June 24, 1941. G. F. ASBURY 2,246,496

DIRECTION-FINDING ARRANGEMENT

Filed July 21, 1938 8 Sheets-Sheet 1

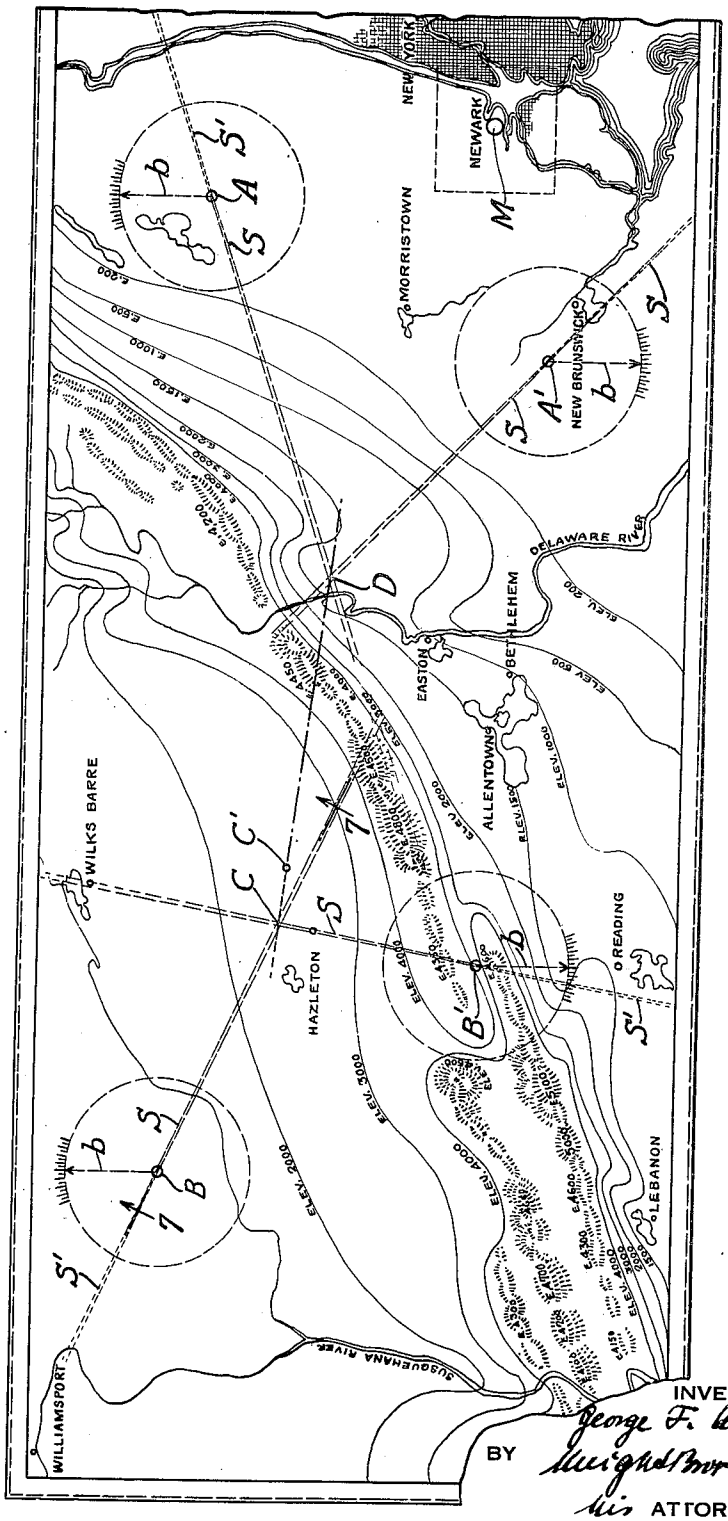


Fig. 1.

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June 24, 1941. G. F. ASBURY 2,246,496

DIRECTION-FINDING ARRANGEMENT

Filed July 21, 1938 8 Sheets-Sheet 2

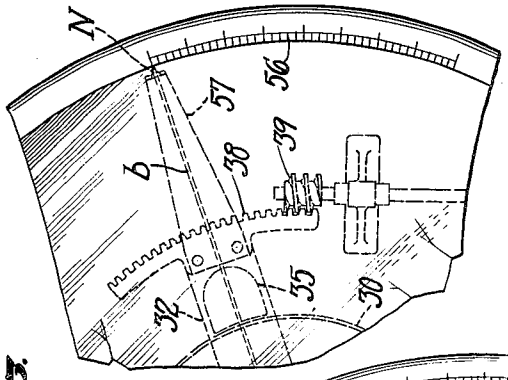


Fig. 3.

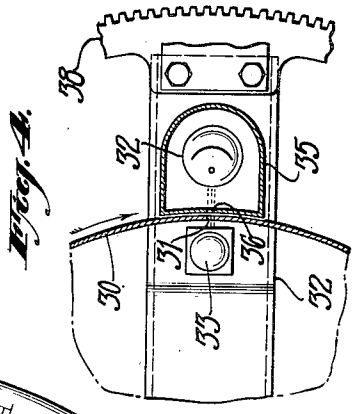


Fig. 4.

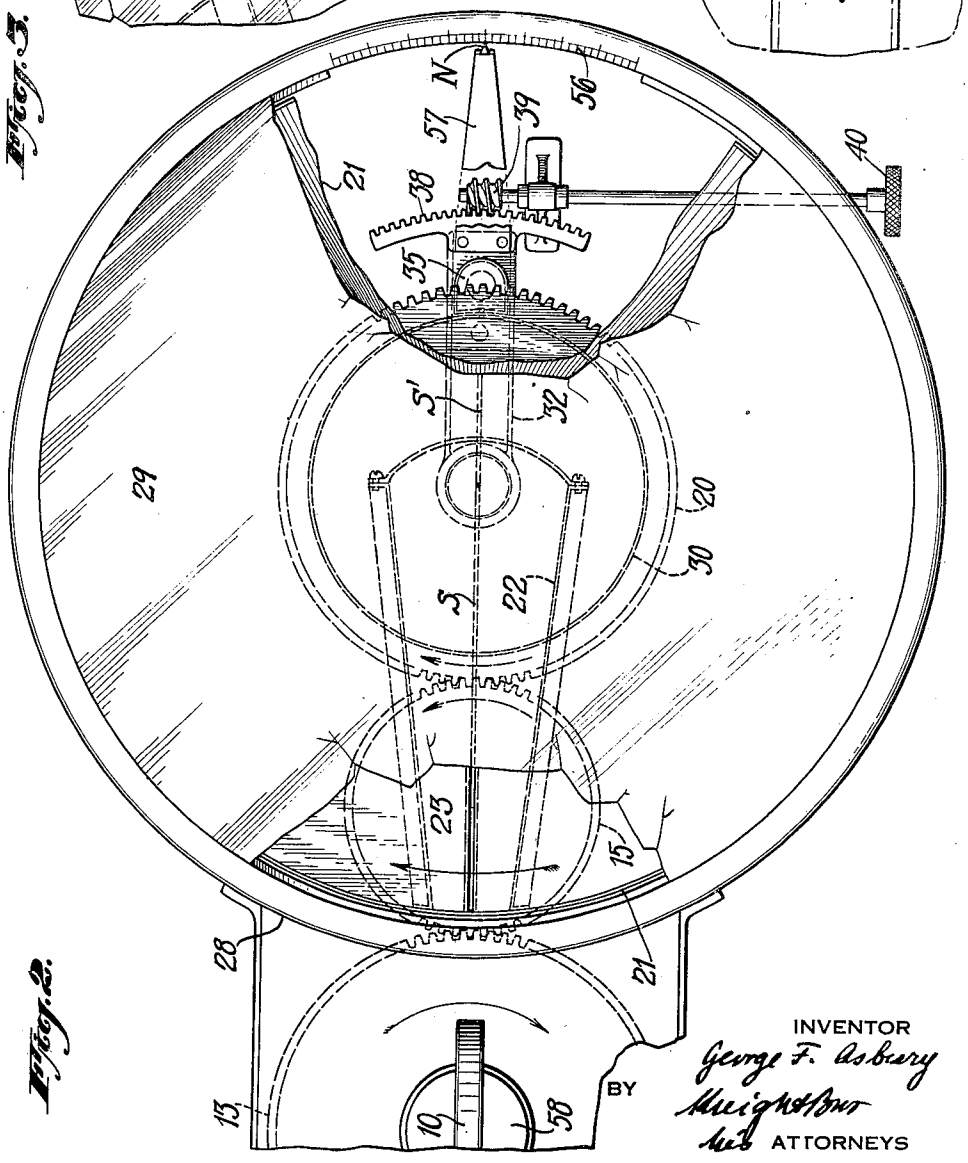


Fig. 2.

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June 24, 1941. G. F. ASBURY 2,246,496

DIRECTION-FINDING ARRANGEMENT

Filed July 21, 1938 8 Sheets-Sheet 3

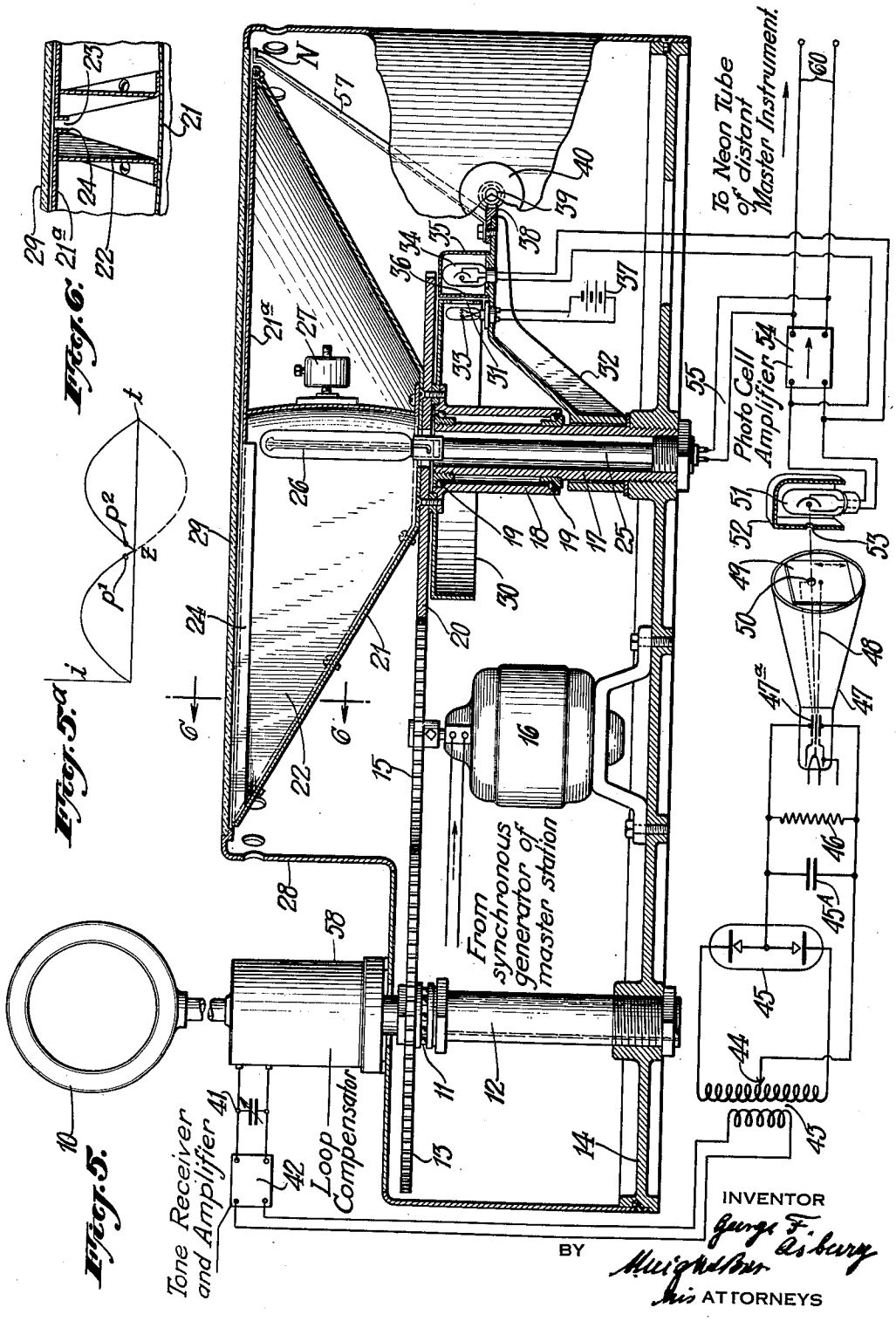


Fig. 6.

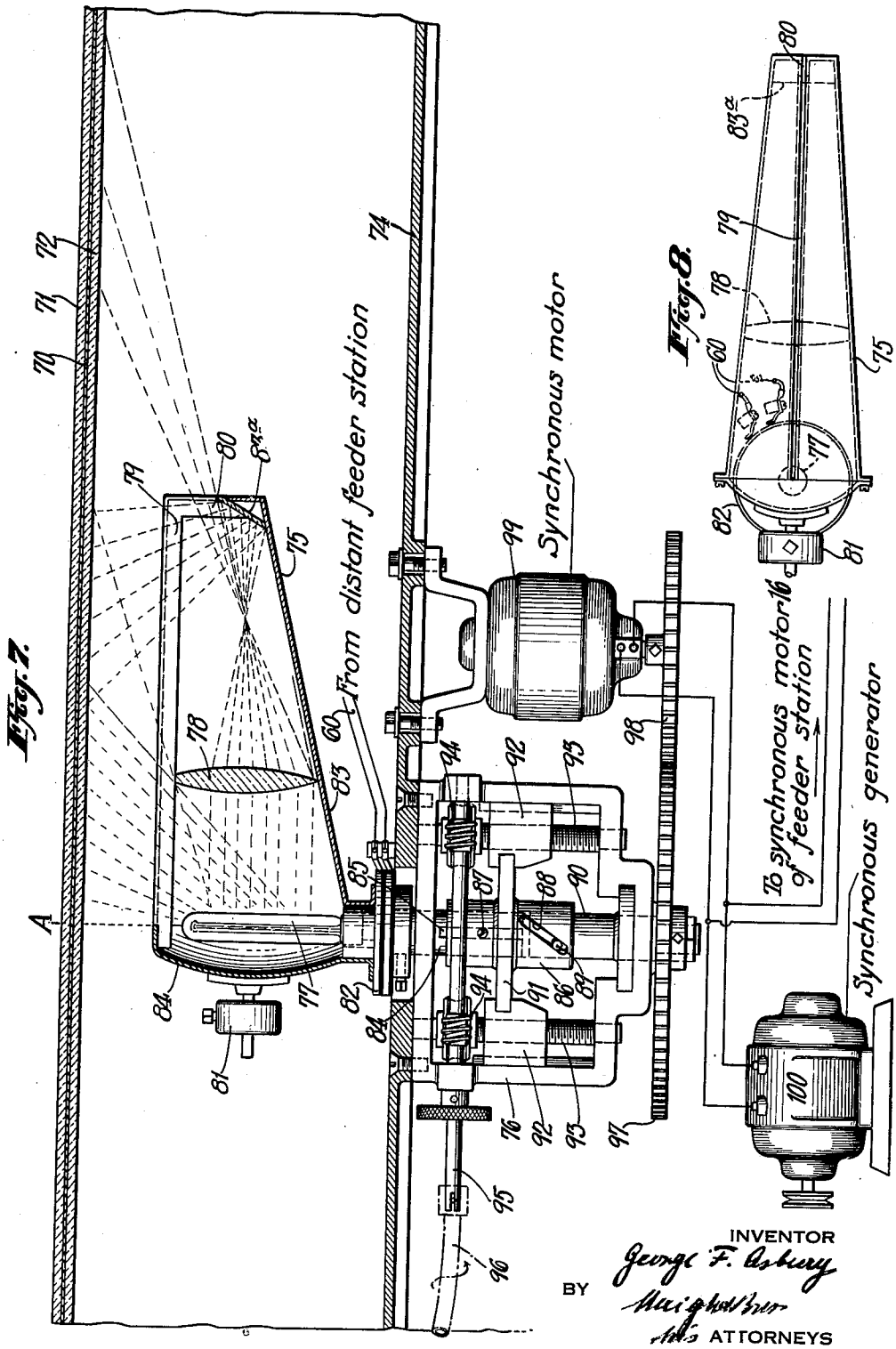
Fig. 5-a.

Fig. 5.

June 24, 1941. G. F. ASBURY 2,246,496

DIRECTION-FINDING ARRANGEMENT

Filed July 21, 1938 8 Sheets-Sheet 4



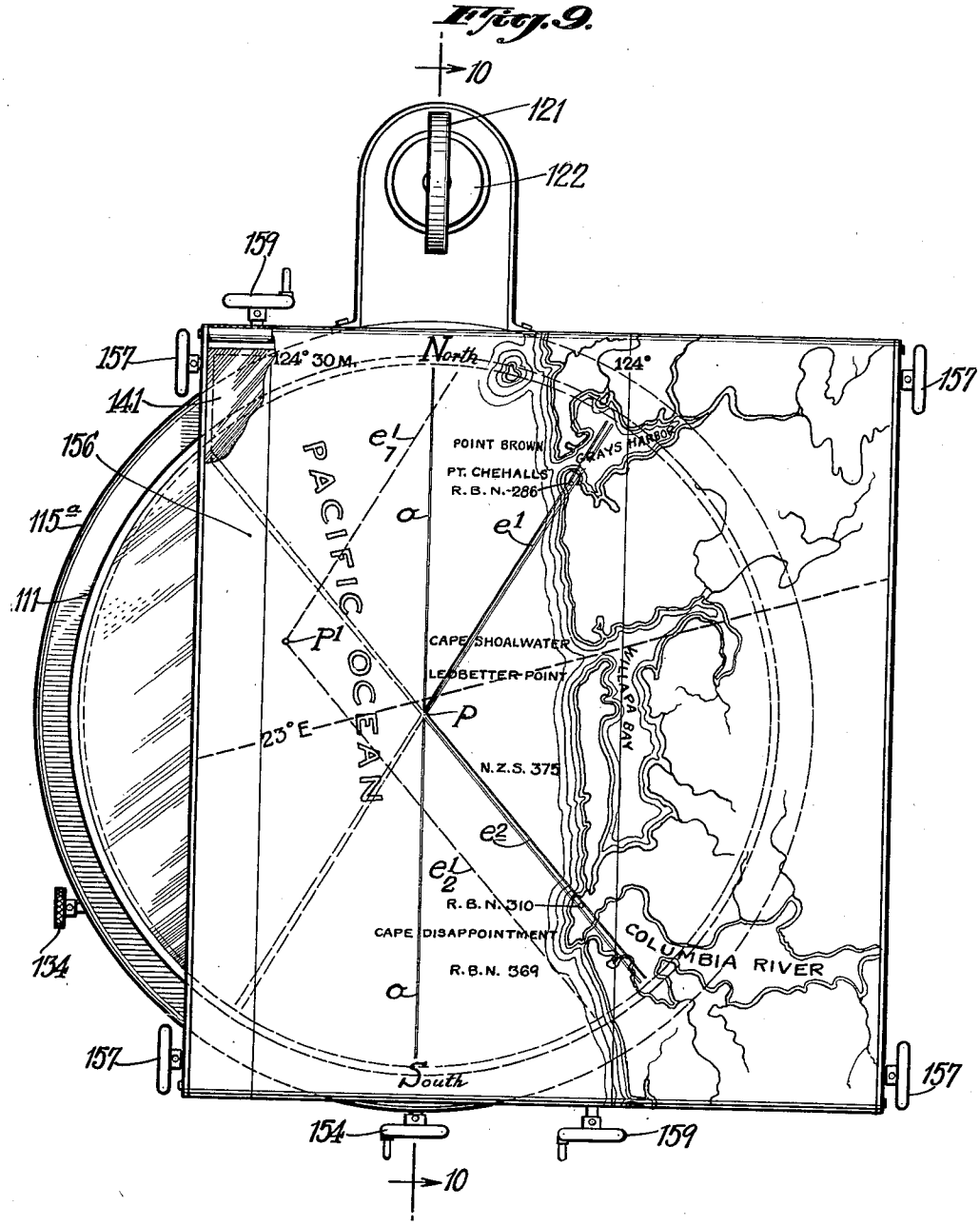
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June 24, 1941. G. F. ASBURY 2,246,496

DIRECTION-FINDING ARRANGEMENT

Filed July 21, 1938 8 Sheets-Sheet 5

Fig. 9.



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June 24, 1941. G. F. ASBURY 2,246,496

DIRECTION-FINDING ARRANGEMENT

Filed July 21, 1938 8 Sheets-Sheet 6

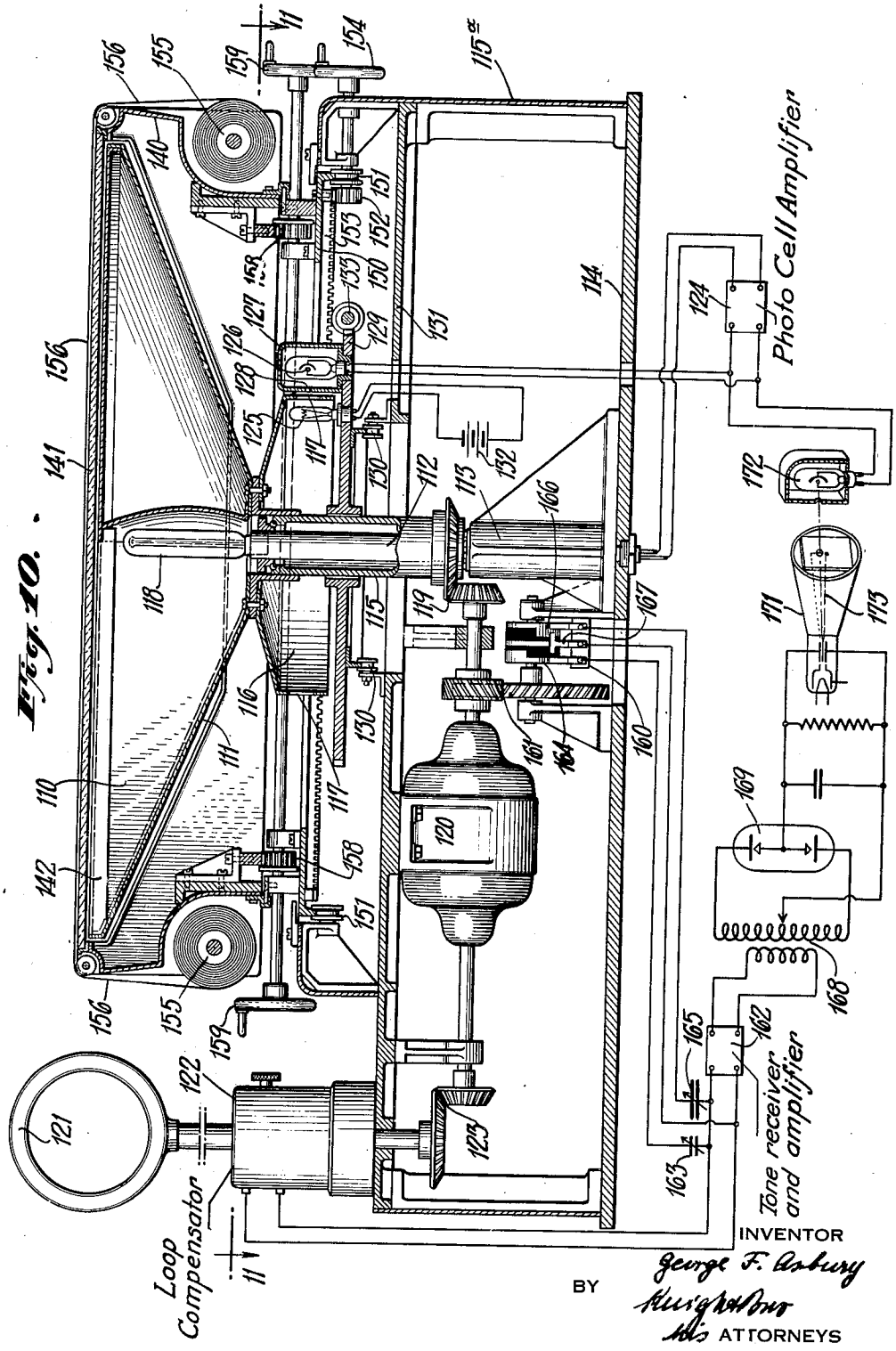


Fig. 10.

June 24, 1941. G. F. ASBURY 2,246,496

DIRECTION-FINDING ARRANGEMENT

Filed July 21, 1938 8 Sheets-Sheet 7

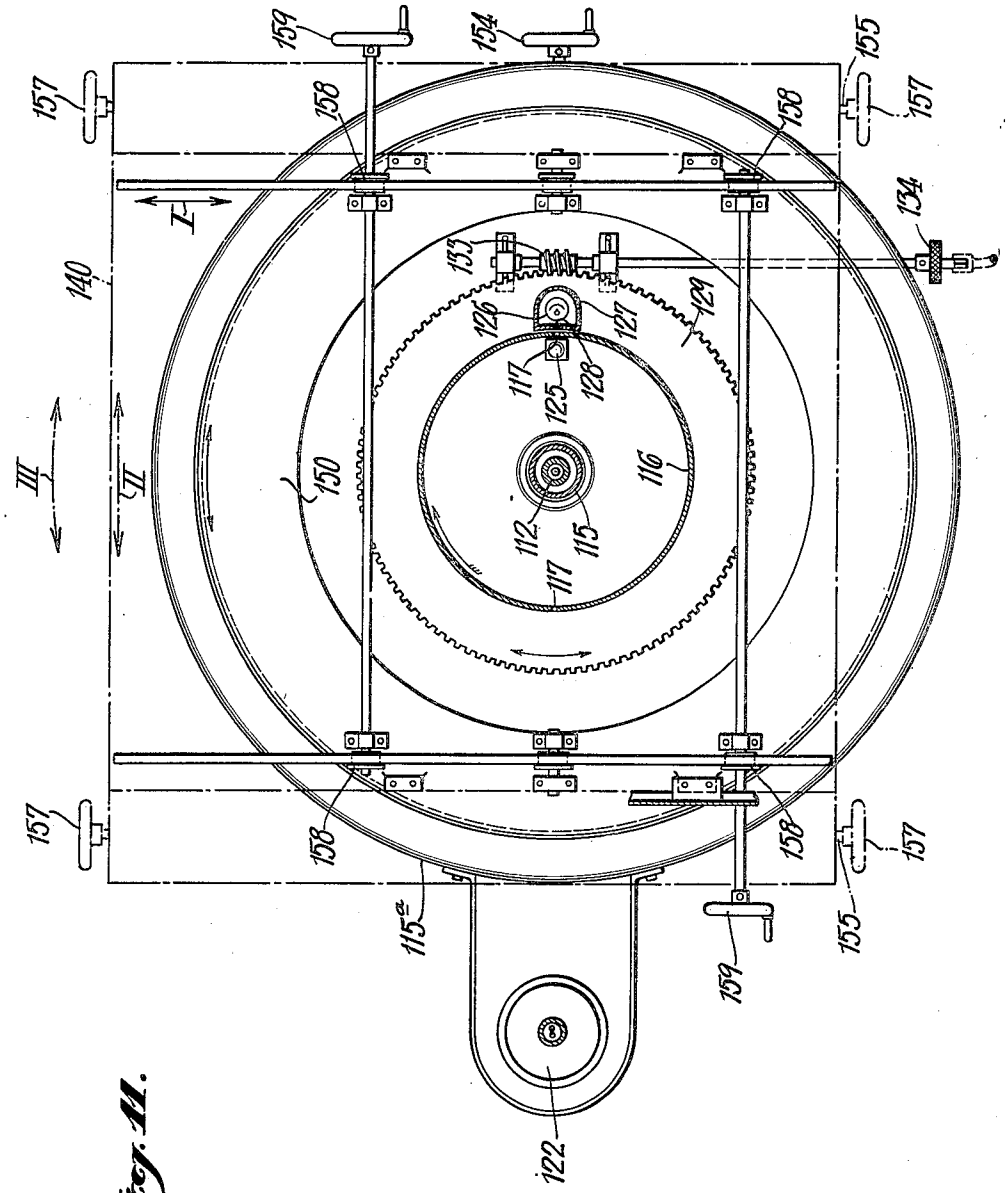


Fig. 11.

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June 24, 1941. G. F. ASBURY 2,246,496

DIRECTION-FINDING ARRANGEMENT

Filed July 21, 1938 8 Sheets-Sheet 8

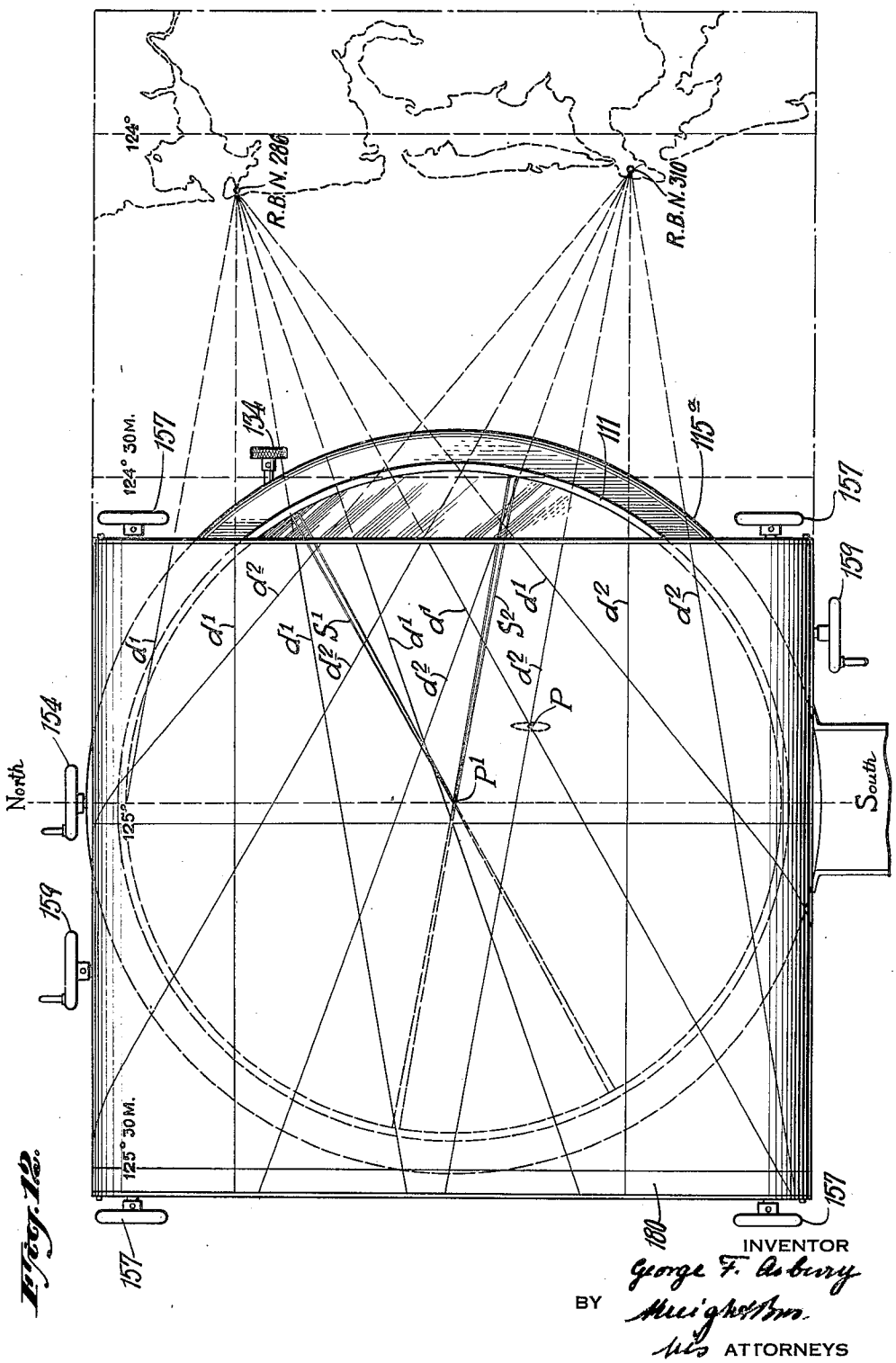


Fig. 12.

Patented June 24, 1941 2,246,496

UNITED STATES PATENT OFFICE

2,246,496

DIRECTION-FINDING ARRANGEMENT

George F. Asbury, New York, N. Y., assignor to Octavius Knight, as trustee for George F. Asbury, Otto G. Lindberg, and the firm of Knight Brothers, all of New York, N. Y.

Application July 21, 1938, Serial No. 220,459

18 Claims. (Cl. 250—11)

My invention relates to position-indicating systems developed for the purpose of giving to marine and aerial craft an added degree of safety and simpler means of geographically indicating their position at sea or above ground to aid the master of a vessel or the dispatchers or controllers of aircraft by showing the craft's position instantaneously and automatically upon a map to scale, and to enable the observers to follow the course of the ship across such a map continuously, and to observe the speed at which such ship is traveling.

Referring first to aerial craft, in view of the high speed of such craft and when they are flying on instruments, i. e. flying "blind", quite often the pilot wishes the ground stations to determine and notify him of his position. Many types of apparatus now in use, or disclosed in the prior art, require for this purpose that the pilot of the craft and two observers on the ground, located some distance apart, agree upon a given second when, for instance with the aid of radio signals from the craft, the bearings are to be taken by the ground stations by the ordinary well-known methods of triangulation. After this is done, the information so received from the two ground stations by a central station is plotted upon a chart, sometimes manually and sometimes mechanically. When the location of the craft is found, the information is radioed to the craft.

This operation takes from three to seven minutes, normally about five minutes. The craft itself is traveling at conventional speeds over three miles per minute, and thus receives this information fifteen or more miles away from the spot where the bearings were taken. Such information is of little or no use, especially in mountainous regions where ground elevations in places often exceed the normal level of the flight of the plane.

It is essential for safety and for the saving of time and gasoline that this information be given instantaneously, and for any desired duration of time, to the craft that has lost its bearings in bad weather. The purpose of the present invention is to give such information practically instantaneously and with a high degree of accuracy. The novel arrangement further avoids crowding the pilot with additional apparatus and charts to be observed.

Under the present and coming traffic conditions of aircraft at high speeds it is also necessary to know from a controller's or dispatcher's point the elevation, position and ground speed of all craft located within the supervised portion of the airway. Following a prescribed radio beam in the present practice, their paths are similar to a highway, but rather than keeping to the right and passing on the left, they are traveling one above the other at different altitudes. When a number of planes approach an air base together, it is necessary for a dispatcher upon the ground to know the ground position of each plane and also the altitude at which they are flying, in order that he may so direct these ships as to have ample space between them for a safety factor and to enable them to land without unnecessary delay. The instrument according to the invention facilitates giving this picture to the dispatcher or controller instantaneously and continuously.

Referring to marine vessels, the invention is preferably modified by having the receiving and plotting devices for the directional energy beams together with the map located on the vessel which has more room for such devices than small aircraft, so that in this case the master of the vessel can observe directly on this map the location and course of his vessel with respect to fixed shore stations, instead of having his position radioed to him, which latter is preferable in aircraft, at least in the smaller of the heavier-than-air type with its already crowded condition in the control cabin.

The invention employs for direction finding, the well-known method of triangulation, for instance by broadcasting from the aircraft a radio signal which is received by two ground stations, spaced apart across the airways, by means of a directional receiver in each station. The directions of the object observed at these stations are in the prior art devices usually plotted on a map, and by the intersection point of the directional lines the position of the object is determined. This is, as was pointed out at the beginning, a slow process. In accordance with my invention, the direction of the object ascertained at each receiving station is made instantaneously perceptible by means of a directional vector visible in its angular relation to a fixed geographically oriented base line vector, the latter being produced and controlled by local means while the directional signal vector is produced by the received signal. Thus the signal vector constantly changes its angular relation to the base line as the craft proceeds. It follows, that if the signal vectors of the two ground stations, together with their respective oriented base-line vectors, are made visible or reproduced together in a similarly oriented relation on a map at the respective

points on it at which the receiving stations are located in the field, the crossing point of the signal vectors will indicate the location of the craft. Assuming for the moment that the craft continues broadcasting radiant energy, this crossing point of the vectors will wander on the map along the course which the craft pursues in actual flight. Thus not only the craft's momentary location and its past course, but also its ground speed, can be readily continuously learned and practically instantaneously communicated to the pilot.

Except in an emergency it would not be practical for the craft to continuously broadcast signals but preferably to only broadcast intermittently at stated times and for stated periods of, for instance, each minute or parts of each hour. This would enable other craft flying in the same territory covered by the map and to which other signalling periods are assigned, to likewise render their positions and courses visible on the map so that, for instance, the dispatchers or "master station," as it will be called hereinafter, at which the map with its vector-reproducing receivers from the feeder stations in the field would be most conveniently located, is at all times clearly informed of the actual momentary whereabouts of the planes traversing its territory. This is of great importance not only for traffic regulation near a central airport, especially in case of blind flying, but also for each craft on its course, especially over mountainous territory where at points the ground elevations are higher than the average flying altitude otherwise prescribed for the craft. For instance, an altitude of two thousand feet may be prescribed for the pilot as safe over low altitude territory, and an altitude of five thousand feet for crossing a mountain range on its course. By read reckoning in case of poor ground visibility, the pilot may conclude that he can still safely fly at the altitude of two thousand feet for some miles before he arrives at the mountain range. He may have miscalculated a strong tail wind which brings him to the range sooner than he intends to rise to the higher altitude. If his course is observed, however, at short intermittent periods at the master station as described, he can readily and instantaneously be forewarned of his actual position and be instructed to rise to the higher prescribed altitude in due time. Incidentally, by means well known in the art and not shown and described here, the pilot may automatically through a barograph-radio transmitter, or by hand signalling during his allotted signal periods, communicate his present altitude which the dispatcher at the master station records on the map at the observed appertaining ground position, which would thus practically bring up to the minute at the master station the log of the craft during its entire trip within the map territory.

My invention is illustrated in the accompanying drawings, in which—

Figure 1 represents an airway map assumed to be located at the master station and portraying an airway territory supervised by the master station and on which the receivers for the direction-indicating feeder stations, placed along the actual airway, are correspondingly located.

Figure 2 represents a plan view partly in section, of a feeder-station arrangement for receiving the energy beam from the traveling object and for transmitting its directional angular value with respect to a given oriented base line together with the base line to the master station.

Figure 3 represents the sectional portion of Figure 2 broken away in that figure and showing a portion of an oriented base line.

Figure 4 represents in plan view and on slightly larger scale the means for producing the base line in the desired oriented position.

Figure 5 represents a sectional elevation of the feeder-station mechanism with its local directional signal-receiving circuits and the directional beam-producing and transmitting circuits.

Figure 5a represents an explanatory graph.

Figure 6 is a transverse sectional elevation of the light beam chamber in the rotating cone taken on the line 6—6 of Figure 5.

Figure 7 represents in sectional elevation, on the line 7—7 of Figure 1, one of the several receivers from the feeder stations located beneath the map at the master station corresponding to the actual location of its appertaining feeder station on the airway.

Figure 8 represents a plan view of the rotating arm 75 of Figure 7.

Figure 9 represents in plan view a modified map and a master station device located on a traveling craft for locating its position with respect to two geographically spaced and fixed base points, for instance two shore or ground stations.

Figure 10 represents a sectional elevation of the device of Figure 9, on the line 10—10 of that figure.

Figure 11 represents a sectional plan view of the device, Figure 10, on the line 11—11 of that figure, and

Figure 12 represents a plan view similar to Figure 9 showing a modified form of the map used in case the craft is located too far from the fixed base points to conveniently show the base points as on the map, Figure 9.

While the improvement involved in the present invention may be reduced to practice with the aid of any kind of energy capable of being broadcast and of being directionally received, I prefer to use electromagnetic waves as most convenient and best suited for my purposes, and the arrangements and devices described hereinafter and illustrated are designed for this form of signal transmission.

It is well known that an object on the ground or in the air, broadcasting radio signals, can be located in direction by a distant receiving station by means of an attuned rotating loop antenna radiogoniometer coil or similar direction-responsive device in which the maximum receiving current flows when the device lies in a definite position in the direction of the signal source, and the minimum or zero current condition prevails when the device is turned at right angles to the signalling direction. Thus, for instance, in case of a loop antenna, the loop plane lies in the signal direction at maximum current and at right angles to it at minimum current. In both positions the receiver can be used for direction indication. I prefer using the zero current position, because it defines the directional loop position more sharply than the maximum current position. If we should provide means by which a lamp, placed at the rotary center and inside of a hollow scanning arm, rotating synchronously with the loop and provided with a radial slot at the top, is flashed each time the loop is in zero current position, a radial streak or beam of light can be produced on a transparent or translucent screen, for instance a ground glass plate located directly above the arm. Assuming for the moment that the

signal source is stationary, this radial light beam will appear intermittently at the same place on the screen when the loop and the arm are rotated. If we now produce by a local source of energy intermittently a second radial light flash always at a given fixed place on the screen, there exists a fixed angular relation between the two beams. If we now assume the signal source to travel around the receiving station, the angular relation between the two beam vectors constantly varies. If the local light beam, which I shall hereinafter call the base line or base-line vector, be produced so that it always appears oriented in a given compass direction, the direction of the signal beam vector represents the direction of the signalling object with respect to the orienting direction of the base-line vector.

An arrangement for accomplishing this effect is illustrated in Figures 2 to 6. As shown in Figure 5, a loop antenna 10 is rotatably disposed by means of a bearing 11 and stud 12 mounted on the base 14 of the instrument. The loop shaft carries a gear wheel 13 in mesh with the pinion 15 carried by motor 16 also mounted on the instrument base 14. On base 14 is further mounted an upright hollow stud 17 which rotatably supports as by bearings 19, 19 a sleeve 18, the latter carrying a gear wheel 20 at its upper end, which wheel meshes with motor pinion 15 and is of exactly the same diameter as loop gear 13, so that both are rotated by the motor at the same speed and in the same direction. Sleeve 18 carries fixed on top of its gear 20 a funnel-shaped rotor 21 which has fixed to it in its interior a radially extending narrow hollow scanner arm 22 shown in cross section in Figure 6 and in plan view in Figure 2. This arm is closed on all sides except at its flat top which is level with the cover 21*a* of rotor 21, and which is provided with a narrow radial slot 23 with inwardly turned light beam guiding edges 24. Within hollow stud 17 is fixed a stationary tubular lamp support 25 which carries at its upper end, protruding into scanner arm 22, a preferably rod-type neon lamp 26 which thus becomes located in the rotation center of arm 22. In place of a neon lamp I may employ any other type of luminous tube which in its light effect instantaneously responds to an applied voltage, in other words, a lamp or tube which has no heat inertia. The inner surfaces of scanner 22 are made light reflecting where necessary, so that when the tube is flashed at a suitable voltage, a narrow radial beam of light emanates from scanner slot 23. A counterweight 27 of suitable size is fixed to scanner 22 as shown, to counterbalance the radially extending mass of the scanner arm and to afford smooth running of the scanner funnel. The whole apparatus excepting the loop is covered by a casing 28 which carries at its top and closely adjacent to the scanner top a transparent or translucent screen 29, for instance a ground glass plate against which the radial light flashes of the neon lamp aforescribed become visible in the form of radial or vector lines, such as *s* in Figure 2.

To the underside of scanner gear 20 is fixed an annular skirt 30 provided with an axially extending slot 31 in its peripheral wall and located in the axial plane through scanner slot 23, i. e. in Figure 5 in the plane of the drawing. Further, on stud 17 is rotatably mounted a bracket 32 which extends to skirt 30 and carries adjacent to the inner peripheral wall of the skirt an incandescent lamp 33 assumed to be continually lighted from a current source 37, and outside of this wall a photo-electric cell 34, enclosed in a light-tight casing 35, provided with an aperture 36. Lamp 33, slot 31, aperture 36 and photo-cell 34 are arranged in radial alinement so that each time slot 31 passes between lamp 33 and aperture 36 at each revolution of the scanner, photo-cell 34 is energized by a light flash. The angular position of arm 32 with respect to stud 17 is controlled by means of a worm sector 38 attached to it and by a worm wheel 39 suitably journalled on the base (not shown) and operated by a thumb screw 40 (Figures 2 to 4), so that the point at which the photo-cell is energized can be peripherally adjusted in any desired compass direction by means of hand 57 and fixed scale 56.

In order to cause neon tube 26 to flash and produce the signal and base-line light vectors on the screen 29 during the rotation of the loop, the following circuit arrangement is provided: The loop circuit is tuned by condenser 41 to the operating frequency of the observed transmitting station which broadcasts the signals. As is necessary in all rotating loop receivers, also in this case the loop is compensated by means of a loop compensating circuit or device to correct the errors in the true directional indication of the loop, due to local influences. This type of device is well known in the art, and forms no part of the present invention, and its location in my apparatus is merely indicated by the labeled container 58. The signals are delivered from compensator 58 to a conventional tone receiver and amplifier 42, the output of which would normally produce, for instance, a signal audible in a telephone in the conventional manner. In the present case, however, these signals which constitute an alternating current of tone frequency are fed into the primary winding of a step-up voltage transformer 43, the ends of the secondary winding of which are connected to the anodes of a conventional two-way rectifier 45. The cathodes of this rectifier are connected to one terminal of a condenser 45A of relatively large capacity, the other terminal of this condenser being connected to the center tap 44 of the secondary of transformer 43, so that the unidirectional voltage applied across condenser 45A approximately equals the average rising and falling voltage when the loop current passes from zero through maximum back to zero value as the loop rotates from zero-receiving to maximum-receiving back to zero-receiving position. A high ohm leakage resistance 46 is placed across condenser 45A so as to secure as much as possible zero value of the condenser charge when the loop current is zero. Condenser 45A is connected to the deflecting plates 47A of a conventional cathode ray tube 47, the beam 48 of which is normally, i. e. at zero loop current, in its central or zero position, indicated by a dash line. As the condenser 45A is gradually charged by the accumulating unidirectional voltage impulses produced by the rising loop current, beam 48 is gradually deflected into the dotted position which represents the maximum average value of the current impulses delivered by the loop. As the loop current gradually drops, the average value of the unidirectional impulses delivered by the rectifier drops and thus the condenser charge, so that the cathode beam gradually returns to zero. This occurs twice for each complete loop revolution. The conventional window of the cathode ray tube, at which the beam is visible as a point of light, is screened by an opaque screen 49 provided with an aperture 59 located very close

to but not at the zero point of the cathode beam and in the path of its travel. The aperture may be shifted into the desired distance position by shifting screen 49 as indicated by the double head arrow in any suitable and conventional manner not shown here. Thus the cathode beam passes through aperture 50 on the outstroke and on the instroke. Theoretically the aperture could be located at the zero position of the beam but in practice this point is not very sharply defined and might give rise to erroneous indications. A near zero point is more reliable for indicating timely the loop zero current point, as will be seen from Figure 5a. In this figure the two curves represent the currents *i* rectified by rectifier 45 and flowing in the loop during a complete revolution as they affect the cathode beam. Midway between the presentation of each loop shank toward the signal source, the current drops substantially to the zero point *z*. This point, as stated before, is very uncertain as to time and in actual value, and therefore difficult to indicate by the cathode beam uniformly during a number of loop revolutions. On the other hand, if we shift the screen aperture 50 slightly above the zero point of the beam in the direction of the beam path, the beam will on its instroke strike the aperture at the current value p_1 in Figure 5a and at its outstroke at the current value p_2. These two current values can still be considered uniform for all loop revolutions. Therefore, as to time, the zero point of the current is located midway between p_1 and p_2.

In front of the cathode ray screen 49 is arranged a photo-cell 51 light-shielded by a casing 52 provided with an aperture 53. Cell 51 and apertures 53 and 50 are in alinement so that when the beam strikes aperture 50, cell 51 is energized twice at the short time interval p_1—p_2 in Figure 5a for each half revolution of loop 10.

The current impulses thus produced by photo-cell 51 are highly amplified in a conventional photo-cell amplifier 54, not shown here in detail, and are delivered from the output side of the latter to neon tube 26 through connection 55. The earlier described photo-cell 34 is also connected to the input side of amplifier 54 so that the current impulses of this cell are also amplified and will also flash the lamp, namely as aforedescribed, at the time when slot 31 in skirt 30 passes between lamp 33 and cell 34.

The system so far described operates as follows. If, during its rotation, loop 10 receives signals in the direction of the signal source, a zero current condition occurs twice for each complete revolution and thus twice for each loop revolution photo-cell 51 is energized and neon tube 26 flashed at zero loop current. Since scanner arm 22 rotates synchronously with loop 10, two radial light lines *s*, *s'* will appear on scanner screen 29, 180° apart, as shown in Figure 2, of which, however, only one, *s*, is used, and thus always the same side of the loop is used for receiving. This is important because it is very difficult to wind a radiogoniometric receiver so that both sides produce the same voltage. Such deviations might in the present case seriously affect the direction indication. Since, as aforedescribed, each zero current indication flash of the tube consists really of two closely adjacent flashes (at points p_1, p_2 in Figure 5a), there really appear at *s* and *s'* two closely adjacent angularly spaced light lines of which the observer takes the geometric middle as the actual location of the zero position of the loop. In practice the loop should rotate about 900 R. P. M. so that these light flashes occur often enough on screen 29 to appear to the observer as substantially permanent light lines. Let us assume now that we have set the upper radially extending portion of arm 32 which carries lamp 33 and photo-cell 34 by the worm gear 38, 39 into the position N on the fixed scale 56 provided in the apparatus casing which may, for instance, mean an orientation in the direction north-south. Then every time slot 31 of skirt 30 passes between lamp 33 and photo-cell 34 (i. e. every revolution), the latter is energized and produces a neon lamp flash and thus a radial light line vector on screen 29 in the north-south direction. We obtain, therefore, in addition to the diametrical signal vector lines *s*, *s'*, a visible base-line vector which appears to the eye as a fixed radial line *b* on the screen (see Figure 3). If now the signal source, for instance a plane, travels along its course, the directions of the signals received by the loop continually vary and thus the angular directions of the light vectors *s*, *s'* with respect to the fixed base-line vector *b* vary correspondingly, pointing with respect to the base vector in the direction of the signal source from which the signals are received. Thus, if we should have two devices of the character shown in Figures 2 to 6, geographically spaced apart an appreciable distance, say fifty miles, and if we would locate on a common map to scale the directional and the oriented base-line vectors with their respective common centers at the points on the map where these receiving stations are respectively located in the field so that the base lines are oriented on the map respectively in the same direction in which they are oriented at the stations in the field, the intersection point of the signal vectors of the two stations on the map would indicate the geographic location of the source on the map, and this point would travel on the map along the same course along which the plane travels. This arrangement is shown in Figures 1 and 7.

At the master station M, which controls a given territory and which may be located anywhere in the territory even at one of the feeder or receiving stations, a large transparent map, similar in size and character to the maps now used with airways, is fixed, for instance, on a table in the dispatcher's office irrespective of its compass orientation. This map is represented in Figure 1. It shows the location of the master station M, in the present example at an airport, and the field locations of several pairs A, A' and B, B' of feeder stations, each assumed to be of the constructional character shown in Figures 2 to 6. Underneath the map at each of the points A, A', B, B', is located a rotary scanner mechanism of the character shown in Figure 7. In this figure a transparent glass table top (used only for the preservation of the map) is shown at 71, the transparent map underneath at 70, and below that a translucent screen 72, preferably of ground glass. The latter screen is not absolutely necessary, and transparent plate may be used for supporting the map. On the base 74, which is located some distance below the glass top, is rotatably mounted a scanner 75 by means of a U-shaped frame 76. This scanner is similar in character and construction to scanner arm 22 in Figure 5, and carries also a preferably rod-type neon lamp 77 in its center of rotation. In distinction from Figure 5, however, its radial light slot 79 extends down the blunt arm end as shown at 80 so that a narrow beam of light can

also emanate radially from the scanner end. Further, a suitable optical system, indicated at 78, is provided by which, with the aid of the reflecting surfaces 83 and 83a, a comparatively long narrow radial light line can be thrown against the underside of ground glass screen 72 from the rotation center far beyond the radial length of the scanner. This line becomes visible through map 70 and rotates within a given area of the map with the lamp 77 as center. This center is located exactly at the points A, A', B, B' respectively, and the light beam such as shown at *s* extends for each feeder-station location far beyond the area covered by the rotating scanner indicated by a dash-line circle. The scanner arm 75 is balanced by counterweight 81.

The scanner shaft 84 is coupled to the drive shaft 90, also journalled in frame 76, by means of a coupling 86 to which the scanner shaft is splined at 85, 87. The coupling is connected to drive shaft 90 by means of a helical slot 88 in the coupling and a pin 89 fixed on shaft 90 and located in slot 88. Thus, when the coupling is shifted either way in axial direction, scanner shaft 84 is rotated slightly with respect to the drive shaft for timing purposes which will be referred to later. Coupling sleeve 86 is provided for shifting purposes with a collar 91 engaging at each of two diametrically opposite points a sliding block 92, each block slidingly disposed in frame 76 and threaded on a spindle 93. The two spindles are simultaneously operated by their respective worm gear drives 94 and a common shaft 95 either directly by hand or from a distance through a flexible shaft 96. Drive shaft 90 is geared at 97, 98 to synchroncus motor 99 at a ratio similar to that prevailing at the feeder station, Figure 5. This motor 99 receives its operating current from a synchronous generator 100 which furnishes also current to the motors of the distant feeder stations (such as motor 16 in Figure 5) so that the motors of each appertaining pair of scanners at a feeder station and at the master station are operated in synchronism. Such synchronous generator-motor systems are well known in the art and commercially obtainable (for instance the so-called Selsyn generators and motors). Current for the neon lamp 77 of each scanner at the master station, Figure 1, is supplied through slip rings 82 and distance line 60 extending from photo-cell amplifier 54 of the appertaining feeder station, Figure 5, in the field, with interposition of amplifiers (not shown), if necessary, in the conventional manner. A direct wire line connection from each feeder station to each scanner is assumed, in the present example, for simplicity of explanation.

Thus, each scanner of the master station rotating synchronously with the scanner at the appertaining feeder station, a neon lamp flash will be produced at a master scanner at the time when it occurs at the appertaining feeder scanner. When, for instance, the oriented base-line beam *b* occurs at the feeder station, Figure 5, it is reproduced at the same time at *b* on the map with the same orientation by the corresponding master scanner, and when a directional line flash occurs at the feeder station in a certain angular relation to its base line, a directional line flash *s* is reproduced at the same time by the corresponding master scanner in a similar angular relation to the map base line. In order that the correct orientation of each feeder station base line may be maintained on the map of the master station, the afore-described shifting mechanism 84—94, Figure 7, is provided by which each master scanner may be caused to lead or lag within a limited range over its synchronously running drive shaft 90 as conditions may require to correctly orient on and relatively to the map each base line in the same compass direction in which it is actually oriented in the corresponding feeder station. Besides, at each feeder-station location on the map, a dashed circle is drawn with a radial line *b* and a peripheral graduation. This indicates the designated orientation of the base-line vectors. If the produced base-line vector should deviate from this line, its amount of deviation can be read at the graduation and thus also the deviation of the directional vector from its true position, since both vectors have the same angular relation at the feeder and master stations. Correction can then be made at both stations.

With this visible reproduction of the directional vectors on the master map, we can now, for instance, by observing on the map the intersection point of the directional vectors *s*, *s'* of feeder stations B, B', ascertain the actual ground position C of a traveling plane sending signals at that moment. At the next stated sending period of that plane the vector intersection point may appear at C', and we can thus observe the new ground position of the plane and incidentally fairly accurately calculate its ground speed by reading on the map the distance traveled between observed sending periods. Accordingly, as mentioned in the introduction, the dispatcher can, through periodically obtaining from the plane also its altitude, forewarn the pilot of an approaching mountain range as shown to the right of C' in Figure 1 and give him practically instantaneously (i. e. within a few seconds) his actual ground position with respect to this range. As the craft proceeds, for instance towards the master station M and its destination, it soon comes within the signalling range of the feeder stations A, A' and the dispatcher will now note on the map the directional light vectors *s*, *s'* of these stations and see by their intersection point D that the plane has passed the mountain range and approaches the airport M. In the meantime other planes may have entered this territory or leave the airport. Such other craft have different sending periods assigned to them so that each plane can be instantaneously observed as to its momentary location and progress.

My novel idea of visibly coordinating two intersecting directional vectors on a map with relation to a given fixed oriented base line may be utilized in a slightly modified form for position determination of marine craft. As pointed out in the introduction, in this case it is preferable that the vessel should carry the map, and at least two shore stations spaced a substantial mileage apart should do the signal broadcasting. Thus the vessel becomes at the same time the master station. This modification is shown in Figures 9 to 12.

Referring first to Figure 10, on the vessel is installed a scanner and a synchronously driven radiogoniometric receiver, such as a receiving loop, of the same or similar construction shown in and described with reference to Figures 5 and 6. In Figure 10, 110 is the scanner arm rotatably mounted with its funnel 111 by a sleeve 115 on a stationary pin 112 fixed in a stud 113 on the apparatus base 114. The arm is driven at a suitable speed, for instance 900 R. P. M. through a bevel gear 119 by a motor 120 which also rotates the

radio-receiving loop 121 through bevel gear 123 at the same speed and in the same direction. Also in this case, the loop is provided with a compensator 122, which compensates in well-known manner the directional errors, caused in this case by the body structure of the vessel.

In the rotation center of scanner arm 110 is mounted a preferably rod-type neon lamp 118 on pivot pin 112 and supplied with current from photo-cell amplifier 124. As in Figure 5, an annular skirt 116 is fixed to rotary funnel 111, but in this case the skirt is provided with two diametrically disposed axially directed slots 117, 117. On a disk coaxially disposed with respect to pivot 112 and rotatable on rollers 130 mounted on the top plate 131 of the apparatus, is fixed an incandescent lamp 125 inside of skirt 116, and a photo-cell 126 outside of the skirt. The cell is light-shielded by a casing 127 which latter is provided with an aperture 128 in alinement with lamp 125, slots 117 and the photo-cell, so that each time a slot 117 passes between the permanently lighted lamp and aperture 128, the photo-cell is energized. Lamp 125 is supplied with current from a source 132 and assumed to be constantly lighted. Disk 129 can be rotated into any desired angular position with respect to base 131 by means of worm gear drive 133, which latter may be operated either by hand or from a gyro-compass device (not shown) so as to keep the radial line of disk 129, on which lamp 125 and photo-cell 126 are located, always oriented in a given compass position, for instance, in the true north-south position. Automatic gyro-compass adjusting devices of this type are well known in the art, and their construction and mode of application form no part of the present invention. If an automatic gyro-compass adjustment of disk 129 is not used, the disk should be oriented as above described by means of hand knob 134 (Figure 11) in accordance with an outside compass reading.

On top of a frame portion 140 within which the scanner funnel is disposed, is mounted a transparent or translucent screen 141, preferably a ground glass plate, closely to scanner arm 110, so that a light flash from neon tube 118 in passing through the scanner slot 142 will appear on screen 141 as a radial line. Since two slots 117 are provided in skirt 116 in diametrically opposite positions, photo-cell 127 will be excited twice each arm revolution and these excitations amplified at 124 will produce light flashes of lamp 118 accordingly, and these flashes occurring alternately 900 times per minute will appear on screen 141 to the eye of the observer as a diametrical line, oriented N-S if the disk 129 is so oriented in the manner aforedescribed.

Frame 140 carries two parallel rollers 155 (shown in Figure 11 in dot-dash lines) mounted on opposite sides of the frame and operatable individually by a hand wheel 157. On these rollers is wound a transparent navigation chart 156 showing the coast line in the vicinity of which the vessel is being navigated, and this chart stretches from one roller over screen 141 to the other roller, so that by turning one or the other wheel 157, the particular coast line portion, in the vicinity of which the master knows he is approximately located, comes to lie across screen 141, as for instance shown in Figure 9.

Frame 140 is slidingly disposed in either direction at right angles to the chart movement on an annular sub-frame 150 by means of rack and pinion gears 158, 158 provided on both sides of the frame and operable from either side by hand wheels 159, 159. Subframe 150 is rotatably disposed on rollers 151 journalled in the upper portion of the main casing. It is rotated by means of an annular rack 153 fixed on the frame and a pinion 152 journalled in the upper part of the main casing 115a and operated by hand wheel 154. Thus, by the aforedescribed means, chart 156 can be shifted and rotated in its own plane, for instance in Figure 10 toward and away from the observer, from left to right and vice versa, and rotated on the rotation center of scanner arm 110 (see arrows I, II, III, respectively, Figure 11).

The radio loop circuit is in its general character and purpose similar to that shown in Figure 5 except for the following modification. It is desirable, for reasons to be explained hereinafter, though not absolutely necessary, to alternately receive during the loop rotation from two spaced fixed stations which send signals at different wave lengths. For this reason, a rotary commutator switch of any suitable construction is interposed between the loop and the tone receiver and amplifier 162 which includes in one circuit the tuning condenser 163 and slip ring 164, and in the other circuit, tuning condenser 165 and slip ring 166. The common return circuit is by way of the central slip ring 167. Thus for one-half revolution of the switch, the tuning condenser 163 adjusted to one wave length is thrown across the loop circuit, and for the next half revolution tuning condenser 165 adjusted to the other wave length is thrown across the loop circuit. The rotary switch 160 is rotated by motor 120 and gear 161 at the ratio of 1:2 with respect to loop 121 and scanner 110, so that for one loop revolution condenser 163 is in circuit and for the next revolution condenser 165, and thus alternately the loop circuit is first tuned to the frequency of one station and then to the frequency of the other station, and the signals from the two stations are alternately received. As in Figure 5, the received signals are sent through a voltage transformer 168 to a two-way rectifier 169 and delivered rectified to cathode ray tube 171 so that the cathode ray beam is deflected in accordance with the rise and fall of the loop current due to the rotation of the latter, and thereby a photo-cell 172 is energized at the zero current value of the loop, all in the same manner as described with reference to Figure 5, except that in the present case the energizing of the cell occurs alternately, first when the zero position of the loop points in the direction of one sending station and then when the zero position points in the direction of the other sending station. Accordingly, assuming that the observer has first oriented chart 156 in Figure 9 in the manner aforedescribed by means of the locally produced orienting flashes *o*, *o* so that its meridian lines are oriented N-S, the directional vector line flashes due to the signalling, for instance from short stations RBN 286 and 316, may appear first on the chart as the dash lines e_1', e_2' if the chart happens to be set in a position longitudinally and transversely so that the intersection point P′ of these lines coincides with the rotation center of scanner 110. In such a position the observer will not that these directional vectors, while properly oriented with respect to the meridian lines, do not pass through the two stations aforementioned from which he knows he receives the signal flashes. He would therefore roll the chart upwardly in Figure 9 by operating the upper roller wheel 157 and also

shift the chart to the left by operating one of the wheels 159 until the directional light vectors e_1', e_2' traverse respectively the location points of the sending stations RBN 286 and 310. This shifted position is indicated by the full beam lines e^1 and e^2. Their intersection point P will then indicate the geographic position on the chart at which the receiving vessel is located. By receiving on request signals from the shore stations successively at stated times, the master of the vessel can thus instantaneously observe its actual course without calculating and plotting himself the position as is now necessary with ordinary directional receiving arrangements from coast guard beacon stations.

There are, of course, limitations as to the range from the coast within which positions can be determined on a given chart, which limitations are set by the width of the chart roll. For instance, in Figure 9 the chart extends from 124° longitude westward to slightly beyond the 124° 30′ longitude. Especially if the coast line should vary greatly in easterly and westerly direction, for instance, a supplemental chart may be held in readiness on which the next westerly meridian appears, extending for instance from 124° 30′ to 125° 30′, as shown in Figure 12. The portion of this chart in this figure may portray, for instance, the same latitude as the chart portion shown in Figure 9. Of course, the positions of stations RBN 286 and 310 of Figure 9 would not be visible on this chart. They are indicated, however, for explanatory purposes, on the dotted coast line in this figure. On the chart 180 are shown merely two groups of directional lines d^1—d^1 and d^2—d^2 radiating respectively from the distant stations 286 and 310. The meridians of the chart are again oriented due north-south in the manner aforedescribed. Assuming now that during the sending period of these stations the observer should note on the chart the intersection point of the oriented visible directional light vectors s^1, s^2 (shown in double lines) at P′, he would shift the chart upwardly in Figure 12 and to the left, until the light vector s^1 coincides directionally with one of the directional radii d^1 (emanating from station 286) and the light vector s^2 coincides with one of the directional radii d^2 (emanating from station 310). The intersection point P of these particular radii d^1, d^2 gives the actual position of the vessel on the chart. Of course, in actual practice the radii d^1, d^2 in each group would be spaced much closer than shown in Figure 12, in order to give the position of the vessel more exactly.

The direction-determining arrangement shown in Figures 7 to 12, while applicable to best advantage to marine vessels, is of course also applicable to oceanic air navigation where sufficient room can be spared to set up such a receiving and observing apparatus. Further, also in this case the directional vectors, by virtue of the circuit arrangement and for the reasons described with reference to Figure 5, appear in double lines.

I claim:

1. A method of visibily reproducing on a map to scale the geographic location of a distant object, consisting in sending radiant energy signals from the object, directionally receiving said signals simultaneously at two geographically spaced known points in the field, visibly locally producing at each field point, in a constant known direction, a geographically oriented base-line vector, visibly producing at each field point a directional vector controlled by and directionally varying in accordance with the direction of the signal receiver with respect to the distant object and angularly coordinated with said constant direction base-line vector, visibly reproducing on said map at each corresponding field point location a corresponding base line and a directional vector in the same angular relation to each other as at the corresponding field point synchronously with their occurrence at the field point, and manually adjusting the orientation of each base line visibly reproduced on said map to the known direction of the corresponding base line locally produced at the respective field point so that the intersection point of the reproduced directional vectors of the two field points visibly indicates on the map the geographic location of the object.

2. A method of visibly reproducing on a map to scale the geographic location of a distant object, consisting in sending radiant energy signals from the object, directionally receiving said signals simultaneously at two geographically spaced known points in the field, visibly locally producing at each field point by rapidly succeeding light pulses a base-line vector geographically oriented in a constant known direction, visibly producing at each field point by rapidly succeeding light pulses a directional vector controlled by and directionally varying in accordance with the direction of the signal receiver and angularly coordinated with said constant direction base-line vector, visibly reproducing on said map at each corresponding field point location by rapidly succeeding light pulses a corresponding base line and a directional vector in the same angular relation to each other as at the corresponding field point synchronously with their occurrence at the field point, and manually adjusting the orientation of each base line visibly reproduced on said map to the known direction of the corresponding base line locally produced at the respective field point so that the intersection point of the reproduced directional vectors of the two field points visibly indicates on the map the geographic location of the object.

3. Means for visibly reproducing on a map to scale the geographic location of a distant object, comprising means at the object for sending radiant energy signals, means at each of two geographically spaced known points in the field represented by the map for directionally receiving said signals simultaneously, rotary means at each field point for producing rapidly succeeding radial light line pulses, local means for controlling said producing means to create recurrent pulses in a constant geographic direction to produce an oriented visible base line, means at each field point controlled by said received directional signals for controlling said light pulse producing means to additionally create recurrent directional light line pulses angularly coordinated with said base-line pulses in accordance with the angular relation of the directional signal to said base line, and means associated with said map at points corresponding with the respective field point locations and connected with the respective light line producing means for reproducing at each field point location on said map similarly oriented base-line and angularly coordinated directional light line pulses synchronously with their occurrence at the field points, so that the intersection point of the reproduced directional

lines of the two field points visibly indicates on the map the geographic location of the object.

4. In a system for visibly reproducing on a map to scale the geographic location of a distant object, means at the object for sending energy signals, two geographically spaced field receiving stations, each station including a rotary radiogoniometric receiver for directionally receiving said signals, a radially slotted rotary scanner geared to said rotary receiver to synchronously rotate therewith and a motor for rotating said receiver and scanner, a luminous tube in said scanner and local means for energizing said tube to produce a light flash each time the scanner slot is in a given geographically oriented position, and a screen mounted above said scanner on which said flash appears as an oriented vector, said tube being also connected to said rotary receiver to respond to a given current intensity due to the direction-indicating position of the receiver to flash each time when the receiver is in a signal direction-indicating position to instantaneously produce a directional vector line on said screen which has the same angular relation to the oriented base vector as the direction of the received signal.

5. In a system for visibly reproducing on a map to scale the geographic location of a distant object, means at the object for sending energy signals, two geographically spaced field receiving stations, each station including a rotary radiogoniometric receiver for directionally receiving said signals, a radially slotted rotary scanner geared to said rotary receiver to synchronously rotate therewith and a motor for rotating said receiver and scanner, a luminous tube in said scanner and local means for energizing said tube to produce a light flash each time the scanner slot is in a given geographically oriented position, a screen mounted above said scanner on which said flash appears as an oriented vector, said tube being also connected to said rotary receiver to respond to a given current intensity, due to the direction-indicating position of the receiver, to flash each time when the receiver is in a signal direction-indicating position to instantaneously produce a directional vector line on said screen which has the same angular relation to the oriented base vector as the direction of the received signal, and means for visibly reproducing on said map at the locations of said field stations respectively the base-line and directional vectors in the same oriented and angular relation as in said stations, so that the intersection of the reproduced directional vectors indicates on said map the geographic location of the object.

6. In a system for visibly reproducing on a map to scale the geographic location of a distant object, means at the object for sending energy signals, two geographically spaced field receiving stations, each station including a rotary radiogoniometric receiver for directionally receiving said signals, a radially slotted rotary scanner geared to said rotary receiver to synchronously rotate therewith and a motor for rotating said receiver and scanner, a luminous tube in said scanner and local means for energizing said tube to produce a light flash each time the scanner slot is in a given geographically oriented position, a screen mounted above said scanner on which said flash appears as an oriented vector, said tube being also connected to said rotary receiver to respond to a given current intensity, due to the direction-indicating position of the receiver, to flash each time when the receiver is in a signal direction-indicating position to instantaneously produce a directional vector line on said screen which has the same angular relation to the oriented base vector as the direction of the received signal, a rotary scanner for each station located adjacent to and rotating in the plane of said map, each scanner having its rotation center at the location of one of said field stations on said map and each scanner having a luminous tube and being radially slotted to throw a vector light beam onto said map when the tube is energized, a motor connected with the appertaining field station motor and geared to the map scanner for rotating the latter synchronously with the scanner at the respective field station, and means for electrically connecting the tube of each map scanner to the scanner tube of the appertaining field station whereby each map scanner reproduces the corresponding field station base-line and directional line vector flashes on said map instantaneously, synchronously with and in the same orientation as the scanner at the field station, so that the intersection on the map of the directional vectors of the two map scanners indicates the location of the object on the map.

7. A field station having a rotary receiver and scanner arrangement according to claim 4, and having a translucent screen and its rotary scanner in the form of an arm rotatably disposed beneath said screen and containing a luminous tube at its rotation center and being provided with a radial slot to render the light emanating from said tube visible on said screen as a radial line, a normally fixed and permanently energized local light source disposed beneath said arm, a photo-cell disposed to be energized by said source and arranged to control by its response the lighting of said tube, an annular apron rotating with said arm and disposed between said light source and said photo-cell to normally shield the latter from said source and an aperture in said apron permitting the energization of said cell when the aperture passes between the light source and the cell, means for circumferentially adjusting said light source and said cell together in a desired compass direction to produce by said tube on said screen a base vector light line oriented in the desired direction each time the apron aperture passes said light source, means for rotating said scanner arm at a sufficiently high speed to create in the observer's eye the impression of a fixed oriented base vector line on said screen, gearing connected to said rotating means, for rotating said rotary receiver synchronously with said scanner arm, and electrical means connected with said tube and responsive to a given current intensity produced in said receiver due to its direction-indicating position for flashing said tube each time the receiver has rotated into a signal direction-indicating position, to produce in the eye of the observer a directional vector line on said screen in the same angular relation to the base-line vector as the received directional signal and at the instant the direction-indicating position is attained.

8. A field station having a rotary receiver and scanner arrangement according to claim 4, and having a translucent screen and its rotary scanner in the form of an arm rotatably disposed beneath said screen and containing a luminous tube at its rotation center and being provided with a radial slot to render the light emanating from said tube visible on said screen as a radial line, a normally fixed and permanently energized local light source disposed beneath said arm, a

photo-cell disposed to be energized by said source and arranged to control by its response the lighting of said tube, an annular apron rotating with said arm and disposed between said light source and said photo-cell to normally shield the latter from said source and an aperture in said apron permitting the energization of said cell when the aperture passes between the light source and the cell, means for circumferentially adjusting said light source and said cell together in a desired compass direction to produce by said tube on said screen a base vector light line oriented in the desired direction each time the apron aperture passes said light source, means for rotating said scanner arm at a sufficiently high speed to create in the observer's eye the impression of a fixed oriented base vector line on said screen, gearing connected to said rotating means, for rotating said rotary receiver synchronously with said scanner arm, and electrical means connected with said tube and responsive to the current flowing in said receiver due to its directional responses to energize said tube each time the receiver has rotated into a direction-indicating position in which its current flow is substantially zero, to produce in the eye of the observer a directional vector line on said screen in the same angular relation to the base-line vector as the received directional signal and at the instant the direction-indicating position is attained.

9. In a system for visibly reproducing on a map to scale the geographic location of a distant object, means at the object for sending radiant energy signals, two geographically spaced field receiving stations, each station including a rotary radiogoniometric receiver for directionally receiving said signals, a radially slotted rotary scanner geared to said rotary receiver to synchronously rotate therewith and a motor for rotating said receiver and scanner, a luminous tube in said scanner and local means for energizing said tube to produce a light flash each time the scanner has rotated into a given geographically oriented position, a screen mounted above said scanner on which said flash appears as an oriented vector, said tube being also connected to said rotary receiver to respond to its current variations due to the directional signal responses of the receiver to flash each time when the receiver is in a signal direction-indicating position to instantaneously produce a directional vector line on said screen which has the same angular relation to the oriented base vector as the direction of the received signal, a rotary scanner for each station located adjacent to and rotating in the plane of said map, each scanner having its rotation center at the location of one of said field stations on said map and each scanner having a luminous tube and being radially slotted to throw a vector light beam onto said map when the tube is energized, a motor connected with the appertaining field station motor and geared to the map scanner for rotating the latter synchronously with the scanner at the respective field station, and means for electrically connecting the tube of each map scanner to the scanner tube of the appertaining field station whereby each map scanner reproduces the corresponding field station base-line and directional line vector flashes on said map instantaneously, synchronously with and in the same orientation as the scanner at the field station, so that the intersection on the map of the directional vectors of the two map scanners indicates the location of the object on the map, and means for adjusting each map scanner to produce within a given range a lag or a lead with respect to the scanner at its appertaining field station to correct errors in the common orientation of the base-line and directional vectors of the appertaining scanners.

10. In a system for visibly reproducing on a map to scale the geographic location of a distant object, means at the object for sending radiant energy signals, two geographically spaced field receiving stations, each station including a rotary radiogoniometric receiver for directionally receiving said signals, a radially slotted rotary scanner geared to said rotary receiver to synchronously rotate therewith and a motor for rotating said receiver and scanner, a luminous tube in said scanner and local means for energizing said tube to produce a light flash each time the scanner has rotated into a given geographically oriented position, a screen mounted above said scanner on which said flash appears as an oriented vector, said tube being also connected to said rotary receiver to respond to its current variations due to the directional signal responses of the receiver to flash each time when the receiver is in a signal direction-indicating position to instantaneously produce a directional vector line on said screen which has the same angular relation to the oriented base vector as the direction of the received signal, a rotary scanner for each station located adjacent to and rotating in the plane of said map, each scanner having its rotation center at the location of one of said field stations on said map and each scanner having a luminous tube and being radially slotted to throw a vector light beam onto said map when the tube is energized, a motor connected with the appertaining field station motor and geared to the map scanner for rotating the latter synchronously with the scanner at the respective field station, means for electrically connecting the tube of each map scanner to the scanner tube of the appertaining field station whereby each map scanner reproduces the corresponding field station base-line and directional line vector flashes on said map instantaneously, synchronously with and in the same orientation as the scanner at the field station, so that the intersection on the map of the directional vectors of the two map scanners indicates the location of the object on the map, a phase-shifting coupling connecting each map scanner with its drive gear for angularly shifting the scanner with respect to its drive gear within a given range to cause the map scanner to lag or lead with respect to the scanner at the appertaining field station for correcting errors in the common orientation of the base-line and directional vectors of the appertaining scanners, and means for actuating said coupling.

11. In a system for visibly reproducing on a map to scale the geographic location of a distant object, means at the object for sending radiant energy signals, two geographically spaced field receiving stations, each station including a rotary radiogoniometric receiver for directionally receiving said signals, a radially slotted rotary scanner geared to said rotary receiver to synchronously rotate therewith and a motor for rotating said receiver and scanner, a luminous tube in said scanner and local means for energizing said tube to produce a light flash each time the scanner has rotated into a given geographically oriented position, a screen mounted above

said scanner on which said flash appears as an oriented vector, said tube being also connected to said rotary receiver to respond to its current variations due to the directional signal responses of the receiver to flash each time when the receiver is in a signal direction-indicating position to instantaneously produce a directional vector line on said screen which has the same angular relation to the oriented base vector as the direction of the received signal, a rotary scanner for each station located adjacent to and rotating in the plane of said map, each scanner having its rotation center at the location of one of said field stations on said map and each scanner having a luminous tube and being radially slotted to throw a vector light beam onto said map when the tube is energized, a motor connected with the appertaining field station motor and geared to the map scanner for rotating the latter synchronously with the scanner at the respective field station, means for electrically connecting the tube of each map scanner to the scanner tube of the appertaining field station whereby each map scanner reproduces the corresponding field station base-line and directional line vector flashes on said map instantaneously, synchronously with and in the same orientation as the scanner at the field station, so that the intersection on the map of the directional vectors of the two map scanners indicates the location of the object on the map, a phase-shifting coupling connecting each map scanner with its drive gear for angularly shifting the scanner with respect to its drive gear within a given range to cause the map scanner to lag or lead with respect to the scanner at the appertaining field station for correcting errors in the common orientation of the base-line and directional vectors of the appertaining scanners, means for actuating said coupling, and means for indicating on the map the desired base vector orientation to ascertain the deviation of the produced vector from the desired orientation.

12. In a system for visibly reproducing on a map to scale the geographic location of a distant object, means at the object for sending radiant energy signals, two geographically spaced field receiving stations, each station including a rotary radiogoniometric receiver for directionally receiving said signals, a radially slotted rotary scanner geared to said rotary receiver to synchronously rotate therewith and a motor for rotating said receiver and scanner, a luminous tube in said scanner and local means for energizing said tube to produce a light flash each time the scanner has rotated into a given geographically oriented position, a screen mounted above said scanner on which said flash appears as an oriented vector, said tube being also connected to said rotary receiver to respond to its current variations due to the directional signal responses of the receiver to flash each time when the receiver is in a signal direction-indicating position to instantaneously produce a directional vector line on said screen which has the same angular relation to the oriented base vector as the direction of the received signal, a rotary scanner for each station located adjacent to and rotating in the plane of said map, each scanner having its rotation center at the location of one of said field stations on said map and each scanner having a luminous tube and being radially slotted to throw a vector light beam onto said map when the tube is energized, a motor connected with the appertaining field station motor and geared to the map scanner for rotation the latter synchronously with the scanner at the respective field station, means for electrically connecting the tube of each map scanner to the scanner tube of the appertaining field station whereby each map scanner reproduces the corresponding field station base-line and directional line vector flashes on said map instantaneously, synchronously with and in the same orientation as the scanner at the field station, so that the intersection on the map of the directional vectors of the two map scanners indicates the location of the object on the map, and optical means disposed within each map scanner for projecting the light from said tube through the radial scanner slot adjacent said map beyond the map area over which the scanner rotates.

13. In a direction-finding system of the character described, having a radiogoniometric rotary receiver designed to indicate by its rotary positions the direction from which radiant energy signals from a distant station are received, a radially slotted rotary scanner arm containing a luminous tube and a translucent screen disposed adjacent to the scanner slot and in parallel to the plane of rotation of said arm to produce a radial light line on said screen when the tube is momentarily energized during rotation, a motor for driving said rotary receiver and said scanner at synchronous speeds, means for momentarily energizing said tube at each arm revolution to produce a base line on said screen when the arm slot is in a given geographically oriented direction, a photo-cell having its energy output terminals suitably connected to said tube to energize the latter when the cell is energized, and a radiant energy receiving circuit including said rotary receiver and means controlled by the received currents for energizing said photo-cell when the receiver is in a signal direction-indicating position, to produce a line flash by said tube on said screen forming a directional line angularly related to said base line similar to the angular relation of the signal direction to said base line.

14. In a direction-finding system of the character described, having a radiogoniometric rotary receiver designed to indicate by its rotary positions the direction from which radiant energy signals from a distant station are received, a rotary scanner arm containing a luminous tube and having a radially directed slot in its upper portion and a translucent screen disposed adjacent to said slot and in parallel to the plane of rotation of said arm to produce a vector-shaped light line on said screen when the tube is momentarily energized during rotation, a motor for driving said rotary receiver and said scanner at synchronous speeds, means for momentarily energizing said tube at each arm revolution to produce a base-line vector on said screen when the arm slot is in a given geographically oriented direction, a photo-cell having its energy output terminals suitably connected to said tube to energize the latter when the cell is energized, a radiant energy receiving circuit including said rotary receiver and means controlled by the received currents for energizing said photo-cell when the receiver is in a signal direction-indicating position, to produce a line flash by said tube on said screen forming a directional vector angularly related to said base-line vector similar to the angular relation of the signal direction to said base-line vector, whereby said angularly correlated vector is always produced by the same

receiving side of the rotary receiver, means for adjusting said base vector producing means for the desired oriented vector position, and means for indicating the deviation of the produced base vector position from the desired oriented position.

15. In a direction-finding system of the character described, having a radiogoniometric rotary receiver designed to indicate by its rotary positions the direction from which radiant energy signals from a distant station are received, a radially slotted rotary scanner arm containing a luminous tube and a translucent screen disposed adjacent to the scanner slot and in parallel to the plane of rotation of said arm to produce a vector-shaped light line on said screen when the tube is momentarily energized during rotation, a motor for driving said rotary receiver and said scanner at synchronous speeds, means for rectifying the received undulating current intensity variations produced by the rotation of said receiver into unidirectional current pulses, a cathode ray tube and connections with said rectifier for applying said pulses to the cathode ray whereby it is unilaterally deflected from a given normal position at receiver current flow and returns to normal position at zero receiver current, a photo-electric cell having its terminals connected to said luminous tube and being disposed to be energized by said cathode ray, to light said luminous tube, an apertured screen between said cathode tube and said cell having its aperture positioned so that the cathode ray can energize the cell through said aperture only at a given distance from its normal position after its deflection from and before its return to normal position, whereby two angularly spaced radial light flashes are produced by said luminous tube on said screen, the bisecting line between which represents directionally the zero current position of the receiver with respect to an assumed oriented radial line through the scanner rotation center.

16. In a direction-finding system of the character described, having a radiogoniometric rotary receiver designed to indicate by its rotary positions the direction from which radiant energy signals from a distant station are received, a rotary scanner arm containing a luminous tube and having a radially directed slot in its upper portion and a translucent screen disposed adjacent to said slot and in parallel to the plane of rotation of said arm to produce a vector-shaped light line on said screen when the tube is momentarily energized during rotation, a motor for driving said rotary receiver and said scanner at synchronous speeds, means for rectifying the received undulating current intensity variations produced by the rotation of said receiver into unidirectional current pulses, a cathode ray tube and connections with said rectifier for applying said pulses to the cathode ray whereby it is unilaterally deflected from a given normal position at receiver current flow and returns to normal position at zero receiver current, a photo-electric cell having its terminals connected to said luminous tube and being disposed to be energized by said cathode ray, to light said luminous tube, an apertured screen between said cathode tube and said cell having its aperture positioned so that the ray can energize the cell through said aperture only at a given distance from its normal position after its deflection from and before its return to normal position, whereby two angularly spaced radial light flashes are produced by said luminous tube on said screen, the bisecting line between which represents directionally the zero current position of the receiver with respect to an assumed oriented radial line through the scanner rotation center, said apertured screen being adjustable in the direction of the cathode ray deflection to control the angular spacing between said radial line flashes.

17. In a direction-finding system of the character described, having a radiogoniometric rotary receiver designed to indicate by its rotary positions the direction from which radiant energy signals from a distant station are received, a rotary scanner arm containing a luminous tube and having a radially directed slot in its upper portion and a translucent screen disposed adjacent to said slot and in parallel to the plane of rotation of said arm to produce a vector-shaped light line on said screen when the tube is momentarily energized during rotation, a motor for driving said rotary receiver and said scanner at synchronous speeds, means for rectifying the received undulating current intensity variations produced by the rotation of said receiver into unidirectional current pulses, a cathode ray tube and connections with said rectifier for applying said pulses to the cathode ray whereby it is unilaterally deflected from a given normal position at receiver current flow and returns to normal position at zero receiver current, a photo-electric cell having its terminals connected to said luminous tube and being disposed to be energized by said cathode ray, to light said luminous tube, an apertured screen between said cathode tube and said cell having its aperture positioned so that the ray can energize the cell through said aperture only a given distance from its normal position after its deflection from and before its return to normal position, whereby two angularly spaced radial light flashes are produced by said luminous tube on said screen, the bisecting line between which represents directionally the zero current position of the receiver with respect to an assumed oriented radial line through the scanner rotation center, said apertured screen being adjustable in the direction of the cathode ray deflection to control the angular spacing between said radial line flashes, and means for instantaneously energizing said luminous tube at a given point of each scanner revolution to produce said oriented radial line.

18. Means for visibly reproducing on a map to scale the geographic location of a distant object transmitting radiant energy, which comprises in combination a direction-finding receiving station disposed at each of two spaced apart points within the field represented by the map, and a master station in communication with each of said receiving stations, each receiving station having a rotary scanner and energy-controlling device with means for delivering an orienting pulse of energy each time the rotary scanner passes through an angular orienting position corresponding with a constant known geographical direction, for orienting the scanner, and another pulse of energy each time the rotary scanner passes through an angular position angularly related to said orienting position as the direction of the distant object is angularly related to said known geographical direction, and the master station having a map to scale and associated therewith for each receiving station a rotary scanner with means for projecting upon

the map a light line extending in a radial direction from the point on the map representing each receiving station each time a pulse of energy is received therefrom, and means for adjusting each master station scanner to orient the light line resulting from the receipt of an orienting pulse of energy in the same geographical direction on the map as the said known geographical direction with which the angular orienting position of the receiving station corresponds.

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