sailing in those seas. Owing to the limited room on board, the greater part of the expedition members had to camp on shore during the flying period and the darkroom was erected on shore.

In West-Greenland no floe-carrying current runs in the summer. The chances for emergency landing are far better here than on the east coast. Here too are many inhabited places capable of rendering assistance. Here it has been possible to base the work on motorboats sized about 15 or 22 tons (36 or 48 feet in length). Most of the members of the expedition camped on the shore, where the darkroom was erected. When moving from one flying base to another, the schooners of the Administration of Greenland rendered assistance, as it was often impossible for the motorboats to carry all the supplies.

Wherever the survey flying has been undertaken the mother-ship as well as the motorboats and the seaplane have been equipped with wireless facilities for safety. In the plane, the wireless station was a Telefunken Radio Type Station 274 u.F. During all the flying, the mother-ship or the base-motorboat was listening for the plane. It may be noticed that the motorboats very often corresponded with the Danish inspection ships so that they might be called to aid in case of emergency.

As to the weather it may be said in general that:

1. In Iceland the chances for proper weather for photographing are very small, the atmosphere being full of humidity setting many clouds. Only very seldom is the weather fine and clear over great areas.

2. In Greenland the east coast as a rule offers better chances for fine weather than the west coast. Here, especially in the southern part, it is generally cloudy, misty and foggy, but days with real fine and clear weather may also come. In the southern part of Greenland strong gales have been observed at a height of 4,000 meters (13,124 feet), and rapid vertical atmospheric currents have been observed as well.

The air surveys expeditions are organized and sent out under a leader from the Geodetic Institute. The staff of the expeditions comprises besides the people from the Institute (surveyors, photographer, boatsmen) the crew of the aircraft from the Danish Navy and an air photographer from the air force of the Army.

Further information regarding the areas where air photographs have been taken is stated in the report to Committee No. 4.

Finland

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For air photographic surveying in Finland only the Nenon camera of the Zeiss-Aerotopograph Company is being used.

For remaining at a constant altitude during the photographic flights a Leader statoscope, constructed by Dr. V. Väisälä, Helsinki, is being used. For greater accuracy, a recording statoscope is attached to the camera; this indicates slight variations of the fixed height for every picture with an accuracy of 1 to 2 meters (3 to 6 feet).

All air photographs for surveying purposes are being taken on panchromatic film. The question of film shrinkage in Finland has not been settled as yet, as up to the present time we are without stereoscopic measuring devices. The paper shrinkage is avoided because of the wet-process (refer to the magazine *Bildmessung und Luftbildwesen*, 1932).

A Junkers airplane is being used. To simplify the navigation, the photographer is equipped with an Aldis Sight and the photographic strips are taken in the direction of the wind.

THE STATOSCOPE OF DR. V. VÄISÄLÄ[1]

The importance of the statoscope constructed by Dr. V. Väisälä for air survey in general and especially for aero-triangulation and aero-leveling is already known because of earlier reports. A description of its development, construction and practical use should be interesting.

The first experiments with air surveying, namely by the rectifying method, in Finland were made in 1927 under the supervision of Lt. Gen. V. Nenonen.

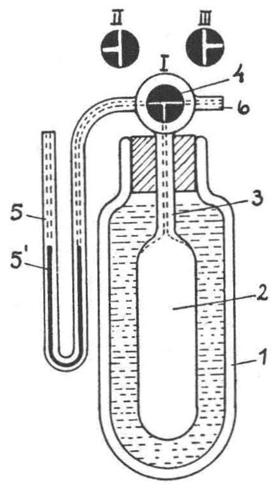

FIG. 1

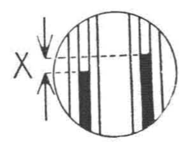

FIG. 2

The primary interest was to find methods and instruments for directly determining the exterior orientation of air photographs. In the following year, a satisfactory solution to the problem was obtained, by measuring the shift of the apparent horizon in photographs taken simultaneously with the main vertical one. However, there still existed the difficulty of constructing an accurate instrument to determine the altitude.

The first experiments, which depended on barometrical measurement of altitude, were not satisfactory for various reasons, but mainly because of the effect of factors which were difficult to determine, as temperature, moisture content, etc. of the air at various stratified altitudes. These effects were very great and reduced the accuracy of the results. The changes of altitude in horizontal flight could be more accurately determined barometrically. In this method, the altitude changes to be measured are so small, and the effect of annoying factors have no practical importance. It became necessary to find an accurate differential altitude-meter for which various instruments were tested. It was found, however, that the mechanical instruments available were so constructed that differences in temperature, variable after effects, vibrations of the motor, etc. affected the readings to such an extent that the desired accuracy could not

[1] This article by Major K. Löfström, Engineer, is reprinted from the article in the March, 1936, issue of *Bildmessung und Luftbildwesen*.

be obtained. With the idea of a differential altitude-meter in mind and in cooperation with Dr. Väisälä, additional tests were made to overcome the above mentioned disadvantages. The solution was soon found in which the main parts of the barometer, the metal compression chamber and the indicating mechanism were replaced by an air cushion and a liquid-manometer. As a result, in the year 1929, the statoscope of Dr. Väisälä was originated, which has more than fulfilled all expectations.

The principal construction of the statoscope is very simple (see Fig. 1). An air chamber (2) is connected by a tube (3) with a T-tap (4). A U-shaped capillary tube (5) serves as a liquid-manometer, one end of which is always open and the other connected tightly to the tap. This tap may be turned to three different positions. In position I (Fig. 1), the air chamber and manometer are in direct connection with the outside air through an opening (6). The pressure in the chamber is the same as that of the surrounding air and the liquid columns (5′) of the manometer are at the same height. In position II, the opening (6) is closed and the air chamber is in connection with the outside air only through the manometer. The difference in height of the liquid columns shows the difference of pressure and direction between inside and outside air. In this position the manometer is ready for use. In position III of the T-tap, the air chamber is connected with the outside air and the manometer is closed. The liquid columns will remain stationary while the manometer is tilted, therefore this position is suitable for transporting the statoscope.

The existing air pressure in the chamber (2) during the operation of the statoscope serves to balance pressure and should be kept constant. It is most important that the temperature of the enclosed air also be kept constant. Isolation, as for example in a Dewar flask alone is not sufficient, and additional precautions become necessary. The air chamber (2) is within a Dewar flask (1), which is filled with ice and water. As we know, this solution accurately maintains a temperature of $\pm 0°$ C. The greatest, and one might say, the only error in the statoscope construction is fully avoided by this simple arrangement. The effect of the small amount of air in the capillary tubes between the air chamber and manometer outside of the ice-water-solution has no practical importance.

The difference of elevation (h) of the liquid columns is proportional to the difference between balancing pressure and outside pressure. Thus the statoscope shows the amount of altitude change (ΔH). The latter may be determined from the following formula:

$$\Delta H = \frac{\delta}{1000\rho} \cdot h$$

Where

ΔH = the change of altitude in meters

h = the deflection of the statoscope in millimeters

δ = density of manometer liquid (Amylalcohol = 0.81)

ρ = density of air

In order to give a large deflection of the statoscope for small altitude changes, a light liquid (Amylalcohol) is used in the manometer. According to the preceding formula the statoscope deflection will show the following values for an altitude of 1 meter at various altitudes of flight:

Altitude of Flight in meters	Air			Statoscope Reading for Meter Altitude in mm.
	Pressure mm.—hg	Tempera-ture, °C.	Density grams/c.c.	
0	760 (30″)	0	0.001293	1.60
1500 (5,000 ft.)	631 (25″)	0	0.001074	1.32
3000 (10,000 ft.)	522 (20″)	0	0.000888	1.10
4500 (16,000 ft.)	433 (17″)	0	0.000737	0.91

The statoscope as a differential measure is so sensitive that a change of 1 meter in altitude corresponds to a scale reading of 1 mm. Furthermore, the device is free from variable after effects and is not sensitive to changes of outside temperature. There is no difficulty in reading the statoscope since the vibration of the motor or other action does not appreciably affect the movement of the liquid columns.

The statoscope and its reactions were tested by Zeiss-Aerotopograph in an elevator 40 meters high. After testing its scale, a mean error of ± 0.54 m. was noted at the different floor elevations. Between the highest and lowest points on this elevator the statoscope reading showed a maximum systematic error of 1.6 m. In the field, however, flights will seldom show proportionately large errors. Generally, a relative accuracy of the statoscope reading of 1 to 2 meters may be expected.

During the first four years, the statoscope was used as an aid to level flights only. This so-called pilot statoscope (see Fig. 2) is mounted on the instrument board. During ascent the statoscope remains open, with the T-tap in position I. When the desired altitude has been reached the statoscope is put into action, *i.e.*, the tap is turned to position II. As previously mentioned, the statoscope will show accurately the changes in altitude from the selected zero-point, since the liquid column of the open tube will be higher when the altitude is too high and vice versa. After setting the statoscope, the pilot can maintain an altitude within the limits of ± 5 m. constantly during the photo flight.

These changes are so slight that for most survey purposes it is reasonable to assume that the altitude—that is, the elevation of all photos with reference to see level—remains constant. Such is the case in Finland, where photos are made at an altitude of 3,300 meters (12,000 feet) for the scale of 1:20,000. The resulting scale differences of the various photos are so small that the accuracy limit of 0.2 mm. in cartography is exceeded only in rare cases.

It has also been noted that the zero-point of the statoscope varies with air pressure. Actual experience has shown, however, that the air pressure is very low and very uniform in fair weather. As picture flights are only undertaken in clear weather, we are assured of a very constant atmosphere.

If the terrain to be photographed is level and of the same elevation, the average altitude of all pictures may be determined from one photo simply by known points or regions. This fact has often been confirmed during our eight years of practical work. In the construction of mosaics of coasts and cultivated areas where the elevations are determined with reference to sea level, one can usually keep the same scale while using the rectifier for all photos, even though the duration of flight is from four to five hours and covers a total area of 200 to 400 square kilometers (80 to 160 square miles). The simplicity and efficiency of rectifying work with known orientation, slope, tilt and altitude is understood by experts. Also at irregular elevations of the open country a sectional reduction of altitude by means of a secondary triangulation-net may easily be accomplished.

For the construction of picture plans under the conditions stated, the pilot statoscope alone has been found valuable. For more accurate photos, in stereoscopic plotting for instance, all altitude changes from the zero-point must be recorded. For this purpose a so-called recording statoscope was built.

This device consists of an electrically operated recording camera to which a statoscope is attached in front of the exposure glass. The recording camera operates in synchronism with the air camera. At each exposure the recording camera receives an electrical impulse and records the millimeter scale reading of the statoscope on a film with a ratio of 1:2. After the current is cut off, the film change takes place automatically and the recording camera is again ready for action. In order to identify each air photo with its corresponding statoscope photo, there is continuous numbering on the recording film, and in addition there is a watch attached to the recording camera which is photographed on each exposure.

The recording statoscope is always used with the pilot statoscope. To fly with an ordinary altitude meter, it would be almost impossible to keep within the limits of the register of the recording statoscope (about ± 30 meters or 100 feet). A nearly constant altitude which can be obtained only by the use of a pilot statoscope is also more favorable for scale accuracy. It is best to keep the recording statoscope in a remote corner of the plane. It should be remembered that the statoscope is sensitive and its readings will be affected by strong and varying air pressures. For instance, the opening of the plane door during a flight wil change the air pressure within the plane and accordingly, the zero-point of the statoscope. However, by a suitable location for the statoscope and by avoiding unnecessary handling during the flight, these sources of error may be considerably reduced.

From the recording film the statoscope readings in millimeters are read and converted into meters. The resulting figures represent the deviation in meters from the assumed zero-point on every picture. The elevation of the zero-point is determined by known points on a picture pair, for example, at the beginning of the flight and if necessary controlled by points along the serial. Should the zero-point vary as caused, for example, by the gradual change of air pressure, a linear reduction is made in the altitude.

There has been little practical use for the recording statoscope in Finland, since we do not have suitable stereoscopic plotting devices at our disposal. The above mentioned tests made by the firm of Zeiss-Aerotopograph, together with a more thorough description by Professor v. Gruber, show good reason for the conclusion as to the accuracy obtained by use of the recording statoscope. Following is a short outline of the test in this respect. The test data consisted of pictures covering a distance of about 20 kilometers (12 miles) taken with a Nenon camera ($f=16.5$ cm.) at an altitude of 3,300 meters (12,000 feet). Given were the tilt variations, determined by horizon photographs, the altitude changes as recorded by the recording statoscope on every picture, and the fixed point of altitude at the beginning and at the end of the picture flight. The first picture pair was placed under the stereoplanigraph and the other data of orientation (slope, swings and altitude changes) recorded. After this arrangement all evident parallaxes were eliminated by tilting and moving of the photos in the vertical direction on its axis. The scale and horizontal location were determined by shifting and tilting the pictures and by plotting the known fixed point of altitude. The photos were now free of all parallax which gave proof of the accuracy of the given outside orientation. By this procedure the general slope corrections and zero-point were determined for the entire picture series.

To control the zero-point, the last picture pair was adjusted to outside orientation and made free of parallaxes. Had the zero-point of the statoscope changed during the flight, it would have shown a difference in the cartographic scale (1:10,000) as compared to the photo scale obtained at a known altitude. It resulted in the fact that after the elevation of a given point on the indicator was fixed, the scale of the photo corresponded with the map (within 1–2 meters), depending on the scale accuracy of the planigraph. The selected zero-point, in other words, was kept constant along the entire flight of 20 km. (12 miles), so that the data of the statoscope could be used in plotting altitudes. In concluding the discussion of the result of these figures, we state the opinion of Professor v. Gruber regarding the statoscope. The importance of the altitude measurements of the recording statoscope for air triangulation and air levelling is so definite that one has good reason to name this device the "Air Level."

France

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In this report we have endeavored to brief, and deal with (1) the description of cameras and accessories, (2) progress made in the manufacture of plates, films, and papers, (3) the study of airplanes used for air photography with their special navigating instruments, and (4) the general organization of the work and the employment of specialized personnel.

Cameras and Equipment

Single Lens Cameras for Reconnaissance

1. Planiphote (Richard make): These cameras, picture size 18×24 cm. (7×9½ inches) are made in three focal lengths, namely 30 cm., 50 cm., and 70 cm. (12, 20, and 27½ inches). They come furnished with an automatic magazine of 24 plates or with a film magazine giving 200 pictures. They are entirely automatic and electrically controlled at a distance. This camera is also made in picture size 13×18 cm. (5×7 inches) with a focal length of 20 cm. (7.9 inches). The same camera is made in the non-automatic.

2. Hand Cameras: These unsuspended cameras are remarkable for their lightness of weight. They are intended chiefly for panoramic photography in connection with archeological research (type R. P. Poidebard).

3. Altiphote (Richard make): Camera of picture size 13×18 cm. (5×7 inches). Focal length 20 cm. (7.9 inches) or 26 cm. (10 inches). Magazine for 100 pictures on film.

4. Aviophote (Richard make): Camera of picture size 13×18 cm. (5×7 inches). Focal length 20 cm. (7.9 inches) or 30 cm. (12 inches). Magazine, 12 plates.

5. Toporex Krauss (made by Barbier Benard and Turenne): These cameras use film, giving a picture of 18×24 cm. (7×9½ inches). They are automatic or semi-automatic.

They are provided with 3 interchangeable cones of 30, 50, and 70 cm. (12, 20, and 27½ inch) focal length.

Persienne (*i.e.*, Venetian blind type) shutter and variable speed.