impossible. Studies of airborne sensors, terrain quantification, data storage and retrieval, and terrain-effect determination should be evaluated and oriented in the light of a comprehensive military geographic program. Optimum utilization of airborne sensors in military geography is dependent upon the development and conduct of a comprehensive program of this type.

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*Use of Photographic Cameras and of Photogrammetric Methods in Mining Aerology**

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(*Abstract is on the next page*)

Investigations concerning the effect of airflow on the effectiveness of mechanical plumbing in mines and on the light ray-refraction in optical measurements, are conducted by the Chair of Mining Geology in the Academy of Mining and Metallurgy. In the

* The Polish detailed text of the study was published in "Przeglad Górniczy" Nr 12, 1961, Katowice, Mining Review entitled "A Tentative Application of Photogrammetric Methods to the determination of Airstream Flow in Mines."

course of these investigations, the necessity of determining the distribution of the airstream directions in shafts and galleries became evident.

Laboratory methods—such as hot-wire anemometer or micromanometer measurements with adequately shaped feelers—were found to be impractical in mining conditions, because of excessive amount of labor and the delicacy of apparatus.

In seeking a speedy and simple method which would make possible the simultaneous determination of airflow distributions in a number of points, the authors conducted trial investigations. These consisted of measurements of the deviations of thin silk threads freely hanging from a specially constructed frame. (See Figure 1) These were placed in different sections of galleries and shafts. These threads supply information on the direction and strength of the airflow stream. For recording the position of the threads there are used photographic cameras of the 6×6 cm. size and focal-length f=78 mm., adapted to taking photogrammetric pictures (3). Two cameras are placed on a stereometric base—Figure 2—as devised by Z. Kowalczyk (2). The optical axes are made perpendicular to their bases. The length of the bases can be adjusted to the distance between the frame with the threads and the cameras. A simultaneous exposure of a pair of photographs—one stereogram—is effected by means of electronic lamps having a flash-time ca 1/1,000 sec. The measurements of the coordinate and parallaxes on the photographs are carried out on a stereocomparator.

ABSTRACT: *The article presents tersely the possibility of using stereophotogrammetric methods in the determination of directions of airstream flow in mines. Results of measurements are partly shown and their accuracy is briefly discussed.*

The results of measurements are made known by using customary graphic methods. From the stereoscopic pictures, horizontal projections of each separate thread are obtained on the required scale in a photogrammetric coordinate system. At the same time there are obtained the heights of suspension points of the threads and the positions of their ends relative to the camera axis level. These data determine in a uniform manner the position of the ends of the freely hanging threads displaced by action of the airstream.

Repeated photographing of the frame which remains in the same position makes possible establishing the degree of turbulence of the airflow—the frequency and magnitude of direction changes in time. This possibility results from employing various positions of the ends of the threads, freely blown about in comparison with their fixed suspension points, the latter in all series of photographs being in the same position—in some given point of a gallery or shaft.

By utilizing the above method, the authors carried out measurements of the distribution of directions of airstream flow in galleries and shafts of several coal-mines. Figure 3 pictures a fragment of a shaft-plat at 500 m. depth, where tests were made. That picture makes evident: (1) the situation of the frames with threads, (2) the stereometric camera positions, and (3) a part of measurement results of the deviated threads, picturing the horizontal components of air-flow directions inside of the shaft on the height of the investigated horizontal cross-section.

The scale of photograms for all accomplished measurements was 1:50 to 1:95. The graphic elaborated scale was 1:5. In establishing the measurement accuracy are computed mean errors of the coordinates of thread suspension points. These errors are reckoned on the basis of comparison of the distance directly measured between the points on the frame with the distances resulting from photogrammetric development. From the comparison of 100 points on 8 different stereograms was obtained the average $m_x = \pm 0.32$ cm., $m_y = \pm 0.50$ cm. and $m_z = \pm 0.32$ cm. Consequently the mean error of the actual position of a point in space $m_s = \sqrt{m_x^2 + m_y^2 + m_z^2} = \pm 0.67$ cm., and the error of the position of a point on the horizontal plane is $m_p = \pm 0.53$ cm.

Assuming the mean error of the position of the end of the thread to be identical with the error of the point of suspension, the mean error of the obtained direction of the thread deviation can be computed according to the mean square error theory

$$m_\beta = \frac{m_s}{d} \rho^\circ$$

where d is the length of thread in the above measurements

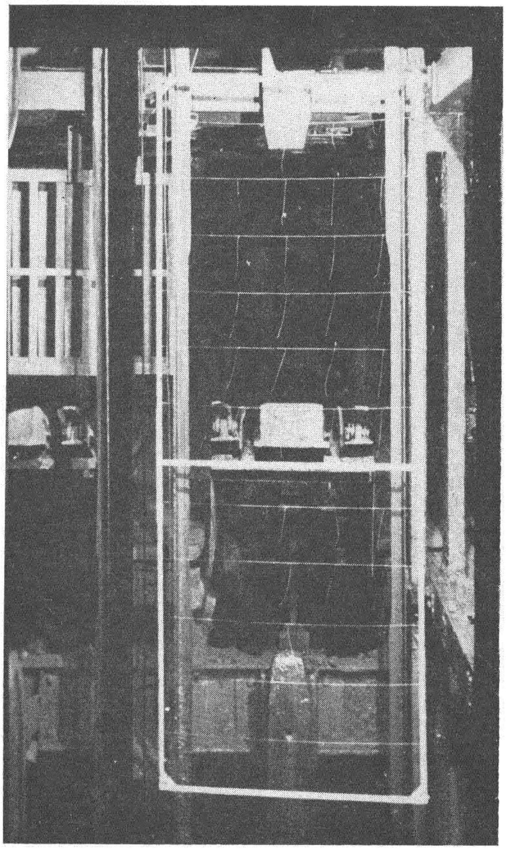

FIG. 1. Frame with threads in a shaft.

$$d = 20 \text{ cm}$$

$$\rho^\circ = 57{,}2^\circ$$

The mean error of the horizontal deviation component in analogy with the above:

$$m_\alpha = \frac{m_p}{a} \rho^\circ$$

where

a = length of the thread projection on the horizontal plane.

By substituting given values for d and m_s we obtain

$$m_\beta = \pm 1{,}9^\circ$$

and for the direction marked up from three independent measurements, in the same position of the frame,

$$m_{\beta_3} = \frac{m_s}{\sqrt{3} \cdot d} \cdot \rho^\circ \cong 1^\circ.$$

Taking into consideration the airflow pulsation—directional changes in time—a greater precision of airflow direction measurements is not required.

In general on the basis of the tests made by the above described method it can be stated that:

1. The amount of time required in the mine for the measurement process is less than by any other method; measurements of airflow directions in about one thousand different points were made in 5 hours.

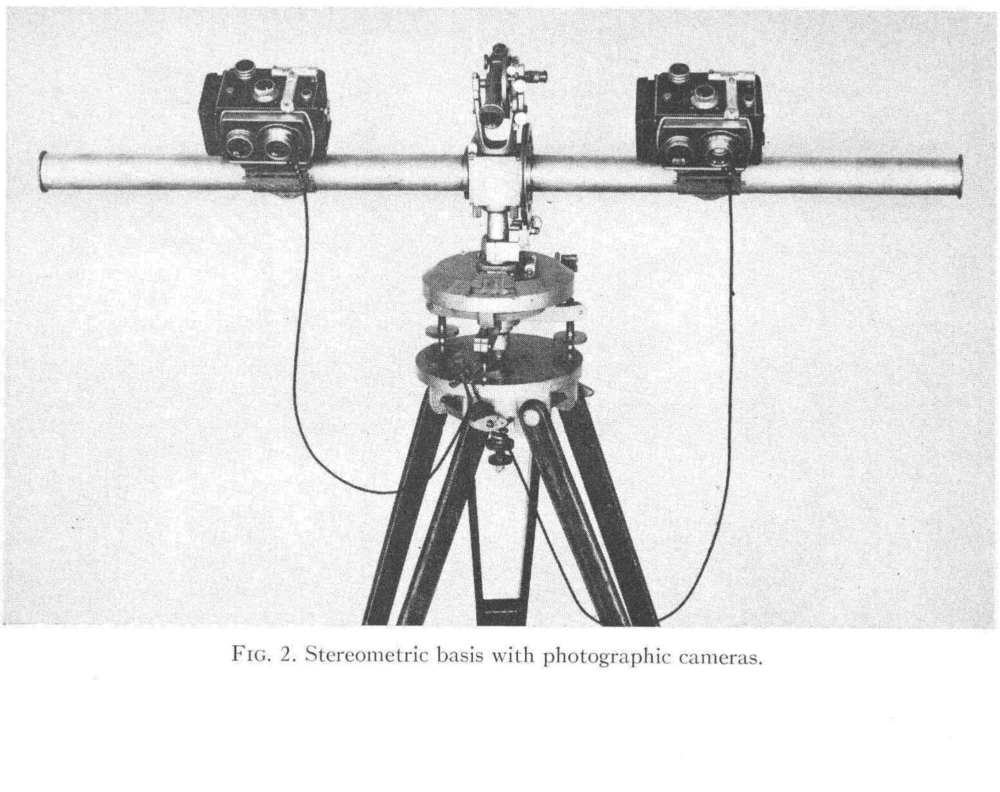

FIG. 2. Stereometric basis with photographic cameras.

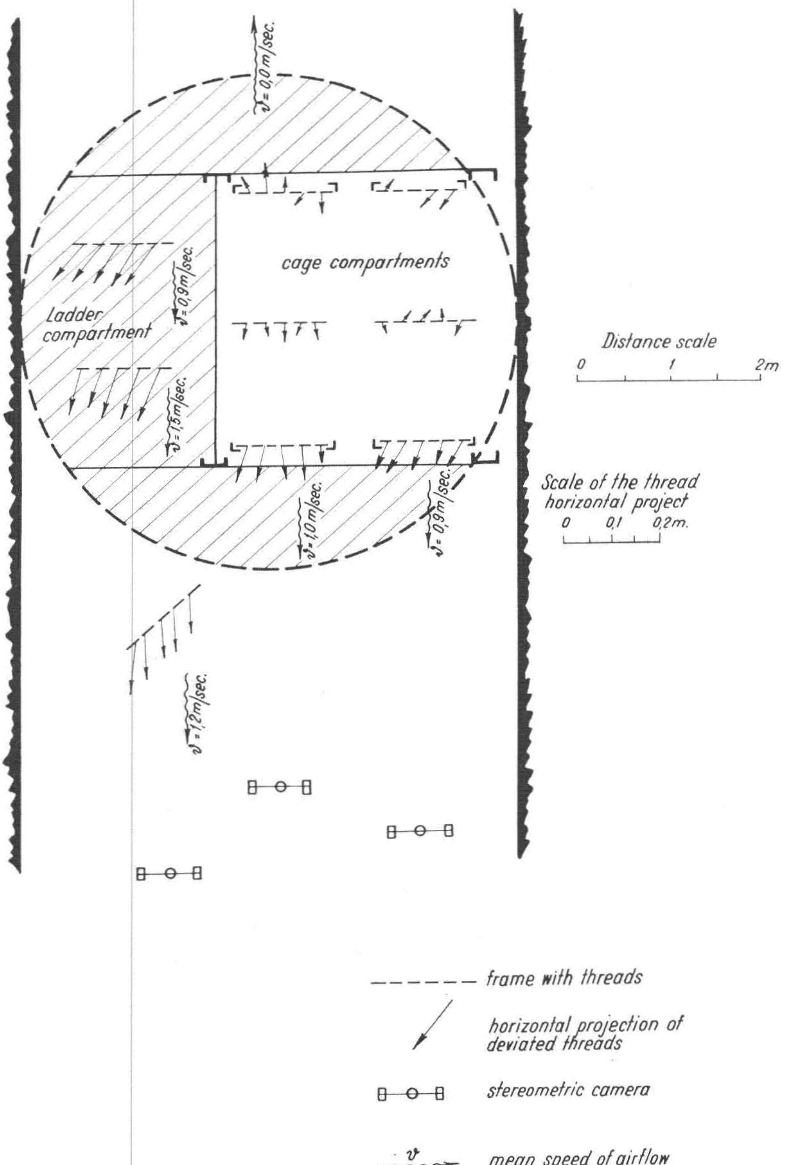

FIG. 3. Horizontal components of the airstream directions in a shaft-plat cross-section.

2. In the investigated section of the airway, the presence of the operator and registering apparatus does not interfere with the airflow, as the measurements are made from a distance of 4 to 6 meters.
3. Simultaneously with registering the thread deviation, the gallery—or shaft—situation details are photographed. This is of great importance for the consequent analysis of the airflow.

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