FRIDAY MORNING SESSION

JANUARY 24, 1947

The meeting reconvened at nine-fifteen o'clock, Mr. Revere G. Sanders, President of the Society, presiding.

PRESIDENT SANDERS: Ladies and Gentlemen: The time has come to begin the second session of the Annual Meeting of the American Society of Photogrammetry.

In the past years we have heard on several occasions from our friends in Latin America. Yesterday we also heard from some of our southern neighbors. We have not had much opportunity in many years to hear anyone from the European continent. Now that the war is over, there will be a freer intercourse, I believe, certainly of a technical nature, hopefully of a political nature. Although our interests are scientific, we hope that there will be a freer intercourse between ourselves and those countries of Europe that have shown such leadership in the scientific aspects of our profession.

We are very fortunate this year to start that intercourse, which I hope will go on for a long time to come. We have with us today a representative from the Henry Wild Survey Instrument and Supply Company, of Heerbrugg, Switzerland. Mr. Edmond Staub has come over to this country in connection with the importation of some automatic map plotting instruments made by the manufacturer whom he represents. These plotting instruments, as you have all noted, are in the exhibit room. Mr. Staub is Assistant to the Chief Engineer of the Wild Company. He is a graduate of the Federal Technical University in Switzerland and has the degree of Photogrammetric and Survey Engineer. I hope that the time will not be too far off when in this country there will be degrees available with such a title as that.

Mr. Staub, fortunately, is able to discuss his paper with us in a good brand of English. This comes from having served with an English Photogrammetric Mapping Company for approximately five months. In addition, he has served in various commercial and governmental mapping agencies in Switzerland. Mr. Staub is going to speak to us on the subject of Photogrammetric Practices in Switzerland. I would like at this time to introduce to you our first speaker, Mr. Edmond Staub.

MR. EDMOND STAUB: President Sanders, Members of the American Society of Photogrammetry, and Distinguished Guests: On behalf of the Henry Wild Surveying Instruments Supply Co., Ltd., of Heerbrugg, Switzerland, I wish to express to the American Society of Photogrammetry gratitude for their kind invitation to appear on this program and to participate in the exhibition of photogrammetric equipment. We are fully aware of the great honor accorded to us. I wish also to take this opportunity to express to the Geological Survey sincerest thanks for their permission to exhibit the Wild A-5 and A-6 which they recently acquired and for their assistance in assembling these machines. Mr. Schmidheiny our director and Mr. Berchtold, our chief engineer, deeply regret their inability to be present at this important meeting. They have asked me to extend to you their most cordial greetings.

Before approaching the subject of Photogrammetric Practices in Switzerland, may I review a few of the characteristic features of my country which have influenced the development of mapping.

Switzerland has a population of 4,200,000. Its size is 16,000 sq. miles, or a little more than one-third the area of Pennsylvania. More than one-third of Switzerland belongs to the alpine region with heights up to 15,000 ft., the remaining portion is from hilly to mountainous with heights from 700 ft. to 5,500 ft. This topography gives Switzerland its natural charm which has at all times stimulated mapping, and noticeably the artistic side of it.

Otherwise, nature does not treat us too kindly. Our natural resources are few, with the exception of waterpower. Our agronomy can normally sustain only about half the population. During war with its restrictions and concentrated efforts the production could satisfy about 80% of the demand. The duty to utilize every available corner of the country for agricultural production necessitated a lot of land melioration projects, such as drainage, roadbuilding, new repartition of land parcels, agricultural housing, the clearing of woodland for tillage of the soil, etc. Photogrammetry helped much in procuring necessary plans in useful time.

In order to maintain a balanced economy, Switzerland is forced to have a large export industry. In fact, after England and Belgium, it is, relative to population, the most highly industrialized country in the world. We have four cities with a population of more than 100,000 and one with nearly a half million inhabitants. The industries are rather specialized. The chief products are precision instruments, machinery, textiles and chemicals. Switzerland is a typical country which cannot accept the principle of absolute self-sustenance, but believes in an international exchange of goods and ideas.

And now a few words on the organization of our official surveying work, which can be divided into mapping and cadastral survey. Mapping is principally the task of the Swiss Topographic Institute, which is adjoined to the military department of the government. As in most Euroepan countries, the organized military mapping was intensively started by French engineers following the armies of Napoleon on their way through Europe after 1800. Since then, great efforts were made in topographic works, and history has proved that the value of a carefully planned map to the economic development of a country is many times greater than its initial cost. This fact fully justifies all the big work done in the last years.

Today Switzerland possesses a well established triangulation net throughout the country, with about 1.2 to 11 points per square mile in different zones. The mean error of the points is about ±0.6 inches in position and ±1.2 inches in height. Some measurements for the bases and the largest triangles date from as far back as 1880. For the greater part they were carried out from 1910 to 1922 by the Topographic Institute. This same organization accomplished the actual precision levelling throughout Switzerland between 1903 and 1925. At the same time, the existing official maps had to be kept up to date, viz., the Dufour map at 1:100,000; and the more recent Siegfried map at 1:50,000, and partly 1:25,000. Both were famous in their time, and they really show the hands of artists in topography. The accuracy of these maps, however, is no longer sufficient.

In 1924 the Topographic Institute began new mapping based on the then recently finished main control work, and making use of the already tested modern photogrammetric method. This mapping has been carried over the most mountainous part of Switzerland until 1939, in order to establish the fundamental sheets for an entirely now set of maps. In the lower portions of Switzerland, the cadastral survey is procuring the basic plans. In 1935, the first sheets at 1:50,000 of the new map set appeared. It will take years of cartographic work to accomplish the entire program of the maps at 1:25,000; 1:50,000; 1:100,000; 1:200,000; 1:500,000; and 1:1,000,000 scales.

The cadastral survey in its present modern form, together with compulsory land registration, or recording of deeds, was introduced throughout Switzerland by the new Civil Code of Law in 1912. Its purpose is first of all to legally document and define the boundaries. The Cadastral Survey is controlled by a directorate attached to the Department of the Interior, and is actually carried out by licensed private surveyors. All work must be executed in accordance with exact instructions, and is rigidly checked on the ground. The first part of the survey was the measuring and computing of the lower order triangles of the main control. This part is now finished. I have mentioned before the resulting actual density of all triangulation points.

The next step is to officially mark the boundaries on the ground, to establish additional control and take the necessary detail measurements, then to carry out the Cadastral plan, which contains the full planimetry, and finally to make the area computations and the accompaning registers. The required accuracy has to keep within a reasonable relation to the price of the land, which takes any value between a maximum in the cities and a minimum in the rocky regions of the Alps. Different zones with different surveying methods had to be prescribed. The usual point accuracy ranges from 1 inch in cities up to 30 inches in alpine pastures. The plan scales vary from 1:250 to 1:10,000. The methods are really well chosen, for the relative cost of the survey is constant in all zones—equal to about 0.7% of the land price. This is only possible by the use of photogrammetry in the less valuable country. The last work of the Cadastral Survey is the establishment of a contour plan at 1:5,000 or 1:10,000, which, once finished, will be the fundamental topographic map of Switzerland. Here again photogrammetry is usually the method. The Cadastral Survey is progressing village by village, and more than 50% is already finished. It is, of course, continually and automatically revised by the appointed surveyors.

Now some historical and general remarks: Although one-picture photogrammetry or rectification is nowadays of some importance, the classic method in our hilly country is double-picture or stereo-photogrammetry. It started essentially from the surveying side, that means a photographic camera was considered as an angle-measuring instrument. As you know, the horizontal angle alpha between the horizontal camera axis and the direction to any point is given by tangent alpha being equal x-parallax of the picture point over focal distance. With two shots from different standpoints, an indefinite number of conjugate angles to ground points can be obtained. Provided the position and orientation of the cameras were measured (terrestrial photogrammetry), these ground points can be correctly intersected in the office. To this purpose toilsome graphical constructions and stereo-comparator computations were used in the beginning and until 1919 when the first plotting machine was bought by the private office of Dr. Helbling. The use of this machine with its possibility of automatically and correctly drawing any planimetric or contour line, just by stereoscopic observation, was found to be such an advantage that until today all stereo-photogrammetric work is done with stereoscopic machines.

When the Swiss Topographic Institute started the fundamental mapping 1:25,000 as a base for the new map set they were well aware that this work should serve for many generations. Great general accuracy and really correct contour lines were wanted. Only the most precise photogrammetric equipment could guarantee an economical solution of this problem. The Wild machines and phototheodolites which were the products of new inventions were found to suit very well. Until 1937 about 6,000 sq. miles of mountain peaks were mapped by terrestrial photogrammetric methods. In the meanwhile, aerial photogrammetry was developed and introduced in 1928 in 1:25,000 mapping. This new method offered the following advantages: the accuracy is more uniform, there are usually less gaps to be filled in on the ground, and the fieldwork is reduced. Terrestrial photogrammetry has therefore lost its importance as a general mapping method but is still very useful in steep country and for special applications. In our mountains a combined use was quite satisfactory. The aerial photographs were mostly taken as so-called "vertical-obliques." That means that always after a vertical picture the next shot is oblique backwards in order to cover the same area. The map can consequently be integrated by a series of 100% overlaps. Side obliques with a hand-held camera were tried out but with no advantage. Nowadays very often strips of usual verticals are taken.

In the Cadastral Survey of less valuable country, aerial photogrammetry proved to be the ideal method and approximately 6,000 sq. miles have so far been surveyed at scales of 1:5,000 and 1:10,000. The usual proceeding can be described in short words as follows: Signalization of the control and other interesting points on the ground by white sheets, taking of vertical-obliques from 8,500 ft. relative altitude above ground, establishing of additional control on the ground in order to get about 4 to 5 control points per overlap, to make a careful identification of the whole planimetry on enlarged prints and measure the necessary details on the ground. The relative and absolute orientation of the original negatives in the plotting machine takes place according to all the rules of error propagation so as to get the utmost coincidence of the restituted and given data. The actual plotting is then carried out according to the official drawing instructions and strictly following the content of the identification sketch. This means the map redaction is made on the ground and interpretation mistakes are nearly impossible. Very often the work can be speeded up by an auxiliary operator helping at the drawing coordinatograph.

I must add that in order to reach the greatest precision glass negatives are usually used, the taking camera being the normal-angle distortion-free Wild plate camera.

The innumerable official checks give a clear picture of the accuracy, $\pm 24''$ mean error in height and $\pm 37''$ mean error in position. We can say that accuracy and cost fit to the best in the purpose of the survey.

It is a great advantage of photogrammetry that it can so easily be adapted to a certain task. With a given equipment the required accuracy is obtained in correctly choosing the flying height. Naturally the most accurate machine permits the choosing of the greatest altitude. Fewer pictures are necessary and hence the proceeding is more economical. This fact is equal to the principle of getting as much information as possible out of the photograph. Further progress is possible by the improvement of picture quality.

According to the great application of photogrammetry the offices grew one after the other and today we have 16 precision plotting machines in our small country, 7 in private use and partly working day and night. Besides the official mapping they do a great amount of private work in Switzerland and overseas. Much of this work is somewhat similar to the official one but many special and new applications are carried out as well.

Terrestrial photogrammetry is frequently used for very large scales such as 1:100 and is therefore a big help for detailed technical studies. Large projects, such as the construction of dams, are facilitated. Periodical surveys during the execution of the job provide an elegant and accurate way of computing the payable volume.

In the bigger cities the police are today mapping most scenes of accidents with the aid of special photogrammetric equipment. The same instruments can be used for the measurement of water waves. Furthermore, any complicated objects or parts of living bodies can be represented by accurate contour lines for scientific, reconstruction or modeling purposes. The extreme in this direction is microphotogrammetry which allows three-dimensional measurement of things of microscopic size. A special camera is used in ballistics and permits the stereoscopic determination of shooting characteristics.

A wide and very useful application is the survey of the geological structure of the earth surface with aerial photogrammetry. Specialists identify the geological structure lines on the ground. These lines can afterwards be exactly mapped together with topography. Our universal plotting machines here offer an additional advantage. It is possible to project the interesting features on a vertical plane and often the resulting plot is of astonishing clearness with regard to geological structure.

Since 1939 aerial photogrammetry has, with great success, found application to surveys at the scale of 1:1,000. Plans of this scale had to be made, in great number, of villages with bad property parcelling. They served first of all to make a new repartition of the land with the purpose of facilitating agronomy and were therefore carried out as Cadastral plans. In most cases contours were drawn at the same time, and the resulting plans were of course ideal for technical planning.

The flight altitude is chosen around 4,500′ and with careful work the obtained accuracy is the following: $\pm 8''$ mean error in position for well-marked points and $\pm 12''$ mean error in height for contours. Special points can be quoted as $\pm 6''$. The cost of this survey may be as much as 40% lower than the plane table work when the topographic detail is dense. The plans are more accurate and carried out in much less time. These experiences show clearly that the Wild A-5 is capable of quick production of accurate and cheap topographical plans at 1:1,000 from aerial photographs and this naturally means again an extremely wide field of action. Wherever the organization of a Cadastral Survey is studied this possibility cannot be neglected.

As you have seen, the control net in Switzerland is rather dense and we do not have the problem of bridging great areas. Our practices include only the photogrammetric determination of single passpoints where it is necessary. However, the dense control is favorable for exact testing purpose and for many years the Federal Technical University has been systematically analyzing the results of aerial triangulation. Great point accuracies have been reached over distances of 30 and 60 miles.

We have the wish and the duty to make the best use of our experiences in the solution of photogrammetric problems which might arise anywhere. On the scientific side the efforts are characterized by profound studies and thorough checks; on the manufacturing side they are characterized by the careful and precise construction of reliable equipment.

Every country has its own development. We fully appreciate the great work being done in the United States and I am persuaded that a collaboration between our two countries can only be productive.

President Sanders: I think you have all had a rare treat this morning in hearing Mr. Staub. I can only hope that in the future we will have more men of his caliber come to visit us from overseas.

This is Mr. Staub's first visit to the United States, and I urge every one of you who has not met him thus far to make yourself known to him and give him a personal hearty welcome to our country, so that he may carry back to Switzerland a firm conviction of the hospitality of the members of the American Society of Photogrammetry, so that he may spread the word that we are good fellows over here who really want to get closer to the photogrammetrists in other countries.

The European continent not only sends us occasional visitors like Mr. Staub, but it sends us also people of great scientific attainment who become citizens of our country and spend the rest of their lives working with us to advance science in this country. The Bausch and Lomb Optical Company, of Rochester; New York, is fortunate in having such a man, Dr. Konstantin Pestrecov, who is now in charge of photographic projection optics design of the Scientific Bureau of Bausch and Lomb. He is going to speak to us this morning.

Dr. Pestrecov was born in Russia and studied in Russia. He received several prizes for his outstanding work in spectrographic X-ray work. He came to this country in 1931 and became associated first with the Rockefeller Institute for Medical Research, and Columbia University. He eventually went to the Bausch and Lomb Optical Company, and of course we know him best for his work with that Company. During the war Dr. Pestrecov was very closely involved in the development of aerial camera lenses and multiplex equipment, and every one of us here recognizes the importance of that phase of the work. I would like to introduce to you now Dr. Pestrecov.

DR. KONSTANTIN PESTRECOV: I have a secret to reveal to you about why this paper is being presented today. The reason is simple. I had to talk so often with so many people about the subject of resolution that I got tired and decided to write everything that I knew about it. I hope that the paper will be eventually published in PHOTOGRAMMETRIC ENGINEERING, and then my job will be simple. I will just distribute reprints and forget the whole matter. In the meantime, we have prepared some advanced mimeographed copies of the talk, and those who are really interested can obtain them from Mr. Reynolds at our exhibit booth. It is really to him that the major credit should be given for this paper, because he really forced me into it, and then later when he realized how difficult the job was, he did all possible to render technical assistance, with some others of my colleagues. Well, let's go to the business of resolution.*

Basic factors pertaining to photographic resolution are summarized in this paper. Extensive material now available indicates that the resolving power of a lens is a rather indeterminate quantity which may vary widely depending upon the conditions of tests. To be of real meaning, the resolution data for a given lens should always include an identification of the target and of the emulsion used.

Criteria are suggested for the establishment of resolution requirements, and formulas are discussed which predict the probable resolutions of lens-film combinations. A formula is derived indicating the minimum focal length required for recording ample detail from a specified altitude.

BASIC REQUIREMENTS OF PHOTOGRAPHIC OPTICS

In designing a lens system for photographic applications, the lens designer strives to satisfy the following two basic requirements. The first is that the system devised by him should be capable of reproducing on a photographic emulsion the variety of subjects surrounding us. The second is that the reproduction should be as faithful as it is possible to achieve within the limitation of our knowledge.

There are many factors which determine the faithfulness of reproduction. The most important of them are the freedom from distortion and the availability of a sufficient amount of detail in the image.

The problem of distortion, not being within the scope of this paper, will not be discussed here. We may note, however, that the condition of freedom from

* Part of this material was presented on October 31, 1946, before the Rochester Convention of the Photographic Society of America, and published in PSA Journal, Vol. 13, No. 3, pp. 155–159, 1947.