orientator shall be provided with a hinged top containing a window through which the map may be viewed by the pilot when instrument is mounted on the instrument panel of an airplane. Said window shall be ruled with reference lines in a manner to be determined by the contractor and shall represent what he believes to be the best arrangement from the standpoint of legibility, convenience and information.

3. The hinged cover shall be provided with a friction stop to retain it in the raised position during the map changing operation.

4. Means shall be provided operable by the caging knob to interrupt suction to instrument during a map change so as to prevent unfiltered air from entering the instrument.

5. An air filter shall be provided and mounted in the housing in such a manner as to permit quick and easy replacement. Air entering the instrument shall pass through said filter which shall be designed in a manner best calculated to remove such foreign substances as might prove injurious or detrimental to the operation of the instrument.

6. The instrument shall contain a mounting for a circular airport map.

7. The map mounting shall maintain the map in synchronism in azimuth with the stabilizing element.

8. The map shall be so located and driven as to insure proper relation between the map and the mounting.

9. The map mounting and the instrument shall be so designed as to permit quick and easy change of the map by the pilot during flight.

Section 3. Inspection and Tests.

1. The manufacturer is solely responsible for compliance with these specifications and for material and workmanship, and for proper inspection thereof during the process of manufacture. However, any authorized representative of the Department of Commerce shall be afforded all reasonable means for making an inspection, if and when the Department elects to do so, but such inspection shall in no way relieve the manufacturer from responsibility.

2. The manufacturer shall make such tests as may be specified by the Department of Commerce to determine whether or not the instrument was built in accordance with these specifications. A representative of the Department of Commerce may witness such tests as are deemed necessary.

3. The instrument shall satisfactorily meet the requirements of sub-section H of Sperry Gyroscope Company's specification no. X.69410, copy of which is attached to this specification and forms a part thereof.

Section 4. Time of Delivery.

The completed instrument shall be submitted for acceptance to a representative of the Bureau of Air Commerce at the contractor's plant within one hundred and fifty (150) days of the date of the contract.

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APPENDIX II

QUESTIONNAIRE SENT TO PILOTS OF
PENNSYLVANIA-CENTRAL AIRLINES

Dear Mr. Blank:

As in the course of your work you have doubtless flown the Pennsylvania-Central Airline airplane equipped with the Sperry-Stark Airport Orientator, the Bureau would appreciate receiving an expression of your opinion regarding it.

The Bureau spent the money necessary to build the instrument for one purpose only, namely, the simplification of the pilots' job. Only the pilots can tell us if it actually does what it was designed to do. A free candid expression of your opinion is invited relative to the following points as well as to any others on which you believe your opinion valuable in appraising the value to the pilot of this instrument:

1. Does it reduce the pilots' effort of visualizing a picture of the airport?

(a) Airport en route.

(b) Alternate airport.

2. Is it a worthwhile and simple way of giving the pilot information and does it do this as well or better than manuals?

3. Can most of the information you consider essential be placed on the map? If not, what should be added?

4. Would its universal use simplify any phase of the traffic control problem?

5. Has any characteristic of the instrument caused it to mislead you? Is the instrument confusing in any respect?

6. Do you have <u>any</u> suggestions for the improvement of the device or the maps?

Your cooperation in transmitting your opinion and suggestions will be greatly appreciated as it is only thereby that any really valid estimate can be made of the value of this instrument.

Very truly yours,

REPLIES OF AIRLINE PILOTS TO QUESTIONNAIRE

While the number of pilots who have had an opportunity to use the Orientator under service conditions is not as large as could be wished, a remarkable unanimity of opinion exists among them relative to the help it gives them through the simplification it affords.

About twelve pilots replied to the questionnaire as follows:

1. Does it reduce the pilot's effort of visualizing a picture of the airport?

	Affirmative	Negative	Dubious
(a) Airport en route	10	0	2
(b) Alternate airport	12	0	0

2. Is it a worthwhile and simple way of giving the pilot information and does it do this as well or better than manuals?

Affirmative: 8 Negative: 0

Four pilots did not answer this question directly but indicated that:

(A) The Orientator was more convenient but less complete than a manual.

(B) The instrument was superior to the manual provided that it was arranged so it could be seen without eyestrain by both members of the crew.

(C) The instrument and the manual served different purposes and both were desirable; the manual to be studied and the Orientator to serve as a reminder.

(D) A manual is necessary to permit the pilot to plan a method of approach during which the Orientator is invaluable in keeping the pilot informed as to the location of the field and the plane's position relative to the field.

3. Can most of the information you consider essential be placed on the map? If not, what should be added?

Affirmative: 10 Negative: 0

One pilot believed that the back of the map should be used for additional information which while not exactly essential would be readily available for reference. Also that the hazards around the airport be printed thereon in red ink. The placing of obstructions on the map proper in red is intended when these maps are printed in color. One pilot indicated that the map should be slightly larger.

4. Would its universal use simplify any phase of the traffic control problem?

The answers to this question were difficult to separate into simple groups of affirmative and negative answers. Two pilots did not believe its use would simplify traffic control problems but all of the others believed it might or should either directly or indirectly. Several pilots indicated the manner in which they believed this simplification would be effected and a few described circumstances under which its use had simplified their problems. There seems to be reason to believe that the map before the pilot helps him to visualize the location of other planes in the vicinity as these are reported to him. Also there seems to be ample reason to believe that the use of the Orientator materially reduces the time necessary in orienting after receiving instructions to land.

5. Has any characteristic of the instrument caused it to mislead you? Is the instrument confusing in any respect?

Affirmative: 0 Negative: 12

6. Do you have any suggestions for the improvement of the device or the maps?

Several pilots replied with suggestions relative to this important point. It is probable that the development of a map which most pilots will agree is ideal will require considerable time and study. That it will be, in fact, evolved through the use of the instrument by an increasing number of pilots all of whom are contributing their experience to the development of a more satisfactory picture of the airport vicinity.

A letter addressed to [illegible], Operations Manager for Pennsylvania-Central Airlines Corporation is appended together with Mr. Neale's reply. These are self-explanatory.

DEPARTMENT OF COMMERCE
BUREAU OF AIR COMMERCE
WASHINGTON

April 22, 1938

Mr. J. Hamilton Neale
Superintendent of Flight Operations
Pennsylvania-Central Airlines, Inc.
Allegheny County Municipal Airport
Pittsburgh, Pa.

Dear Mr. Neale:

As you know, the Bureau of Air Commerce, through a contract with the Sperry Gyroscope Company, assisted Pilot Stark of your organization to develop his Airport Orientator. Upon completion of the first instrument, it was loaned to Mr. Stark who arranged to have it installed in a Pennsylvania-Central airplane.

We understand that the instrument has now had considerable flight testing by most, if not all, of your pilots. Therefore, in order that we may determine the value of the instrument, upon the development of which Government funds were expended, we have written to each of your pilots requesting his candid opinion of the instrument. A copy of the letter to one of the pilots is enclosed for your information.

In order to make our estimate of the value of this instrument conclusive, we shall appreciate receiving your opinion of the instrument and any suggestions you may care to offer concerning it. We also have asked Mr. C. Bedell Monro to comment on the value of the instrument.

Thanking you for your cooperation in this matter, I am,

Very truly yours,

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PENNSYLVANIA-CENTRAL AIRLINES CORPORATION

Allegheny County Airport Pittsburgh, Pa.

May 25, 1938

Mr. John Easton
Chief, Aircraft Section
Department of Commerce
Bureau of Air Commerce
Washington, D. C.

Dear Mr. Easton:

I have been away from my desk for a few weeks and regret the delay in answering your inquiry concerning the Sperry-Stark Airport Orientator.

We were able to arrange a very convenient installation on the instrument board and I believe that adaptation of the map dial to the pilot's routine was immediate and without any confusion since it conformed to the diagrams which most of the pilots carry for orientation with regard to each of their route range stations. A general comment which I received from the pilots in relation to the use of the map on let down procedure was the impression of solidity which the open face gives with changes in the heading of the aircraft as contrasted with the familiar flashing of numbers in the standard gyro window.

The map could be made a very simple means of conveying information about airport areas. This is extremely important to us as it applies to alternate fields. In serving this purpose and the needs of itinerant pilots, I believe the map should resemble the charts which the pilot has been using. In discussing this with Horace Stark, there was some thought of trying a circle cut from a regional chart with an additional prominent display of the airport position. Pilots unfamiliar with the area would then see landmarks at the correct angle relative to their heading.

According to discussion with pilots the map dial lends itself to more precision in let down procedure and approach to runway airports. This leads to the thought that the orientator might be very valuable as an adjunct to landing beams in preventing variation from the straight line of approach.

A desirable change in the Airport Orientator would be to combine it with a visual indicating instrument in connection with the directive loop receiver to lessen the demands on the pilot's attention during the short period of the approach.

Very truly yours,

PENNSYLVANIA-CENTRAL
AIRLINES CORPORATION

/s/ J. H. NEALE, Operations Manager