The plane is of the pusher type with motor in the rear and seating arrangement forward to improve the visibility for the pilot. It is equipped with outriggers or booms connecting the tail and control surfaces, and with three wheel landing gear with oil and spring hydraulic shock absorbers. The rear wheels are equipped with brakes and the front wheel is steerable.

The gondola is of welded steel covered with a stressed aluminum covering. The wings are full cantilever of monospar steel tube construction, with balance type ailerons and special flaps which are partially lowered in the take-off to increase the lifting capacity and fully lowered in landing to reduce speed.

Stick and rudder controls are available for both the pilot and cameraman, and can be separately or simultaneously operated by either. A full set of instruments and engine controls are within sight and reach of both pilot and cameraman.

A special mapping porthole with a special camera mount is provided for in the floor of the gondola and the arrangement is such that pictures can be taken straight down through this opening, the aperture being hermetically sealed when the camera is in place. Supercharging of the cabin is provided for by sealing in the safety glass which, besides serving as windows, also serves as the outside covering of the gondola.

The detailed specifications of the initial model of the new plane as furnished by the manufacturer are as follows:

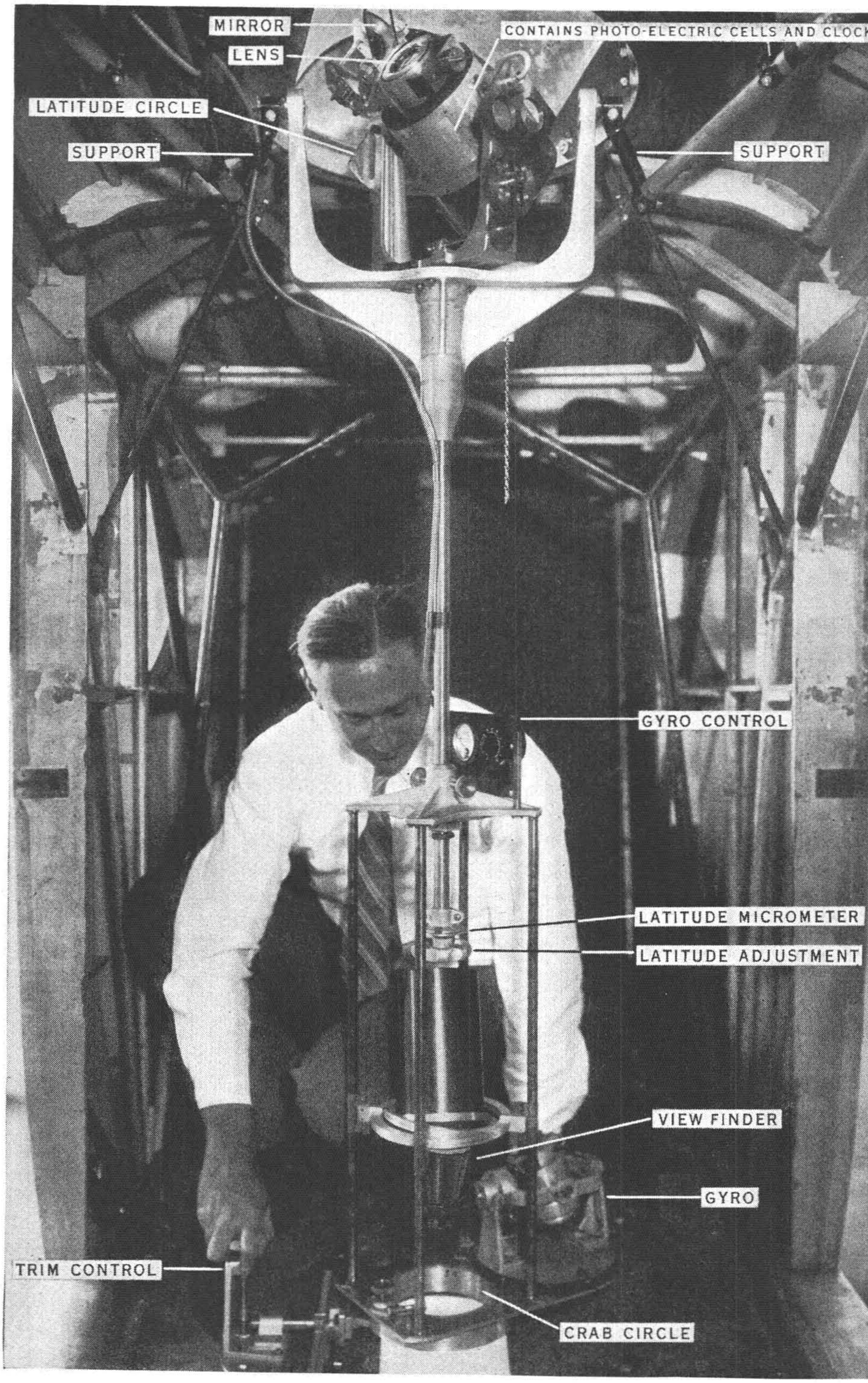
AREAS		
Wings	191.00 square feet	(17.75 sq. m.)
Ailerons	18.40 square feet	(1.71 sq. m.)
Flaps	12.74 square feet	(1.12 sq. m.)
Stabilizers	20.70 square feet	(1.92 sq. m.)
Elevators	9.80 square feet	(0.91 sq. m.)
Fin	7.66 square feet	(0.71 sq. m.)
Rudder	6.86 square feet	(0.64 sq. m.)
WEIGHTS		
Gross	3,200 pounds	(1,450 kg.)
Empty	1,790 pounds	(810 kg.)
Useful	1,410 pounds	(640 kg.)
Equipment	50 pounds	(23 kg.)
Gas and Oil	800 pounds	(360 kg.)
Crew	380 pounds	(172 kg.)
PERFORMANCE		
Maximum Speed (sea level)	185 miles per hour	(300 km.)
Maximum Speed (10,000 feet)	200 miles per hour	(320 km.)
Cruising Speed	165 miles per hour	(265 km.)
Landing Speed	66 miles per hour	(107 km.)
Rate of Climb	1,800 feet per minute	(550 m.)
Service Ceiling	21,000 feet	(6,400 m.)
Cruising Range	1,400 miles	(2,300 km.)
POWER PLANT		
Engine Wright R975-E 330 H.P. at 2,100 r.p.m.		

FAIRCHILD SOLAR NAVIGATOR[1]

Leon T. Eliel

As photogrammetry has been approaching closer and closer to an exact science during the last several years, it has become increasingly apparent that the ultimate quality of the work is dependent upon good flying. Ragged flying

[1] From an article by the author in the October-November-December, 1937 issue of PHOTOGRAMMETRIC ENGINEERING.



FAIRCHILD SOLAR NAVIGATOR

where the pilot weaves back and forth along his course results in too many badly tilted pictures which, of course, are not susceptible to satisfactory results when used for radial control. If the objective of the survey is a contour map, ragged flying means extra strips, extra pictures, more costly control and slower plotting.

It has been the writer's experience over a long period of years that a good many pilots can fly acceptable pictures over either sectionized country or unsectionized country with excellent maps. When, however, the area is unsectionized and substantially unmapped, the pilots who can turn in an acceptable piece of work are few and far between.

The most obvious object from which to take a compass bearing in the daytime is the sun. This is particularly true in aerial mapping which is only attempted in fair weather. We have been frequently asked why we did not go to gyroscopic instruments. The answer to this is that direction indicating gyroscopes to date are subject to precession which means that the instrument does not stay put exactly in a desired direction. A gyro compass in excellent adjustment may not vary over a degree in 15 minutes of time but frequently gyro compasses are not in such perfect adjustment and will precess as much as a degree in a minute or two. It is for this reason that to date neither gyro compasses nor automatic pilots (which utilize the gyro compass) have proved practical for aerial survey navigation.

The sun compass appeared to be the answer to all the requirements of the problem. The instrument is mounted in a dome in the top of the ship and is set up exactly like an astronomical telescope, its axis pointing north in space so that a clock rotating a mirror on an axis parallel to the axis of the earth follows the sun. This mirror is adjustable for the varying declination of the sun from day to day and reflects the sunlight into a lens at the top of the instrument. After passing through the lens the sunlight is directed to two photoelectric cells. When the compass points exactly north no light falls on the cells, but with the slightest deflection, sunlight falls on one cell or the other, creating a current registering the deflection on a galvanometer mounted on the instrument board. The head or compass part of the instrument is supported by forks, the base of which is extended in the form of a column connecting the compass to the view-finder which is in the bottom of the fuselage.

The view-finder is essentially a conventional instrument consisting of a lens and ground glass with drift lines thereon. When the desired course is north or south, the drift lines are arranged to be set parallel with the axis of the compass. When the course is in any other direction, such as 20°, the drift sight is rotated to an angle of 20° with the compass axis and clamped in this position. The drift sight is stabilized by a gyroscope against the roll of the airplane. The whole instrument is mounted pendulously at the base of the dome with provision on the base of the instrument for leveling it fore and aft. On the base of the instrument also is a slow motion screw for causing the images to exactly follow the drift lines.

It is the duty of the pilot to keep the ship on an even keel laterally and it is the duty of the photographer to keep the navigator levelled up longitudinally. If the instrument is off level a reading will appear on the galvanometer which is not truly indicative of a change in azimuth. For this purpose the pilot has a very sensitive level bubble mounted beneath the galvanometer by means of which he maintains the ship on an even lateral keel. In smooth air the instrument works very satisfactorily. In rough air, however, its performance is somewhat short of perfection.

In operation the instrument is easy to set up and handle. The photographer can learn to make the necessary settings for latitude, longitude, equation of time and declination in one lesson and, in fact, if he will study his manual for an hour he can make all of these settings without any instruction. Two factors must be looked up in tables each day.

1. The declination of the sun
2. The equation of time

The operator carries in his kit a little pocket solar ephemeris table in which under the particular date the declination and equation of time are listed side by side.

Since the axis of the instrument points north in space (that is toward the north star) the plane of the lens of the instrument is parallel to the equator of the earth. As the sun apparently moves through its seasonal changes from 23° north of the equator to 23° south of the equator, the declination mirror of the instrument must be set from day to day so that the sunlight is turned directly into the lens. That's all there is to the declination setting.

The equation of time setting is necessary because the sun day is not exactly twenty-four hours long. During part of the year the clock gets ahead of the sun by as much as 16 minutes and during the balance of the year the clock lags behind the sun. Therefore, the equation of time must be added to and subtracted from the time carried on the watch to equal sun time. This factor is read directly out of the ephemeris table and merely has to be set on the clock.

Theoretically, as the airplane flies north or south, the latitude adjustment of the instrument should be changed to correspond to the latitude of the point over which the airplane is flying from instant to instant. Practically, however, this factor is usually negligible so long as the flights do not exceed 70 miles in length. For example, flying at latitude 37° north with a declination of 20° north (this means the sun is only 13° from the zenith at noon) the following maximum errors will result in the flight 70 miles long north and south with a latitude set for the mean of the strip. One hour and fifteen minutes from noon a flight of this length will be deflected approximately 400 meters from a true north and south line by reason of failure to change the latitude setting. With a higher and lower sun the errors get less and less, being zero at noon time and negligible about three hours from noon. If the flight lines are only 35 miles long, the deflection from a straight line due to this cause is only one-quarter of the above or 100 meters.

Theoretically and actually, the instrument breaks down completely when the sun is in the zenith which means that when flying in the tropics there will be a brief time around noon when the instrument is inoperative. Ordinarily, however, in the tropics, photography must be done early in the day before cumulous clouds commence to form. Thus, there is little likelihood that there would be any occasion to use the instrument during that period. Practically speaking, the instrument may be successfully used until the sun gets within about 10° of the zenith. This means that on one day a year in any tropical project there would be a period in the middle of the day of about an hour and a half when the instrument could not be used. On this day from soon after sunrise until about 11:20 in the morning the operation would be very satisfactory.

The solar navigator has now been used for about 16,000 square miles of actual mapping at a scale of 1/20,000. When the pilot is a totally inexperienced operator, the solar navigator will give him 80% acceptable stripping in unchartered country without section lines. The pilot who has had some experience with the solar navigator will have 95% or better acceptable results and the 5% of rejections will be due in the main to the pilot not having moved over the proper amount at the beginning of the strips.

During the last 4,000 square miles mapped by an experienced pilot, the mean azimuth of his strips was 13′ from the desired direction.

At the present time the solar navigator is installed on three airplanes which are engaged on mapping a tropical territory in Central America. This terrain would be extremely difficult to fly without some such aid because the jungle is of a solid monotonous character and is completely devoid of distant landmarks which can be recognized.

In addition to the uses of the solar navigator already described, it may be used for establishing triangulation of a very rough nature in inaccessible country. For example, there are many sections of the world where astronomical determinations are unreliable because of deflection of the vertical. There are other regions where because of jungle or inaccessible mountains it is too expensive to establish control on the ground. In such cases, flights may be made with the solar navigator starting over a known point and taking a strip of photographs toward some objective at which control is desired. A second strip may be similarly flown to some different azimuth starting at some other point and intersecting the first strip. In this manner a regular triangulation net can be built up and the intersection of the various picture strips computed according to the direction in which the flight was made. Under these circumstances, the precision of the solar navigator should be very good as an altitude may be selected at which the air is smooth and a time of day selected at which the instrument is at its maximum effectiveness. In other words, the method offers a means of triangulation with angles that can be depended upon within 15′. If greater accuracy is desired three or more lines may be flown to intersect at a common point and the mean thus determined should prove accurate enough for most inaccessible and unchartered regions.

NOTE: The solar navigator is manufactured by the Fairchild Aerial Surveys Inc.

TABLES OF SOLAR ALTITUDE

C. L. Nelson

In 1935, the Committee on Specifications of the American Society of Photogrammetry made several drafts of standard specifications for single lens aerial photographs. None of these drafts restricted the angle of elevation of the sun above the horizon at which photographs could be taken.

In September 1935, the last draft of these specifications was submitted to the Director of Procurement, Treasury Department, for consideration and adoption as standard specifications. Director of Procurement referred the specifications to the Inter-departmental Committee of Contracts and Adjustments, which held many meetings before the specifications were approved. Two members of the Committee on Specifications served as technical advisers to the Inter-departmental Committee.

The first draft of the specifications as revised by the Inter-departmental Committee, sent to the members of the American Society of Photogrammetry in July, 1936, contained the specification that photographs would be rejected "which are taken when the sun is at an angle of elevation above the horizon of less than 30°." This provision resulted in objection by several aerial photographers because it would restrict the taking of photographs in northern latitudes of the United States to a few months in the summer season. The Inter-