

C. No.

2,685,226

THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

Whereas

Carl J. Crane,

of

Sacramento,

California,

PRESENTED TO THE COMMISSIONER OF Patents A PETITION PRAYING FOR THE GRANT OF LETTERS PATENT FOR AN ALLEGED NEW AND USEFUL INVENTION THE TITLE AND A DESCRIPTION OF WHICH ARE CONTAINED IN THE SPECIFICATION OF WHICH A COPY IS HEREUNTO ANNEXED AND MADE A PART HEREOF, AND COMPLIED WITH THE VARIOUS REQUIREMENTS OF LAW IN SUCH CASES MADE AND PROVIDED, AND

Whereas UPON DUE EXAMINATION MADE THE SAID CLAIMANT is ADJUDGED TO BE JUSTLY ENTITLED TO A PATENT UNDER THE LAW.

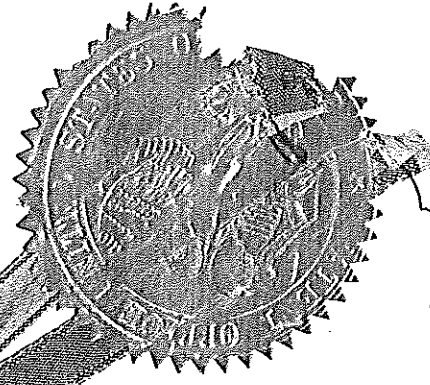
NOW THEREFORE THESE Letters Patent ARE TO GRANT UNTO THE SAID

Carl J. Crane, his heirs

OR ASSIGNS

FOR THE TERM OF SEVENTEEN YEARS FROM THE DATE OF THIS GRANT

RIGHT TO EXCLUDE OTHERS FROM MAKING, USING OR SELLING THE SAID INVENTION THROUGHOUT THE UNITED STATES.



In testimony whereof I have hereunto set my hand and caused the seal of the Patent Office to be affixed at the City of Washington this third day of August, in the year of our Lord one thousand nine hundred and fifty-four, and of the Independence of the United States of America the one hundred and seventy-ninth.

Attest:
Carl J. Crane
Attaching Officer.

Robert C. Watson
Commissioner of Patents.

Aug. 3, 1954

C. J. CRANE

2,685,226

AIRCRAFT FLIGHT CONTROL OPTICAL INDICATING DEVICE

Filed July 10, 1950

5 Sheets-Sheet 5

Fig. 14

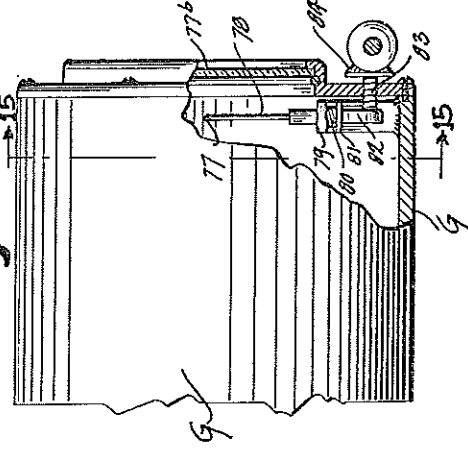


Fig. 15

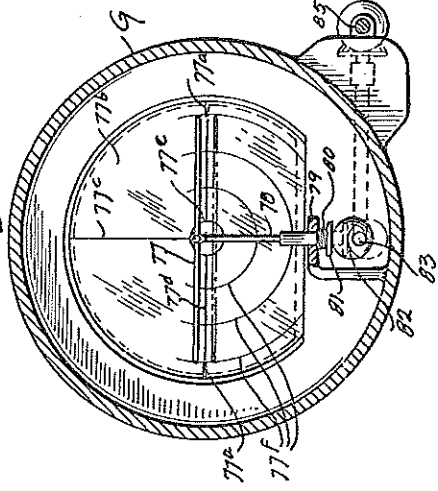
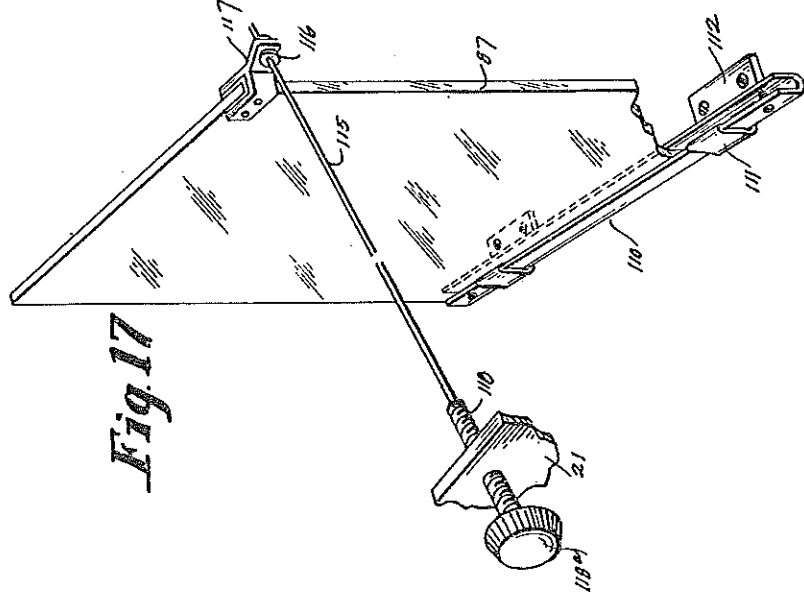


Fig. 16



Fig. 17



Aug. 3, 1954

C. J. CRANE

2,685,226

AIRCRAFT FLIGHT CONTROL OPTICAL INDICATING DEVICE

Filed July 10, 1950

5 Sheets-Sheet 4

Fig. 5

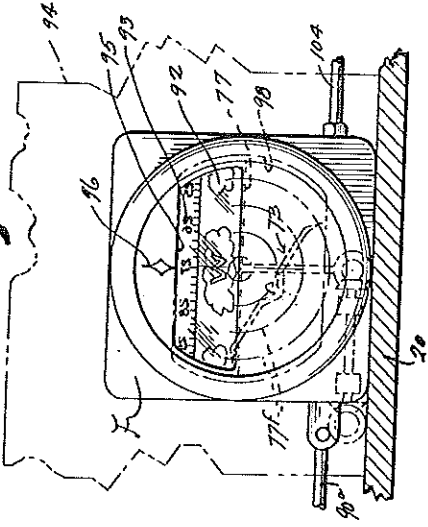


Fig. 7

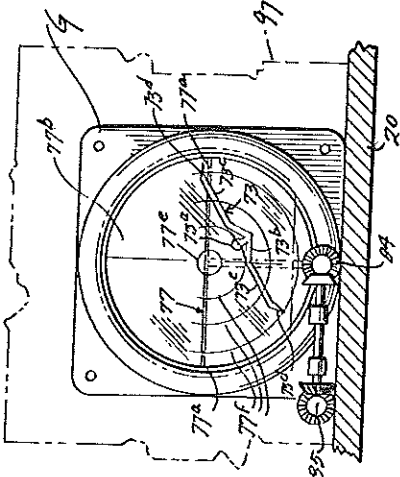


Fig. 8

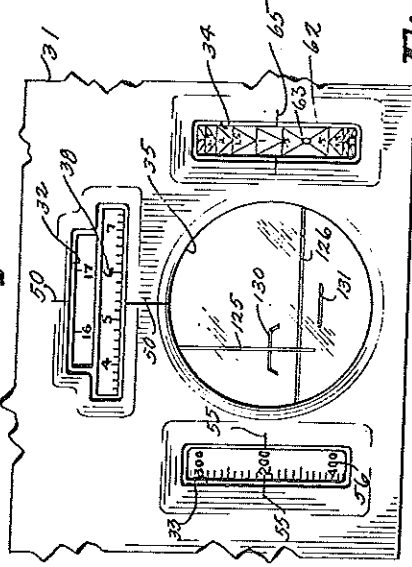


Fig. 9

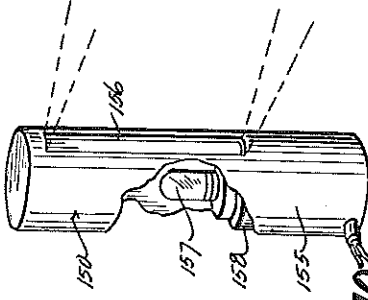
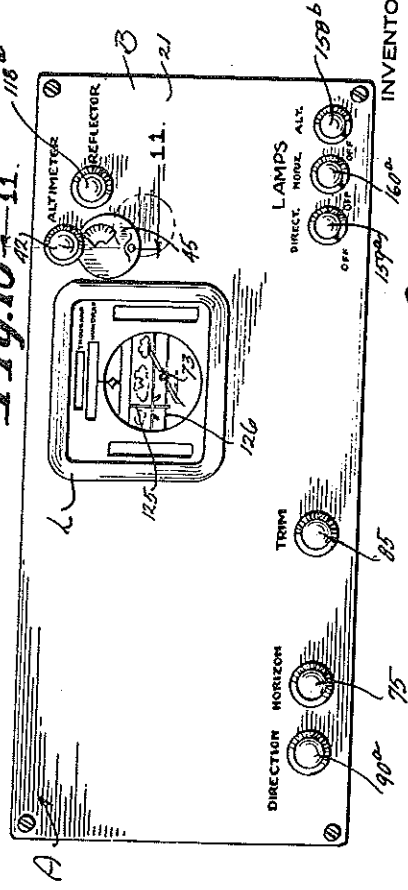


Fig. 10



BY *Carl J. Crane*
CARL J. CRANE
INVENTOR.
BY *Lawrence, Allen & Rammel*
ATTORNEYS.

Aug. 3, 1954

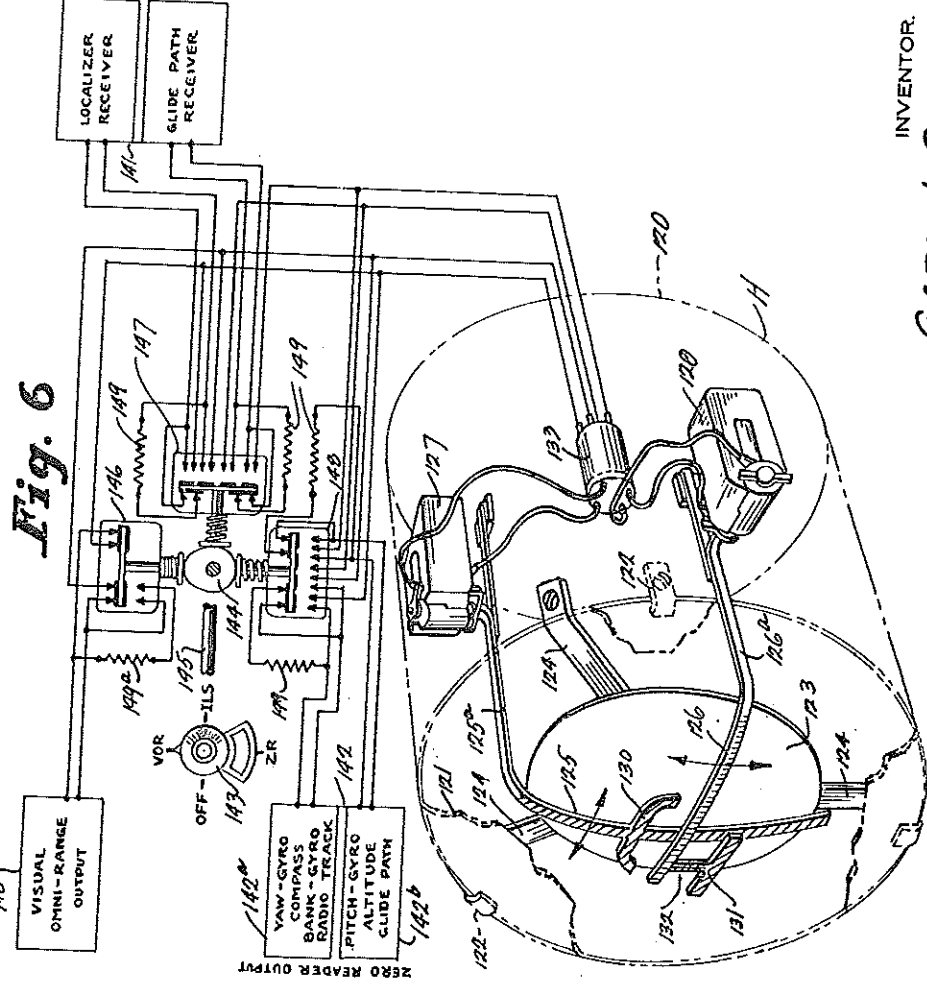
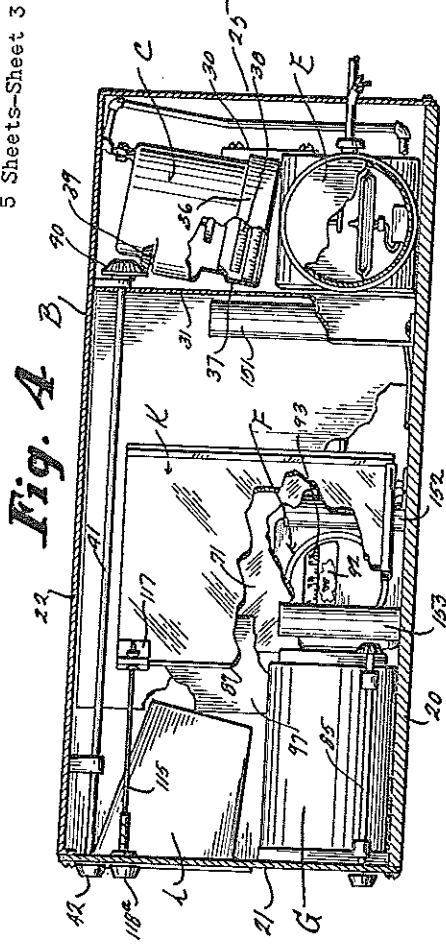
C. J. CRANE

2,685,226

AIRCRAFT FLIGHT CONTROL OPTICAL INDICATING DEVICE

Filed July 10, 1950

5 Sheets-Sheet 3



INVENTOR
CARL J. CRANE
BY *Lawrence, Allen & Pomeroy*
ATTORNEYS.

Aug. 3, 1954

C. J. CRANE

2,685,226

AIRCRAFT FLIGHT CONTROL OPTICAL INDICATING DEVICE

Filed July 10, 1950

5 Sheets-Sheet 2

Fig. 2

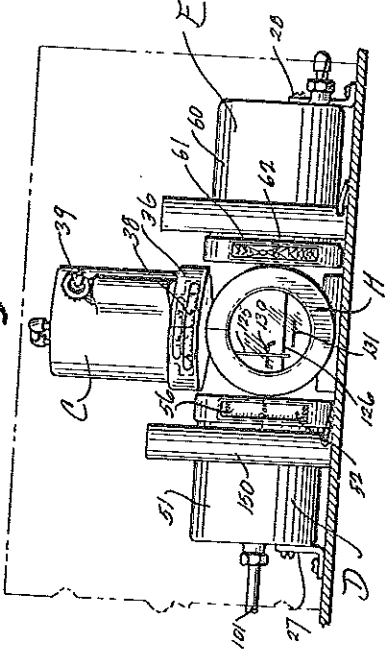
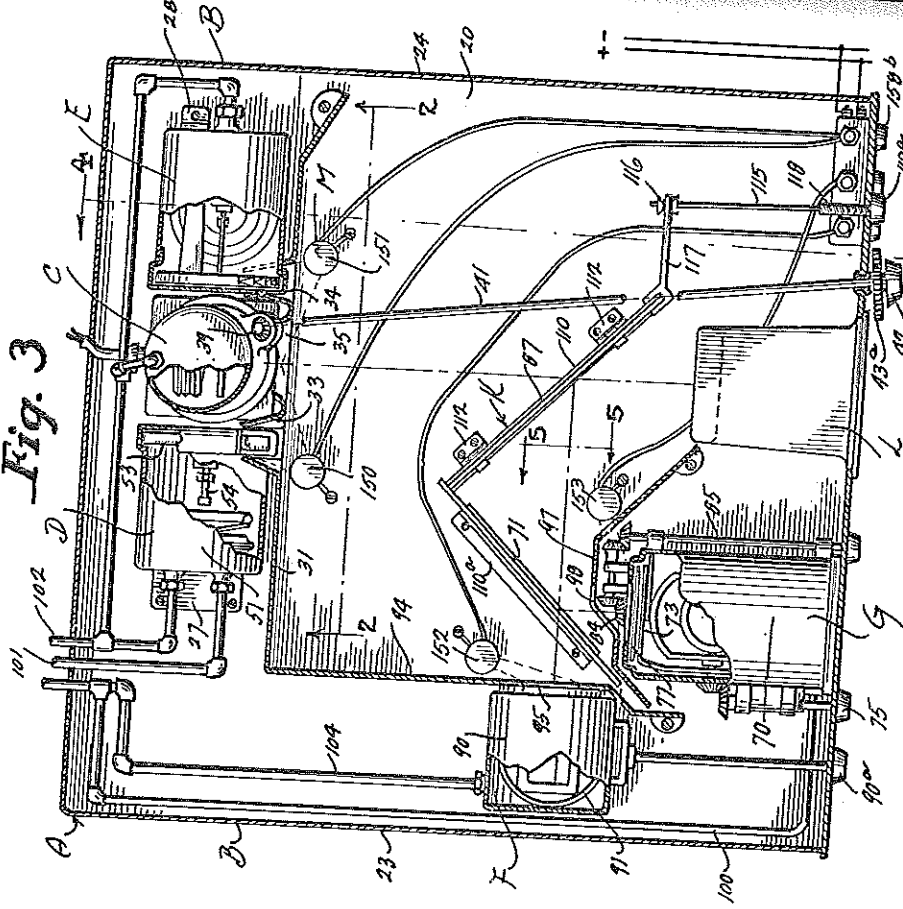
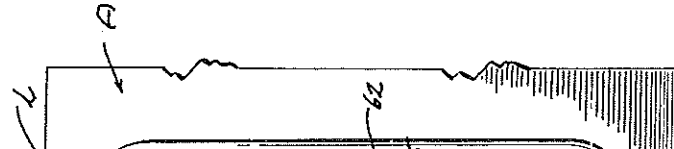


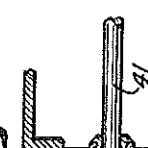
Fig. 3



BY *Sanatka, Allen & Conner*
CARL J. CRANE
INVENTOR
ATTORNEYS



g. 11



INVENTOR.

CRANE



ATTORNEYS.

Patented Aug. 3, 1954

2,685,226

UNITED STATES PATENT OFFICE

2,685,226

AIRCRAFT FLIGHT CONTROL OPTICAL
INDICATING DEVICE

Carl J. Crane, Sacramento, Calif.

Application July 10, 1950, Serial No. 172,831

7 Claims. (Cl. 88—24)

1

This invention relates generally to a unitary device for visual reference by the pilot in the control of an aircraft under blind flight conditions. Generally it relates to a device of this kind in which are embodied the indicating elements required to enable the pilot to control the aircraft in relation to terrestrial objects as well as radiated electronic space patterns simultaneously and efficiently.

It is well known that aircraft are maneuvered under conditions of blind flight with respect to airborne instruments which indicate an artificial terrestrial horizon, an azimuth reference and indicating speed devices.

So far as is known no device has been made available by which the pilot of an aircraft can roll or pitch or turn the aircraft with visual reference to indicia responsive to electronic patterns which present a similar visual reference to that provided in artificial means commonly known as artificial horizons, directional gyros and the like. Neither is it known that there exists in the art a unitary indicating means which presents both an artificial terrestrial and an artificial electronic horizon each substantially indicated parallel to each other by which the craft can be maneuvered in order to satisfy spatial orientation as well as space pattern electronic indication in a manner conventionally understandable to the pilot, who viewing the unitary indicator can take advantage of trained reflexes to safely and accurately control his craft.

In the type of flight instruments using an electron beam traced upon a fluorescent screen of a cathode ray tube there is no unitary indicating reference which approximates the normal natural visual flight stimulus viewed in clear weather, and neither do such instruments provide like artificial indicia by which visual reference thereto can reconstruct on the part of the pilot an electronically radiated space pattern, both horizontal and vertical.

Various attempts have been made in the past to accomplish the result of controlling an aircraft with respect to the earth and to electronically radiated space patterns. These attempts have resulted in separated reference indicia having no visual resemblance to objective reality nor indeed if combined into a unitary indicator did the resultant present a visual reference to which the pilot could react in a normal manner with the speed required for safe and accurate flight control in the normal clear weather manner in which he was trained to fly.

The present invention therefore provides a unit-

2

tary indicator natural in its presentation by which the experienced and inexperienced pilot may control his craft with respect to terrestrial and electronic planes of references. It not only provides in a unitary indicator information of bank, pitch, turn, heading deviation from electronic glide path, deviation from vertical electronic course path and rates of approach thereto, and rates of departure therefrom, but, presents this information in a normal highly interpretable and natural manner.

It is therefore a primary object of this invention to provide novel instrumental means to accomplish craft control in relation to electronic and terrestrial reference data.

Another object is to present the instrumental data for visual reference in a unitary and natural manner.

Another object is to provide instrumental means for "selecting out" or "selecting in" those visual reference indicia instantly desired by the pilot.

Another object of this invention is to provide a means of approach to an electronically radiated space pattern for control of the aircraft in a manner which will prevent or reduce the hunting or over-controlling of the craft in the space adjustment of its flight path to that of the electronically radiated path.

A further object of this invention is the combination use of the artificial horizon established by a gyroscope having a vertical spin axis, and the presentation of the "card" of a compass, gyro-controlled compass or directional gyro, to portray a unitary replica of the "natural" instrument, seen in its visual manifestations of turning, banking, climbing and gliding.

Another object of the invention is the simple means of optically selecting various elements or indicia to be included in the unitary portrayal of needed indicia depending on the particular flight problem confronting the pilot.

Still another object of the invention is the means for optically associating turn rate and heading of the aircraft with the bank angle of the aircraft to provide the all-important concept of coordination of control with "feel" thereby giving the pilot a freedom from "vertigo" and "leans."

Another feature of the unitary instrumental presentation of indicia responsive to electronic glide path and course path is the manner of portraying the banking and pitching attitude of the aircraft index with respect to these two paths. Another improved feature of the device is the

manner in which the portrayed electronic horizon may be used alone as a reference for flight spatial and electronic spatial reference and then used in conjunction with the artificial terrestrial horizon to justify the flight path of the airplane along a glide beam, with the pitch attitude of the aircraft.

Another novel feature of the arrangement of combined indicia is the presentation in the same field of view, and in the same plane of reference the numerical value of landing air speed and a sky pattern.

Another feature of the portrayal of related and combined indicia into a unitary indicator for flight control and electronic navigation control is the pleasant normal natural indicating face in which the cloud pattern and horizon can appear slightly beyond the airplane index as is normal to clear-weather flight relieving the pilot of eye strain common to cathode ray type of reference indicators which need frequent adjustment for brilliance control and flicker control.

A further object of this invention is the provision of an improved arrangement of aircraft instruments which have been modified so as to adapt themselves in an improved optical system wherein by simple reflection means the functional visual stimuli designated in naturally viewed clear weather manner portrays the flight attitude and rate changes of the aircraft.

Other objects and advantages of this invention will be apparent during the course of the following detailed description.

In the accompanying drawings, forming a part of this specification, and wherein similar reference characters designate corresponding parts throughout the several views.

Figure 1 is a display of front elevation of the indicating face of the unitary flight control indicia consisting of all optically associated elements of the instrument.

Figure 2 is a fragmentary front elevation showing various instruments of the improved craft control device, the view being taken substantially on the line 2-2 of Figure 3, but with a shield removed.

Figure 3 is a fragmentary plan showing certain instruments of the improved craft indicating system.

Figures 4 and 5 are vertical cross sectional views taken through the instrument substantially on the respective lines 4-4 and 5-5 shown in Figure 3.

Figure 6 is a fragmentary perspective view, partly diagrammatic, showing an improved type of flight gauge known as an electronic space instrument.

Figure 7 is an elevational view of the gyro-horizon looking at the index end thereof showing the casing base in cross section and the screen in dot and dash lines.

Figure 8 is a view taken in front of the shield which blocks the instrument shown in Figure 2, and showing the indicia visible through the openings in that shield.

Figure 9 is a fragmentary perspective view showing an instrument lamp, several of which are employed in the device in connection with the optical system and instrument display indicia.

Figure 10 is a front view of the panel of the instrument.

Figure 11 is an enlarged cross sectional view taken through the altimeter control resetting means, the view being taken substantially on the line 11-11 of Figure 10.

Figure 12 is a diagrammatic view showing electric illuminating means for the instrument.

Figure 13 is a direct front view of improved display indicia for the directional gyro.

Figure 14 is a fragmentary view, partly in section, showing a horizon turn knob arrangement for raising and lowering a horizon bar of the gyro horizon instrument.

Figure 15 is a cross sectional view taken substantially on the line 15-15 of Figure 14.

Figure 16 is a cross sectional view taken substantially on the line 16-16 of Figure 14.

Figure 17 is a perspective view of an optical mirror associated with the instrument.

Figure 18 is a fragmentary view showing a pivot mounting of one of the optical mirrors.

In the drawings, wherein for the purposes of illustration is shown only a preferred embodiment of the invention, the letter A may generally designate the flight instrument. It includes a casing structure B having associated therein an altimeter C; air speed indicator D; rate of climb instrument E; directional gyro F; gyro horizon G and an electronic space instrument H. Optical means K is provided to optically blend or merge the various indicia from these instruments at the reference plane or locus of the indicating face of the electronic space instrument "E" viewed through an eye piece L. Improved illuminating means M is provided, and a shield mechanism N is associated within the instrument to perfect the display of the various indicia of the instruments, as will be subsequently mentioned.

The casing structure B preferably includes a base 20 having a panel 21 upon which the eye piece L is positioned. The casing structure furthermore includes a top wall 22, side walls 23 and 24 and a rear wall 25. The walls 22-25 may be of metal, plastic or other material. Preferably they are integral and detachably connected to the base and the front panel, as shown.

The eye piece or viewing tube L has a tapered passageway therethrough and it is directed so as to permit viewing therethrough a blended assemblage of various instrument indicia, both direct and as reflected by means of an optical system.

In the compartment of the casing is located an altimeter C; air speed instrument D; rate of climb instrument E and the electronic space instrument H. The air speed and rate of climb instruments are respectively supported on the base 20 by means of brackets 21 and 23. The electronic space instrument H is directly secured to the base 20, and a bracket 30 secured therewith, as shown in Figure 4, mounts the altimeter C in position.

Forming part of the shield assemblage N is shield panel 31, shown in Figure 3, located forwardly of the instruments C, D, E, and H, and is provided with openings 32, 33, 34 and 35 therein for the respective instruments C, D, E and H, as shown in Figure 8. These instruments are located in such relation that the markings thereon are clearly visible to an observer looking through the eye piece L.

The altimeter C is somewhat different from the conventional altimeter construction in that its casing cylindrical wall 36, as shown in Figure 1, is provided with sight opening 37 through which is visible the rotatable barometric dial reading 38. The latter are located peripherally upon the dial or card which takes the place of the pressure actuated pointer of the conventional altimeter and is therefor rotatable. The instrument

C is provided with a knob for calibrating the instrument conditions. The barometer gear 39, shown in the drawings, which adjusting control gear is rotatably disposed; panel 21 where it is controlled knob 40; panel 21 is provided with a button 43a keyed in Figure 11, and a window opening 43, as shown in the drawings, which may be provided with a reading 38 of the air speed indicator.

The air speed indicator is shown in cross sectional view in Figure 2. In place of the conventional cylindrical format 42 in the peripheral portion of the instrument is a stationary dial or card 53 is provided with a pointer shaft 54, the card 53 is provided with a reading 55 to facilitate reading of the rate of climb that of the air speed structure 60 provide opening 61 in the cylindrical casing which are readable peripheral flange 62. The dial is keyed to the instrument through the shield through the shield and said shield has for determining the air speed type, but is mounted upon the instrument A. The horizon does not function in the direction of flight. movable horizon bar 63 of the drawings as shown in the drawings as a V-shaped central part 64, the outer surface of 45° to the wings of the left wing root of the instrument is parallel to the horizontal in a 45° left bank the bank the right wing would be perpendicular to the horizontal. The gyro-horizon colored horizontal bar 65 raising and lowering the gyro-horizon the altimeter mechanism, whereas the white horizontal bar 66 in the conventional bar

The rate of climb that of the air speed structure 60 provide opening 61 in the cylindrical casing which are readable peripheral flange 62. The dial is keyed to the instrument through the shield through the shield and said shield has for determining the air speed type, but is mounted upon the instrument A. The horizon does not function in the direction of flight. movable horizon bar 63 of the drawings as shown in the drawings as a V-shaped central part 64, the outer surface of 45° to the wings of the left wing root of the instrument is parallel to the horizontal in a 45° left bank the bank the right wing would be perpendicular to the horizontal. The gyro-horizon colored horizontal bar 65 raising and lowering the gyro-horizon the altimeter mechanism, whereas the white horizontal bar 66 in the conventional bar

The rate of climb that of the air speed structure 60 provide opening 61 in the cylindrical casing which are readable peripheral flange 62. The dial is keyed to the instrument through the shield through the shield and said shield has for determining the air speed type, but is mounted upon the instrument A. The horizon does not function in the direction of flight. movable horizon bar 63 of the drawings as shown in the drawings as a V-shaped central part 64, the outer surface of 45° to the wings of the left wing root of the instrument is parallel to the horizontal in a 45° left bank the bank the right wing would be perpendicular to the horizontal. The gyro-horizon colored horizontal bar 65 raising and lowering the gyro-horizon the altimeter mechanism, whereas the white horizontal bar 66 in the conventional bar

The rate of climb that of the air speed structure 60 provide opening 61 in the cylindrical casing which are readable peripheral flange 62. The dial is keyed to the instrument through the shield through the shield and said shield has for determining the air speed type, but is mounted upon the instrument A. The horizon does not function in the direction of flight. movable horizon bar 63 of the drawings as shown in the drawings as a V-shaped central part 64, the outer surface of 45° to the wings of the left wing root of the instrument is parallel to the horizontal in a 45° left bank the bank the right wing would be perpendicular to the horizontal. The gyro-horizon colored horizontal bar 65 raising and lowering the gyro-horizon the altimeter mechanism, whereas the white horizontal bar 66 in the conventional bar

The rate of climb that of the air speed structure 60 provide opening 61 in the cylindrical casing which are readable peripheral flange 62. The dial is keyed to the instrument through the shield through the shield and said shield has for determining the air speed type, but is mounted upon the instrument A. The horizon does not function in the direction of flight. movable horizon bar 63 of the drawings as shown in the drawings as a V-shaped central part 64, the outer surface of 45° to the wings of the left wing root of the instrument is parallel to the horizontal in a 45° left bank the bank the right wing would be perpendicular to the horizontal. The gyro-horizon colored horizontal bar 65 raising and lowering the gyro-horizon the altimeter mechanism, whereas the white horizontal bar 66 in the conventional bar

atic view showing elevations of the instrument, and a top view of improved design of the gyro.

Referring to Figure 3, 14 and 15, the white horizontal bar 77 is mounted upon the upper end of a vertically disposed shaft 78 sliding in a bearing 79. The shaft is spring loaded at 80 to normally force the flanged end 81 of the shaft against a cam 82. The latter is rotatably mounted upon a shaft 83. The latter has a gear 84 in mesh with a gearing and trim knob control assembly indicated at 85 leading to the face of panel 21. The terrestrial horizon reference marks 77^a are etched on the cover glass 77^b of instrument, as are also a vertical line 77^c, a horizontal line 77^d, a center circle 77^e, and concentric arcs 77^f.

Referring to the direction gyro F, the same includes a casing 90 with its axis normal to the axis of the instrument G. It is supported upon the frame of the casing B, adjacent to the side wall 23.

The directional gyro F is substantially equivalent to the conventional "Sperry" directional gyro except that its card 91, as indicated in Figure 13 of the drawings, is provided with a cloud pattern 92 and degree indicia. The latter are reversed, since they will be reflected from an optical mirror, as will be subsequently described. This instrument may be replaced by other directional indicating devices, such as the repeater card of well known and conventional gyrosyn or fluzgate compass repeaters, if so desired.

The cloud pattern can be tinted in contrasting colors. For instance clouds in the North quadrant can be tinted white; in the East blue; in the South amber and in the West red. This will associate cardinal directions with the cloud line.

As part of the shielding assembly N, a second shield 94 is provided, as shown in Figures 3 and 13 of the drawings. It has an opening 95 therein through which are visible the cloud pattern 92 and the indicia 93 with reference to a white indicator mark 96, which may be located upon the shield 94. The dot and dash lines in Figure 5 show the opening in this shield.

A third shield 97 is shown in Figure 3, within the casing B in front of the instrument G. It has an opening indicated by the dot and dash line 98 in Figures 5 and 7, through which are visible the terrestrial horizon 77 and the airplane index 73.

The gyro horizon G and directional gyro F are provided with the usual operating section to the cases thru the conduits 100 and 104 as shown in Figure 3. Air withdrawn from the cases is replaced with air that enters thru any suitable openings (not shown) to the cases.

The air speed meter D is provided with two tubes 101 and 102, the former leading to the pressure element at the Pitot-static tube, and the other leading to the static element of the Pitot-static tube. The static line is connected to the cases of the air speed meter, altimeter and vertical speed indicator and functions as in conventional practice.

Referring to the optical image concentrating means K, the same includes partial mirrors 71 and 81. That is, they are both transparent, partially surfaced mirrors and are disposed vertically with their faces substantially 90° to each other. The mirror 71 is fixed, but mirror 81 has

C is provided with the usual adjusting means to calibrate the instrument for varying atmospheric conditions. The adjusting means includes a beveled gear 39, shown in Figures 2, 3 and 4 of the drawings, which meshes with the manual adjusting control gear 40. The latter has a horizontally disposed shaft 41 extending through the panel 21 where it is provided with a manually controlled knob 42, as shown in Figure 11. The panel 21 is provided with a wheel 43 in mesh with a pinion 43^a keyed upon the shaft 41, as shown in Figure 11, and a shield 45 is provided, having a window opening to see the readings on the wheel 43, as shown in Figure 10. The shield 31 may be provided with a white index marking 50 thereon in complementary relation to the altimeter readings 38 of the dial, as shown in Figure 8.

The air speed indicator D is mainly conventional in construction including a casing 51 of cylindrical formation having a window opening 52 in the periphery of the casing, as shown in Figure 2. In place of the pointer of the conventional air speed instrument moving over a stationary dial or card, the card 53 of the present instrument is connected to the conventional pointer shaft 54, and the flanged periphery of the card 53 is provided with the air speed markings 55 thereon, as shown in Figure 2. The shield 31 is provided with fixed white indicating marks 55 to facilitate reading of the dial air speed marks 55.

The rate of climb instrument E, is similar to that of the air speed indicator D, has a casing structure 60 provided with a segmental peripheral opening 61 in the cylindrical end thereof through which are readable the markings 62 upon a peripheral flange of movable dial or card 63. The dial is keyed to the pointer shaft of the conventional instrument. The readings 62 are visible through the shield opening 34 of Figure 8, and said shield has white reference markings 65 for determining the proper reading.

The artificial horizon G is basically of the Sperry type, but modified as hereinafter mentioned. It includes a casing structure 70 mounted upon the front panel base of the instrument A. The visible opening of the instrument does not face the pilot, but faces the direction of flight. In place of the conventional movable horizon bar the instrument G is provided with an airplane index 73, shown in Figure 7 of the drawings and elsewhere. The index 73 has a nose simulation portion 73^a located within a V-shaped central portion 73^b. The ends of the latter have aligning wings 73^c and angled tip 73^d, the outer surfaces of which are at an angle of 45° to the wings 73^c. In a 30° left bank the left wing root of the V portion 73^b will be parallel to the horizontal as shown in the drawings; in a 45° left bank the left wing tip 73^d would be perpendicular to the horizon, and in a 60° left bank the right wing root of the V portion 73^b would be perpendicular to the horizon. The index 73 functions the same as the horizon bar of the conventional gyro-horizon instrument. A conventional caging adjustment is provided of the knob and gearing type shown at 75 of Figure 3. The gyro-horizon instrument G has a white colored horizontal bar 77 and means for manually raising and lowering it. In the conventional gyro-horizon the airplane index is manually moved upward or downward by means of a trim mechanism, whereas in the present invention the white horizontal bar 77 is so raised and lowered. In the conventional instrument the horizontal bar 75

is operated by the gyroscopic mechanism, but in the present instrument the airplane index shown at 73 is so operated. The horizon 77 is the terrestrial horizon and the index 73 is the bank and climb index, as will be subsequently mentioned.

Referring to Figures 3, 14 and 15, the white horizontal bar 77 is mounted upon the upper end of a vertically disposed shaft 78 sliding in a bearing 79. The shaft is spring loaded at 80 to normally force the flanged end 81 of the shaft against a cam 82. The latter is rotatably mounted upon a shaft 83. The latter has a gear 84 in mesh with a gearing and trim knob control assembly indicated at 85 leading to the face of panel 21. The terrestrial horizon reference marks 77^a are etched on the cover glass 77^b of instrument, as are also a vertical line 77^c, a horizontal line 77^d, a center circle 77^e, and concentric arcs 77^f.

Referring to the direction gyro F, the same includes a casing 90 with its axis normal to the axis of the instrument G. It is supported upon the frame of the casing B, adjacent to the side wall 23.

The directional gyro F is substantially equivalent to the conventional "Sperry" directional gyro except that its card 91, as indicated in Figure 13 of the drawings, is provided with a cloud pattern 92 and degree indicia. The latter are reversed, since they will be reflected from an optical mirror, as will be subsequently described. This instrument may be replaced by other directional indicating devices, such as the repeater card of well known and conventional gyrosyn or fluzgate compass repeaters, if so desired.

The cloud pattern can be tinted in contrasting colors. For instance clouds in the North quadrant can be tinted white; in the East blue; in the South amber and in the West red. This will associate cardinal directions with the cloud line.

As part of the shielding assembly N, a second shield 94 is provided, as shown in Figures 3 and 13 of the drawings. It has an opening 95 therein through which are visible the cloud pattern 92 and the indicia 93 with reference to a white indicator mark 96, which may be located upon the shield 94. The dot and dash lines in Figure 5 show the opening in this shield.

A third shield 97 is shown in Figure 3, within the casing B in front of the instrument G. It has an opening indicated by the dot and dash line 98 in Figures 5 and 7, through which are visible the terrestrial horizon 77 and the airplane index 73.

The gyro horizon G and directional gyro F are provided with the usual operating section to the cases thru the conduits 100 and 104 as shown in Figure 3. Air withdrawn from the cases is replaced with air that enters thru any suitable openings (not shown) to the cases.

The air speed meter D is provided with two tubes 101 and 102, the former leading to the pressure element at the Pitot-static tube, and the other leading to the static element of the Pitot-static tube. The static line is connected to the cases of the air speed meter, altimeter and vertical speed indicator and functions as in conventional practice.

Referring to the optical image concentrating means K, the same includes partial mirrors 71 and 81. That is, they are both transparent, partially surfaced mirrors and are disposed vertically with their faces substantially 90° to each other. The mirror 71 is fixed, but mirror 81 has

adjusting means which will be subsequently described.

It is understood in the art that a partial mirror is one that has a chromium or aluminum deposit on the front of the glass rather than the back. The intensity or amount of the deposit will determine the amount of light transmitted thru the mirror in relation to the amount reflected. Since the reflecting agent is on the front of the glass only, one image is reflected.

The mirror 71 faces diagonally at an angle of 45° with respect to the indicia reading of faces of instruments F and G. The mirror 81 faces the opening of tube L at angle of 45°. The mirror 87 reflects the card of the directional gyro to the observer. The airplane index and horizon of the instrument G, are viewed thru two reflections, one from the first surface of the mirror 71 and again from the first surface of the mirror 87, to the eye of the observer. These images of the two instruments F and G are thus reflected substantially as shown in Figure 5, where the dot and dash lines designate the reflection from the instrument G; the card of the instrument F being clearly visible thru the mirror 71. The broken border dot and dash lines in this view designate the shield 94.

The readings from the instruments C, D, E and H are visible thru the mirror 87, without reflection.

The mirror 71 is preferably mounted in suitable channel moulding 116^a shown in Figure 3 of the drawings, upon the base 20 of the casing structure.

The mirror 87 is mounted as shown in Figures 3, 17 and 18, in order that it can be adjusted. As shown, the mirror 87 is mounted in suitable moulding 119, channelled at the bottom margin thereof. The moulding 119 is preferably provided with suitable extensions 111, which have hinge barrels adapted to align with complementary hinge barrels of leaves 112 screwed or otherwise detachably mounted upon the base 20 of the casing structure. These hinge barrels receive pintles 113.

The means for manually controlling the position of the mirror 87 includes a stiff but flexible spring steel wire 115 rotatably bearing at 116 in a bracket 117 attached to the mirror 87. The wire 115 at the panel 21 is provided with screw threads 118 threaded in a suitable opening in the panel 21. The wire is controlled by means of a knob 118a thru feeding the wire in or out the mirror may be caused to tilt to the desired degree in order to properly transmit the image to the eye of the observer.

Referring to the illuminating means M (Figures 3 and 12) the same includes lamps 150 and 151 for casting rays of light upon the indicia of the instruments C, D, E and H; a lamp 152 for casting rays of light upon the indicia of the instrument F, and a lamp 153 to cast rays of light upon instrument G.

The type of lamp is shown in Figure 9. It includes a Flexiglas tube 155 externally of dull black color, and provided with a slot 156 therein thru which light rays are transmitted. A lamp bulb 157 is supported by the usual socket mechanism 158.

As shown in Figure 12 of the drawings the lamps are connected in a circuit 157a. The lamps 150 and 151 are provided with a rheostat switch 158a for the control thereof, and the lamps 152 and 153 respectively have individual rheostat switches 159 and 160. The knobs for control of

the switches 158a, 159 and 160 are shown upon the panel 21 at 158b, 159a and 160a respectively.

All of the shields 31, 94 and 97 of the shield means N are provided with dull black surface facing, particularly the sides facing the optical arrangement, in order to expose to view only the scales and indicia, and to kill all unwanted reflections and exposed parts.

It should be noted that the density of the two partial mirrors is such that there is a pleasing balance of readability between the various images. This is also controlled by the amount of illumination which is cast upon the indices of the various instruments. The intensity of illumination will be regulated by the rheostat switches to suit the observer. The distances from the instrument, however reflected, or illuminated, must be substantially the same in order that the eye will impose of the various instrument indications will provide an absence of parallax. This principle may be departed from slightly in order to give an impression of depth when receiving reflected images, such as may be desired in having upon which the face of the directional card slightly greater distance away; giving the effect of a cloud pattern line beyond the airplane index of the artificial horizon instrument. Slightly greater distance will not result in parallax of any order that would be detrimental to the precise use of the instrument.

Referring to the electronic space indicators as shown in the various views of the drawings and in fragmentary and diagrammatic form in Figure 6 of the drawings, the instrument includes a casing structure 120 which supports a cover glass 121 at the front thereof, held in the case by means of clips 122. A shield 123, which is spherically curved and segmental in cross section, is supported by brackets 124. The convex face is colored dull black and over it operate the electronic vertical bar 125 and electronic horizontal bar 126.

The casing structure 120 supports galvanometers 127 and 128 in any approved manner. The vertical bar 125 is connected by an arm 129 to the movable coil of galvanometer 127. The horizontal pointer 126 sweeps up and down and is connected by an arm 126a to the movable coil of galvanometer 128. The arrows shown in Figure 6 at the face of the instrument designate the sweep of the bars 125 and 126.

The galvanometers 127 and 128 are essentially microammeter types, the coils thereof rotating, swinging the pointers either left or right or up and down, depending on the flow direction of current. Of course the pointer 125 only swings left and right and the pointer 126 up and down. The galvanometers are actuated by means of energy received from associated radio-receiving equipment and may be the well known ILS localizer beam, the energy received from an Omni-Range receiver; the energy received from a Directional Finder Receiver, or that received from a "Sperry Zero-Reader."

The vertical electronic actuated bar or pointer 125 is provided with laterally extending horizontal arms 130, the ends of which are downturned, and the general appearance of which is that of a silhouetted perspective view of an approaching runway head-on. Complementary thereto, the electronic horizon bar 126 is provided with a horizontal arm portion 131 supported below the bar 126 by a bracket 132. The arm 131

is intended to present the runway.

The vertical bar is tinted green up to the top, the complement 131 may be tinted green, may be tinted some other color.

The horizontally extending arm or pointer when the aircraft is "down" when the beam. The vertical bar, of the ILS localizer, or indicator Range course, or indicator outputs from the selected switching.

When the cross point neutral or zero position 140 and 131 will represent the socket plug 133 the galvanometers 127 and 128 indicated in Figure 6 always remain in close proximity, and thereby eliminates of their position.

Switching means disclosed in Figure 6 is provided of the Instrument Landing System, installed at U. S. Navy Air Station, San Diego, California, the "Omni-Directional" of such other device "Reader."

Figure 6 shows the output 140, the ILS output at 141, the output at 142, a pivoted switch 143, diagrammatically, is a cam 144 by means of the "Omni-Range" output 145, the ILS output 146, the ILS output 147, the ILS output 148, the ILS output 149, the ILS output 150, the ILS output 151, the ILS output 152, the ILS output 153, the ILS output 154, the ILS output 155, the ILS output 156, the ILS output 157, the ILS output 158, the ILS output 159, the ILS output 160, the ILS output 161, the ILS output 162, the ILS output 163, the ILS output 164, the ILS output 165, the ILS output 166, the ILS output 167, the ILS output 168, the ILS output 169, the ILS output 170, the ILS output 171, the ILS output 172, the ILS output 173, the ILS output 174, the ILS output 175, the ILS output 176, the ILS output 177, the ILS output 178, the ILS output 179, the ILS output 180, the ILS output 181, the ILS output 182, the ILS output 183, the ILS output 184, the ILS output 185, the ILS output 186, the ILS output 187, the ILS output 188, the ILS output 189, the ILS output 190, the ILS output 191, the ILS output 192, the ILS output 193, the ILS output 194, the ILS output 195, the ILS output 196, the ILS output 197, the ILS output 198, the ILS output 199, the ILS output 200, the ILS output 201, the ILS output 202, the ILS output 203, the ILS output 204, the ILS output 205, the ILS output 206, the ILS output 207, the ILS output 208, the ILS output 209, the ILS output 210, the ILS output 211, the ILS output 212, the ILS output 213, the ILS output 214, the ILS output 215, the ILS output 216, the ILS output 217, the ILS output 218, the ILS output 219, the ILS output 220, the ILS output 221, the ILS output 222, the ILS output 223, the ILS output 224, the ILS output 225, the ILS output 226, the ILS output 227, the ILS output 228, the ILS output 229, the ILS output 230, the ILS output 231, the ILS output 232, the ILS output 233, the ILS output 234, the ILS output 235, the ILS output 236, the ILS output 237, the ILS output 238, the ILS output 239, the ILS output 240, the ILS output 241, the ILS output 242, the ILS output 243, the ILS output 244, the ILS output 245, the ILS output 246, the ILS output 247, the ILS output 248, the ILS output 249, the ILS output 250, the ILS output 251, the ILS output 252, the ILS output 253, the ILS output 254, the ILS output 255, the ILS output 256, the ILS output 257, the ILS output 258, the ILS output 259, the ILS output 260, the ILS output 261, the ILS output 262, the ILS output 263, the ILS output 264, the ILS output 265, the ILS output 266, the ILS output 267, the ILS output 268, the ILS output 269, the ILS output 270, the ILS output 271, the ILS output 272, the ILS output 273, the ILS output 274, the ILS output 275, the ILS output 276, the ILS output 277, the ILS output 278, the ILS output 279, the ILS output 280, the ILS output 281, the ILS output 282, the ILS output 283, the ILS output 284, the ILS output 285, the ILS output 286, the ILS output 287, the ILS output 288, the ILS output 289, the ILS output 290, the ILS output 291, the ILS output 292, the ILS output 293, the ILS output 294, the ILS output 295, the ILS output 296, the ILS output 297, the ILS output 298, the ILS output 299, the ILS output 300, the ILS output 301, the ILS output 302, the ILS output 303, the ILS output 304, the ILS output 305, the ILS output 306, the ILS output 307, the ILS output 308, the ILS output 309, the ILS output 310, the ILS output 311, the ILS output 312, the ILS output 313, the ILS output 314, the ILS output 315, the ILS output 316, the ILS output 317, the ILS output 318, the ILS output 319, the ILS output 320, the ILS output 321, the ILS output 322, the ILS output 323, the ILS output 324, the ILS output 325, the ILS output 326, the ILS output 327, the ILS output 328, the ILS output 329, the ILS output 330, the ILS output 331, the ILS output 332, the ILS output 333, the ILS output 334, the ILS output 335, the ILS output 336, the ILS output 337, the ILS output 338, the ILS output 339, the ILS output 340, the ILS output 341, the ILS output 342, the ILS output 343, the ILS output 344, the ILS output 345, the ILS output 346, the ILS output 347, the ILS output 348, the ILS output 349, the ILS output 350, the ILS output 351, the ILS output 352, the ILS output 353, the ILS output 354, the ILS output 355, the ILS output 356, the ILS output 357, the ILS output 358, the ILS output 359, the ILS output 360, the ILS output 361, the ILS output 362, the ILS output 363, the ILS output 364, the ILS output 365, the ILS output 366, the ILS output 367, the ILS output 368, the ILS output 369, the ILS output 370, the ILS output 371, the ILS output 372, the ILS output 373, the ILS output 374, the ILS output 375, the ILS output 376, the ILS output 377, the ILS output 378, the ILS output 379, the ILS output 380, the ILS output 381, the ILS output 382, the ILS output 383, the ILS output 384, the ILS output 385, the ILS output 386, the ILS output 387, the ILS output 388, the ILS output 389, the ILS output 390, the ILS output 391, the ILS output 392, the ILS output 393, the ILS output 394, the ILS output 395, the ILS output 396, the ILS output 397, the ILS output 398, the ILS output 399, the ILS output 400, the ILS output 401, the ILS output 402, the ILS output 403, the ILS output 404, the ILS output 405, the ILS output 406, the ILS output 407, the ILS output 408, the ILS output 409, the ILS output 410, the ILS output 411, the ILS output 412, the ILS output 413, the ILS output 414, the ILS output 415, the ILS output 416, the ILS output 417, the ILS output 418, the ILS output 419, the ILS output 420, the ILS output 421, the ILS output 422, the ILS output 423, the ILS output 424, the ILS output 425, the ILS output 426, the ILS output 427, the ILS output 428, the ILS output 429, the ILS output 430, the ILS output 431, the ILS output 432, the ILS output 433, the ILS output 434, the ILS output 435, the ILS output 436, the ILS output 437, the ILS output 438, the ILS output 439, the ILS output 440, the ILS output 441, the ILS output 442, the ILS output 443, the ILS output 444, the ILS output 445, the ILS output 446, the ILS output 447, the ILS output 448, the ILS output 449, the ILS output 450, the ILS output 451, the ILS output 452, the ILS output 453, the ILS output 454, the ILS output 455, the ILS output 456, the ILS output 457, the ILS output 458, the ILS output 459, the ILS output 460, the ILS output 461, the ILS output 462, the ILS output 463, the ILS output 464, the ILS output 465, the ILS output 466, the ILS output 467, the ILS output 468, the ILS output 469, the ILS output 470, the ILS output 471, the ILS output 472, the ILS output 473, the ILS output 474, the ILS output 475, the ILS output 476, the ILS output 477, the ILS output 478, the ILS output 479, the ILS output 480, the ILS output 481, the ILS output 482, the ILS output 483, the ILS output 484, the ILS output 485, the ILS output 486, the ILS output 487, the ILS output 488, the ILS output 489, the ILS output 490, the ILS output 491, the ILS output 492, the ILS output 493, the ILS output 494, the ILS output 495, the ILS output 496, the ILS output 497, the ILS output 498, the ILS output 499, the ILS output 500, the ILS output 501, the ILS output 502, the ILS output 503, the ILS output 504, the ILS output 505, the ILS output 506, the ILS output 507, the ILS output 508, the ILS output 509, the ILS output 510, the ILS output 511, the ILS output 512, the ILS output 513, the ILS output 514, the ILS output 515, the ILS output 516, the ILS output 517, the ILS output 518, the ILS output 519, the ILS output 520, the ILS output 521, the ILS output 522, the ILS output 523, the ILS output 524, the ILS output 525, the ILS output 526, the ILS output 527, the ILS output 528, the ILS output 529, the ILS output 530, the ILS output 531, the ILS output 532, the ILS output 533, the ILS output 534, the ILS output 535, the ILS output 536, the ILS output 537, the ILS output 538, the ILS output 539, the ILS output 540, the ILS output 541, the ILS output 542, the ILS output 543, the ILS output 544, the ILS output 545, the ILS output 546, the ILS output 547, the ILS output 548, the ILS output 549, the ILS output 550, the ILS output 551, the ILS output 552, the ILS output 553, the ILS output 554, the ILS output 555, the ILS output 556, the ILS output 557, the ILS output 558, the ILS output 559, the ILS output 560, the ILS output 561, the ILS output 562, the ILS output 563, the ILS output 564, the ILS output 565, the ILS output 566, the ILS output 567, the ILS output 568, the ILS output 569, the ILS output 570, the ILS output 571, the ILS output 572, the ILS output 573, the ILS output 574, the ILS output 575, the ILS output 576, the ILS output 577, the ILS output 578, the ILS output 579, the ILS output 580, the ILS output 581, the ILS output 582, the ILS output 583, the ILS output 584, the ILS output 585, the ILS output 586, the ILS output 587, the ILS output 588, the ILS output 589, the ILS output 590, the ILS output 591, the ILS output 592, the ILS output 593, the ILS output 594, the ILS output 595, the ILS output 596, the ILS output 597, the ILS output 598, the ILS output 599, the ILS output 600, the ILS output 601, the ILS output 602, the ILS output 603, the ILS output 604, the ILS output 605, the ILS output 606, the ILS output 607, the ILS output 608, the ILS output 609, the ILS output 610, the ILS output 611, the ILS output 612, the ILS output 613, the ILS output 614, the ILS output 615, the ILS output 616, the ILS output 617, the ILS output 618, the ILS output 619, the ILS output 620, the ILS output 621, the ILS output 622, the ILS output 623, the ILS output 624, the ILS output 625, the ILS output 626, the ILS output 627, the ILS output 628, the ILS output 629, the ILS output 630, the ILS output 631, the ILS output 632, the ILS output 633, the ILS output 634, the ILS output 635, the ILS output 636, the ILS output 637, the ILS output 638, the ILS output 639, the ILS output 640, the ILS output 641, the ILS output 642, the ILS output 643, the ILS output 644, the ILS output 645, the ILS output 646, the ILS output 647, the ILS output 648, the ILS output 649, the ILS output 650, the ILS output 651, the ILS output 652, the ILS output 653, the ILS output 654, the ILS output 655, the ILS output 656, the ILS output 657, the ILS output 658, the ILS output 659, the ILS output 660, the ILS output 661, the ILS output 662, the ILS output 663, the ILS output 664, the ILS output 665, the ILS output 666, the ILS output 667, the ILS output 668, the ILS output 669, the ILS output 670, the ILS output 671, the ILS output 672, the ILS output 673, the ILS output 674, the ILS output 675, the ILS output 676, the ILS output 677, the ILS output 678, the ILS output 679, the ILS output 680, the ILS output 681, the ILS output 682, the ILS output 683, the ILS output 684, the ILS output 685, the ILS output 686, the ILS output 687, the ILS output 688, the ILS output 689, the ILS output 690, the ILS output 691, the ILS output 692, the ILS output 693, the ILS output 694, the ILS output 695, the ILS output 696, the ILS output 697, the ILS output 698, the ILS output 699, the ILS output 700, the ILS output 701, the ILS output 702, the ILS output 703, the ILS output 704, the ILS output 705, the ILS output 706, the ILS output 707, the ILS output 708, the ILS output 709, the ILS output 710, the ILS output 711, the ILS output 712, the ILS output 713, the ILS output 714, the ILS output 715, the ILS output 716, the ILS output 717, the ILS output 718, the ILS output 719, the ILS output 720, the ILS output 721, the ILS output 722, the ILS output 723, the ILS output 724, the ILS output 725, the ILS output 726, the ILS output 727, the ILS output 728, the ILS output 729, the ILS output 730, the ILS output 731, the ILS output 732, the ILS output 733, the ILS output 734, the ILS output 735, the ILS output 736, the ILS output 737, the ILS output 738, the ILS output 739, the ILS output 740, the ILS output 741, the ILS output 742, the ILS output 743, the ILS output 744, the ILS output 745, the ILS output 746, the ILS output 747, the ILS output 748, the ILS output 749, the ILS output 750, the ILS output 751, the ILS output 752, the ILS output 753, the ILS output 754, the ILS output 755, the ILS output 756, the ILS output 757, the ILS output 758, the ILS output 759, the ILS output 760, the ILS output 761, the ILS output 762, the ILS output 763, the ILS output 764, the ILS output 765, the ILS output 766, the ILS output 767, the ILS output 768, the ILS output 769, the ILS output 770, the ILS output 771, the ILS output 772, the ILS output 773, the ILS output 774, the ILS output 775, the ILS output 776, the ILS output 777, the ILS output 778, the ILS output 779, the ILS output 780, the ILS output 781, the ILS output 782, the ILS output 783, the ILS output 784, the ILS output 785, the ILS output 786, the ILS output 787, the ILS output 788, the ILS output 789, the ILS output 790, the ILS output 791, the ILS output 792, the ILS output 793, the ILS output 794, the ILS output 795, the ILS output 796, the ILS output 797, the ILS output 798, the ILS output 799, the ILS output 800, the ILS output 801, the ILS output 802, the ILS output 803, the ILS output 804, the ILS output 805, the ILS output 806, the ILS output 807, the ILS output 808, the ILS output 809, the ILS output 810, the ILS output 811, the ILS output 812, the ILS output 813, the ILS output 814, the ILS output 815, the ILS output 816, the ILS output 817, the ILS output 818, the ILS output 819, the ILS output 820, the ILS output 821, the ILS output 822, the ILS output 823, the ILS output 824, the ILS output 825, the ILS output 826, the ILS output 827, the ILS output 828, the ILS output 829, the ILS output 830, the ILS output 831, the ILS output 832, the ILS output 833, the ILS output 834, the ILS output 835, the ILS output 836, the ILS output 837, the ILS output 838, the ILS output 839, the ILS output 840, the ILS output 841, the ILS output 842, the ILS output 843, the ILS output 844, the ILS output 845, the ILS output 846, the ILS output 847, the ILS output 848, the ILS output 849, the ILS output 850, the ILS output 851, the ILS output 852, the ILS output 853, the ILS output 854, the ILS output 855, the ILS output 856, the ILS output 857, the ILS output 858, the ILS output 859, the ILS output 860, the ILS output 861, the ILS output 862, the ILS output 863, the ILS output 864, the ILS output 865, the ILS output 866, the ILS output 867, the ILS output 868, the ILS output 869, the ILS output 870, the ILS output 871, the ILS output 872, the ILS output 873, the ILS output 874, the ILS output 875, the ILS output 876, the ILS output 877, the ILS output 878, the ILS output 879, the ILS output 880, the ILS output 881, the ILS output 882, the ILS output 883, the ILS output 884, the ILS output 885, the ILS output 886, the ILS output 887, the ILS output 888, the ILS output 889, the ILS output 890, the ILS output 891, the ILS output 892, the ILS output 893, the ILS output 894, the ILS output 895, the ILS output 896, the ILS output 897, the ILS output 898, the ILS output 899, the ILS output 900, the ILS output 901, the ILS output 902, the ILS output 903, the ILS output 904, the ILS output 905, the ILS output 906, the ILS output 907, the ILS output 908, the ILS output 909, the ILS output 910, the ILS output 911, the ILS output 912, the ILS output 913, the ILS output 914, the ILS output 915, the ILS output 916, the ILS output 917, the ILS output 918, the ILS output 919, the ILS output 920, the ILS output 921, the ILS output 922, the ILS output 923, the ILS output 924, the ILS output 925, the ILS output 926, the ILS output 927, the ILS output 928, the ILS output 929, the ILS output 930, the ILS output 931, the ILS output 932, the ILS output 933, the ILS output 934, the ILS output 935, the ILS output 936, the ILS output 937, the ILS output 938, the ILS output 939, the ILS output 940, the ILS output 941, the ILS output 942, the ILS output 943, the ILS output 944, the ILS output 945, the ILS output 946, the ILS output 947, the ILS output 948, the ILS output 949, the ILS output 950, the ILS output 951, the ILS output 952, the ILS output 953, the ILS output 954, the ILS output 955, the ILS output 956, the ILS output 957, the ILS output 958, the ILS output 959, the ILS output 960, the ILS output 961, the ILS output 962, the ILS output 963, the ILS output 964, the ILS output 965, the ILS output 966, the ILS output 967, the ILS output 968, the ILS output 969, the ILS output 970, the ILS output 971, the ILS output 972, the ILS output 973, the ILS output 974, the ILS output 975, the ILS output 976, the ILS output 977, the ILS output 978, the ILS output 979, the ILS output 980, the ILS output 981, the ILS output 982, the ILS output 983, the ILS output 984, the ILS output 985, the ILS output 986, the ILS output 987, the ILS output 988, the ILS output 989, the ILS output 990, the ILS output 991, the ILS output 992, the ILS output 993, the ILS output 994, the ILS output 995, the ILS output 996, the ILS output 997, the ILS output 998, the ILS output 999, the ILS output 1000, the ILS output 1001, the ILS output 1002, the ILS output 1003, the ILS output 1004, the ILS output 1005, the ILS output 1006, the ILS output 1007, the ILS output 1008, the ILS output 1009, the ILS output 1010, the ILS output 1011, the ILS output 1012, the ILS output 1013, the ILS output 1014, the ILS output 1015, the ILS output 1016, the ILS output 1017, the ILS output 1018, the ILS output 1019, the ILS output 1020, the ILS output 1021, the ILS output 1022, the ILS output 1023, the ILS output 1024, the ILS output 1025, the ILS output 1026, the ILS output 1027, the ILS output 1028, the ILS output 1029, the ILS output 1030, the ILS output 1031, the ILS output 1032, the ILS output 1033, the ILS output 1034, the ILS output 1035, the ILS output 1036, the ILS output 1037, the ILS output 1038, the ILS output 1039, the ILS output 1040, the ILS output 1041, the ILS output 1042, the ILS output 1043, the ILS output 1044, the ILS output 1045, the ILS output 1046, the ILS output 1047, the ILS output 1048, the ILS output 1049, the ILS output 1050, the ILS output 1051, the ILS output 1052, the ILS output 1053, the ILS output 1054, the ILS output 1055, the ILS output 1056, the ILS output 1057, the ILS output 1058, the ILS output 1059, the ILS output 1060, the ILS output 1061, the ILS output 1062, the ILS output 1063, the ILS output 1064, the ILS output 1065, the ILS output 1066, the ILS output 1067, the ILS output 1068, the ILS output 1069, the ILS output 1070, the ILS output 1071, the ILS output 1072, the ILS output 1073, the ILS output 1074, the ILS output 1075, the ILS output 1076, the ILS output 1077, the ILS output 1078, the ILS output 1079, the ILS output 1080, the ILS output 1081, the ILS output 1082, the ILS output 1083, the ILS output 1084, the ILS output 1085, the ILS output 1086, the ILS output 1087, the ILS output 1088, the ILS output 1089, the ILS output 1090, the ILS output 1091, the ILS output 1092, the ILS output 1093, the ILS output 1094, the ILS output 1095, the ILS output 1096, the ILS output 1097, the ILS output 1098, the ILS output 1099, the ILS output 1100, the ILS output 1101, the ILS output 1102, the ILS output 1103, the ILS output 1104, the ILS output 1105, the ILS output 1106, the ILS output 1107, the ILS output 1108, the ILS output 1109, the ILS output 1110, the ILS output 1111, the ILS output 1112, the ILS output 1113, the ILS output 1114, the ILS output 1115, the ILS output 1116, the ILS output 1117, the ILS output 1118, the ILS output 1119, the ILS output 1120, the ILS output 1121, the ILS output 1122, the ILS output 1123, the ILS output 1124, the ILS output 1125, the ILS output 1126, the ILS output 1127, the ILS output 1128, the ILS output 1129, the ILS output 1130, the ILS output 1131, the ILS output 1132, the ILS output 1133, the ILS output 1134, the ILS output 1135, the ILS output 1136, the ILS output 1137, the ILS output 1138, the ILS output 1139, the ILS output 1140, the ILS output 1141, the ILS output 1142, the ILS output 1143, the ILS output 1144, the ILS output 1145, the ILS output 1146, the ILS output 1147, the ILS output 1148, the ILS output 1149, the ILS output 1150, the ILS output 1151, the ILS output 1152, the ILS output 1153, the ILS output 1154, the ILS output 1155, the ILS output 1156, the ILS output 1157, the ILS output 1158, the ILS output 1159, the ILS output 1160, the ILS output 1161, the ILS output 1162, the ILS output 1163, the ILS output 1164, the ILS output 1165, the ILS output 1166, the ILS output 1167, the ILS output 1168, the ILS output 1169, the ILS output 1170, the ILS output 1171, the ILS output 1172, the ILS output 1173, the ILS output 1174, the ILS output 1175, the ILS output 1176, the ILS output 1177, the ILS output 1178, the ILS output 1179, the ILS output 1180, the ILS output 1181, the ILS output 1182, the ILS output 1183, the ILS output 1184, the ILS output 1185, the ILS output 1186, the ILS output 1187, the ILS output 1188, the ILS output 1189, the ILS output 1190, the ILS output 1191, the ILS output 1192, the ILS output 1193, the ILS output 1194, the ILS output 1195, the ILS output 1196, the ILS output 1197, the ILS output 1198, the ILS output 1199, the ILS output 120

is intended to present the leading edge view of the runway.

The vertical bar 125 and the arm positions 130 are tinted green upon their visible faces. Likewise, the complementary segment or arm portion 131 may be tinted green. The face of the arm 126 may be tinted some contrasting color, if desired.

The horizontally disposed up and down swinging arm or pointer 128 registers movement "up" when the aircraft is below the glide beam and "down" when the aircraft is above the glide beam. The vertical arm or pointer 125 represents the movement of the plane to the right or left, of the ILS localizer beam, or the Omni-Range course, or indicates the transmitted signal outputs from the "Sperry" Zero Reader by selected switching.

When the cross pointers 125 and 126 are in the neutral or zero position for landing, the portions 130 and 131 will represent a closed figure.

The socket plug 133 receives the wire leads from the galvanometers 127 and 128 as shown. The pointers 125 and 126 are transversely curved, as indicated in Figure 6, in order that they will always remain in close proximity to each other as the pivoted pointers of the galvanometers swing, and thereby eliminating parallax, regardless of their position.

Switching means diagrammatically illustrated in Figure 6 is provided for selecting the output of the Instrument Landing System, now common VHF, installed at U. S. ports, or the output from the "Omni-Directional Range," or the output of such other devices as the "Sperry Zero Reader."

Figure 6 shows the "Omni-Range" output at 140; the ILS output at 141 and the "Sperry Zero Reader" output at 142. In Figure 6, 143 represents a pivoted switch handle which, as shown diagrammatically, is connected to a switch actuating cam 144 by means of a shaft 145. The "Omni-Range" output is provided with a switch 146; the ILS output with a switch 147; and the "Sperry Zero Reader" output with a switch 148. The single cam 144 is intended to selectively actuate the switches 146, 147 and 148, as shown. The lines leading to the electronic vertical and horizontal actuating galvanometers 127 and 128 are shown in the drawings. It is to be noted that placing the switch arm or handle 143 in position for actuating the switch 147 to the cam 144 will energize both pointers of the cross pointer instrument H, the runway localizer vertical pointer and the glide path horizontal pointer, as indicated. Actuating the "Omni-Range" switch 146 by means of the cam 144, through turning the handle 143, will actuate the vertical pointer of the instrument H by whatever current, in microamperes, is flowing from the receiver to the cross pointer galvanometer. At this time the current to the glide path (horizontal pointer) is left open, since the "Omni-Range" receiver includes no glide path receiver.

The "Sperry Zero Reader" output 142 consists of the yaw, compass, bank and radio track unit 142^a, and the pitch, altitude and glide path unit 142^b, as is known to those skilled in the art. The unit 142^a actuates the galvanometer of the cross pointer instrument controlling the vertical electronic bar, and the unit 142^b actuates the galvanometer of the electronic horizontal bar.

It is to be noted that the movable switch members of the switches 146, 147 and 148 are spring loaded to normally opened position. They may be of any commercially available type, and are only diagrammatically shown in Figure 6. As 75

shown in the drawings, the springs are of the compressor types.

It is to be noted that resistors 149 are provided for each of the two units of the ILS output and Sperry Zero Reader output, and a single resistor unit 149^a for the "Omni-Range" output. In the open position for the switches, the switch contacts are electrically made to place the resistors across the circuits leading to the switches respectively from the outputs 140, 141 and 142. The high resistance resistors have the purpose of placing an electrical load on the output of the respective devices, in order that they may be left in a "hot" or stand-by condition, electrically ready for on-switching at all desired times, even though the switch handle 143 is in an "off" position.

With the switch handle 143 in an "off" position the resistor of the switch 146 is shunted across the two wire circuits leading to the said switch from the output 140; the resistors of the switch 147 are shunted respectively across the two wire circuits leading from the localizer unit of the output 141 and the two wire circuits leading from the glide path receiver portion of the output 141, and the resistors of the switch 148 are shunted, one of them across the two wire circuits leading to the switch from the unit 142^a and the two wire circuits leading to the switch from the unit 142^b.

It will be apparent from the foregoing that the invention consists of a real combination of flight stimuli imparting a visual coordination or mixing of natural flight attitudes and rates. The invention does not consist of a mere projected aggregation on a screen of a plurality of instrument indications. It is an optical combination, by a simple reflection, of functional visual stimuli, reporting simultaneously in naturally viewed clear weather manner the flight attitude and rate changes of the aircraft, with respect to terrestrial planes of reference as well as to electronic planes of reference; or to mixtures thereof.

Referring again to the gyro-horizon instrument G, the airplane index 73 remains parallel to the real horizon, and the horizon line 77 banks with the aircraft. Thus is imparted correct knowledge of the bank angle in a manner to relieve the pilot of bank vertigo. At the same time this imparts a banking reference to the artificial terrestrial horizon, as well as the artificial electronic horizon of the instrument H. In Figure 1 is shown the observer's view of the various indications. It indicates to the pilot the aircraft is flying with the left wing down, and the degree is determined by the relation of the lines of the index 73 to the horizon and vertical lines otherwise visible. That is, if the left wing tip line assumes a position perpendicular to the horizon, a bank angle of 45° would instantly be indicated to the pilot, etc. The aircraft upon which the instrument of Figure 1 is located is in a left bank and turn, resulting in the cloud pattern of the background and its markings of azimuth moving from left to right. The speed with which this movement takes place depends upon the type and speed of the aircraft used. The pilot familiar with the type of aircraft soon learns and "feels" the proper bank angle for rate of turn when he can see the natural instrument in clear weather, and in the case of the present invention a similar result can be achieved. Should the aircraft begin to climb while in the left turn, the airplane index 73 would appear to rise above the horizon line 77 and its silhouette would then appear to be passing across the cloud pattern.

Should a diving turn to the left be started, the airplane index 73 will begin to fall, passing the horizon line 77 and then assume some position below the horizon line representative of the glide angle. It is therefore quite obvious that various combinations of bank, turn, climb and glide will present to the pilot a realistic visual stimulus of the various flight attitudes and turn rates which will be presented in the normal natural manner rather than in the split unnatural present methods of indicating flight attitudes and changes.

Referring to the pilot's view of the instruments as shown in Figure 1, it will be noted that the lubber line 96 is over the directional scale indicating 270°. The airplane index shows the aircraft to be to the right of the runway course beam as represented by the electronic vertical marker 125. The airplane index 73 indicates a gliding left turn in progress, and it lies above the glide path electronic horizontal bar 126. The latter lies below the terrestrial horizon line 77, indicating that the aircraft is above and to the right of the flight line which will bring the aircraft to a landing on the runway, for example, whose axis lies 270°.

As the left turn progresses, the desired object would be, first, to have the nose of the airplane index intersect the electronic vertical 125 at the vertical lubber line. This then would insure that the aircraft was on the runway course beam and as this obtains, the pilot noting the direction indicator, will then turn the aircraft to the right to recover a heading of 270°, insuring that the aircraft is headed down the runway axis. This condition can be met and held only in the absence of a cross wind component.

Should a cross wind be present, say from the South, some heading less than 270° will be sought. This would permit the electronic vertical 125 to pass through the nose of the airplane index 73. This procedure of adjustment, using the present invention is quite as easy as would be obtained in an approach to the runway in clear weather.

By visual flight reference, simultaneously viewing of all necessary factors, namely direction, rate of change of direction, displacement from runway course beam, and rate of closure thereto are seen and evaluated in a manner substantially identical with the normal natural instrument.

After reaching a steady runway course, to be held for the approach, the glide beam is approached, either by reducing the speed, maintaining attitude of level flight, and accepting a rate of descent until the electronic horizon 126 rises and intersects the terrestrial horizon 77 in every case, at which moment the aircraft is on the proper glide path.

Another method of reaching the desired glide path is to change the pitch attitude of the airplane index 73, placing the nose on or in the direction of the glide path electronic horizon, applying or reducing engine power to maintain desired air speed, and as the electronic horizon 126 returns coincident with the terrestrial horizon 77, the pitch angle changes producing a "follow-up" method of pitch control of the aircraft to produce the important accurate maintenance of path justification with the glide path to the runway for landing of the aircraft.

In the approach landing just described, no other instrument need be referred to at any time other than the pilot's view through the viewing tube, since all necessary elements are contained in the presentation of indices shown in Figure 1,

Obviously if a landing is not being made, and if the cross pointer electronic vertical or electronic horizon are not needed for navigational purposes, such as would be true in flying a VHF radio range, or the "Omni-Directional" ranges, the light switch controlling current which illuminates the cross pointer indicator may be opened, thereby eliminating the pattern from view. Any of the other scale or index presentations may be eliminated or selected at will. For instance, in clear weather the only desired presentation may be the cross pointer pattern in order to use the electronic vertical in conjunction with the "Omni-Directional" range, or other electronic navigation systems which use a left-right sensing galvanometer.

Various changes in the rearrangement of the various units of the instrument may be made within the casing structure without departing from the spirit of the invention or the scope of the claims.

I claim:

1. In a craft controlling device the combination of a supporting frame, a gyro horizon having an index in the form of an airplane mounted to move in designation of bank, climb and dive and having a terrestrial horizon index disposed to parallel the transverse axis of the air craft to which the instrument is attached, a directional gyro having an index simulating a cloud pattern and turn degree indications sensed functionally, an electronic space indicator having complementary vertical electronic and horizontal electronic indices with radio receiving energy actuated means for movement of said vertical and horizontal indices in designation of plane movement to the right or left and up and down with respect to the localizer beam and glide beam, and reflecting an optical means blending said gyro controlled indicia and the vertical and horizontal indicia of electronic space indicators together in normally sensed complementary relation at a common locus in realistic visual stimulus of the various flight attitudes, turn quantities and path changes of the air craft to which attached whereby to facilitate the pilot's utilization of normal sense impressions.

2. A flight instrument as described in claim 1 wherein the vertical index of the electronic space indicator is provided with an inverted substantially U-shaped index movable with the vertical index and including a horizontal portion and appended outwardly angled portions in complementary position to cooperate with the horizontal index of the electronic space indicator in flight designation for runway landing.

3. In a craft controlling device the combination of a supporting frame, a gyro horizon having an index in the form of an airplane with a wing and mounted to move in designation of bank, climb and dive and having a terrestrial horizon index located to parallel the transverse axis of the aircraft to which the instrument is attached, said airplane index being provided with a centrally located V-shaped body portion and the extreme wing ends being down-turned in divergent relation, a directional gyro having an index simulating a cloud pattern and turn degree indications correctly sensed, and reflecting and optical means associated with the indicia of said gyro horizon and directional gyro blending all of the indicia thereof together at a common locus in realistic visual stimulus of the various attitudes and turn quantities and path

changes
coordina

4. A flight instrument comprising a gyro horizon having a wing and mounted to move in designation of bank, climb and dive and having a terrestrial horizon index located to parallel the transverse axis of the aircraft to which the instrument is attached, said airplane index being provided with a centrally located V-shaped body portion and the extreme wing ends being down-turned in divergent relation, a directional gyro having an index simulating a cloud pattern and turn degree indications correctly sensed, and reflecting and optical means associated with the indicia of said gyro horizon and directional gyro blending all of the indicia thereof together at a common locus in realistic visual stimulus of the various attitudes and turn quantities and path

5. A flight instrument as described in claim 4 wherein the vertical index of the electronic space indicator is provided with an inverted substantially U-shaped index movable with the vertical index and including a horizontal portion and appended outwardly angled portions in complementary position to cooperate with the horizontal index of the electronic space indicator in flight designation for runway landing.

6. An air

changes of the aircraft to facilitate the pilot's coordination of normal sense impressions.

4. A flight designating instrument for aircraft comprising an index, gyroscopic means for operating said index in designation of turn of an aircraft with movements sensed in accordance with a normal clear weather turning view as seen by a pilot from the aircraft, a second index, gyroscopic means for operating the second index in designation of bank and pitch movements corresponding to those of an aircraft in flight, electronically responsive horizontal and vertical indices, electrical means for operating said electronically responsive indices with locating movements corresponding to the position of the aircraft with respect to radiated space patterns definitive of runway location and orientation, and means for integrating all of said indices and their related movements at a common locus for stimulation of pilot responses in accordance with normal conditioned reflexes.

5. A flight instrument for aircraft as set forth in claim 4 wherein the means for integrating all of said indices comprises an optical system, and intensity adjustable illuminating means for the indices.

6. An aircraft instrument for indicating to the pilot a complete visual stimulus of the movements of the aircraft about its axes and the displacement of the aircraft from space radiated electronic patterns defining landing runway location and orientation, comprising indicating elements defining respectively the movements of the aircraft about its three axes, means for actuating said indicating elements responsive to turn, direction, pitch and bank of the aircraft, electronic actuated horizontal and vertical indices, electronic means for cooperatively actuating said horizontal and vertical indices from space radiated signals, and means for superposing the turn, direction, pitch and bank indicating elements, and electronic vertical and horizontal indices in a superposed relation all in the same field of view of a pilot for giving a complete visual

stimulus of the movements of the aircraft about its three axes and with respect to runway approach.

7. An aircraft instrument for indicating to the pilot a complete visual stimulus of the movements of the aircraft about its axes and the displacement of the aircraft from space radiated electronic patterns defining landing runway location and orientation, comprising indicating elements defining respectively the movements of the aircraft about its three axes, means for actuating said indicating elements responsive to turn, direction, pitch and bank of the aircraft and in degree, rate, direction and sensing corresponding to a pilot's view during clear weather flight, electronic actuated horizontal and vertical indices, electronic means for cooperatively actuating said horizontal and vertical indices from space radiated signals, and means for superposing the turn, direction, pitch and bank indicating elements, and electronic vertical and horizontal indices in the same field of view of a pilot for giving a complete visual stimulus of the movements of the aircraft about its three axes and with respect to runway approach.

References Cited in the file of this patent
UNITED STATES PATENTS

Number	Name	Date
1,760,163	Morris	May 27, 1930
1,980,886	Talafre et al.	Nov. 13, 1934
2,019,234	Nistri	Oct. 29, 1935
2,137,194	Weber	Nov. 15, 1938
2,178,637	Link, Jr.	Nov. 7, 1939
2,283,190	Crane	May 19, 1942
2,291,635	Kenyon	Aug. 4, 1942
2,357,060	Robinson	Aug. 29, 1944
2,458,022	Phelps	Jan. 4, 1949
2,463,529	Ferrill	Mar. 8, 1949
2,467,412	Wathen	Apr. 19, 1949
2,531,492	Angst et al.	Nov. 28, 1950
2,531,521	Link	Nov. 28, 1950
2,537,996	Hankes	Jan. 16, 1951
2,557,380	Hickox	June 19, 1951