

Oct. 16, 1962

L. S. GUARINO ETAL
HORIZONTAL DISPLAY

3,059,233

Filed Nov. 27, 1959

6 Sheets-Sheet 1

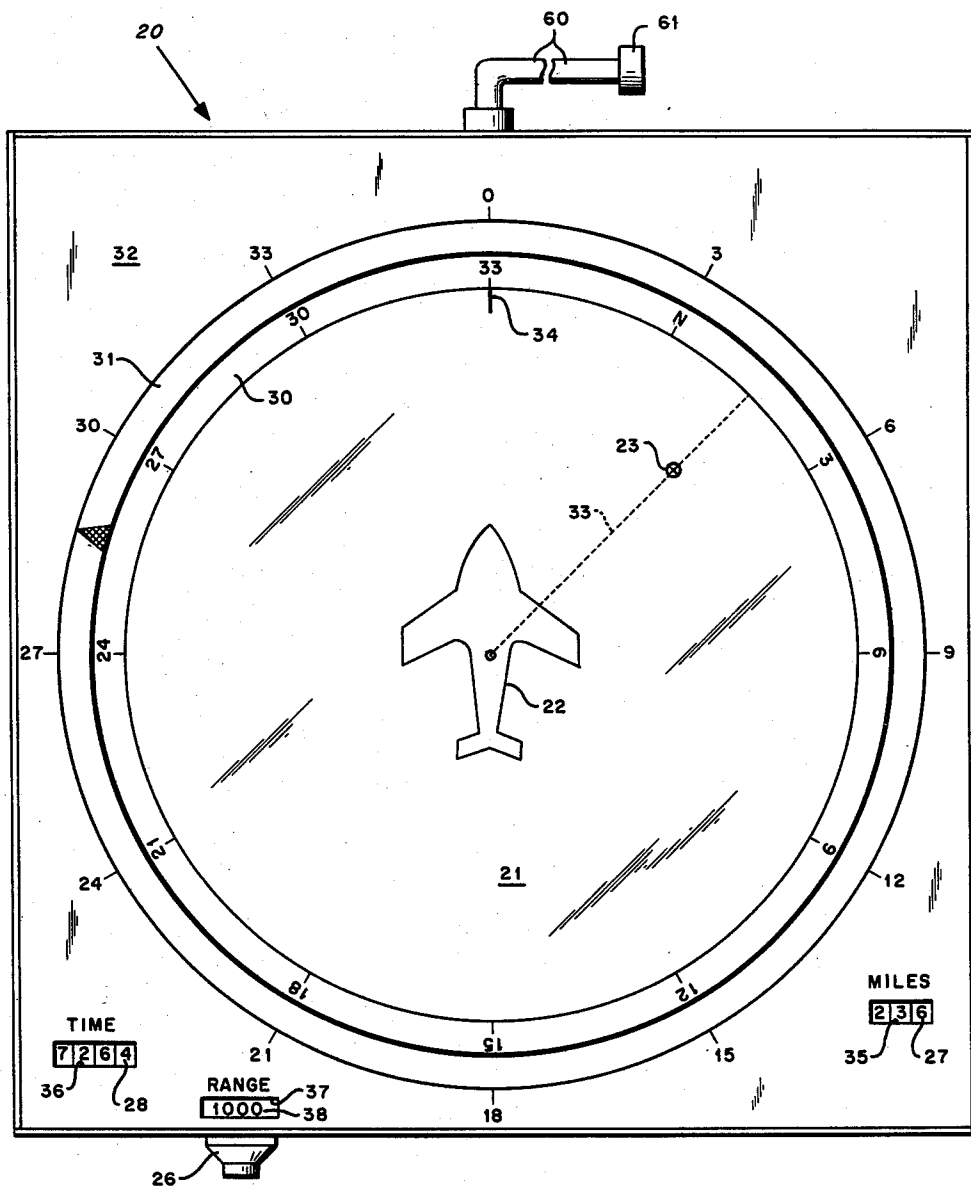


Fig. 1

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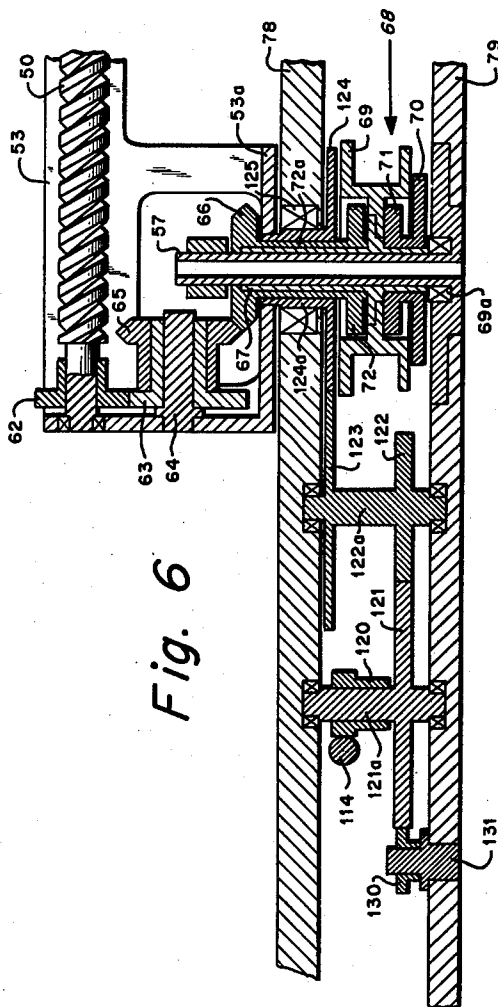
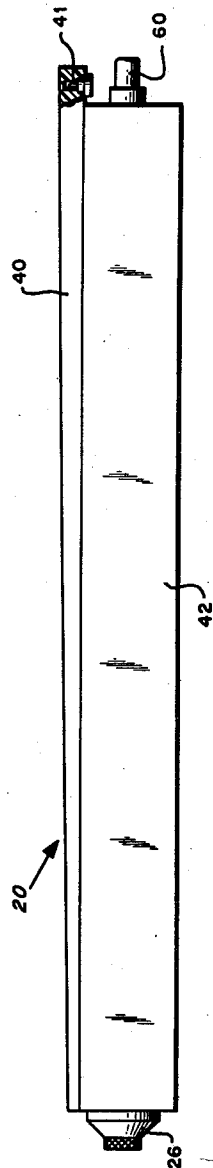
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6 Sheets-Sheet 2



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6 Sheets-Sheet 3

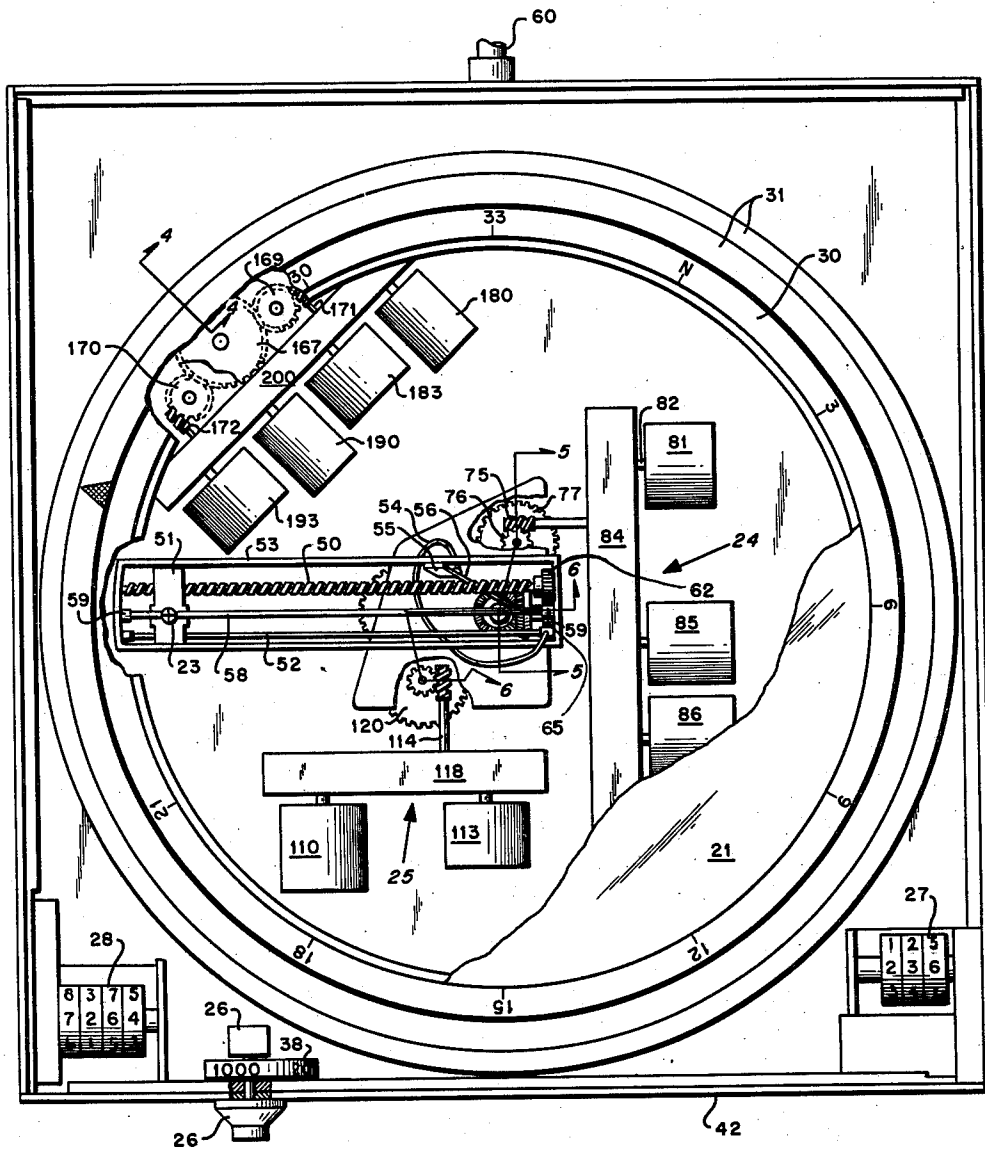


Fig. 3

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6 Sheets-Sheet 4

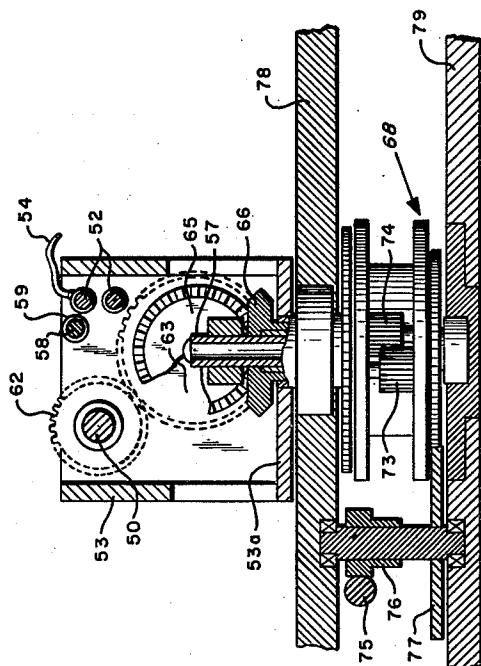


Fig. 5

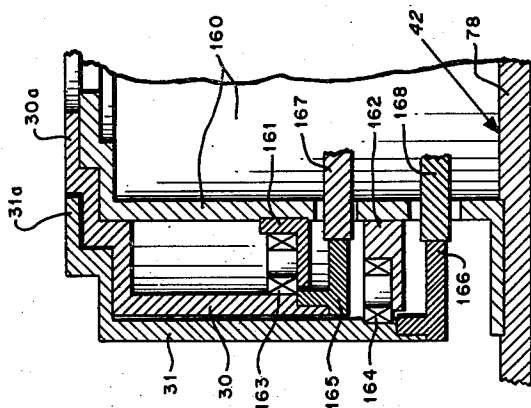


Fig. 4

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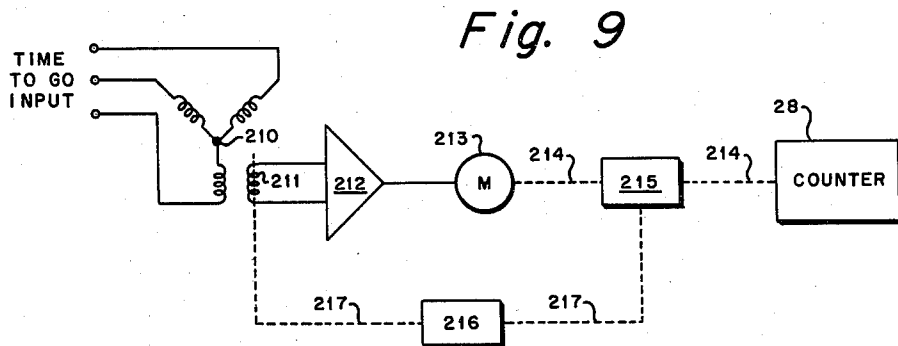
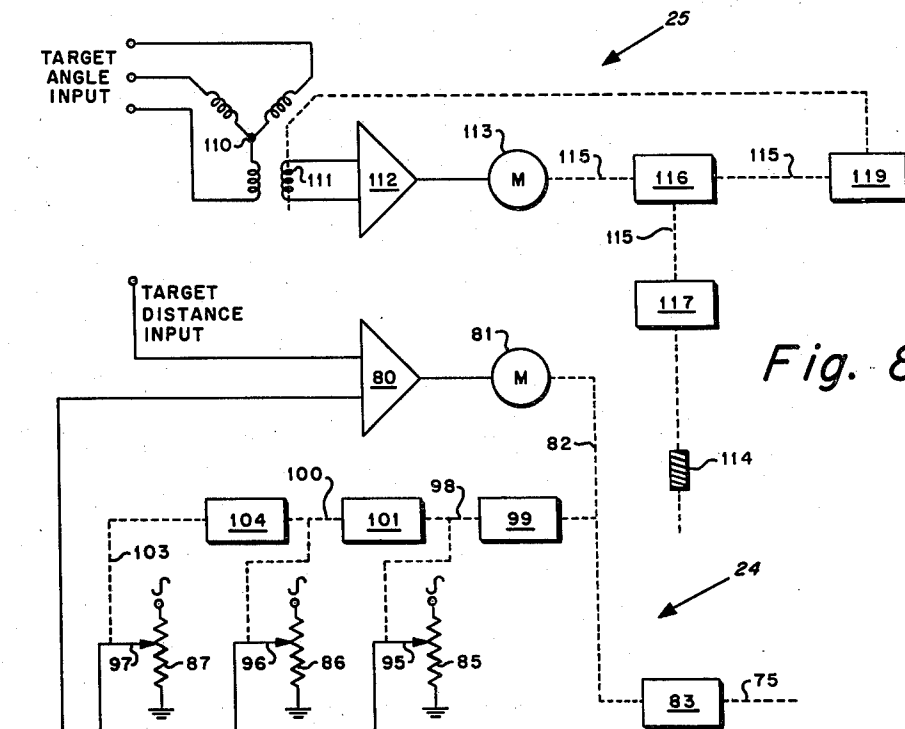
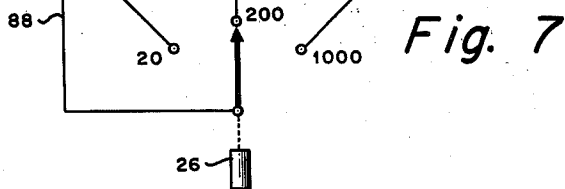
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6 Sheets-Sheet 5



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Fig. 10

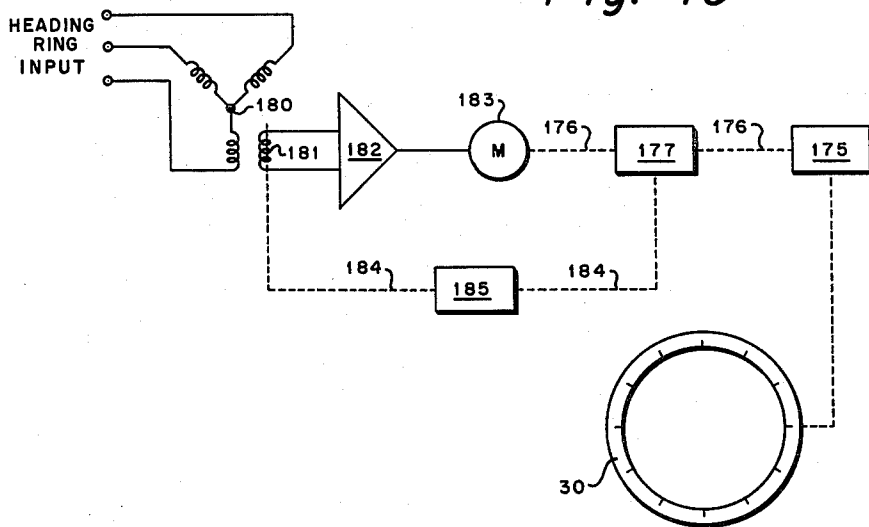
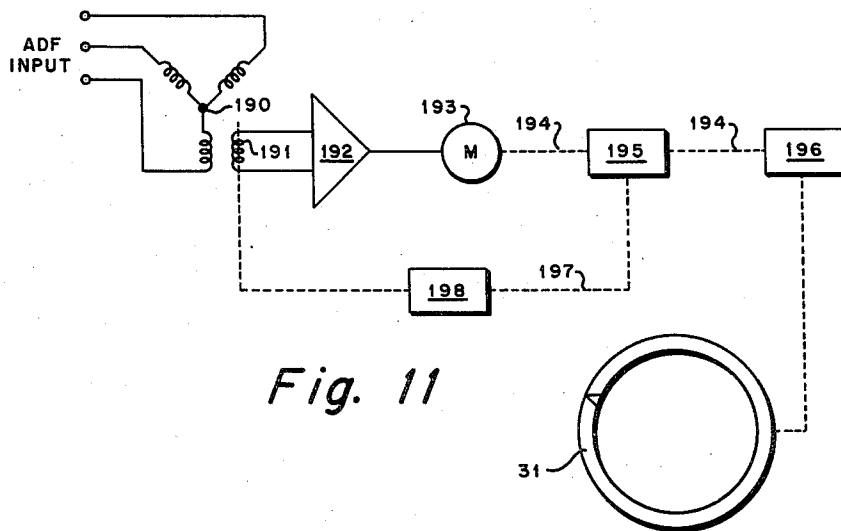


Fig. 11

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3,059,233

HORIZONTAL DISPLAY

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Filed Nov. 27, 1959, Ser. No. 855,949

10 Claims. (Cl. 343-112)

(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

The present invention relates to a navigational aid device that pictorially displays the relative position of a pilot relative to a destination and/or target.

With the advent of high speed vehicles, such as supersonic manned aircraft, there has been the ever increasing necessity and demand for a navigational aid which fully displays the horizontal situation between an aircraft and a destination or target whereby the situation and all necessary navigational data are clearly displayed in readily usable form.

An important requirement is that the navigational aid relieve the pilot of constantly attending to navigational problems.

It is contemplated that this invention will relieve the pilot of constantly attending to navigational problems by presenting all necessary data in readily usable form and pictorially displaying the horizontal position of the destination or target, which may be moving, relative to the pilot in the simplest and clearest manner.

One of the principal objects of the invention, therefore, is the provision of a novel navigational aid that pictorially displays the position of a destination or target, which may be moving, relative to the pilot's aircraft, the pilot's aircraft position remaining fixed on the display.

Another object of the invention is the provision of a novel navigational aid comprising a horizontal display for use in an aircraft wherein the aircraft's position on the display remains fixed and the position of a destination or target relative thereto is displayed and moved relative to the aircraft, whereby an inside-out display is provided and a pilot of the aircraft need only note the relative position of the destination or target. This relieves the pilot of the necessity for noting the positions of the aircraft in addition to the destination or target and the resulting necessity for mentally extrapolating the relative positions of the two before returning attention to the operation of the aircraft.

Another object of the invention is the provision of a horizontal display device, as set forth in the preceding object, that visually displays the probable time to go before the target or destination is reached and the computed distance remaining to the target or destination.

Yet another object of the invention is the provision of a device, as set forth in the preceding objects, that visually displays the relative bearing of a geographically fixed radio transmitter and the magnetic heading of the aircraft.

Yet another object of the invention is the provision of a novel horizontal display-type navigational aid for a pilot of an aircraft capable of displaying horizontal plane navigational information in pictorial rho-theta form, relative bearing of a geographically fixed radio transmitter, the magnetic heading of the aircraft, and range readouts in miles and minutes, the latter being based on the current ground speed of the aircraft.

A still further object of the invention is the provision of a novel navigational aid of the character referred to hereinabove embodied as a compact, lightweight, self-

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contained unit having all of the necessary amplifiers and servo-mechanisms contained therein, the unit being of the pull drawer type suitable for mounting in an instrument panel of a jet type aircraft, and having an umbilical cord type cable exiting from the rear of the unit and terminating into a suitable male electrical connector of the miniature type.

The invention further resides in certain novel features of construction, combination and arrangements of parts, and further objects and advantages of the invention will be apparent to those skilled in the art to which it pertains from the following description of the present preferred embodiment thereof described with reference to the accompanying drawings, which form a part of this specification, and wherein the same reference characters represent corresponding parts throughout the several views, and in which:

FIG. 1 is a plan view of a navigational aid device embodying the invention, but with a transparent cover removed;

FIG. 2 is a side elevational view of the device with the transparent cover in place, part of the cover being in section to show part of the night lighting provisions;

FIG. 3 is a view similar to FIG. 1, but with parts of the device removed to show the internal details thereof;

FIG. 4 is an enlarged fragmentary sectional view along line 4-4 in FIG. 3;

FIG. 5 is an enlarged sectional view along line 5-5 in FIG. 3;

FIG. 6 is an enlarged sectional view along line 6-6 in FIG. 3;

FIG. 7 is a schematic diagram of a rho target distance input servo mechanism embodied in the invention;

FIG. 8 is a schematic diagram of a theta target angle input servo mechanism embodied in the invention;

FIG. 9 is a schematic diagram embodying a time-to-go mechanism of the device of FIG. 1;

FIG. 10 is a schematic diagram of a servo mechanism driving a magnetic heading ring embodied in the invention; and

FIG. 11 is a schematic diagram of a servo mechanism driving an automatic direction finding ring.

It is to be understood that the invention is not limited to the details of construction and arrangements of parts shown in the drawings and hereinafter described in detail, but is capable of being otherwise embodied and of being practiced or carried out in various ways. It is to be further understood that the phraseology or terminology employed herein is for the purpose of description and there is no intention to herein limit the invention beyond the requirements of the prior art.

Referring to FIGS. 1-3, a horizontal display navigational aid device embodying the invention is indicated generally by the reference numeral 20. The device 20 continuously accepts horizontal situation information from a conventional central computer, not shown, embodying all the necessary sensing, receiving, and automatic integrated director equipment, and continuously converts the information into a form readily assimilated by a pilot of an aircraft. The aircraft, referred to herein as a chase aircraft for the purpose of illustrating the invention, is of the interceptor type with a given mission of intercepting a target aircraft.

The horizontal display device 20 comprises a circular white plastic display area 21, FIG. 1, having a chase aircraft 22 inscribed at the center thereof. An illuminated reticule 23 hereinafter referred to as a bug, depicting the target aircraft is projected on the white display area 21. The bug 23 is positioned by rho-theta positioning servo-mechanisms respectively schematically illustrated in FIGS. 7 and 8, which are indicated generally by the reference

numerals 24 and 25. The scale of the rho mechanism 24 may be selected with a range selector knob 26 for maximum ranges of preferably 20, 200 and 1000 nautical miles.

Similarly, distance-to-go and time-to-go to target data is also supplied from a suitable source such as the central computer to readout counters 27 and 28, respectively, for providing the pilot with definite statistical information. Preferably, the counters 27 and 28, respectively, are read in nautical miles and minutes, FIG. 1.

Encircling the white display area are two rotatable rings 30 and 31 and a combination stationary ring and face plate 32. The ring 30 is an annular heading ring having a compass rose, which is preferably divided in one degree increments although divisions of 30 degree increments are only indicated in FIGS. 1 and 3. The stationary ring 32 is a rectangular plate having a circular opening formed therein with compass rose indices marked thereon in preferably five degree increments at the edge of the circle although, as in ring 30, only increments of 30 degrees are indicated on the ring 31 in FIGS. 1 and 3.

The rotatable ring 31 serves as an automatic radio direction finder and has only an arrow head painted thereon for cooperating with the fixed ring 32 for indicating the direction of a radio station being used as a navigational fixed reference point by the pilot. For purpose of illustrating how the bearing ring 30 is read, a dotted line 33, FIG. 1, is drawn from the fixed center of the chase aircraft 22 through the bug 23 to the bearing ring 30 and thereby indicates the bearing to the bug 23. The pilot must attempt to align the bug 23 with the aircraft 22. The bearing or heading of the aircraft 22 is indicated by a fiducial marker 34 inscribed on the plate 21.

Rectangular cutouts 35, 36 are provided in the lower right and lower left hand corners of the fixed ring or face plate 32 for permitting viewing of the counters 27, 28, respectively. An additional cutout 37 is formed in the plate 32 adjacent the cutout 36 for the range indices and selector switch 38 operated by the range selector knob 26.

An illuminated wedge-shaped plastic cover 40, FIG. 2, is secured over the face plate 32 and the display area 21 for permitting the navigational aid device 20 to be easily viewed without eye-strain by the pilot. Preferably, twelve electric light bulbs, of which only one bulb 41 is shown in FIG. 2, are used to illuminate the entire surface of the rectangular device 20, which may be referred to as an electro-mechanical contact analog device. The bulbs 41 are equally spaced and aligned along the overhanging edge of the light wedge 40. Preferably, only red bulbs 41 are used to illuminate the device 20 at night, lighting during daylight having been found unnecessary.

The device 20 is small, compact and lightweight and is contained in a housing 42, comprising a bottom wall and four sides. The present production model of the invention has overall dimensions of ten inches wide, eleven inches long, and one and three-quarters inches thick. Since the lighting wedge 40 is five-sixteenths of an inch thick at the thickest portion thereof, the maximum overall height of the entire unit 20 is two and one-sixteenth inches. These dimensions are provided merely for describing the preferred embodiment of the invention and are not to be considered as delimiting the invention.

As pointed out hereinabove, the rho and theta servos respectively schematically illustrated in FIGS. 7 and 8, position the illuminated reticule or bug 23. More particularly, the rho or range servo 24 drives the bug 23 by means of a lead screw 50, FIGS. 3 and 5, the bug 23 comprising an electric light bulb, not shown, carried by a lead nut 51 additionally supported and guided on a guide rod 52 disposed parallel to the lead screw 50 and fixed at the ends thereof in the opposite ends of

a rectangular carrier frame 53. The bug 23 comprises a small inverted cup-shaped plastic member having a Maltese cross engraved on the upper surface thereof and is disposed over the light bulb and fixed to the lead nut 51. The ends of the guide rod 52 are insulated from the carrier frame 53 because the guide rod 52 is used as an electrical conductor for the bug 23, the ground being formed through the nut 51 and the lead screw 50. A wire 54 is electrically connected to the rod 52 and a terminal 55, fixed to a bearing plate 53a forming the bottomside of the carrier frame 53. A second wire 56 is connected to the wire 54 and extends downwardly through a tubular pintle or post 57, FIGS. 5 and 6, to a suitable power supply, not shown.

In order to eliminate the necessity for the pilot to visualize or lay a straight edge along the centers of the display area 21 and the bug 23 and thereby reading the relative bearing of the bug 23, a line of light is preferably used to aid the pilot in reading the bearing indicated by the dotted line 33 in FIG. 1. This is effected as shown in FIG. 3 by slidably extending a plastic or glass light tube or rod 58 through the bug 23 parallel to the lead screw 50 and securing the same to the ends of the carrier frame 53. Light bulbs 59 are positioned at each end of the light rod 58 for illuminating the same along the entire length thereof. Preferably, the lower half of the light rod 58 is painted to reflect the light back into the rod 58 and thereby increasing the light intensity in the upper half of the rod 58. Accordingly, a line 33 of light will enable the bearing of the bug to be quickly noted.

All power and electrical signal inputs are supplied to the device 20 by means of a pigtail 60 having a suitable multi-pin electrical male connector 61 at the end thereof. Accordingly, the device 20 can be easily removed for inspection and maintenance.

As best seen in FIGS. 5 and 6, the lead screw 50 has the ends thereof journaled in the corresponding ends of the carrier frame 53, the inner end of the lead screw 50 having a spur gear 62 fixed thereto. The gear 62 is driven by a pinion gear 63. The gear 63 is journaled on a stub shaft 64 fixed at one end thereof to the carrier frame 53. A driven bevel gear 65 is fixed to the gear 63 and is driven by a similar bevel gear 66 which is pivotally mounted on a vertical sleeve 67. The sleeve 67 is pivotally mounted about the post 57 and forms a part of a transmission, indicated generally by the reference numeral 68, FIGS. 5 and 6. The transmission 68 is comprised of a spool-shaped carrier member 69 which is fixed to the pivotally mounted sleeve 67. The lower end of the sleeve 67 is journaled on an anti-friction bearing support plate 69a, FIG. 5, and has two integrally-connected parallel gear wheels 70, 71, pivotally connected thereto. A gear wheel 72, similar to the gear wheel 71, is fixed to the bevel gear 66 by means of a sleeve-like neck portion 72a, FIG. 6. A pair of intermeshed planet gears 73, 74 are journaled between the flanges of the spool member 69 and are respectively intermeshed with the gear wheels 71, 72.

FIGS. 3, 5 and 6 show that the bug 23 is radially moved inwardly when a worm 75 drives a helical gear 76 and a gear wheel 77 in a clockwise direction, FIG. 3, the gears 76, 77 being fixed to and interconnected by a vertical shaft that is journaled at the upper and lower ends thereof between parallel mounting plates 78, 79. The mounting plate 78 is trapezoidally-shaped, FIG. 3, and the plate 79 is circular. The mounting plate 79 has the bearing plate 69a flush-mounted therein coaxial with the transmission 68.

The worm gear 75 is driven by an electromechanical analog arrangement schematically shown in FIGS. 3 and 7. The target distance input is continuously supplied in the form of an electrical signal from the central computer or by other suitable means into a transistor servo amplifier 80 similar to the one disclosed in copending

U.S. application of Edward J. Rickner et al., Serial No. 701,686, now Patent No. 2,951,991, filed December 9, 1957 entitled "Transistor Servo Amplifier."

It is understood that other servo amplifiers may be used, but the one referred to has the advantages of being compact and lightweight with a cold plate type of cooling arrangement. Accordingly, the necessity for the usual fan type of cooling arrangement with special cooling passages, ducts and openings is eliminated.

The output of the amplifier 80 drives a synchro motor 81 having output shaft means 82 driving the worm gear 75 through a gear train 83. As seen in FIG. 3, the gear train 83 is enclosed within a housing 84 and has a gear ratio of 52:1.

In order to provide the device 20 with a range selection, a scale changer arrangement comprises grounded cylindrical or drum-type rotary potentiometers 85, 86, 87, which are used as distance follow-ups, adapted to be individually selected and put in circuit by means of the range selector knob 26 which has the indicator 38 fastened thereto. The indicator 38 is a sector having the numbers 20, 200 and 1000 engraved on an arcuate, flanged periphery thereof. Each potentiometer 85, 86, 87 preferably has a gradient of 3.6 degrees per nautical mile.

More particularly, the output shaft means 82, driven by the synchro motor 81, is adapted to null the output of the amplifier 80 by picking-off a nulling feedback signal from one of the three potentiometers 85, 86, 87. The range select knob is adapted to electrically connect via a line 88 one of the wipers 95, 96, and 97 to the input side of the amplifier 80, the potentiometers 85, 86, 87 each being connected at one end to an electrical power supply.

The wiper 95 of the 1000 mile range potentiometer 85 is driven through a mechanical linkage 98 having a 42:1 ratio step-down gear train 99 therein. The wiper 96 of the 200 mile range potentiometer 86 is driven through a mechanical linkage 100 having a gear train 101 with a 5:1 gear ratio between the linkage 98 and the 200 mile range wiper 96 of the potentiometer 86. The wiper 97 of the 20 mile range potentiometer 87 is driven by a mechanical linkage 103 having a gear train 104 with a 5:1 gear ratio. The gear trains 99, 101, 104 are also enclosed within the housing 84 along with the gear train 83, the entrained gears being journaled on shafts fixed between the upright parallel, longitudinally extending side walls of the gear train housing 84.

For compactness, the potentiometers 85, 86, 87 are in synchro-like form wherein the wipers are rotated inside the stator resistances. The bug 23 has been oriented in such a manner that 3600 degrees of rotation of the wiper 95 of the potentiometer 85 is equivalent to four inches of bug travel, the radius of the display area 21 being four inches, preferably. Concurrently, the wiper 96 of the potentiometer 86 will have rotated 720 degrees. For example, a distance-to-go equal to 200 miles when the scale selector knob 38 is in the 1000 mile position is reflected by a 720 degree position of the wiper 95 of the potentiometer 85 and a 145 degree position of the wiper 96 of the potentiometer 86. This will place the bug 23 at a distance of 0.8 inch from the center of the display area 21 by virtue of the gear ratios employed.

If the scale selector knob 26 is changed to the 200 mile range position, potentiometer 86 will be placed in the follow-up or feedback circuit 88. In order to null out the transmitter, the potentiometer 86 must be driven to its 720 degree position, thereby placing the bug 23 in its full scale, four inch radius, position. Accordingly, it is apparent that when the wipers 95, 96, 97 of the potentiometers 85, 86, 87 are at the aforementioned 3600, 720, and 72 degree positions, the output of the amplifier 81 will be nulled out and the mechanism associated with the bug 23 will have override protection. Therefore, when the destination or target range is outside

the range of the display radius, the bug 23 will be maintained at the extreme radial distance from the center of the display area 21 without damage to the mechanism until the display radius and the range information become compatible.

The theta target angle input signal for positioning the bug 23 is supplied to a Y-shaped winding of a receiver synchro 110 and picked off by a rotor coil 111 which has the ends thereof connected to the input side, FIG. 8, of an amplifier 112. The output of the amplifier 112 drives a synchro motor 113 which drives a worm gear 114 via a mechanical shaft linkage 115 having a pair of gear trains 116, 117 therein which are enclosed and journaled in a housing 118 similar to the gearing in the housing 83, FIG. 3. The gear trains 116 and 117 respectively have gear ratios of 9:1 and 4:1. A follow-up follower arrangement having a gear box 119 therein acts to null the input to the amplifier 112 by repositioning the rotor 111 to a null position. The gear box 119 has a gear ratio of 96:1.

The target angle positioning worm 114 is enmeshed with a helical gear 120 that is fixed to a gear wheel 121 having an upright shaft portion 121a journaled at the ends thereof in the support plates 78, 79 by means of suitable anti-friction bearings. The gear wheel 121 is drivingly engaged with a gear wheel 122 which also has a vertical shaft portion 122a with ends journaled in the plates 79, 78 by means of anti-friction bearings. A larger gear wheel 123 is fixed to the shaft portion 122a and drivingly engages a gear wheel 124 that has a tubular hub portion 124a extending vertically upwardly coaxial with the post 57 and fixed to the bottom plate portion 53a of the bug carrier frame 53. The tubular hub portion 124a is suitably pivotally mounted in the plate 78 by means of anti-friction bearings 125. Accordingly, turning of the theta angle input wheel 121 in a clockwise direction will result in the bug 23 being carried in clockwise direction, as best seen in FIGS. 1 and 3.

Because of the range error introduced by the theta target angle servo 25, the inputs from the range and target angle servos 24, 25, respectively, are linked differentially by means of the differential-type transmission 68. Accordingly, a small idler wheel 130, of a high friction material such as hard rubber, is pivotally mounted on a pintle pin 131 fixed to the plate 79 and is adapted to be driven by the gear wheel 121 and thereby reposition the spool-shaped planet gear carrier member 69 of the transmission 68.

When the wheel 121 is driven in a clockwise direction, FIG. 6, the planet carrier member 69 will also be driven in a clockwise direction, FIG. 3. Clockwise movement of the member 69 results in similar movement of the planet 73, since the gear wheel 70 will be assumed as relatively fixed as it is driven by the range input servo 24 only, and the resulting counterclockwise movement of the plane gear 74, FIG. 5, will drive the integrally connected gears 72 and 66 in a clockwise direction so that the bevel gear 65 will remain in fixed relationship to the bevel gear 66 when the frame carrying the bevel gear 65 is turned in a clockwise direction. In other words, the bevel gear 66 is turned with the gear 65 so that they are stationary relative to each other.

Referring to FIGS. 3 and 4, the magnetic heading ring 30 is the innermost of the two rotating rings 30, 31. The ring 30 is preferably calibrated in one degree increments, only 30 degree increments being shown, and heading is read against the fiducial marker 34 inscribed on the plastic display area 21. The heading ring 30, the radio direction finding ring 31 and a cylindrical inner support ring 160, the latter forming part of the housing 42 and fixed atop the support plate 79, are stepped and concentrically interseated so that flat annular portions 30a, 31a of the rings 30, 31 are coplanar with the display area 21. The rings 30, 31 are respectively rotatively supported by parallel, radially outwardly extending sup-

port flanges 161, 162 fixed to the outer surface of the support ring 160. Suitable anti-friction bearings 163, 164 support the rings 30, 31 on the flanges 161, 162, respectively. More particularly, there are three sets of ball bearings 163, 164 supporting each ring 30, 31 with the outer races seating in a radially inwardly opening groove or track formed in the inner cylindrical wall of the rings 30, 31 and with the inner races being pinned to the flanges 161, 162.

Ring gears 165, 166, fixed to the lower portions of the rings 30, 31, respectively, provide the latter with a channel-shaped configuration. Idler gears 167, 168 driven by driving gears 169, 170, respectively, are enmeshed with ring gears 165, 166 FIGS. 3 and 4. Worm gears 171, 172 respectively drive the driving gears 169, 170 via a helical gear fixed to each of the gears 169, 170, FIG. 3.

More particularly, as shown in FIG. 10, the heading ring 30 is driven by a gear train 175, comprised of the gearing 171, 169, 167, 165, having an overall gear ratio of 20:1. The gear train 175 is driven by a mechanical shaft linkage 176 having a gear box 177 therein with a gear ratio of 50:1.

The heading input signal is obtained from a signal in a Y-shaped stator, or primary winding of a control transformer 180 having a secondary or rotor coil 181 connected to the input side of an amplifier 182. The output of the amplifier 182 drives a synchro motor 183, FIGS. 3 and 10, and is nulled by a feedback arrangement comprising a mechanical linkage 184, driven by the motor output linkage 176, which adjusts the rotor coil 181. A gear box 185 with a gear ratio of 20:1 is provided in the feedback nulling linkage 184.

The radio direction finding ring 31 is similarly driven by a signal supplied to a stator or primary winding of a control transformer 190 which is picked off by a rotor coil 191, which serves as a secondary winding, and fed to an amplifier 192. The output of the amplifier 192 energizes a synchro motor 193 which drives a shaft arrangement 194 having a gear box 195 and a second gear box 196 comprising the gearing 172, 170, 168, 166 for driving the radio direction finding ring 31. The rotor 191 is adjusted to a null position by a feedback linkage 197 having a gear box 198 driven by the shaft arrangement 194. The gear boxes 177 and 195 are housed within a housing 200 and constructed similar to the gearing in housings 84, 118, FIG. 3.

The time-to-go counter 28, FIGS. 3 and 9, is driven by a servomechanism similar to the magnetic heading and automatic radio direction finding servos in FIGS. 10, 11, respectively. The counter 28 is comprised of four wheels having digits from 0 to 9 engraved thereon and geared so that 360 degrees of synchro rotation is equivalent to 60 minutes of time. The counter 28 is made to read in minutes and tenths of minutes. FIGURE 9 shows a Y-shaped stator winding 210 adapted to receive a signal from the central computer or other suitable source and cause a rotor coil 211 to pick off and feed the signal to an amplifier 212. The output of the amplifier drives a synchro motor 213 which drives a mechanical shaft arrangement 214 having a gear box 215 therein. The ratio of the gear box is 600:1 and a gear box 216 in a feedback shaft linkage 217 for moving the rotor 211 to a nulling position is 60:1. As pointed out, one complete revolution of the output shaft of the synchro motor 213 is equivalent to 60 minutes of time.

The miles-to-target read-out counter 27 comprises a three drum device, FIG. 3. Each drum is preferably geared to, and driven by, a receiver type synchronous motor, not shown. Their respective transmitting synchros are preferably situated within the central computer, it being understood that signals to all of the aforementioned synchros 80, 110, 180, 190, and 210 can be otherwise provided, i.e., inserted manually or obtained from conventional transmitters, not shown. Each counter wheel is

driven through 36 degrees to effect a one digit change, and accordingly, the gear ratio between each of the servo movements is 10:1.

It will be understood that the present invention may be modified to adapt it to various circumstances and conditions, and it is accordingly desired to comprehend within the purview of this invention such modifications as may be considered to fall within the scope of the appended claims.

What is claimed:

1. In a horizontal display device suitable for use as a navigational aid in a piloted craft, a circular display area having a center representing the relatively stationary position of the piloted craft, illuminated reticule means adapted to be positioned relative to said center of said display area and representing a target, means coupled to said reticule means for continuously positioning said reticule means relative to said center, said display area having a fiduciary marker thereon, heading ring means encircling said display area and having a compass rose thereon, means coupled to said heading ring means for positioning said heading ring means relative to said fiduciary marker on said display area and indicating the heading of the piloted craft, means for projecting a line of light radially from said display area center through said reticule means to the edge of said display area for indicating the bearing position of said reticule means relative to the piloted craft, automatic direction finding ring means encircling said heading ring means and having a reference marker thereon, stationary ring means encircling said automatic direction finding ring means and having a compass rose thereon, means coupled to said automatic direction finding ring means for positioning said reference marker of said automatic radio direction finding ring means relative to said stationary ring for continuously indicating the direction of a radio station having a known geographical location, time-to-go counter means, means coupled to said time-to-go counter means for continuously positioning said time-to-go counter means for indicating the probable time to go before said target is intercepted, distance-to-go counter means, means coupled to said distance-to-go counter means for continuously positioning said distance-to-go counter means for indicating the distance to go before said target is intercepted, range selector means for changing the range scale of said reticule positioning means, means for overriding the drive of said reticule positioning means when said reticule means is at either the center or the periphery of said display area for preventing damage to the horizontal display device.

2. In a horizontal display device as set forth in claim 1, wherein said reticule positioning means comprises carrier frame means pivotally connected at the center of said display area and extending to the periphery of said display area, electromechanical analog target angle input means adapted to be continuously supplied with target angle information for angularly positioning said carrier frame means, lead screw means journaled in said carrier frame means, nut means carrying said reticule means and driven radially in and out by rotating said lead screw means, electromechanical analog target range input means adapted to be continuously supplied with target range information and correspondingly positioning said reticule means relative to said display area center according to the range scale setting of said range scale selector means, and error compensating means offsetting the error introduced by said target angle input means to said target range input means when target angle input information is supplied and said carrier frame is swung through an angular increment.

3. In a horizontal display device suitable for use as a navigational aid in a piloted craft, a circular display area having a center representing the relatively stationary position of the piloted craft, illuminated reticule means adapted to be positioned relative to said center of said display area and representing a target, means coupled to said reticule means for continuously positioning said reticule means relative to said center, said display area having a

fiduciary marker thereon, heading ring means encircling said display area and having a compass rose thereon, means coupled to said relative heading ring means for positioning said heading ring means relative to said fiduciary marker on said display area and indicating the heading of the piloted craft, means for projecting a line of light radially from said display area center through said reticule means to the edge of said display area for indicating the position of said reticule means relative to said display area center and said viewer, range selector means for changing the range scale of said reticule positioning means, means for overriding the drive of said reticule positioning means when said reticule means is at either the center or the periphery of said display area.

4. In a horizontal display device as set forth in claim 3, wherein said reticule positioning means comprises carrier frame means pivotally connected coaxial with said display area center and extending to the periphery of said display area, electromechanical analog target angle input means adapted to be continuously supplied with target angle information for angularly positioning said carrier frame means, lead screw means journaled in said carrier frame means, nut means carrying said reticule means and radially positioned by said lead screw means, and electromechanical analog target range input means adapted to be continuously supplied with target range information for radially positioning said reticule means relative to said display area center according to the range scale setting of said range scale selector means.

5. In a horizontal display device as set forth in claim 4, means pivotally supporting said carrier frame means, gear means fixed to said carrier frame means, said target angle input means driving said gear means and angularly positioning said carrier frame means, first spur gear means fixed to said lead screw means, second spur gear means carried by said carrier frame means meshing with said first spur gear means, first bevel gear means fixed to said second spur gear means, second bevel gear means in driving connection with said first bevel gear means, central post means coaxial with the center of said display area, said second bevel gear means being pivotal about said post means, differential transmission means driven by said range input means and driving said second bevel gear means, gear train means driven by said target angle input means and driving said gear means fixed to said carrier frame means, said differential transmission means having a carrier portion adapted to be angularly positioned by said target angle gear train means for compensating for input error to the range position of said reticule means during angularly positioning of said carrier frame means.

6. In a horizontal display device suitable for use as a navigational aid in a piloted craft, a circular display area having a center representing the relatively stationary position of the piloted craft, illuminated reticule means adapted to be positioned relative to said center of said display area and representing a target, means coupled to said reticule means for continuously positioning said reticule means relative to said center, said display area having a fiduciary marker thereon, heading ring means encircling said display area and having a compass rose thereon, means coupled to said relative heading ring means for positioning said heading ring means relative to said fiduciary marker on said display area and indicating the heading of the piloted craft, automatic direction finding

ring means encircling said heading ring means and having a reference marker thereon, stationary ring means encircling said automatic direction finding ring means and having a compass rose thereon, and means coupled to said automatic direction finding ring means for positioning said reference marker of said automatic radio direction finding ring means relative to said stationary ring for continuously indicating the direction of a geographically fixed radio station of a known geographical location.

7. In a horizontal display device as set forth in claim 6, time-to-go counter means, means coupled to said time-to-go counter means for continuously positioning said time-to-go counter means for indicating the instantaneous time to go before said target is intercepted.

8. In a horizontal display device as set forth in claim 6, distance-to-go counter means, means coupled to said distance-to-go counter means for continuously positioning said distance-to-go counter means for indicating the instantaneous distance to go before said target is intercepted.

9. In a horizontal display device as set forth in claim 6, means connected to said reticule means for projecting a line of light radially from said reticule means to the edge of said display area for indicating the bearing of said reticule means from the piloted aircraft.

10. In a horizontal display device suitable for use as a navigational aid in a piloted craft, a circular display area having a center representing the relatively stationary position of the piloted craft, illuminated reticule means adapted to be positioned relative to said center of said display area and representing a target, means coupled to said reticule means for continuously positioning said reticule means relative to said center, said display area having a fiduciary marker thereon, heading ring means encircling said display area and having a compass rose thereon, means coupled to relative heading ring means for positioning said heading ring means relative to said fiduciary marker on said display area and indicating the heading of said viewer, means for projecting a line of light radially from said display area center through said reticule means to the edge of said display area for indicating the position of said reticule means relative to the piloted craft, time-to-go counter means, means coupled to said time-to-go counter means for continuously positioning said time-to-go counter means for indicating the probable time to go before said target is intercepted, distance-to-go counter means for continuously positioning said distance-to-go counter means for indicating the distance to go before said target is intercepted, range selector means for changing the range scale of said reticule positioning means, and means for overriding the drive of said reticule positioning means when said reticule means is at either the center or the periphery of said display area for preventing damage to the horizontal display device.

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