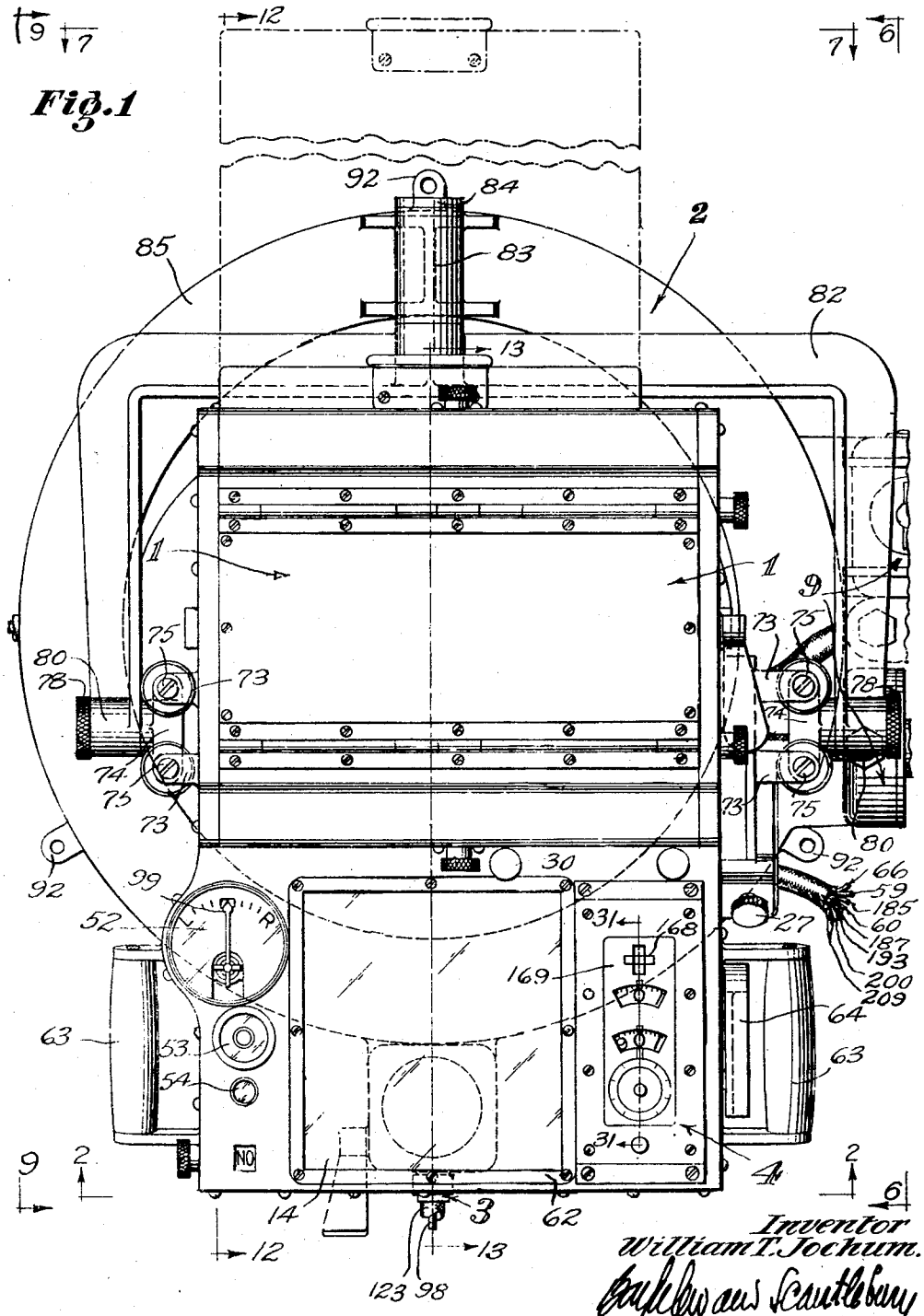
356-150 CROSS REFERENCE SEARCH ROOM

March 6, 1945. W. T. JOCHUM 2,370,966

METHOD AND APPARATUS FOR NAVIGATING AIRCRAFT

Original Filed Oct. 27, 1934 15 Sheets-Sheet 1

Fig. 1



Inventor
William T. Jochum.
Cauldwell and Scantlebury
Attorneys.

March 6, 1945. W. T. JOCHUM 2,370,966

METHOD AND APPARATUS FOR NAVIGATING AIRCRAFT

Original Filed Oct. 27, 1934 15 Sheets-Sheet 2

Fig. 2

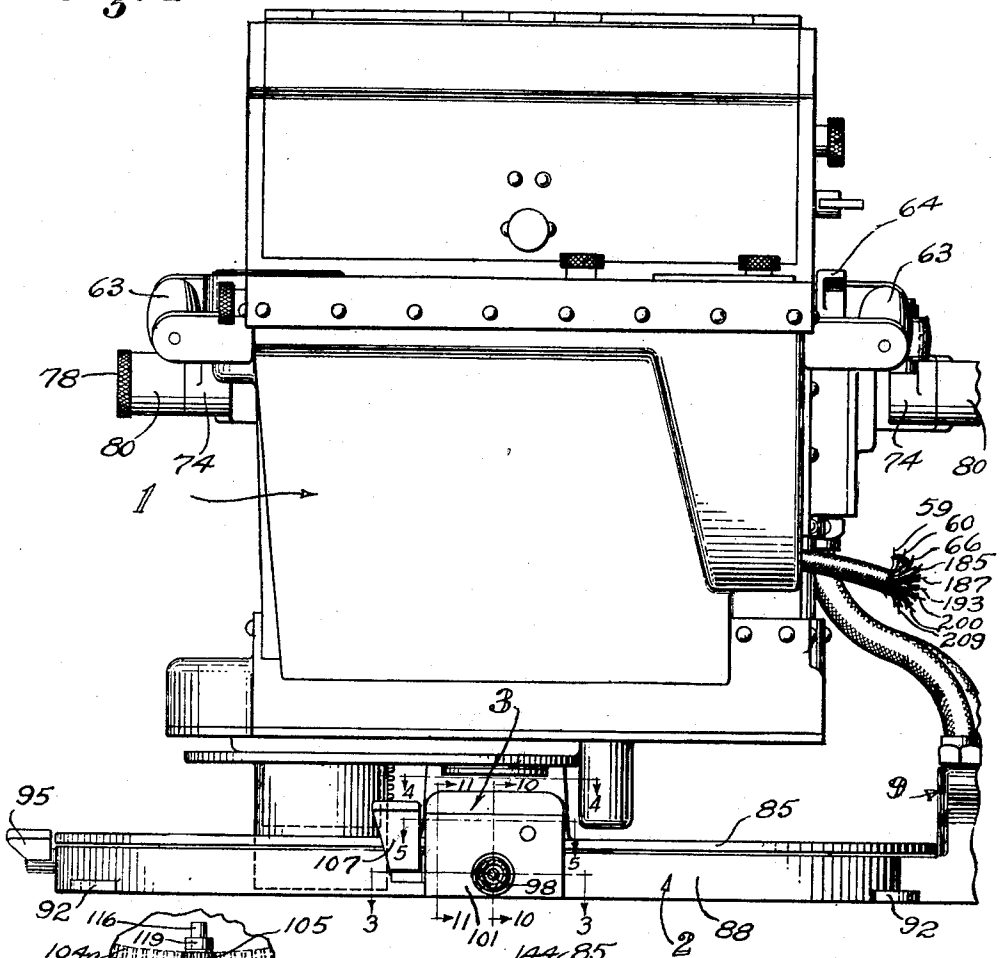


Fig. 3

Fig. 4

Fig. 5

Inventor.
William T. Jochum.

Attorneys.

March 6, 1945. W. T. JOCHUM 2,370,966

METHOD AND APPARATUS FOR NAVIGATING AIRCRAFT

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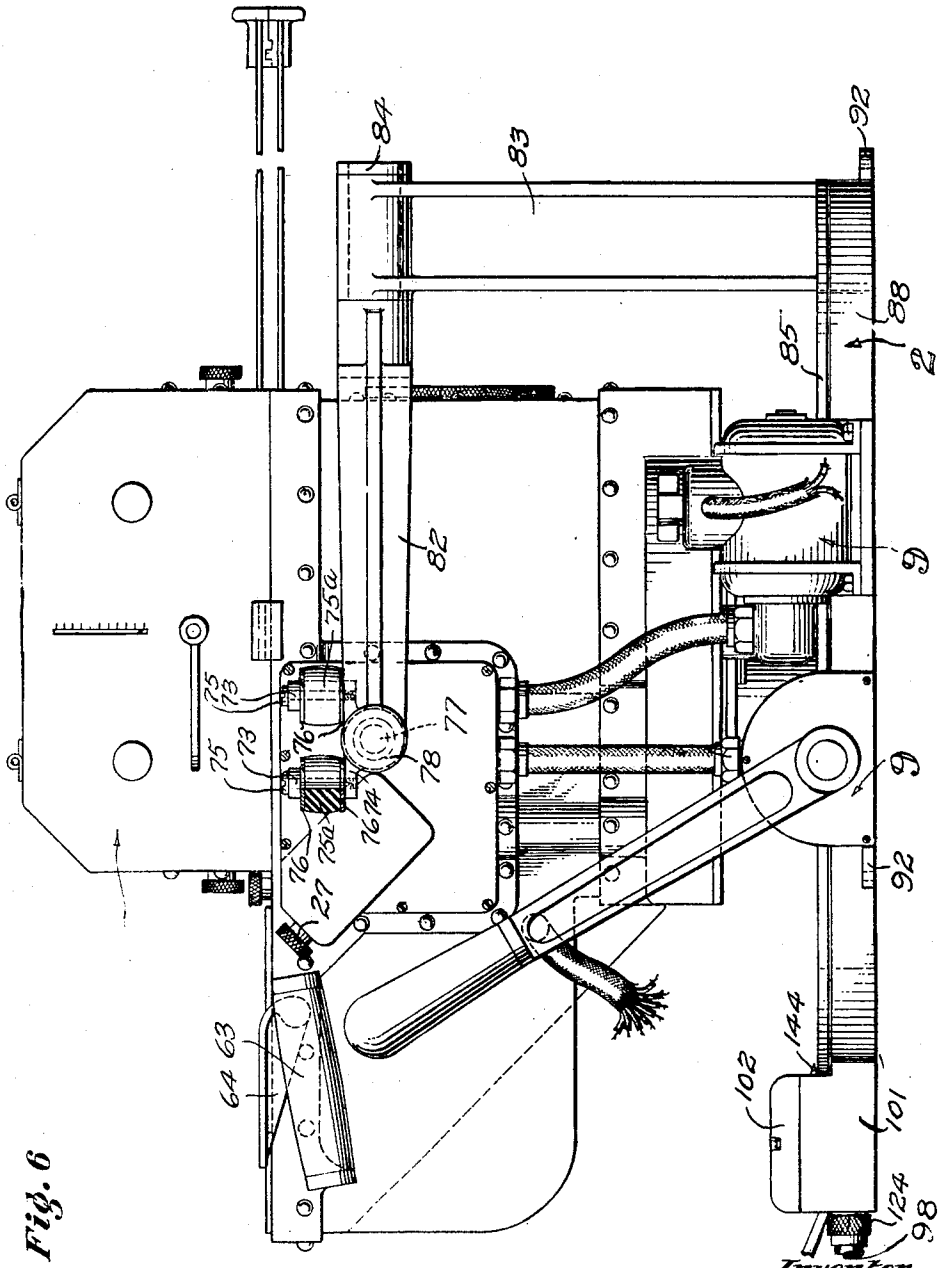


Fig. 6

Inventor
William T. Jochum

Attorneys.

March 6, 1945. W. T. JOCHUM 2,370,966

METHOD AND APPARATUS FOR NAVIGATING AIRCRAFT

Original Filed Oct. 27, 1934 15 Sheets-Sheet 4

Fig. 7.

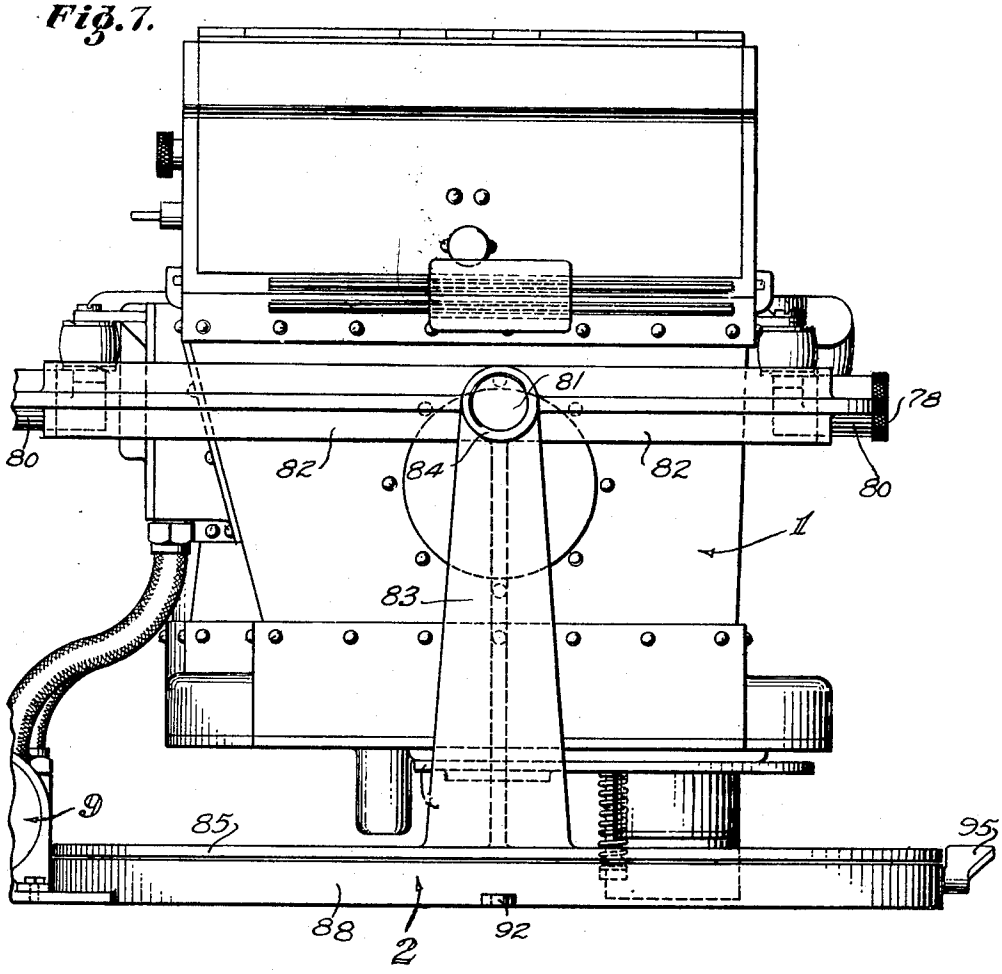
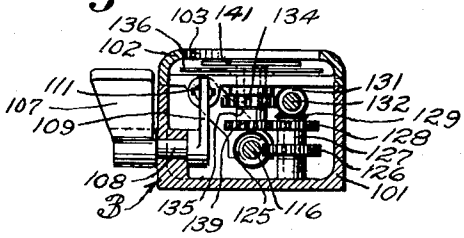


Fig. 8.



Inventor.
William T. Jochum.

Attorneys.

March 6, 1945. W. T. JOCHUM 2,370,966

METHOD AND APPARATUS FOR NAVIGATING AIRCRAFT

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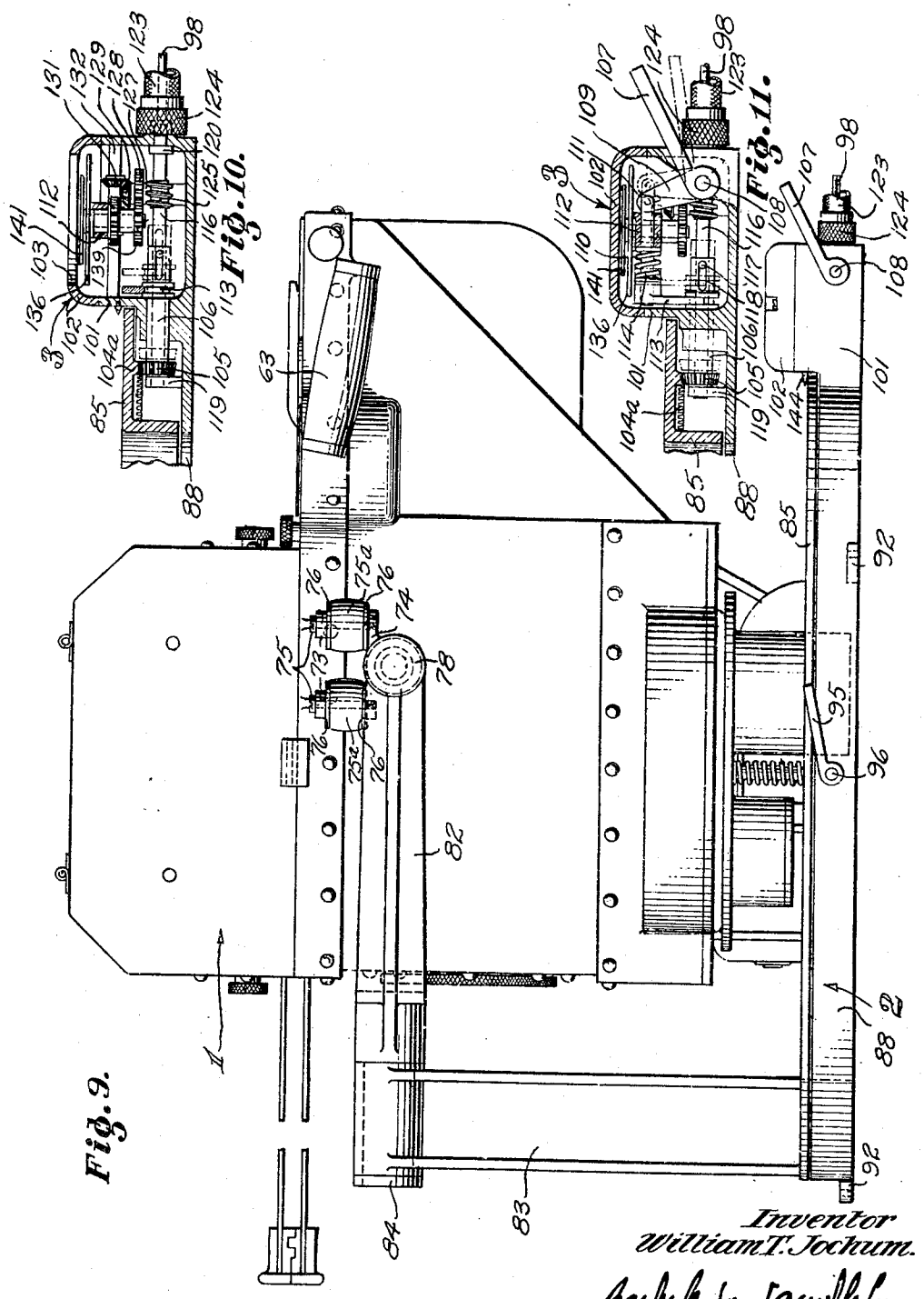


Fig. 9.

Fig. 10.

Fig. 11.

Inventor
William T. Jochum.

Attorneys.

March 6, 1945. W. T. JOCHUM 2,370,966

METHOD AND APPARATUS FOR NAVIGATING AIRCRAFT

Original Filed Oct. 27, 1934 15 Sheets-Sheet 6

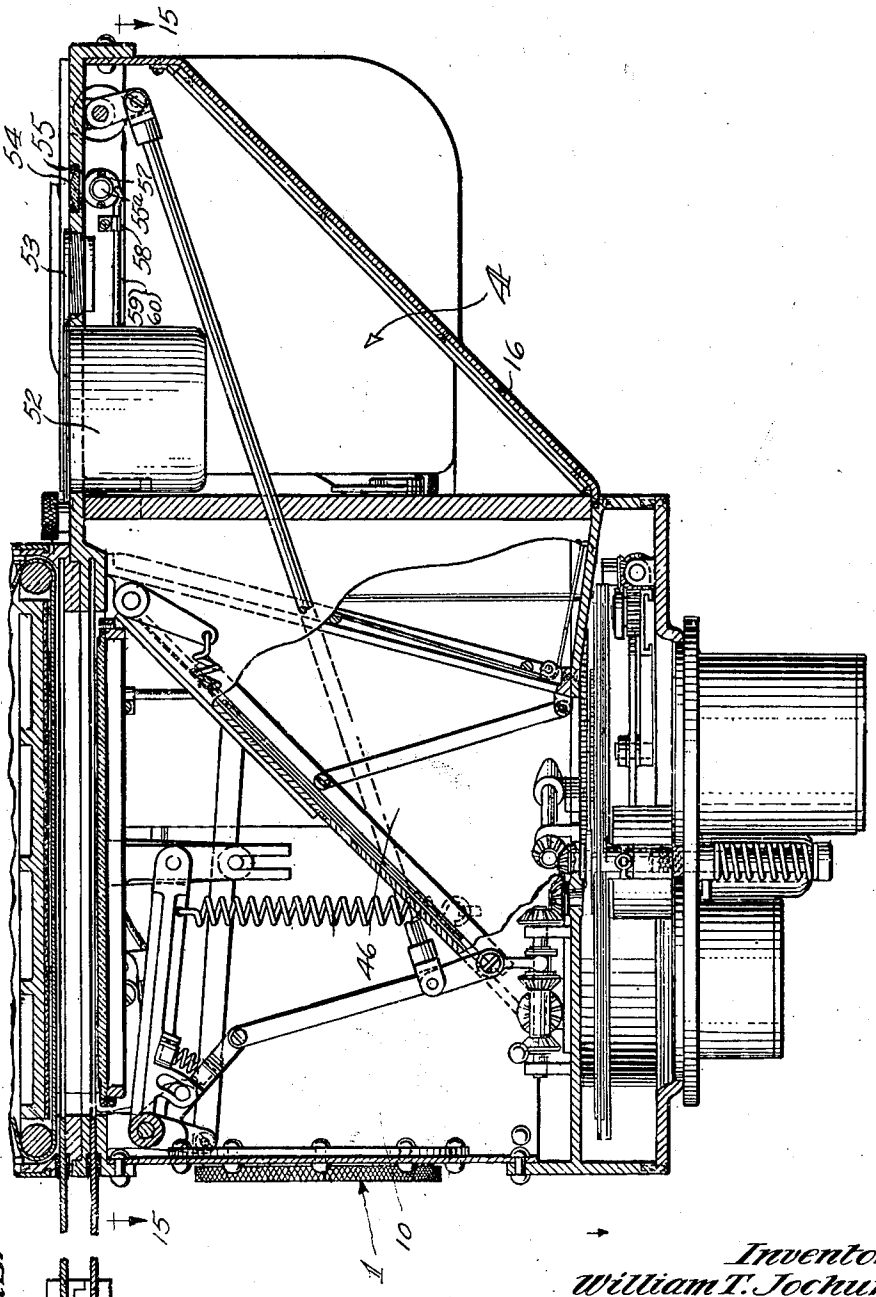


Fig. 12.

Inventor
William T. Jochum.

Bakewell & Scantlebury
Attorneys.

March 6, 1945. W. T. JOCHUM 2,370,966

METHOD AND APPARATUS FOR NAVIGATING AIRCRAFT

Original Filed Oct. 27, 1934 15 Sheets-Sheet 7

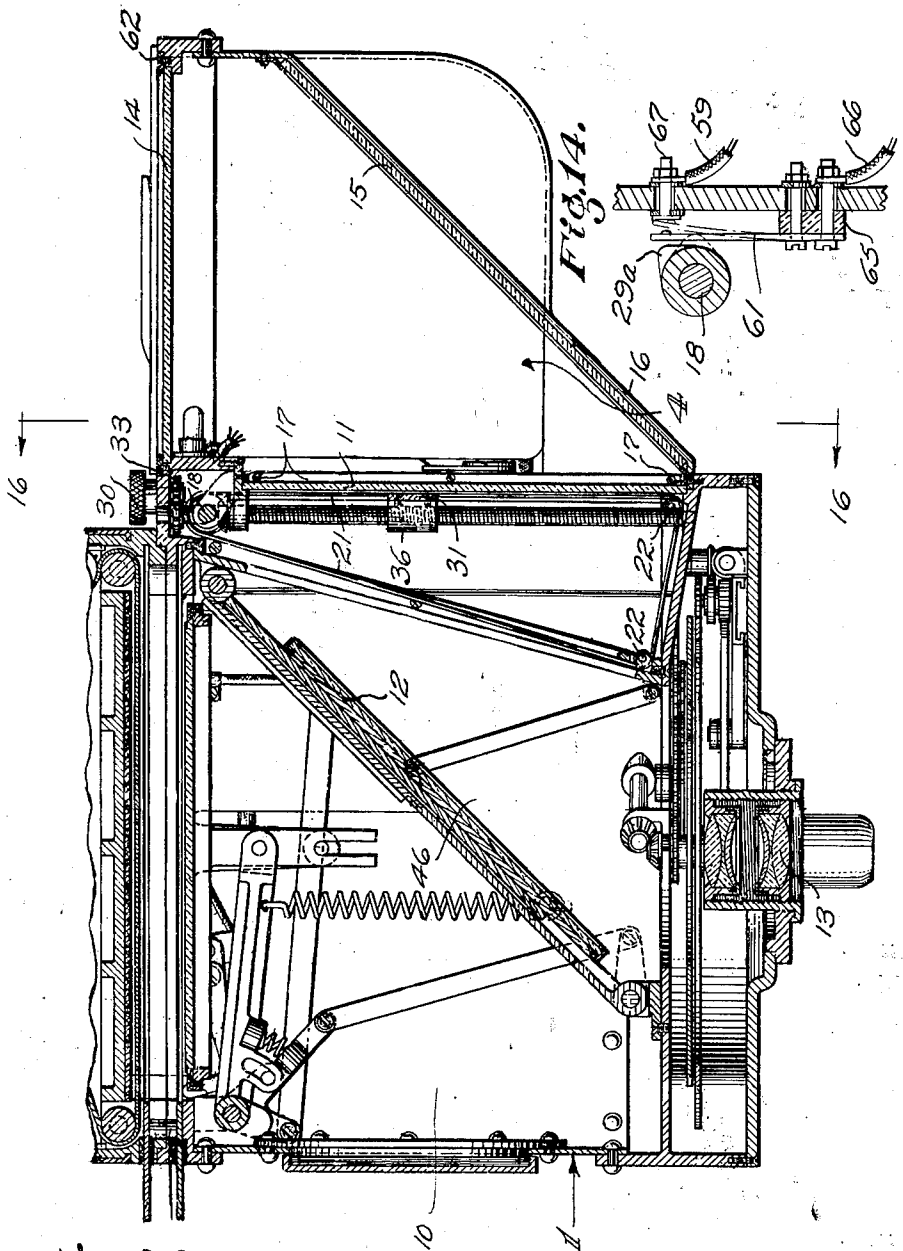


Fig. 14.

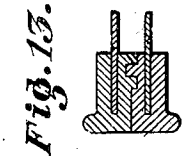


Fig. 13.

Inventor
William T. Jochum.

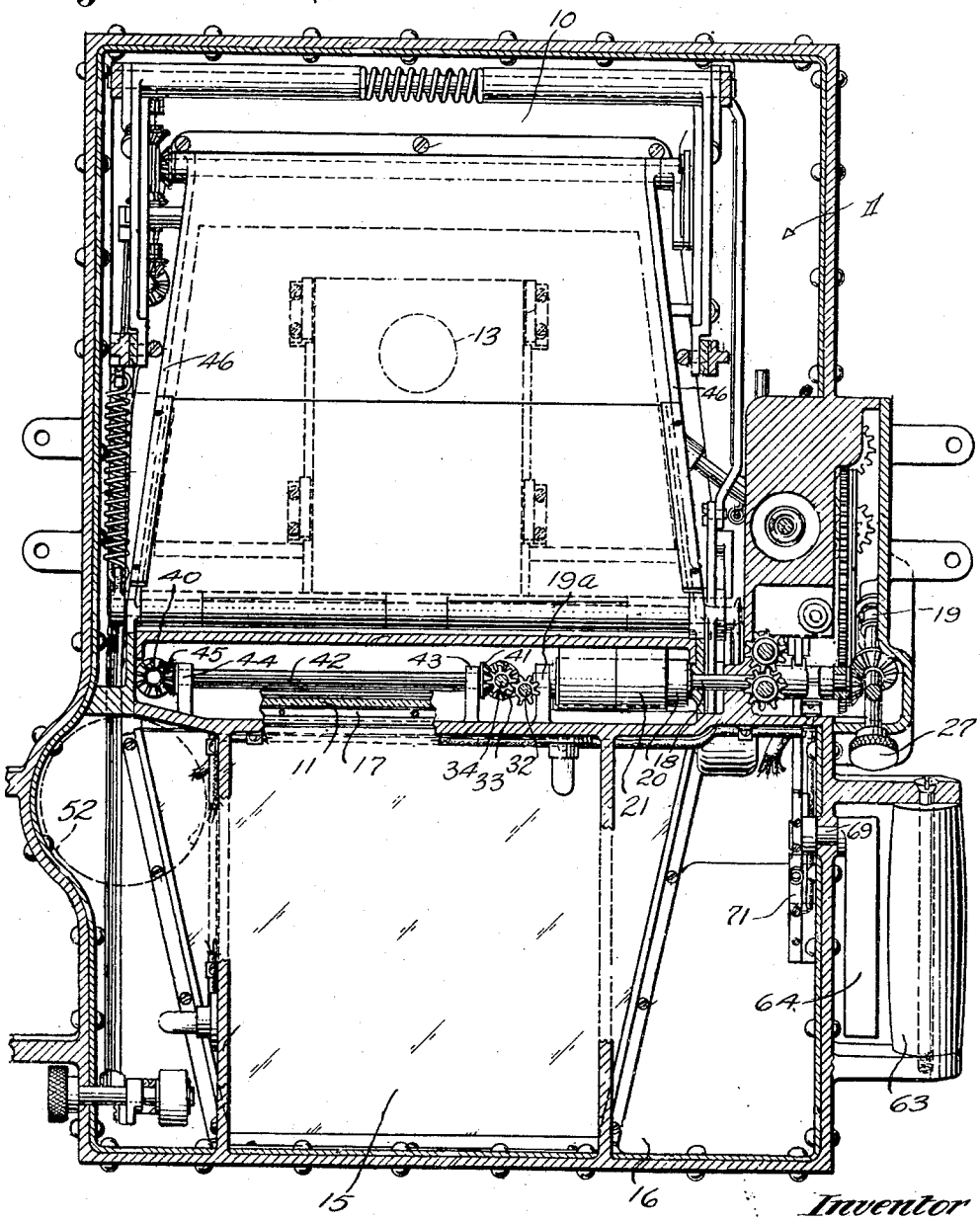
Bakewell & Sandeberg
Attorneys.

March 6, 1945. W. T. JOCHUM 2,370,966

METHOD AND APPARATUS FOR NAVIGATING AIRCRAFT

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Fig. 15.



Inventor
William T. Jochum.

Bakewell & Scantlebury
Attorneys.

March 6, 1945. W. T. JOCHUM 2,370,966

METHOD AND APPARATUS FOR NAVIGATING AIRCRAFT

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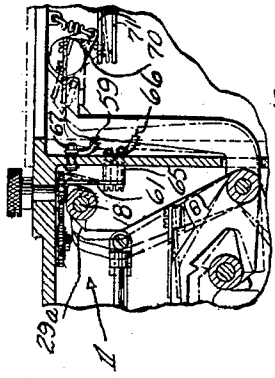


Fig. 17.

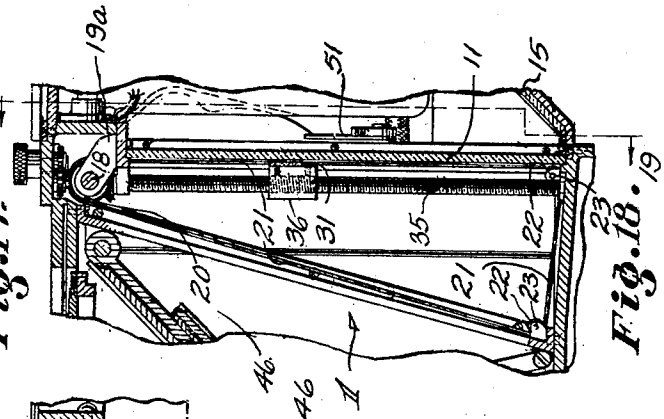


Fig. 18.

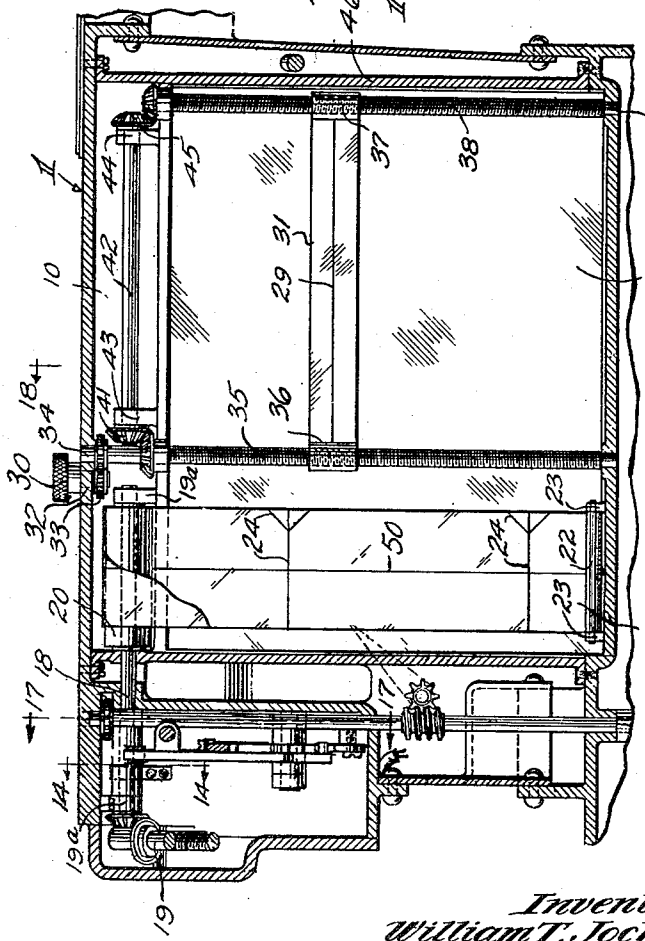


Fig. 16.

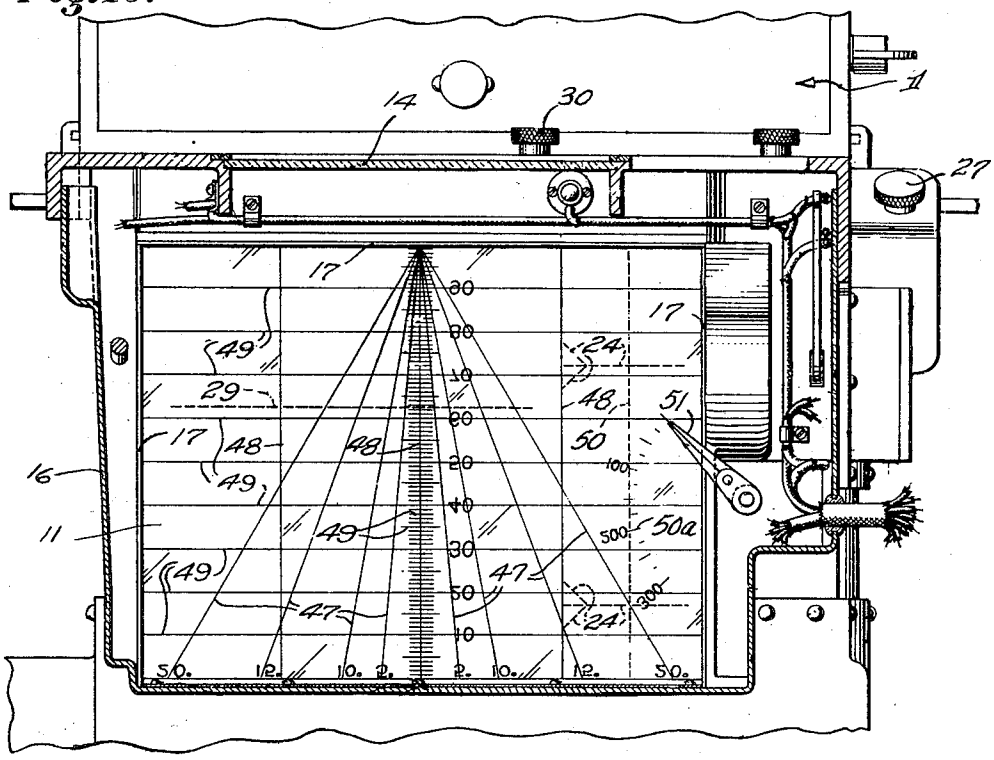
Inventor
William T. Jochum.
Bartlett & Fruitlebury
Attorneys.

March 6, 1945. W. T. JOCHUM 2,370,966

METHOD AND APPARATUS FOR NAVIGATING AIRCRAFT

Original Filed Oct. 27, 1934 15 Sheets-Sheet 10

Fig. 19.



Inventor.
William T. Jochum.
Bakewell & Seawell
Attorneys.

March 6, 1945. W. T. JOCHUM 2,370,966

METHOD AND APPARATUS FOR NAVIGATING AIRCRAFT

Original Filed Oct. 27, 1934 15 Sheets-Sheet 11

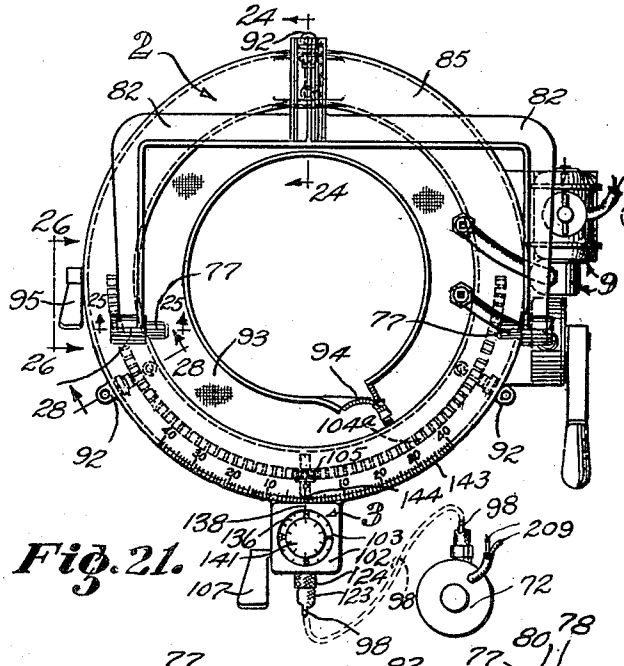


Fig. 21.

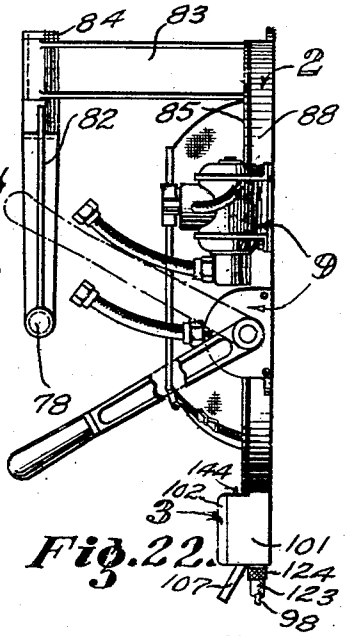


Fig. 22.

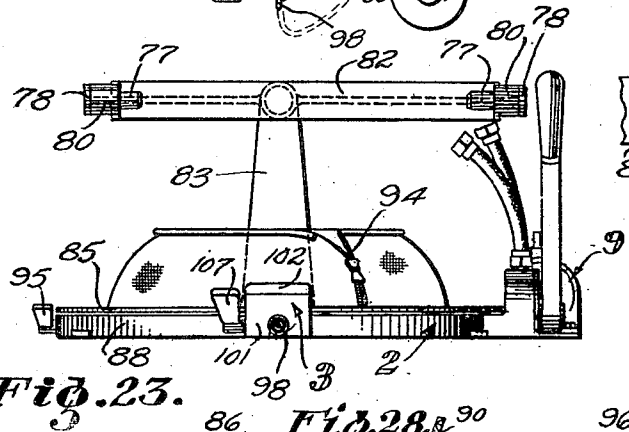


Fig. 23.

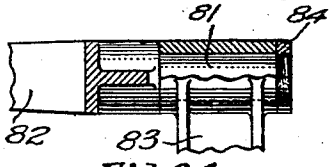


Fig. 24.

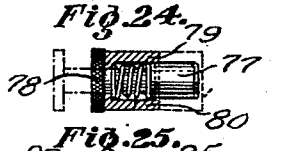


Fig. 25.

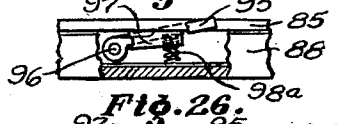


Fig. 26.



Fig. 27

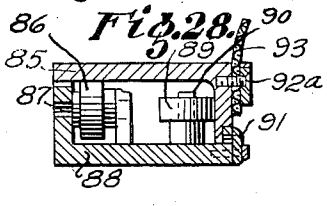


Fig. 28.

Inventor.
William T. Jochum.
Barlow & Scantlebury
Attorneys.

March 6, 1945. W. T. JOCHUM 2,370,966

METHOD AND APPARATUS FOR NAVIGATING AIRCRAFT

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Fig. 29.

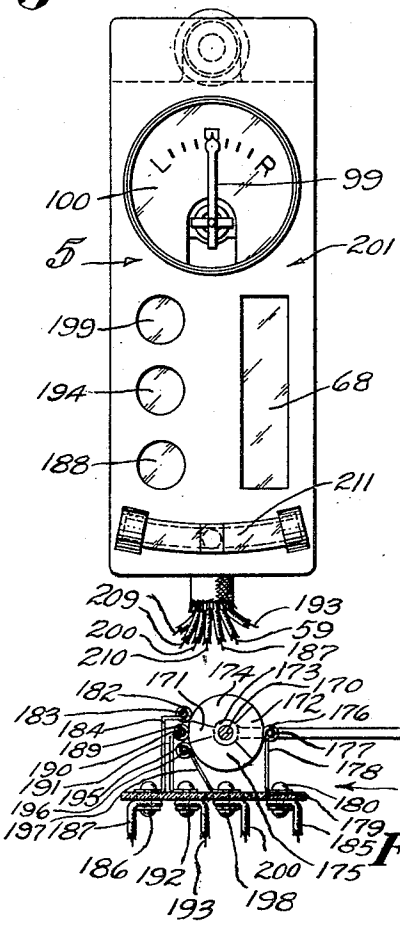


Fig. 30.

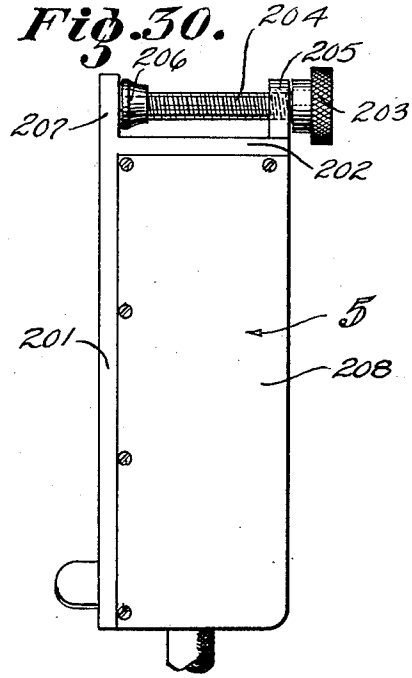


Fig. 31.

Inventor
William T. Jochum

Bakewell & Seawell

Attorneys.

March 6, 1945. W. T. JOCHUM 2,370,966

METHOD AND APPARATUS FOR NAVIGATING AIRCRAFT

Original Filed Oct. 27, 1934 15 Sheets-Sheet 13

Fig. 32.

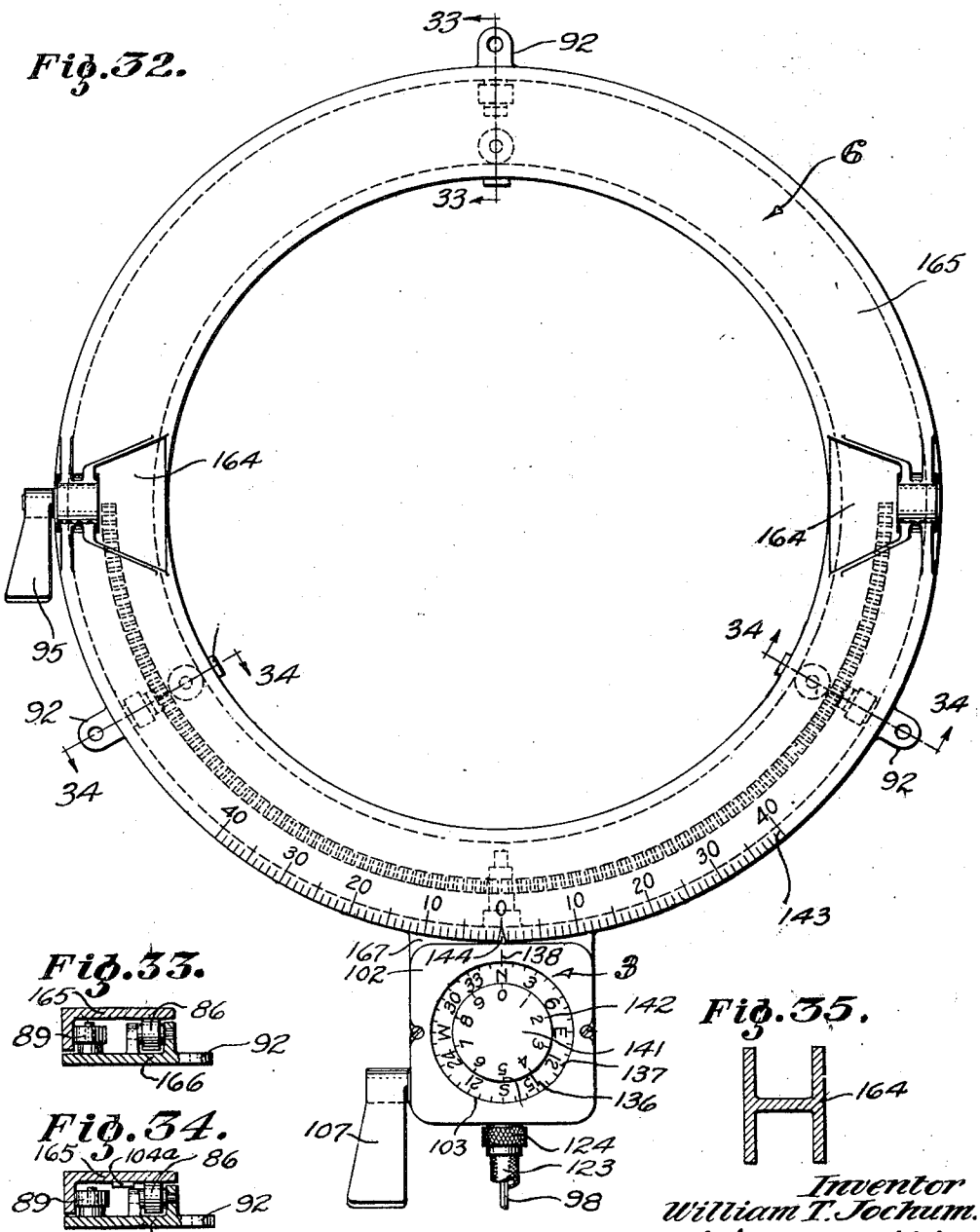


Fig. 33.

Fig. 34.

Fig. 35.

Inventor
William T. Jochum.

Bakewell & Scantlebury
Attorneys.

March 6, 1945. W. T. JOCHUM 2,370,966

METHOD AND APPARATUS FOR NAVIGATING AIRCRAFT

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Fig. 36.

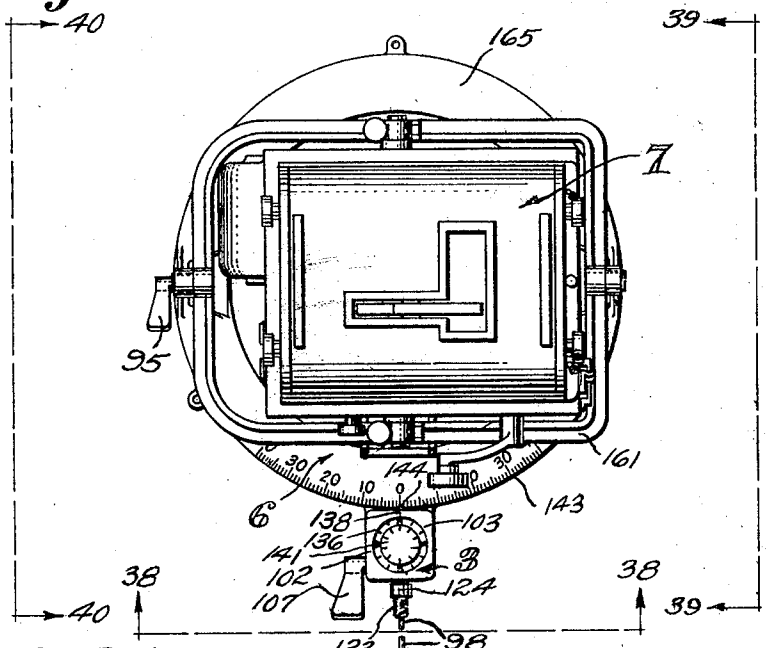


Fig. 37.

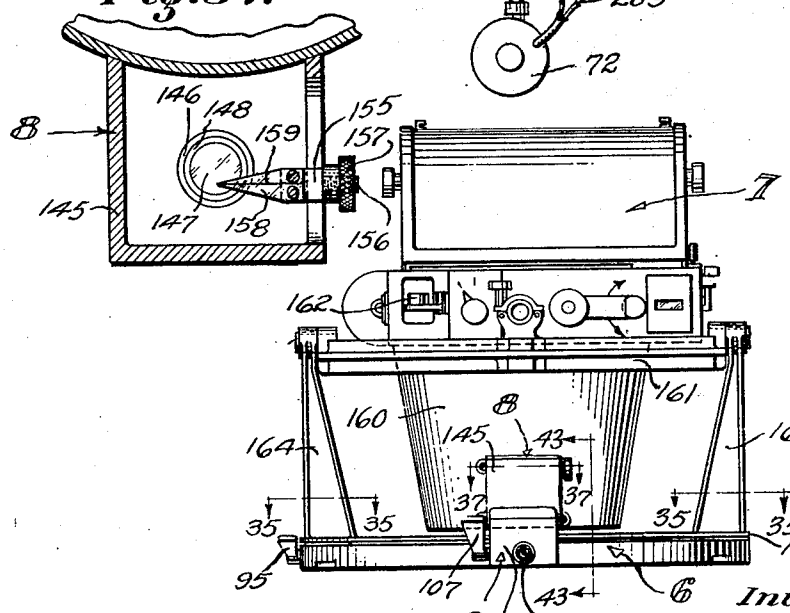


Fig. 38.

Inventor.
William T. Jochum.
Bellows & Leavitt Lucy
Attorneys.

March 6, 1945. W. T. JOCHUM 2,370,966

METHOD AND APPARATUS FOR NAVIGATING AIRCRAFT

Original Filed Oct. 27, 1934 15 Sheets-Sheet 15

Fig. 39.

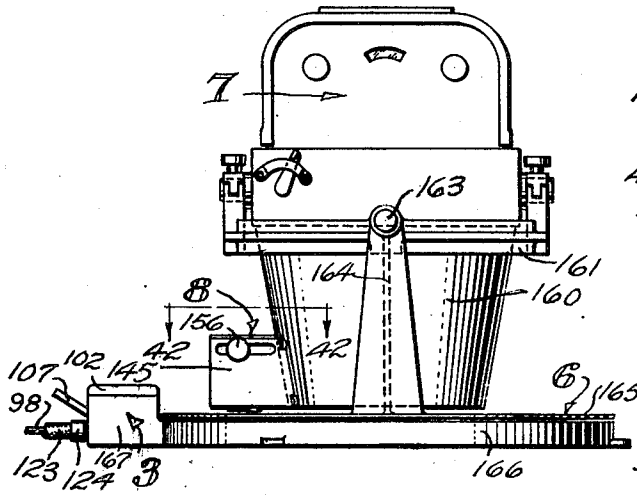


Fig. 40.

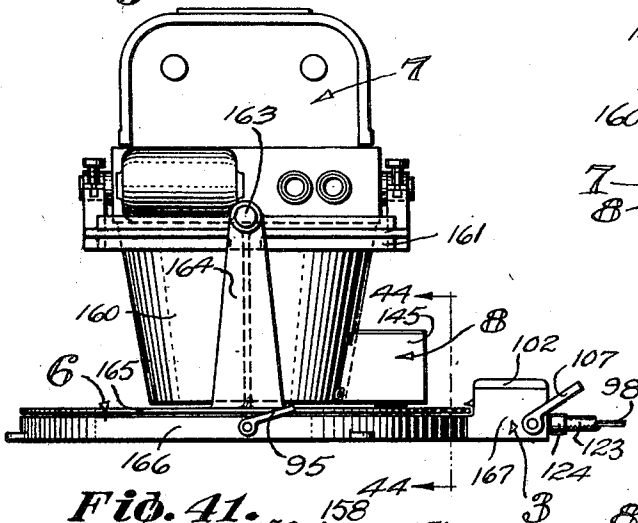


Fig. 41.

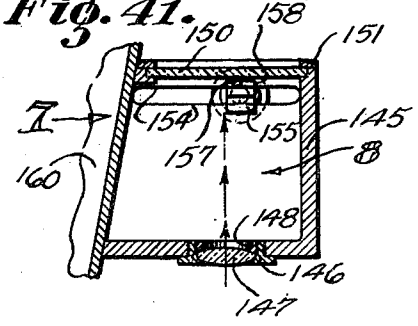


Fig. 42.

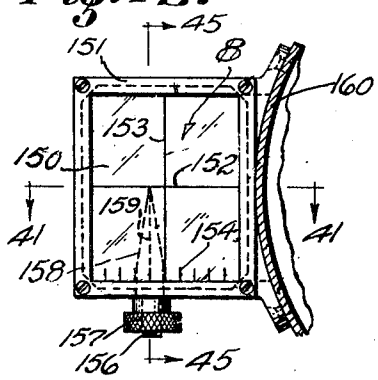


Fig. 43.

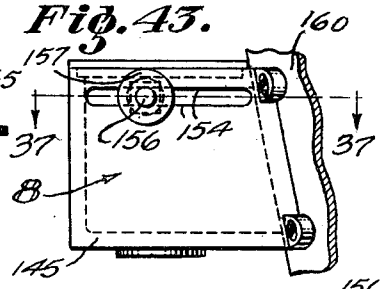


Fig. 44.

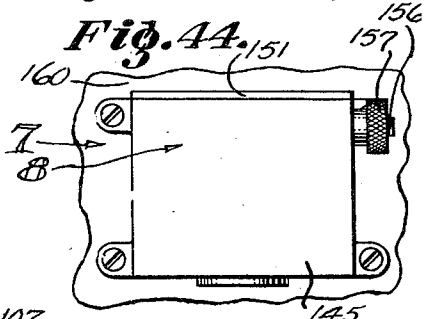
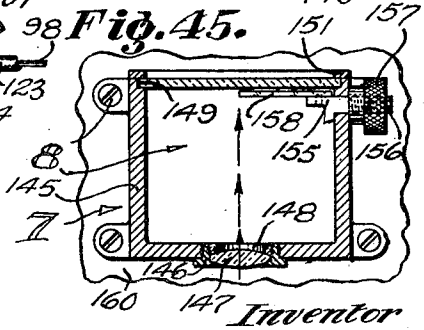


Fig. 45.



Inventor
William T. Jochum.
Bakewell & Leavitt Fury
Attorneys.

Patented Mar. 6, 1945 2,370,966

UNITED STATES PATENT OFFICE

2,370,966

METHOD AND APPARATUS FOR NAVIGATING AIRCRAFT

William T. Jochum, Manhattan Beach, Calif.

Original application October 27, 1934, Serial No. 750,311. Divided and this application October 3, 1939, Serial No. 297,705

25 Claims. (Cl. 88—16)

This invention relates to a navigational method which simplifies the operation of following a predetermined compass course with respect to the terrestrial poles of the earth, regardless of wind conditions which may involve a wind direction not parallel to said compass course.

More specifically, the improvements relate to the means for the adjustment and control of a conventional compass and driftsight in combination for the accomplishment of the aforementioned navigational function.

Said improvements include a means for determining the relative movement between an earth object, or an image of the earth, and an aircraft for the purpose of determining the azimuth and velocity of motion of said aircraft with respect to said earth object.

A primary advantage of the navigational method herein described is accomplished through the cooperation of a manually operated and properly controlled driftsight with a conventional compass to cause said aircraft to, at all times, indicate to the pilot of the aircraft whether or not said aircraft is actually following a predetermined compass course along the earth as defined by a line along the earth corresponding to said predetermined compass course.

Said proper control of said driftsight further includes the orientation thereof in such a manner that a drift line, or radical line, or radical axis of the driftsight is, substantially at all times, maintained parallel to the direction of motion of an image of the earth, or an earth object as observed in conjunction with any suitable means for viewing the earth.

Said proper control of said driftsight also includes the relatively constant maintenance of the principal axis of the lens, or other equivalent means, normal, or at right angles to, a line tangent to the surface of the earth assuming for illustrative purposes that the earth is a perfect sphere, at all times in conjunction with reference by the operator of said driftsight to a conventional suitable levelling means, or equivalent levelling instrument, such as a level bubble, herein used for illustrative purpose. In other words, the principal axis of the lens of the driftsight or other equivalent sighting means must be maintained in a constant position with respect to the earth, preferably in a vertical position.

It is stressed that the proper control of the driftsight requires the relatively constant maintenance thereof in a constant relationship with respect to the earth, since any rolling motion, or oscillatory motion, of the aircraft about the approximate longitudinal axis of the fuselage is conducive to apparent lateral motion of the earth object, or image of the earth, with respect to said drift line, or radical axis, of said driftsight.

As herein disclosed, the driftsight preferably includes an aerial mapping camera of the reflex type, the reflex mechanism thereof incorporating the driftsight as an integral part of the camera in conjunction with the means for viewing an earth object, or an image of the terrain below the aircraft, achieved in conjunction with said reflex mechanism.

The reflex, or reflecting, elements of the camera driftsight may be of such dimensions that the image which appears on the ground glass, or viewing screen, thereof includes identically the same area of terrain as that recorded on the film when a photographic exposure is caused to occur, and said image may be identically the same size as that recorded on the film.

The simplified method of navigation realized in conjunction with the application of my invention is particularly valuable when employed for aerial mapping purposes, in which case it is necessary, conventionally, to fly an aircraft along a number of parallel courses for the purpose of taking a sequence of pictures to completely cover the area. In the photographing of each of the strips of picture required to cover the area it is necessary for the aircraft to be flown on a predetermined course with a minimum of deviation therefrom.

The pictures are conventionally taken at such intervals of time that successive pictures overlap each other by a predetermined amount.

The spacing between adjacent strips is made such that the successive strips of pictures also overlap each other by an amount sufficient to provide for deviation from a straight predetermined compass course that must be parallel to the course of the adjacent strip, or strips. The amount of lateral overlap employed in determining the spacing between strip courses is, therefore, a direct function of the precision and facility with which the aircraft is navigated.

With my method, once the compass has been adjusted for a predetermined compass course, the operator of the camera driftsight is enabled to accomplish the navigational function without expending any more effort than is conventionally required in the normal operation of a conventional mapping camera. No extra mental effort is involved, as the navigational function is automatically accomplished in conjunction with the conventional operation of the camera driftsight, or aerial mapping camera including a driftsight.

It involves no more effort for the pilot of the aircraft to control the aircraft in response to the indication of a compass indicating instrument than is involved in following the indication of a conventional compass, the pilot's duties being actually simplified, since drift correction is automatically accomplished by my method for causing the compass indicator instrument, in conjunction with the camera driftsight, to show

whether or not the aircraft is following a predetermined compass course as defined by a line along the surface of the earth coinciding with said compass course. It is unnecessary to apply a drift correction to the compass indication, as is required in conjunction with the use of a conventional compass.

Without further explanation, it is assumed that it is understood that, although an aircraft may be flown in a conventional manner without drift correction and by reference to the indication of a compass, the aircraft may, under this condition, actually be following quite a different course with respect to the earth than that indicated by the compass, due to the fact that the direction of the wind in which the aircraft is flying may not be parallel to the desired compass course, with the result that the aircraft, unless properly crabbed, or turned to compensate for a wind direction not parallel to said desired compass course, may follow a course with respect to the earth that corresponds to the resultant of two vectors corresponding, respectively, to the airspeed of the aircraft and the velocity of the wind in which the aircraft is flying.

When the aircraft is flown in a wind, the direction of which is not parallel to the direction in which it is desired to fly, it is necessary that the aircraft be turned, or crabbed, by the pilot of the aircraft to cause it to follow, as nearly as possible, the direction in which it is desired to fly.

Heretofore the lack of suitable navigational apparatus has caused the results obtained, in connection with attempted navigation of the aircraft, to be extremely erratic, due to lateral drift of the aircraft, and the strip courses flown under conditions involving the flying of the aircraft in a wind not parallel to the course it has been desired to fly have been so irregular, due to lateral drift of the aircraft, that the resultant strips of photographic pictures obtained have often failed entirely to overlap each other laterally, and a portion of the area which it has been desired to photograph has been missed entirely. It has often been necessary to, at great expense and loss of time, make additional flights for the purpose of obtaining photographs of the area which has been missed in this manner. Because of the expense and loss of time involved in such additional flights it has been conventional practice to fly the parallel strip courses in such a manner that the resultant strips of photographic pictures obtained would have a considerable degree of lateral overlap for the purpose of providing sufficient tolerance to allow for the normal lateral drift of the aircraft which has occurred when existing methods have been employed in aerial photographic mapping.

My method of navigation permits the reduction to a minimum of said lateral overlapping of the resultant strips of photographic pictures, with a resultant economic saving, as well as a saving in time.

It is contemplated that the aerial photographic camera driftsight herein described, when used in conjunction with the method of navigation herein described, will permit the use of aircraft pilots who have not had special training in the art of aerial navigation for photographic mapping purposes.

A further object of this invention is to provide a new and improved method of navigating aircraft.

A further object of this invention is to provide for installation in a mapping aircraft a condensed and comprehensive indicator panel for the use of the pilot of said aircraft, thereby facilitating the control and operation of said aircraft for aerial photographic purposes.

A further object of this invention is to provide for use in conjunction with an aerial photographic mapping camera and driftsight, in combination therewith, a new and improved type of camera mounting incorporating means facilitating the navigation of aircraft, especially for aerial photographic mapping purposes.

A further object of this invention is to provide for use in conjunction with an aerial photographic mapping camera and driftsight, or other equivalent combination of instruments, an improved type of rotary mounting.

A further object of this invention is to provide an improved type of rotary mounting for aerial mapping cameras, or other types of instruments capable of being employed as a means for determining the angle of drift of an aircraft in flight, said mounting including means whereby said camera or instrument may be maintained with a predetermined axis thereof in a predetermined relationship to the vertical axis as defined by a suitable levelling reference means, such as a level bubble.

A further object of this invention is to provide an improved type of rotary mounting for aerial mapping cameras, or other instruments capable of being adapted to determine the angle of drift of an aircraft in flight, said mounting including means to facilitate the maintenance of said cameras or instruments with a predetermined axis thereof at all times having a predetermined relationship with respect to the vertical as defined by a conventional levelling reference means such as a level bubble, and said mounting further including means to control a conventional compass in such a manner that said compass may be caused to indicate whether or not another predetermined axis of said camera or instrument is in coincidence with a predetermined compass course.

A further object of this invention is to provide, in conjunction with the mounting previously described, a compass controlling means previously described and further compass controlling means to permit the adjustment of said compass to cause it to indicate the relationship between a predetermined axis of said camera or instrument and any predetermined compass course.

A further object of this invention is to provide, in conjunction with the mounting and compass controlling means and camera and/or driftsight or other instrument, respectively previously described, a means to indicate the predetermined compass course for which said compass has been preadjusted.

A further object of this invention is to provide a releasable means for holding the said mounting in any position of rotational orientation.

A further object of this invention is to provide in conjunction with said camera, or other instrument, an altimeter adapted to cooperate with and control a remotely located means to indicate the reading thereof.

A further object of this invention is to provide, in conjunction with said camera, means to facilitate the determination of the velocity of motion of the aircraft with respect to the earth.

Further objects of this invention will appear hereinafter.

The invention consists in the novel parts and combination of parts to be described hereinafter, all of which, in conjunction with the method described hereinafter, contribute to the accomplishment of the function of navigating an aircraft in an improved manner.

In the drawings:

Fig. 1 is a plan view of the camera and mount.

Fig. 2 is an elevation taken on line 2—2 of Fig. 1 and discloses the camera and mount.

Fig. 3 is a fragmental plan view, partly in section, taken on line 3—3 of Fig. 2 and discloses the earth inductor compass brush drive shaft.

Fig. 4 is a plan view taken on line 4—4 of the lower part of Fig. 2 and discloses the compass cards, or indicator dials.

Fig. 5 is a sectional view taken in plan on line 5—5 of Fig. 2 and discloses the compass dial or card driving gear and means for disengaging the earth inductor brush drive pinion from the rack or segment on the camera mount carriage.

Fig. 6 is a side elevation taken on line 6—6 of Fig. 1 and discloses the camera and mount.

Fig. 7 is an end elevation taken on line 7—7 of Fig. 1 and discloses the camera and mount from the opposite direction to that shown in Fig. 2.

Fig. 8 is a sectional view in elevation taken on the line 8—8 of Fig. 4 and discloses the gear drive to the compass cards.

Fig. 9 is a side elevation taken on line 9—9 of Fig. 1 and discloses the camera and mount taken from the opposite direction to the elevation shown in Fig. 6.

Fig. 10 is a sectional view in elevation taken on the line 10—10 of Fig. 2 and discloses the earth inductor compass drive shaft and the gear drive to the compass cards.

Fig. 11 is a sectional view in elevation taken on line 11—11 of Fig. 2 and discloses the earth inductor brush drive shaft and means for disengaging the earth inductor brush drive shaft pinion from the rack on the camera mount carriage.

Fig. 12 is a sectional view in elevation taken on line 12—12 of Fig. 1 and discloses the installation of the earth inductor compass indicator instrument in the camera and also discloses one of the warning lights.

Fig. 13 is a sectional view in elevation taken on line 13—13 of Fig. 1 and discloses the disposition of the reflex elements of the camera driftsight.

Fig. 14 is a sectional view in elevation taken on line 14—14 of Fig. 16 and discloses the warning switch actuated by the intervalometer.

Fig. 15 is a sectional view in plan taken on line 15—15 of Fig. 12 and discloses the construction of the reflex elements of the camera driftsight.

Fig. 16 is a sectional view in elevation taken on the line 16—16 of Fig. 13 and shows the ground glass, or viewing screen, of the camera in elevation, together with means for facilitating the determination of the velocity of motion of the aircraft with respect to the earth.

Fig. 17 is a sectional view in elevation taken on line 17—17 of Fig. 16 and discloses means for tripping the camera to cause a sequence of exposures to occur in accordance with the velocity of motion of the image on the ground glass of the camera.

Fig. 18 is a sectional view in elevation taken on line 18—18 of Fig. 16 and discloses the belt employed to synchronize the mechanism shown in Fig. 17 with the motion of the image on the ground glass of the camera.

Fig. 19 is a sectional view in elevation taken on line 19—19 of Fig. 18 and discloses the ground glass, or viewing screen of the reflex camera with lines thereon to facilitate navigation of the aircraft.

Fig. 20 is a wiring diagram for the earth inductor compass indicator system.

Fig. 21 is a plan view of the camera mount at a reduced scale and is similar to Fig. 1 with the camera driftsight removed. Fig. 21 also shows a wind excluding apron omitted in other views.

Fig. 22 is a side elevation of the camera mount shown in Fig. 21 and is similar to Fig. 6 with the camera driftsight removed.

Fig. 23 is an end elevation of the camera mount shown in Fig. 21 and is similar to Fig. 2 with the camera driftsight removed.

Fig. 24 is a fragmental sectional view taken on line 24—24 of Fig. 21 and discloses the camera mount yoke journal and bearing by means of which said yoke, or trunnion, may be tilted in the mount.

Fig. 25 is a fragmental sectional view taken on line 25—25 of Fig. 21 and discloses the spring actuated pins on which the camera driftsight pivots in the yoke.

Fig. 26 is a fragmental view taken on line 26—26 of Fig. 21 and discloses a portion of the carriage and track with parts broken away to disclose the spring brake in a holding position.

Fig. 27 is a view similar to Fig. 26 and discloses the spring brake released to permit rotation of the mount.

Fig. 28 is a sectional view taken on line 28—28 of Fig. 21 and discloses the bearing and centering rollers on which the camera mount carriage rides and by means of which said mount is centered over the track.

Fig. 29 is an elevation of the remote indicator panel.

Fig. 30 is a side elevation of the remote indicator panel.

Fig. 31 is a sectional view taken on line 31—31 of Fig. 1 and discloses the modification of a conventional altimeter to permit remote indication.

Fig. 32 is a plan view of the mount modified to permit the adaptation of a conventional aerial camera for use with the navigational method herein disclosed.

Fig. 33 is a sectional view taken on line 33—33 of Fig. 32 and discloses the bearing and centering rollers on which the camera mount rides.

Fig. 34 is a sectional view taken on line 34—34 of Fig. 32 and discloses the bearing and centering rollers on which the carriage rides and also a portion of the track.

Fig. 35 is a sectional view taken on line 35—35 of Fig. 38 and discloses the shape of the supporting members for the conventional gimbal wherein is mounted a conventional camera to which a driftsight has been added.

Fig. 36 is a plan view at a reduced scale disclosing the modified camera mount in further detail.

Fig. 37 is a sectional view taken on line 37—37 of Fig. 38 and Fig. 43 and discloses the adjustable indicator by means of which is determined the proper distance the earth image must travel between successive photographic exposures to obtain a predetermined percentage of picture overlap.

Fig. 38 is an end elevation taken on line 38—38 of Fig. 36 and further discloses the modified camera mount.

Fig. 39 is a side elevation taken on line 39—39

of Fig. 36 and further discloses the modified camera mount.

Fig. 40 is a side elevation taken on line 40—40 of Fig. 36 and further discloses the modified camera mount.

Fig. 41 is a fragmental view taken on line 41—41 of Fig. 42 and discloses a plan view of the driftsight.

Fig. 42 is a fragmental plan view taken on line 42—42 of Fig. 39 and further discloses the driftsight.

Fig. 43 is a fragmental elevation taken on line 43—43 of Fig. 38 and further discloses the driftsight.

Fig. 44 is a fragmental elevation taken on line 44—44 of Fig. 40 and further discloses the driftsight.

Fig. 45 is a fragmental sectional view taken on line 45—45 of Fig. 42 and further discloses the driftsight.

The navigational method and means disclosed in this specification includes the following units:

Referring to Fig. 6 the camera driftsight is 1.

Referring to Fig. 6 the mount is 2.

Referring to Fig. 4 the earth inductor compass controlling mechanism is 3.

The modified conventional altimeter unit is 4.

The remote indicator panel is 5.

The modified camera mount is 6.

The conventional aerial camera is 7.

The driftsight for the conventional aerial camera is 8.

The driving elements for the reflex mapping camera are 9.

The drawings illustrate an embodiment of my invention as applied to the aerial camera driftsight of my design, further disclosed in my patent, Number 2,230,251, issued February 4, 1941 and also illustrate an embodiment of my invention as applied to a conventional type of aerial camera. Other types of conventional cameras may be similarly adapted to be employed in conjunction with my method of navigation.

The reflex type of aerial camera driftsight herein described, and hereinafter called a camera driftsight for convenience, includes means whereby the image of the earth is, practically at all times, formed, in conjunction with a camera lens and a reflector on a ground glass or viewing screen, said image being in focus thereon. The operator of the camera driftsight views the image on the ground glass by means of a reflector included in a viewing hood. The reflection of the earth image on the ground glass is interrupted only for a brief period during the photographic exposure of a negative. Further means are also provided whereby the frequency with which the photographic exposures occur automatically may be regulated in accordance with the velocity of motion of the image on the ground glass.

The aerial photographic camera driftsight herein described is mounted pivotally in a rotary mount in such a manner that the camera driftsight may be manually levelled in conjunction with a suitable conventional means, such as a level bubble, at which time the ground glass in my reflex type of camera driftsight is in a vertical plane, or substantially so, and the principal axis of the camera lens is substantially in a vertical position. In the case of a conventional camera modified to include a driftsight the principal axis of said driftsight, or equivalent means, is similarly maintained in a substantially vertical position, and the ground glass, or viewing screen, of said driftsight is substantially in a horizontal plane at this time.

This levelling of the camera driftsight facilitates the accomplishment of a very accurate drift reading, or determination, in conjunction with the observation by the operator of the direction of motion of the image appearing on the ground glass. Reference means, in the form of a line on said ground glass, or other equivalent means, is provided to facilitate the orientation of the camera driftsight in such a manner that the motion of the earth image on the ground glass is substantially parallel to said line. The motion of the earth image is also parallel to the direction of motion of the aircraft with respect to the earth. Any lateral rolling motion, or longitudinal pitching motion of the aircraft would otherwise cause the earth image on the ground glass to appear to move in a manner not truly representing the direction of motion of the aircraft with respect to the earth, and an erratic drift reading would be obtained in the latter case. It is imperative that a driftsight be provided with means to eliminate the error arising from motion of the aircraft other than motion corresponding with the forward progress of the aircraft. The method of navigation herein disclosed includes the flexible mounting of the driftsight to permit the levelling thereof by moving said driftsight independently with respect to the aircraft to permit correction of said error. The motion of the earth image on the ground glass of the driftsight is truly in accordance with the motion of the aircraft with respect to the earth when the driftsight is levelled as described.

The driftsights herein described are, respectively, provided with mountings which permit them to be tilted with respect to the aircraft for levelling purposes and which incorporate carriages which turn with said driftsights as manually rotated by the operators to cause the respective predetermined axes of said driftsights, defined by a drift line on the ground glass or equivalent means, to be parallel to the direction of motion of the earth image. Said predetermined axis is conventionally termed the radical axis of the driftsight, and will be referred to as such herein. Said rotation of the carriage, in each case, drives, in conjunction with a controlling means and conventional connecting shafting, the brushes in a conventional earth inductor compass, said brushes being thereby caused to maintain a constant orientation with respect to the radical axis of each driftsight. Said constant orientation of said brushes may be termed "the angular relationship." The application of other types of remotely controllable compasses to the navigational method herein disclosed will be obvious to anyone skilled in the art.

The pilot of the aircraft is provided with an indicator panel incorporating a conventional earth inductor compass directional indicator instrument. When the camera driftsight is oriented in such a manner that the motion of the earth image is parallel to the radical axis of the driftsight said earth inductor compass directional indicator instrument will indicate to the pilot of the aircraft whether or not the aircraft is travelling in a direction with respect to the earth corresponding to a predetermined compass course for which the compass has been initially adjusted and which it is desired to fly. Said conventional earth inductor compass directional indicator instrument is conventionally adapted to also indicate in which direction the aircraft must

be turned to cause it to travel along said predetermined compass course in the event the heading of the aircraft is not correct.

A means is provided whereby the said earth inductor compass brushes may be adjusted for any desired compass course which it may be desired to fly, further means being provided to indicate the heading for which said compass brushes are initially adjusted.

With the navigational method herein disclosed the aircraft may be readily flown on a predetermined compass course along the earth regardless of wind conditions, as the aircraft is automatically placed at the proper angle of crab to compensate for cross-winds when the motion of the image on the ground glass of the driftsight is parallel to the drift lines, or radical lines, on said ground glass and the earth inductor compass indicator instrument shows the aircraft to be following the said predetermined compass course, or on course.

While the reflex type of aerial photographic camera is best adapted for the application of the navigational method herein disclosed, other types of aerial photographic cameras may be provided with suitable view finders, or driftsights, or equivalent means, and used in conjunction with the camera mountings herein disclosed.

The camera driftsight preferably includes means whereby the mechanism therein may be caused to periodically function to cause the exposure of a negative, the interval between exposures being determined by a mechanism which has been conventionally termed an intervalometer. Means are included in the camera driftsight to manually vary the frequency with which the intervalometer causes the occurrence of the exposure of a negative, said means being adapted to be synchronized with the velocity of motion of the image on the ground glass.

The camera driftsight, disclosed herein and elsewhere as noted, also includes means for measuring the distance of travel of the image on the ground glass between exposures to enable the operator to manually trip the camera mechanism at intervals of time corresponding to the travel of the said image between two lines defining said distance. Means are also provided to adjust the location of one of said lines to vary said distance in accordance with the amount of picture overlap desired.

The camera driftsight herein disclosed, incorporates means whereby, when the camera is being automatically controlled by the intervalometer mechanism and the interval of time between the occurrence of exposures is determined thereby, a warning of each impending exposure is given to both the operator of the camera driftsight and the pilot of the aircraft.

The operator of the camera driftsight is thereby enabled to exercise particular diligence in the levelling of the camera at the time of the exposure and, further is enabled to change the orientation of the radical axis of the camera with respect to the longitudinal axis of the aircraft fuselage at a time which will least interfere with the stabilized condition of the aircraft and the levelled condition of the camera at the time of the occurrence of an exposure. The pilot of the aircraft is thereby enabled to avoid maneuvering the aircraft at a time of the occurrence of an exposure, further contributing to the accomplishment of improved performance on the part of the operator of the camera driftsight. Any change in the course of the aircraft introduces an acceleration component which is incidental to such maneuvering and which causes an erratic indication of the level bubble, with the result that an exposure made at such a time will result in a tilted, or distorted, photograph. The same warning means is also caused to function when the camera is manually tripped to cause the exposure of a negative.

Camera driftsight

The camera driftsight 1 includes a housing incorporating a chamber 10 from which all extraneous light is excluded, except that light which is projected onto the film therein by the lens when an exposure of a negative is caused to take place. At substantially all times when a negative is not being exposed the image projected by the lens is reflected in focus on ground glass 11 by means of mirror 12. The lens is 13. Said image may be observed by the operator of the camera driftsight through window 14 in conjunction with mirror 15, which is supported by a portion of the camera driftsight housing enclosing the chamber 16 that functions as a viewing hood. The reflex camera shown is, therefore, essentially employed as a driftsight, and the navigational method herein disclosed is, therefore adaptable for use in conjunction with any driftsight which provides an equivalent means for viewing an earth object or an image of the earth, herein for convenience termed the "earth image." For reasons before set forth herein levelling of the camera driftsight is imperative, and is accomplished in conjunction with reference to level bubble 53, see Fig. 1. The principal axis of lens 13 is in a vertical position when the camera is properly levelled.

The bottom of the aircraft incorporates an opening of sufficient size to clear the field of light included within the angle covered by lens 13, sufficient clearance being provided to allow for the normal amount of motion of the camera driftsight with respect to the aircraft occasioned by levelling the driftsight. The lens is preferably centered over said opening when the longitudinal axis of the aircraft fuselage is in a horizontal position and the camera driftsight is in a levelled position.

Said ground glass 11 is preferably disposed in a vertical plane, or parallel to the principal axis of lens 13, and is supported in a fixed position partly by means of a portion of the camera housing 16 and strips 17, which are attached to the said housing by means of screws, see Fig. 13.

Referring to Figures 13 and 16, shaft 18 is driven by means of a conventional intervalometer mechanism 19 and is journaled in bearings 19a. Said shaft incorporates a roller 20 which is fixed to shaft 18 and drives a transparent endless belt 21, which is suitably guided by rollers 22 which turn freely in bearings 23.

One side of said belt 21 is sufficiently close to ground glass 11 to cause lines 24 on said belt 21 to be clearly visible through said ground glass 11 and to appear to be superposed on the earth image. The other side of said belt is at a sufficient distance from ground glass 11 to cause the lines 24 on said belt to be so indistinct that they are substantially invisible. The thickness of said belt 21 is made such that the refraction of the light passing through it does not materially affect the focus of the image on ground glass 11.

As the aircraft moves forward the image on ground glass 11 will appear to travel from the top of said ground glass to the bottom thereof, and

belt 21 is driven by the conventional intervalometer mechanism 19 in such a manner that the side of said belt which is adjacent said ground glass will travel in the same direction. The speed with which said belt is driven is controlled by means of knob 27, which controls the intervalometer mechanism 19 in a conventional manner. By synchronizing the motion of lines 24 on belt 21 with the speed of motion of the earth image on said ground glass 11, accomplished by properly adjusting knob 27, the camera tripping mechanism including a lever is actuated by cam 29a, which is fixed on shaft 18, each time shaft 18 makes one revolution, with the result that a photographic exposure of a negative is caused to occur. A means is thereby provided for causing a sequence of photographic exposures to be made at intervals of time having a predetermined relationship with the velocity of motion of the earth image on ground glass 11, since shaft 18 is continuously driven by the conventional intervalometer mechanism.

A means is also provided to enable the operator of the camera driftsight to manually trip the camera mechanism for the purpose of taking a sequence of photographic exposures in accordance with a predetermined relationship with the motion of the aircraft in a forward direction and the resultant motion of the image on ground glass 11. To cause the resultant photographs to overlap each other by a predetermined amount it is necessary for an exposure to be made each time the earth image on ground glass 11 travels a predetermined distance on said ground glass. This is accomplished by tripping the camera mechanism each time a discrete portion of the the earth image is observed to move from the upper boundary of said ground glass to exposure guide line 29, which is located in sufficiently close proximity to said ground glass to be clearly visible to the operator of the camera driftsight and to appear as being superposed on the earth image. In conventional practice requirements vary in connection with the desired predetermined amount of overlap of successive pictures. The line 29 is accordingly made adjustable.

Adjustment of the location of line 29 is accomplished by manually rotating knob 30 and thereby raising or lowering the transparent strip 31 which incorporates said line 29. This is accomplished in conjunction with the resultant rotation of shaft 32, to which knob 30 is fixed, and gearing 33, and the shaft 34 which incorporates threads 35, by means of which the threaded member 36, to which one end of strip 31 is attached by means of screws, is correspondingly raised or lowered. The other end of strip 31 is attached by means of screws to a similar member 37 similarly threaded with opposite hand threads engaging threads 38 on shaft 40, which is caused to rotate simultaneously with shaft 34 by means of gearing 41, shaft 42 which is suitably journaled in bearings 43 and 44, and gearing 45. The line 29 may be engraved in strip 31 and rendered opaque by filling it with a suitable paint.

As herein disclosed, ground glass 11 is disposed in a vertical plane that is parallel to the principal axis of lens 13. Mirror 12 is accordingly disposed at 45 degrees with respect to the principal axis of lens 13. Mirror 15 is disposed at 45 degrees with respect to ground glass 11. Other angular combinations of said ground glass and said mirrors and said lens axis may be resorted to and will be obvious to one skilled in the art. The smooth side of ground glass 11 preferably faces mirror 15.

Suitable housings 46 are provided to prevent light from entering chamber 10 while the earth image is being reflected onto ground glass 11.

Referring to Fig. 19, ground glass 11 incorporates a number of lines and calibration numerals which may be engraved in said ground glass 11 and rendered opaque by filling the engraved grooves with a suitable material such as paint.

Inclined drift lines 47 are provided on the viewing field of ground glass 11, that extend at different angles to main axis or radical axis lines 48, to enable the operator of the camera driftsight to estimate the drift angle through the agency of the apparent movement of the image of the terrain below the aircraft. This he can do by observing which of the drift lines the image is moving along or parallel with. This makes it possible to estimate substantially the exact amount of angular correction in the orientation of the camera that should be made to bring the camera quickly into the proper oriented position to actually advance straight ahead and take pictures that will not be cocked on the film. This orientation will also be indicated on a scale to be described hereinafter.

The main axis lines, or radical lines 48, are parallel to the principal axis of the lens 13, if the viewing field is normally in a verical plane. If the viewing field were in a horizontal plane, these radical lines 48 would lie in planes substantially parallel to the principal axis of the lens. These lines 48 define the main or radical axis of the camera driftsight which corresponds to the fore-and-aft line, that is to say, the line of advance of the aircraft in flight in the absence of any drift.

Lines 49 are normal or at right angles to lines 48, and are provided to facilitate location of line 29. Belt 21 incorporates a line 50 which is parallel to lines 48, and serves the same function.

Ground glass 11 also incorporates calibrations 50a for use in conjunction with indicator pointer 51 which may be employed to indicate at all times to the operator of the camera driftsight, the setting for a vital part of the camera mechanism, such as the shutter.

Other combinations of lines and numerals, which are inverted to appear as conventional numerals when viewed in conjunction with mirror 15, may be resorted to.

The adjustment of line 29 may be employed to measure the distance of travel of the earth image from the upper boundary of the ground glass 11 and, in conjunction with a suitable timing means, such as a stop watch, further employed to determine the ground speed of the aircraft in a conventional manner.

Referring to Figures 1 and 12, the instrument panel of the camera driftsight includes the following:

Referring also to Fig. 20, a conventional earth inductor compass directional indicator instrument may be provided to enable the operator of the camera driftsight to observe the facility with which the pilot of the aircraft is responding to the indication of said instrument 52. Said earth inductor compass directional indicator instrument is preferably identically similar to the directional indicator provided in the remote indicator panel 5 for the pilot's reference.

An opening in the top of the camera driftsight housing is provided for a level indicator 53, which may be of a common "bubble" type.

Another opening in said housing is flanged to support a light dispersing lens 54, which is secured in position by means of the threaded annular ring 55, which is screwed therein.

Directly under lens 54 is a light bulb 55a, which may be distinctively colored, mounted in a conventional light bulb socket 57 that is attached to the camera driftsight housing by means of screws.

Leading into said socket 57 and establishing electrical connection with electric light bulb 55a are insulated electric wires 59 and 60, which run in a common cable supported at intervals by means of clips 58, respectively attached to the camera driftsight by means of screws.

Referring also to Fig. 14, wire 59 runs to electric switch member 61, where an electrical circuit is closed shortly before and for the duration of the operation of exposing a negative. Wire 66 runs to a source of supply of electricity preferably located remotely from the camera driftsight.

Window 14 is supported in position by an integral flanged portion of the housing of the camera driftsight 1 and is secured in position by means of a rectangular frame 62 which is attached to said housing by means of screws.

Located at opposite sides of the camera driftsight 1 are handles 63, adjacent one of which lever 64 is provided to enable the operator of the camera driftsight to actuate certain mechanism therein, elsewhere disclosed as noted, for the purpose of exposing a negative.

Exposure warning signal

Referring to Fig. 14, for each revolution of shaft 18 the cam 29a is caused to actuate electric switch member 61, which is a leaf spring and is insulated from the camera driftsight housing by the block of insulating material 65 which is attached to said housing by means of screws which pass through holes therein made sufficiently large to prevent said screws from making electrical contact with said housing. Attached to one of said screws is the insulated electric wire 66 which makes electrical contact with said screw and is prevented from making such contact with said housing by means of an insulating washer. Said wire 66 runs to a source of supply of electricity.

When actuated by cam 29a as shown in Fig. 14, by means of broken lines, switch member 61 is caused to make electrical contact with the head of screw 67, which is insulated from the camera driftsight housing by means of insulating washers and passes through a hole in said housing made sufficiently large to prevent electrical contact with the screw at that point. Making electrical contact with said screw 67 and attached thereto by means of a nut is insulated electric wire 59.

When electric switch member 61 is caused to make electrical contact with the screw 67 an electrical circuit is closed between wires 66 and 59, thereby causing to be illuminated the light bulb 55a located in the camera driftsight instrument panel, and also causing to be illuminated the light bulb located behind the glass covered opening 68 in remote indicator panel 5. Both the pilot of the aircraft and the operator of the camera driftsight are thereby warned of the impending exposure of a negative and maneuvering of the aircraft can be avoided at this time, thereby facilitating levelling of the camera as previously noted.

Actuation of the manual tripping lever 64 to expose a negative also causes to be illuminated the light bulb 55a and the light bulb located behind glass covered opening 68 in remote indicator panel 5. Lever 64 is fixed on shaft 69 to which is also fixed the lug 70 which is adapted to actuate a conventional electric switch 71, see Fig. 17, and thereby close an electrical circuit between wires 59 and 66 which are attached to switch 71. Both the pilot of the aircraft and the operator of the camera driftsight are therefore warned when an exposure of a negative is manually caused to occur. The pilot is thereby enabled to maneuver the aircraft immediately after an exposure has taken place and is enabled to plan such maneuvering in such a manner that levelling of the camera driftsight is facilitated.

Camera driftsight mount

Referring to Figures 1, 6, and 21 to 26 inclusive, the mount for the camera driftsight is indicated by the numeral 2.

Included in the mount are the elements 9 for driving the reflex camera and intervalometer mechanisms.

Also included in the mount is the earth inductor compass controlling mechanism 3.

Said mount 2 is a structure in which the camera driftsight 1 is pivotally and rotatably supported and from which said camera driftsight may be readily removed.

The pivotal mounting of the camera driftsight 1 permits it to be tilted universally for levelling purposes. The mount may be rotated in cooperation with the earth inductor compass 72 to accomplish the navigation of the aircraft. Said rotation is about a substantially vertical axis, and the camera driftsight is thereby oriented in such a manner that the radical axis, defined by radical lines 48 on ground glass 11, is maintained parallel to the motion of the earth image for the accomplishment of the navigational function.

An earth inductor compass, or other type of remotely controllable compass, is adapted to be driven in accordance with the rotation of mount 2 in such a manner that, in the case of the earth inductor type of compass, the brushes therein are caused to maintain a constant angular relationship with respect to the radical axis, or heading, of the driftsight camera, and said compass is thereby caused to indicate whether or not the direction of motion of the aircraft with respect to the earth is in accordance with a predetermined compass course when the radical axis of the camera driftsight is maintained parallel to the direction of motion of the earth image and the camera driftsight is in a level position. If the aircraft is following said predetermined compass course the conventional earth inductor compass directional indicator instrument pointer will, conventionally, be centered. If the aircraft is not following said predetermined compass course said compass indicator instrument pointer will be deflected either to the right or left of centered position, thereby indicating to the pilot of the aircraft in which direction the aircraft must be turned to cause it to follow said predetermined compass course.

Means are provided for initially adjusting the angular relationship between the earth inductor compass brushes and the radical axis of the camera driftsight in accordance with any desired compass heading, or compass course which it may be desired to follow.

The camera mount 2 includes the following component parts:

Referring to Figures 1, 6, 7 and 21, the housing for the camera driftsight incorporates integral supporting lugs 73 located on opposite sides thereof and attached to respective bearing members 74 by means of screws 75. Intermediate said lugs 73 and bearing members 74 cushions 75a and washers 76 are respectively provided to support the driftsight and to dampen out aircraft vibration which might otherwise have a detrimental effect on the performance of the camera driftsight. Said cushions are fabricated from a suitable resilient material such as sponge rubber.

The camera driftsight is free to pivot about one axis defined by the journals 77 respectively bearing in members 74, and may be tilted about said axis for levelling purposes.

Journals 77 respectively incorporate knurled knobs 78, which are fixed thereon. Referring to Fig. 25, pressure exerted on journals 77, respectively, by compression springs 79 normally maintains said journals 77 in their sockets in the bearing members 74. Said journals 77 may be fully retracted into their respective bosses 80 by manually pulling on knobs 78, thereby providing means to permit removal of camera driftsight 1 from mount 2.

The camera driftsight is also free to pivot about another axis, which is preferably normal to, or at right angles to, the first mentioned axis, and by pivoting or tilting the camera driftsight about either or both of said axes said camera driftsight may be universally tilted to permit levelling thereof.

The last mentioned axis about which the camera driftsight may be tilted for levelling purposes is defined by journal 81, (see Figs. 1 and 24) which is an integral part of a yoke, or trunnion member, 82 which also incorporates the integral bosses 80. Said journal 81 is supported in a bearing boss that is an integral part of column 83 which supports the trunnion 82 and the camera driftsight 1, and is retained in said bearing boss by means of threaded collar 84.

By tilting the camera driftsight 1 about either of the aforementioned axes, or about both axes in combination, said camera driftsight may be manually tilted as if mounted on a universal joint, by the operator in conjunction with the observed indication of a suitable levelling reference, such as level bubble 53, for the purpose of maintaining a predetermined axis of the camera driftsight, such as the principal axis of the lens, in a substantially fixed predetermined relationship with respect to the earth. It is imperative that such a relationship be maintained to avoid a spurious indication of drift, which might otherwise be caused by motion of the camera driftsight with respect to the earth and the resultant motion of the earth image not in accordance with the rate of progress of the aircraft in a forward direction.

Column 83 is an integral part of a carriage in the form of an annulus 85, which is a flanged ring preferably supported at three points equally spaced 120 degrees apart by means of rollers 86 (see Fig. 28) which are respectively free to turn about shafts 87 journaled in track 88.

Adjacent each of said rollers 86 additional rollers 89 are provided for centering carriage 85 over track 88. Said rollers 89 are free to turn about shafts 90 which are fixed in track 88.

Disengagement of carriage 85 from track 88 is prevented by means of lugs 91, preferably equally spaced 120 degrees apart. One end of each of said lugs 91 is attached by means of a screw to track 88, the other end being shaped as shown to engage a groove in the flanged portion of carriage 85.

Track 88 incorporates integral lugs 92 by means of which said track 88 and the elements attached thereto may be fastened to the floor of the aircraft, preferably located in such a manner that the principal axis of lens 13 coincides with the center of a suitable opening provided in the floor of said aircraft.

Attached to carriage 85 by means of screws is the annular ring 92a which secures in position a cloth fabric apron 93 which may be drawn up and over lower protruding portions of camera driftsight 1 and secured in position by means of the hookless or zipper fastener 94. Said apron 93 is preferably fabricated from a suitable nonporous material of a flexible nature and provides a means of sealing the cabin of an aircraft and excluding wind which would otherwise blow through the opening provided in the floor of the aircraft to permit observation of the earth in conjunction with camera driftsight 1. Such wind is extremely annoying to the operator of the camera driftsight and impairs efficiency of operation.

Track 88 includes a spring actuated brake mechanism for holding carriage 85 in any desired position of orientation about the vertical axis. When said brake is released carriage 85 may be rotated freely to orient, or crab, the camera driftsight in accordance with the motion of the image on ground glass 11 and to cause said motion to be parallel to radical lines 48 to accomplish the navigational function.

Brake pedal 95 is fixed on shaft 96 which is journaled in a bearing hole or socket in track 88 and which incorporates an integral lever 97, a portion of which is normally caused to bear against the under side of carriage 85 by means of the pressure exerted on lever 97 by compression spring 98a.

Earth inductor compass controlling mechanism

Referring to Figures 2, 3, 4, 5, 6, 8, 9, 10, 11, 21, 22 and 23, the earth inductor compass controlling mechanism 3 is adapted to drive the control shaft 98 of a conventional earth inductor compass 72 in such a manner that said compass 72 is caused to indicate the orientation in azimuth of a predetermined axis, or radical axis, of the camera driftsight 1 as defined by radical lines 48 on ground glass 11 or other equivalent means.

The duties of the operator of camera driftsight 1 to accomplish the navigation of the aircraft involve the maintenance of the camera driftsight 1 in a levelled condition, as previously described herein, and the maintenance of the orientation of said camera driftsight 1 in azimuth in such a manner that the earth image on ground glass 11 travels in a direction that is parallel to the radical lines 48 on said ground glass. It is also necessary for said operator to initially adjust the compass controlling means 3 in accordance with the desired compass course.

The duties of the pilot of the aircraft to accomplish the navigation of the aircraft include the control of the heading and fore-and-aft axis, or apparent direction of travel thereof, in such a manner that the pointer 99 of the conventional compass directional indicator instrument 100 is at all times centered.

As long as the operator of the camera driftsight

fulfills the prescribed duties the compass instrument 100 is caused to indicate the direction of travel of the aircraft with respect to the earth.

The provision of suitable means to permit the levelling of the camera driftsight 1 is a vital part of the novelty of this invention and is imperative for reasons previously described herein.

A means is provided to permit the compass controlling mechanism 3 to be initially adjusted in accordance with any desired compass course, and is accomplished by varying the relationship between the orientation of the brushes in the compass 72 and the radical axis of the camera driftsight 1.

An integral part of track 88 is the housing 101 containing the mechanism for controlling and driving the controlling means for compass 72. A cover plate 102 is attached to housing 101 by means of screws and includes an opening bounded by the side 103 to permit observation of compass cards, or dials, 136 and 141.

Integral with carriage 85 is toothed segment or arcuate rack 104a, indicated by means of broken lines in Fig. 21. This segment or rack 104a extends along a sufficient portion of the circumference of the carriage 85 to provide for the maximum range of rotational motion thereof required in practice. In the present instance this segment is indicated as extending through 180°.

Referring also to Figures 3 and 10, rack 104a is normally engaged by pinion gear 105 which is fixed on sleeve 106 which is journaled in a bearing hole in housing 101.

Referring particularly to Figures 8 and 11, pedal 107 is fixed on shaft 108 which is journaled in a socket or hole in housing 101 and incorporates integral lever 109, the upper extremity of which engages the slotted end of link 110 by means of pin 111 which is press fitted into holes provided in the slotted portion of said link 110 and passes through a slot provided in lever 109.

Said link 110 is free to slide in a guide opening provided in the cross member 112, which is integral with cover plate 102. Referring particularly to Figure 11, fixed on said link 110 is the shifting yoke 113, which is normally held in position to cause pinion 105 on sleeve 106 to engage the segment or rack 104a by means of the pressure exerted on yoke 113 by compression spring 114. The lower end of yoke 113 straddles sleeve 106, its forks riding in a groove provided therein between integral flanges.

Pedal 107, in conjunction with shaft 108, lever 109, pin 111, link 110, shifting yoke 113 and sleeve 106, provides a means whereby sleeve 106 may be caused to slide in housing 101 to disengage pinion 105 from segment or rack 104a for the purpose of adjusting the orientation of the brushes in compass 72 to vary their angular relationship with respect to the radical axis of the camera driftsight 1 in accordance with any desired compass course.

Referring to Figs. 10 and 11, sleeve 106 is fixed to shaft 116 by means of pin 117 which rides in slot 118 in sleeve 106. Adjacent to pinion 105 shaft 116 is journaled in a bearing lug 119 which is an integral part of track 88. Said shaft 116 passes through sleeve 106 and is journaled in a hole in housing 101, adjacent to which there is fixed on shaft 116 collar 120 which retains shaft 116 in position.

Referring also to Fig. 3, shaft 116 protrudes from housing 101 and has a connection for driving it. In the present instance it is made square at that point to fit into a square hole provided in the socket 121 that is an integral part of earth inductor compass brush control shaft 98. Said shaft 98 incorporates a housing 123 having a coupling 124 which is screwed onto a threaded boss that is an integral part of housing 101, thereby providing means for attaching shaft 98 to shaft 116.

Fixed on shaft 116 is worm 125 which engages worm gear 126 having a sleeve 127 rigid with a gear 128 and a bevel gear 129. This sleeve 127 is free to rotate on shaft 130, see Fig. 3, which is fixed in housing 101.

Referring to Figures 5 and 8, the bevel gear 129 engages bevel gear 131 which is fixed on shaft 132 that is mounted for rotation in housing 101. Also fixed on shaft 132 is worm 133 which engages gear 134 fixed on sleeve 135, see Fig. 5, which is mounted for rotation in member 112.

Referring to Figures 4, 8 and 10, integral with sleeve 135 is an annular compass dial or card 136. The gear ratio between shaft 116 and said compass card 136 is preferably such that the angular motion thereof corresponds exactly to the angular motion of carriage 85, in which case suitable numerals, such as 137, see Fig. 4, may be provided by painting them, together with suitable calibration lines, on said card 136. The calibration line which coincides most nearly with line 138 on cover plate 102 will then indicate within ten degrees the heading for which the compass 72 has been adjusted, it being necessary to orient the camera driftsight at zero degree of crab to read said card, or dial, properly.

Gear 128 on sleeve 127 engages gear 139 fixed on shaft 140, see Fig. 10, which passes up through the bore of sleeve 135.

Referring also to Fig. 4, integral with shaft 140 is compass dial or card 141. The gear ratio between shaft 116 and compass card 141 is preferably such that said compass card 141 is caused to make one complete revolution for each ten degrees of rotational motion made by carriage 85, in which case suitable calibrations such as 142, see Fig. 4, may be provided by painting lines and numerals on card 141. The line 142 on card 141 which most nearly coincides with line 138 on cover plate 102 will then indicate within one degree the heading for which the brushes in the compass 72 are adjusted, it being necessary to orient the camera driftsight at zero degree of crab to read said card 141 properly.

The upper surface of carriage 85 is provided with suitable calibrations 143 (see Figs. 4 and 32), which may be painted thereon, and by means of which the orientation, or angle of crab, of carriage 85 with respect to track 88 is indicated in conjunction with reference to pointer 144 fixed in housing 101. When carriage 85 is at zero degree, or angle, of crab, the "0" calibration on carriage 85 will coincide with pointer 144.

When carriage 85 is crabbed, that is, oriented, through ten degrees of rotational motion about the perpendicular, or vertical, axis, the calibration line designated by the numeral 10 will coincide with pointer 144, and so forth, thereby providing means for indicating the number of degrees of rotation which carriage 85 is crabbed in relation to track 88.

The installation of camera driftsight 1 and mount 2 in an aircraft is preferably with track 88 fixed thereto and oriented in such a manner that, when the zero calibration on carriage 85 coincides with pointer 144 the radical axis of camera driftsight 1, defined as previously described herein, is parallel to a vertical plane pass-

ing through the longitudinal axis of the aircraft fuselage.

Mount for conventional camera and driftsight

Referring to Figures 32 to 36, inclusive, and 38 to 40, inclusive, a modified form of camera mount 6 is adapted to support a conventional aerial photographic camera mounting gimbal wherein is mounted a conventional aerial photographic camera 7 provided with a drift indicator, or driftsight, 8, and thereby adapted for use in conjunction with the method of navigation herein disclosed.

Referring to Figures 37 and 41 to 45 inclusive, the construction of the driftsight 8 will now be described.

Housing 145 incorporates in the bottom thereof an opening into which is screwed the threaded flanged ring 146 having a flange on the inside thereof for supporting lens 147, which is secured in position by means of the threaded ring 148.

Housing 145 incorporates at its upper side a recessed opening bounded by sides 149, see Figs. 42 and 45, and completely covered by ground glass 150, which is secured in position by rectangular frame 151 which is attached to housing 145 by means of screws. Said ground glass incorporates lines which may be engraved thereon and rendered translucent by filling the engraved grooves with a suitable material.

Said lines on ground glass 150 include a radical line, or drift line, 152, the center line 153 at right angles to, or normal to, line 152, and overlap lines 154 which divide into ten equal parts the image of the earth which is projected in focus on ground glass 150 by lens 147. Said lens 147 is focused at infinity, preferably, and preferably produces on ground glass 150 an image that is identical to and proportional to the image recorded in the camera when a photographic exposure is caused to occur.

The side of housing 145 incorporates a slot bounded by the side 154. Capable of sliding in said slot is gib 155, an integral part of which is the threaded member 156, onto which is screwed lock nut 157 which secures gib 155 in position.

Fabricated from a suitable transparent material is overlap pointer 158 attached by means of screws to gib 155. Said pointer 158 incorporates overlap line 159, which may be engraved therein and rendered readily visible by filling it with an opaque material. The line 159 is located in sufficiently close proximity to the under side of ground glass 150 to permit said line to be clearly observed through said ground glass 150 and to appear as being superposed on the earth image. When pointer 158 is secured in position line 159 thereon is adapted to be parallel to center line 153.

The driftsight 8 is attached to housing 160 of camera 7 by means of lugs integral with housing 145 and screws.

Referring to Figures 32 to 36 inclusive and 38 to 40 inclusive the construction of the modified camera mount 6 will now be described.

The conventional aerial camera 7 may be tilted universally in conjunction with gimbal 161, of conventional construction, for the purpose of levelling said camera 7, accomplished in conjunction with level bubble 162, see Fig. 38, a conventional part of said camera 7. When camera 7 is levelled the driftsight 8, attached thereto, is also levelled, preferably with the ground glass in a horizontal plane and the principal axis of lens 147 in a vertical position. The principal axis of lens 147 is also preferably parallel to the principal axis of the lens of camera 7. The accuracy of observation of the drift of the aircraft is thereby facilitated.

Gimbal 161 incorporates journal members 163 which are respectively journaled in bearings surmounting supporting columns 164, which are integral parts of modified carriage 165.

Carriage 165 is identically similar to carriage 85, previously described, except for the omission of column 83, a part of mount 2, apron 93 and parts related thereto also being omitted, and except for the addition of columns 164.

Modified carriage 165 is capable of being rotated about an axis perpendicular thereto, being supported and centered by rollers 86 and 89 in a manner identically similar to mount 2 previously described herein. Track 166 is identically similar to track 88, of mount 2, except for the omission of driving mechanism 9.

An integral part of track 166 is housing 167, which is identically similar to housing 101 of mount 2, and provided with cover plate 102.

The housing 167 contains means for controlling a conventional earth inductor compass, said means corresponding identically in construction and operation with the earth inductor compass controlling mechanism 3, previously described herein.

The application of the navigational method herein described to mount 6, camera 7 and driftsight 8, will be obvious to anyone skilled in the art from the previous disclosure herein, and it generally, involves a procedure identically similar to that employed with camera driftsight 1, mount 2 and earth inductor compass controlling mechanism 3.

Modified altimeter

Referring to Figures 1, 29 and 31, the control panel of the camera driftsight 1 includes an altimeter unit 4 of a conventional type modified to permit indication of the reading thereof to be observed by the pilot of the aircraft in conjunction with remote indicator panel 5.

Altimeters conventionally installed in the instrument panel of aircraft have usually been rendered inaccurate in their indication due to improper maintenance and vibration of the aircraft. It is imperative that the aircraft be maintained as constantly as possible at a given predetermined altitude for aerial photographic mapping purposes. For the purpose of further incorporating as nearly as possible in a unified assembly all of the elements required for aerial photographic mapping, and for the purpose of further enabling the operator of the camera driftsight 1 to control the vital factors involved said altimeter is incorporated in the driftsight camera 1.

The following parts are relative to the modification of the conventional altimeter, and are obviously applicable to permit similar modification of other types of altimeters than that shown and described herein.

The conventional altimeter pointer, or arm, 168 extends through a slot in altimeter indicator panel 169 and is attached in fixed relationship to shaft 170, which actuates said arm 168.

The shaft 170 is modified by the addition of a commutator, which is fixed thereon and is of composite construction, consisting of metal segments 171 and 172 and the common boss 173 thereof which are molded integral with segments 174 and 175 comprised of a suitable dielectric

plastic material provided to give the commutator the configuration of a circular disc, which may be relatively thin. Segments 171 and 172 and the common boss 173 thereof comprise an integral member having good electrical conductive qualities.

In electrical contact with segment 172 of the commutator is metal roller 176 which is free to turn about metal pin 177 which is press fitted into a hole formed by the bent over end of metal leaf spring 178. The other end of leaf spring 178 is bent to form a base that is attached to supporting member 179 by means of metal rivet 180, which also secures in position the insulated electric wire 185 which runs to a source of supply of electricity. The dimensions of segment 172 are such that roller 176 is at all times in electrical contact therewith throughout the range of motion of pointer 168, positive contact between roller 176 and segment 172 being assured by the pressure exerted by leaf spring 178 on roller 176.

Supporting member 179 is fabricated from a suitable dielectric material and is rigidly attached to the sides of the conventional altimeter housing.

In contact with the opposite edge of said commutator is metal roller 182, which is free to turn about a metal pin 183 which is fixed in a hole formed by the bent over end of metal leaf spring 184, which exerts a pressure on roller 182 and causes it to at all times maintain a positive contact with the commutator. The other end of leaf spring 184 is bent to form a base that is attached to supporting member 179 by means of metal rivet 186 which also secures in position the insulated electric wire 187 which runs to an electric light bulb located behind glass covered opening 188 in remote indicator panel 5. Electrical connection is established between wire 187 and roller 182.

Also in contact with the edge of said commutator is metal roller 189, which is free to turn about metal pin 190 which is fixed in a hole formed by the bent over end of metal leaf spring 191, which exerts a pressure on roller 189 and causes it to at all times maintain positive contact with said commutator. The other end of leaf spring 191 is bent to form a base that is attached to supporting member 179 by means of metal rivet 192 which also secures in position insulated electric wire 193 that runs to an electric light bulb located behind glass covered opening 194 in remote indicator panel 5. Electrical contact is established between wire 193 and roller 189.

Also in contact with the edge of said commutator is metal roller 195, which is free to turn about a metal pin 196 that is fixed in a hole formed by the bent over end of metal leaf spring 197 which exerts a pressure on roller 195 and causes it to at all times maintain positive contact with said commutator. The other end of leaf spring 197 is bent to form a base that is attached to supporting member 179 by means of metal rivet 198, which also secures in position insulated electric wire 200 which runs to an electric light bulb located behind glass covered opening 199 in remote indicator panel 5. Electrical connection is established between wire 200 and roller 195.

Rollers 182 and 195 are preferably so disposed that commutator segment 171 establishes electrical contact only with roller 189 when pointer 168 is in position to indicate that the aircraft is at the elevation for which altimeter 4 has been adjusted, thereby causing to be illuminated only the light bulb located behind glass covered opening 194 on remote indicator panel 5 when the aircraft is at the elevation for which altimeter 4 has been adjusted.

When the aircraft is above the elevation for which altimeter 4 has been adjusted, commutator segment 171 is caused to establish electrical contact with rollers 189 and 195, thereby causing to be illuminated electric light bulbs respectively located behind glass covered openings 194 and 199 in remote indicator panel 5.

When the aircraft is below the elevation for which altimeter 4 has been adjusted, commutator segment 171 is caused to establish electrical contact with rollers 182 and 189, thereby causing to be illuminated electric light bulbs respectively located behind glass covered openings 188 and 194 in remote indicator panel 5.

Remote indicator panel

Referring to Figures 29 and 30, remote indicator panel 5 is a unit which, for aerial mapping purposes, may be attached to a convenient portion of the aircraft in plain sight of the pilot thereof and comprises a condensed assembly of instruments essential to the piloting of aircraft for aerial photographic mapping purposes, thereby facilitating the control and operation of the aircraft.

Instrument panel member 201 is a metal housing, an integral part of which is top housing 202, which is shaped to provide a means for attaching said indicator panel unit to a convenient portion of the aircraft structure, such as the aircraft instrument panel.

Knurled knob 203 is an integral part of metal screw 204 which is screwed through lug 205, an integral part of housing 202 and has fixed thereon a flange 206. Panel member 201 extends above the top of housing 202 to provide a clamp member 207 which may be made fast to a portion of the aircraft structure by means of tightening screw 204.

The remote indicator panel 5 housing is completed by the addition of housing member 208, a drawn sheet metal member that is attached to panel member 201 and housing member 202 by means of screws.

Panel member 201 incorporates an opening wherein there is installed in a conventional manner the conventional earth inductor compass directional indicator instrument 100, to which are connected electric wires 209 that run in a common cable together with other wires referred to above, to a conventional earth inductor compass 72 which is remotely installed in a conventional manner in the aircraft and is controlled by mechanism referred to above, incorporated in camera mount 2. Said common cable passes through an opening provided in the bottom of housing member 208.

Panel member 201 includes another opening covered with glass 199, that may be distinctively colored, behind which is an electric light bulb installed in a conventional light bulb socket to which are connected the electric wire 200, which runs to altimeter 4 in camera driftsight 1 and also electric wire 210 which runs to a source of supply of electricity. Said light bulb is caused to be illuminated when the aircraft is above the elevation for which altimeter 4 has been adjusted.

Panel member 201 includes another opening covered with glass 194, that may be distinctively colored, behind which is an electric light bulb installed in a conventional light bulb socket to

which are connected the electric wire 193, which runs to altimeter 4 in camera driftsight 1 and also electric wire 210 which runs to a source of supply of electricity.

Panel member 201 includes another opening covered with glass 188, that may be distinctively colored, behind which is an electric light bulb installed in a conventional electric light bulb socket to which are connected the electric wire 187 which runs to altimeter 4 in camera driftsight 1 and also electric wire 210 which runs to a source of supply of electricity. Said light bulb is caused to be illuminated when the aircraft is below the elevation for which altimeter 4 has been adjusted.

Panel member 201 includes another opening covered with glass 68, which may be distinctively colored, behind which is located an electric light bulb installed in a conventional light bulb socket to which is connected the wire 59, see Fig. 14, which runs to electric switch member 61 and also to electric switch 71, see Fig. 17. Also attached to said socket is wire 210 which runs to a source of supply of electricity. Said light bulb is caused to be illuminated when an exposure of a negative takes place in conjunction with the operation of incidental mechanism in camera driftsight 1, thereby warning the pilot of the aircraft to avoid maneuvering of the aircraft at that time for reasons elsewhere recited herein.

Mounted on panel 201 there is also provided a conventional aircraft flight instrument 211, a conventional aircraft bank indicator being shown and described for illustrative purposes. It is conceived that panel 201 may be enlarged to include a unified assembly including other aircraft instruments compactly grouped for convenience of the pilot of the aircraft to facilitate control and operation of the aircraft.

This application is a division of my prior application, Serial No. 750,311, filed October 27, 1934, entitled Aerial photographic cameras and navigation apparatus, on which my Patent No. 2,230,251 was issued February 4, 1941.

Certain modifications may appear to one versed in the art, but such modifications may well be made without departing from the spirit of the invention as defined in the following claims.

I claim:

1. In a system of the character described, an aerial camera, means for supporting the camera so that it is freely movable for orientation about two different axes, said camera having a lens mounted with its principal axis in a substantially vertical position, means for alternately exposing a photographically sensitized surface to a photographically projected image through said lens, and producing a physically visible image through said lens for observation; said camera also having a definite reference axis, which may be observed in relation with a distinctive portion of said image as it appears to move past, means for mounting said camera for orientation at will at all times to cause said axis to coincide substantially with the direction of the relative motion of the said distinctive portion of said image, and means for indicating the azimuth of said axis with respect to a predetermined compass course being flown by the aircraft.

2. In a navigation instrument for use on an aircraft, the combination of a movable frame member mounted to swing about a substantially vertical axis, and also for tilting, means for maintaining thereon a main reference axis line extending so that the terrain or image thereof moves in a general longitudinal direction along said reference line as the aircraft advances, means for maintaining a plurality of drift lines diverging from the main axis line at predetermined angles in the direction toward which the image of the terrain moves, said movable frame capable of being oriented on the said substantially vertical axis to bring any of the drift lines into substantial coincidence with the apparent direction of movement of the terrain to indicate the angle of drift.

3. In a navigation instrument for use on an aircraft, the combination of a movable frame member mounted to swing about a substantially vertical axis, and also for tilting, means for maintaining thereon a main reference axis line extending so that the terrain or image thereof moves in a general longitudinal direction along said reference line as the aircraft advances, means for maintaining a plurality of drift lines diverging from the main axis line at predetermined angles in the direction toward which the image of the terrain moves, said movable frame capable of being oriented on the said substantially vertical axis to bring any of the drift lines into substantial coincidence with the apparent direction of movement of the terrain to indicate the angle of drift, and a level indicator associated with the frame member for enabling the frame to be maintained in a substantially level condition when the angle of drift is being observed.

4. In a navigation instrument for use on an aircraft, the combination of a movable frame member mounted to swing about a substantially vertical axis, and also for tilting, means for maintaining thereon a main reference axis line extending so that the terrain or image thereof moves in a general longitudinal direction along said reference line as the aircraft advances, means for maintaining a plurality of drift lines diverging from the main axis line at predetermined angles in the direction toward which the image of the terrain moves, said movable frame capable of being oriented on the said substantially vertical axis to bring any of the drift lines into substantial coincidence with the apparent direction of movement of the terrain to indicate the angle of drift, and means for superposing transverse speed lines on said first named lines, and for advancing the same at an adjustable speed approximating the apparent speed of the image.

5. In a navigation instrument for use on an aircraft, the combination of a movable frame member mounted to swing about a substantially vertical axis, and also for tilting, means for maintaining thereon a main reference axis line extending so that the terrain or image thereof moves in a general longitudinal direction along said reference line as the aircraft advances, means for maintaining a plurality of drift lines diverging from the main axis line at predetermined angles in the direction toward which the image of the terrain moves, said movable frame capable of being oriented on the said substantially vertical axis to bring any of the drift lines into substantial coincidence with the apparent direction of movement of the terrain to indicate the angle of drift, a camera associated with said frame member, and means for superposing a transverse exposure guide-line on said first named lines as a guide to the navigator in timing the instant of taking photographs of the terrain.

6. In a navigation instrument for use on an

aircraft, the combination of a movable frame member mounted to swing about a substantially vertical axis, and also for tilting, means for maintaining thereon a main reference axis line extending so that the terrain or image thereof moves in a general longitudinal direction along said reference line as the aircraft advances, means for maintaining a plurality of drift lines diverging from the main axis line at predetermined angles in the direction toward which the image of the terrain moves, said movable frame capable of being oriented on the said substantially vertical axis to bring any of the drift lines into substantial coincidence with the apparent direction of movement of the terrain to indicate the angle of drift, a transparent strip with means for guiding the same along, and adjacent to, the said main axis line, and in the direction in which the image of the terrain moves, said strip having a transverse exposure guide line to operate as a guide to the navigator in timing the instant of taking photographs of the terrain, and means for adjusting the strip to alter the position of said guide line.

7. In a navigation instrument for use on an aircraft, the combination of a movable frame member mounted to swing about a substantially vertical axis, and also for tilting, means for maintaining thereon a main reference axis line extending so that the terrain or image thereof moves in a general longitudinal direction along said reference line as the aircraft advances, means for maintaining a plurality of drift lines diverging from the main axis line at predetermined angles in the direction toward which the image of the terrain moves, said movable frame capable of being oriented on the said substantially vertical axis to bring any of the drift lines into substantial coincidence with the apparent direction of movement of the terrain to indicate the angle of drift, a direction indicator with a pointer for indicating to the pilot of the aircraft whether the aircraft is deviating from a predetermined course, and means for controlling the pointer of the direction indicator in accordance with the orientations imparted to the said frame member.

8. In a navigation instrument for use on an aircraft, the combination of a movable frame member mounted to swing about a substantially vertical axis, and also for tilting, means for maintaining thereon a main reference axis line extending so that the terrain or image thereof moves in a general longitudinal direction along said reference line as the aircraft advances, means for maintaining a plurality of drift lines diverging from the main axis line at predetermined angles in the direction toward which the image of the terrain moves, said movable frame capable of being oriented on the said substantially vertical axis to bring any of the drift lines into substantial coincidence with the apparent direction of movement of the terrain to indicate the angle of drift, a pilot's direction indicator, a navigator's direction indicator, and means for controlling both of said direction indicators in accordance with the orientations imparted to the said frame member.

9. In a navigation instrument for use on an aircraft, the combination of an annulus mounted for rotation about a substantially vertical axis in normal flying, a movable frame member mounted for tilting on the said annulus, means for maintaining on the frame member a main reference axis line extending so that the terrain or image thereof moves in a general longitudinal direction along said reference line as the aircraft advances, means for maintaining a plurality of drift lines associated with the main axis line and diverging from the same at predetermined angles in the direction toward which the image of the terrain moves, said movable frame capable of being oriented with the said annulus on said vertical axis to bring any of the drift lines into substantial coincidence with the apparent direction of movement of the terrain to indicate the correct angle of drift; a course indicator having a dial for indicating compass directions and a relatively fixed point to cooperate with the compass dial to indicate a predetermined compass direction, means for controlling the position of the said dial in accordance with the orientation of the annulus, and means for enabling the course dial to be set to indicate the correct predetermined compass course for the aircraft when the drift indicating means is correctly indicating the drift of the aircraft.

10. In a navigation device for use on an aircraft, the combination of a viewing field, a lens for projecting an image of the terrain onto the viewing field, said field having a main reference axis line indicated thereon corresponding to the fore-and-aft line of the aircraft, and also having indicated drift lines extending at different angles to said main axis line; movable means including an annulus capable of rotation about a substantially vertical axis and means connecting the same with the viewing field for orienting the field to bring one of the said drift lines into coincidence with the direction of movement of the image of the terrain across the field of view, a direction indicator with a pointer normally held in a neutral position for indicating whether the aircraft is deviating from its predetermined course, means for controlling the pointer of the direction indicator in accordance with orientations of the said viewing field imparted thereto, said means including a disconnectible driving connection to said annulus, said disconnectible connection operating when disconnected to permit shifting of the annulus through the necessary degrees to bring the said drift lines into coincidence with the direction of movement of the image of the terrain across the said field of view, said connection to be closed thereafter to connect up the direction indicator to the annulus while the direction indicator is in its neutral position.

11. In a navigation device for use on aircraft, the combination of a viewing field including a ground glass plate, a lens for projecting an image of the terrain onto the plate, said plate having a main reference axis line indicated thereon corresponding to the fore-and-aft line of the aircraft, a transparent film with transverse speed lines thereon with means for guiding the same adjacent to the rear face of the plate, said plate also having indicated drift lines thereon extending at different angles to said main axis line, movable means for supporting the lens and the plate capable of being moved for orienting the viewing field about a substantially vertical axis to bring one of the said drift lines into coincidence with the direction of movement of the image of the terrain across the said plate, to indicate the degree of orientation to give to the plate, and means for driving said film at different predetermined speeds to enable the navigator to observe whether the said speed lines move at the same speed as the apparent speed

of the image of the terrain passing across the plate.

12. A method of navigating an aircraft manned by a navigator and a pilot, through the agency of a leveled drift indicator controlled by the navigator, and a direction pointer for the pilot, which consists in maintaining the drift indicator level by direct hand manipulation at all times, and connecting the drift indicator to the direction pointer so that when the drift indicator is correctly indicating the drift, the direction pointer indicates a correction to be made by the pilot in directing the aircraft on its course.

13. In combination, a device adapted for installation in association with an aircraft, levelling reference means attached to the said device in fixed relationship thereto and adapted to indicate the position of the said device with respect to a first axis substantially simultaneously intersecting with a portion of the said device and also intersecting with a point generally corresponding to the center of gravity of the earth, means to permit the said device to be maintained in a substantially fixed predetermined relationship with respect to the said first axis irrespective of the motion of the said aircraft incidental to the normal approximately level flight thereof, means to define a second axis of the said device, means to permit the visual observation of an earth object or objects and the movement thereof with respect to the said second axis as the said movement is induced by progress of the said aircraft, and cooperative means to permit the orientation of the said device in such a manner that the said second axis may be maintained substantially parallel to the direction of the said motion of the said earth object or objects and to cause a compass to indicate whether or not the heading of the said second axis is in coincidence with a predetermined heading that may be varied, the said last named means including a first ring fixed to the structure of the said aircraft, a second ring coaxial with the said first ring and adapted to be rotated with respect thereto, a driving means normally in engagement with and actuated by the said second ring and adapted to maintain a predetermined relationship between the said second axis and elements of a compass, a means to permit disengagement of the said driving means from the said second ring to permit the said predetermined relationship between the said second axis and elements of the said compass to be varied, and means actuated by the said driving means and adapted to indicate the said predetermined heading.

14. In a navigation device to be mounted on an aircraft, the combination of a casing, a lens supported by said casing, means for mounting said casing for free orientation at will to maintain the casing with the principal axis of the said lens disposed in a substantially vertical position, means for holding a photographically sensitized negative in said casing for exposure to take a picture of terrain below the aircraft through said lens, means for presenting to the operator of the device a field of view including a visually discernible reference axis, and at which an image of the said terrain is projected, drift indicating means operating when said casing is oriented, to indicate the angle of drift, means for indicating the azimuth of said reference axis in any position of orientation at said field of view that the said casing may take in a substantially horizontal plane, a movable speed-indicating part, with means for driving the same always in the same direction and at a speed controlled at will, at substantially the same apparent speed and direction of movement as the apparent movement of the terrain viewed at said field of view, said parts related to each other so that the azimuth and the speed of movement of said speed indicating part can be observed at the said field of view.

15. A navigation device constructed as defined in claim 14, in which the said movable speed indicating part consists of a transparent member with means for projecting an image thereof superposed on said field of view, said speed indicating part having transverse lines thereon disposed in a general transverse direction to the direction in which said speed indicating part moves across said field of view.

16. In a navigation device to be mounted on an aircraft, the combination of a casing, a lens supported by said casing, means for mounting said casing for free orientation at will to maintain the casing with the principal axis of the said lens disposed in a substantially vertical position, means for holding a photographically sensitized negative in said casing for exposure to take a picture of terrain below the aircraft through said lens, means for presenting to the operator of the device a field of view at which an image of the said terrain is projected through said lens, means to define a visually discernible primary reference axis, drift indicating means operating when said casing is oriented, to indicate the angle of drift, means for indicating the azimuth of said primary reference axis in any position of orientation at said field of view that said casing may take in a substantially horizontal plane, a transparent speed indicating web mounted adjacent the field of view with means for driving the same at a speed controlled at will so that it can be made to approximate the same apparent speed and direction of movement as the apparent movement of the image of the terrain induced by progress of the aircraft viewed at said field of view, said web having transverse marks thereon for enabling the operator of the device to ascertain whether or not the web is moving at substantially the same apparent speed as the terrain.

17. A navigation device constructed as defined in claim 16, in which said means for presenting a field of view includes a viewing screen with means for reflecting an image of the terrain upon the same, and in which the speed indicating web is guided across the face of said viewing screen and driven in the same direction in which the image of the terrain apparently moves across said viewing screen.

18. In a system of the character described, an aerial camera having a casing and a lens, adapted to be mounted in association with an aircraft and having means cooperating with the lens for projecting in succession photographic images upon a photographic recording medium, said camera including means mounted on the camera casing defining a reference axis line having a definite relation to said camera, means for mounting the camera for free orientation at will and into a substantially level position relative to the earth and irrespective of the position of the aircraft during normal approximately level flight, means for establishing a field of view for observing the passing terrain, means including the camera lens for projecting an image of the terrain onto said field of view for observing objects on the terrain and their apparent movement in relation to said axis line and to determine the angle of drift, said

camera capable of being oriented freely at will to cause said axis to coincide substantially with the direction of apparent relative motion as indicated on said field of view, between the terrain and said aircraft, speed indicator means driven at will at a controlled speed, means for superposing a reflection of the same onto said field of view for comparing the same with the speed of movement of the aircraft along said axis; and means for indicating the azimuth of orientation of said axis with respect to a predetermined compass course.

19. In a navigation system, a device mounted so that it may be maintained in a substantially horizontal position and may be horizontally oriented with reference to the earth, and having means defining a horizontal axis, a course indicating compass located to one side of said device, and including a dial rotated on its own axis by the said orientation of said device, means for establishing a field of view on said device, means for visually indicating on said field of view the direction and apparent motion of the terrain passing below relative to the defined axis, drift indicating means for indicating on the said field of view the true angular relation between said defined axis and the predetermined compass course indicated by said course-indicating compass, and means associated with the drift indicating means for indicating at the same field of view the substantially horizontal velocity of said device relative to the apparent indicated speed of the terrain.

20. A navigation system constructed as defined in claim 19, and including a reflector associated with the field of view with means for superimposing the reflection of the drift indicating means upon the said reflector so that the same may be observed simultaneously with the said horizontal axis definition to render the reverted calibrations on the field of view legible as conventional calibrations.

21. In a navigation instrument for use on an aircraft, the combination of means including a photographic lens for taking pictures of the terrain, said lens being disposed with the principal axis thereof in a substantially vertical position, a movably supported frame for said instrument attached to the aircraft for enabling the instrument to be oriented about a substantially vertical axis substantially coinciding with the principal axis of the lens, means carried on the instrument to indicate the degree of orientation of the same with respect to the fore-and-aft axis of the aircraft, means enabling the said instrument to be held at will at any moment, in a substantially fixed position with respect to the said fore-and-aft axis irrespective of the motion of the said aircraft incidental to the normal approximately level flight thereof, means to define the drift axis for the said instrument, means on the instrument for presenting an image of the earth to the observer's view through the agency of light passing through said photographic lens, and for simultaneously presenting an indication of the fore-and-aft axis of the instrument and an indication of the angle of said drift axis with reference thereto, said parts cooperating to enable the indication of said drift axis to be held at will in coincidence with the apparent direction of movement of an earth object as the said aircraft progresses along its course, and a compass in operative connection with the instrument to indicate directly the true compass direction of the said drift axis.

22. A navigation instrument constructed as defined in claim 21, including means for projecting on the field of view indications of the direction of the said fore-and-aft axis and the said drift axis.

23. In a navigation instrument for use on an aircraft, the combination of an annulus comprised of a member fixed to the aircraft, and a movable member mounted on said fixed member for rotation about a substantially vertical axis in normal flying, a movable frame member mounted for tilting on the said movable member, means carried by said frame member for establishing a field of view for observing the terrain and along which the terrain appears to move, means for maintaining on the said field of view a main reference axis line extending so that the image of the terrain moves in a general longitudinal direction along said reference line as the aircraft advances, drift indicating means associated with said main reference axis line visible simultaneously with said main field of view for indicating approximately the angle of drift and for enabling the same to be observed, means for indicating the angular relationship between said frame and said fixed member, a course indicator normally connected to said movable member and having a dial for indicating compass directions, and a relatively fixed point to cooperate with the compass dial to indicate a predetermined compass direction, said movable frame capable of being oriented by the movable annulus member on the said substantially vertical axis to orient simultaneously the said main reference axis and the drift indicating means in observing the angle of drift, means for controlling the position of said dial in accordance with the orientation of the movable annulus member, and means for optionally disconnecting the course dial from the movable annulus member for the purpose of enabling the course dial to be set to indicate the correct predetermined course for the aircraft after the drift indicating means has correctly indicated the drift of the aircraft.

24. A method for navigating an aircraft, said method including providing a field of view in conjunction with a common lens alternately projecting an image of the earth onto a photographically sensitized surface for photographic purposes and projecting an image of an object on the terrain onto said field of view, and observing the relative motion of an earth object on said field of view, simultaneously indicating on said field of view a first axis and a drift-indicating axis, maintaining a predetermined fixed relationship with respect to a third axis simultaneously intersecting with a point generally corresponding to the center of gravity of the earth and intersecting with a portion of the said lens, orienting the said field of view so that the said first axis is in a position substantially parallel to the visually observed motion of the said earth object, or the said image thereof, as said visually observed motion is induced by progress of the said aircraft, and transmitting the motion incidental to the said orientation of the said first axis to a compass that indicates the compass point to indicate the heading of the said first axis.

25. The method for navigating an aircraft, as defined in claim 24, including the step of differentially setting an indicator on the elements of the compass in accordance with a predetermined course, as indicated by a compass cooperating in fixed relationship with respect to said elements.

WILLIAM T. JOCHUM.