COMMERCIAL PHOTOGRAMMETRY IN ITALY

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IN MARCH of this year, I visited Europe to obtain detailed performance data and information regarding the availability of precise stereoplotting equipment for use in the United States. While there, I had the opportunity to study the history and operations of a company in Milan, Italy, engaged in the practice of photogrammetric engineering. This company is known as "Istituto di Rilievi Terrestri ed Aerei, S.A." (Institute for Terrestrial and Aerial Surveying). Dr. Ing. Lodovico Ottolenghi is Executive Director and Guiseppe Moro is Assistant Director of the Institute.

The Institute was established in 1930 by "Societa Italiana Politecnica Industriale" (Italian Polytechnic Industrial Company). "S.I.P.I.," founded in the year 1882, manufactures drafting and surveying equipment, blueprinting machinery and engineering materials. It is a counterpart of the well known American companies which manufacture drafting, surveying, and reproduction equipment and supplies.

The initial function of Istituto di Rilievi Terrestri ed Aerei, which is known as "I.R.T.A.," was to conduct operational studies in photogrammetry, particularly as they relate to commercial applications. About two years prior to the establishment of I.R.T.A., the S.I.P.I. company had purchased a WILD A–2 autograph. This stereoscopic plotting instrument became the basic equipment for the I.R.T.A. company. At that time, I.R.T.A. was the only commercial organization in Italy engaged in the field of photogrammetric surveying. Within the next few years, two more companies were established. These were "Ente Italiano Rilevamenti Aereofotogrammetrici," ("Officine Galileo") of Florence, Italy, using SANTONI equipment and "Ottico-meccanica Rilevamenti Aereofotogrammetrici," ("S.A.R.A.") of Rome, Italy, using NISTRI equipment.[1] Of Course, Nistri had, for some years previous to this time, been building stereoplotting equipment.

It is well to note at this point that the "Istituto Geografico Militaire" (Institute of Military Geography), official mapping agency for the Italian government, has been making aerial photographic surveys since about 1925.[2] This agency, located in Florence, utilizes SANTONI stereoscopic plotting equipment and has also a considerable installation of photographic and rectification instruments.

Also, there is the "Ministerio delle Finanze, Servizio Catasto" (Ministry of Finance, Cadastral Division) a bureau of the Italian national government, which has for some years contracted for cadastral mapping by photogrammetric means. The taxation of land, a prerogative of the national government, accounts for a substantial portion of the general revenues. In special cases, for valuation and inventory purposes, the Ministry of Finance uses large scale cadastral maps. Usually the addition of contour lines is specified on these maps; scales are 1:500, 1:1,000, 1:2,000 and 1:4,000, with contour intervals of 1, 2 and 4 meters.

To complete the general picture of photogrammetry in Italy, mention should also be made of the educational activities. Photogrammetry is offered as post-

[1] Cassinis, G. "Aerophotogrammetric Mapping on a Large Scale and the Italian Contribution," *News Notes*, American Society of Photogrammetry, Sept.–Oct., 1935, Vol. I, No. 7, pp. 41–47.

[2] Maranca, Francesco "Photogrammetry in the Geographic Military Institute of Italy," *News Notes*, American Society of Photogrammetry, April, 1935, Vol. 1, No. 4, pp. 30–33.

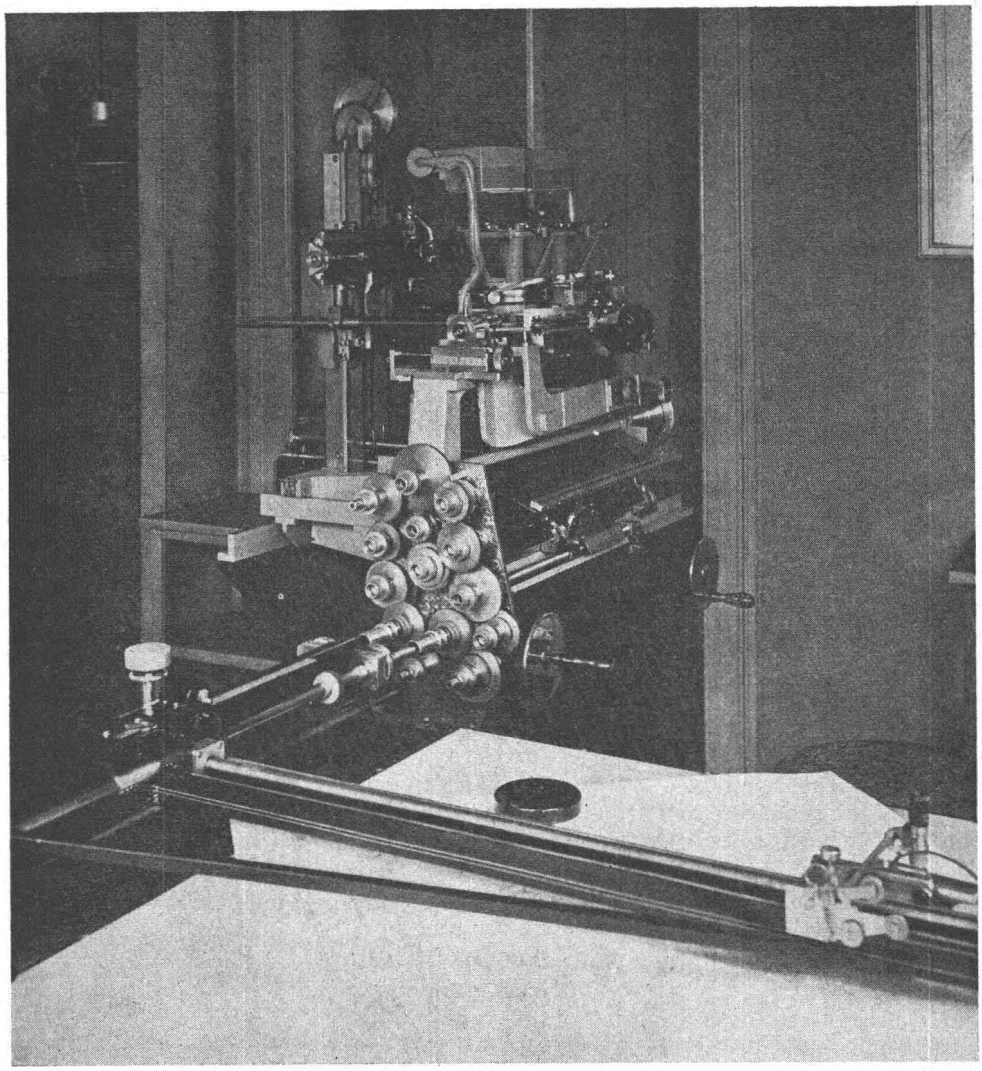
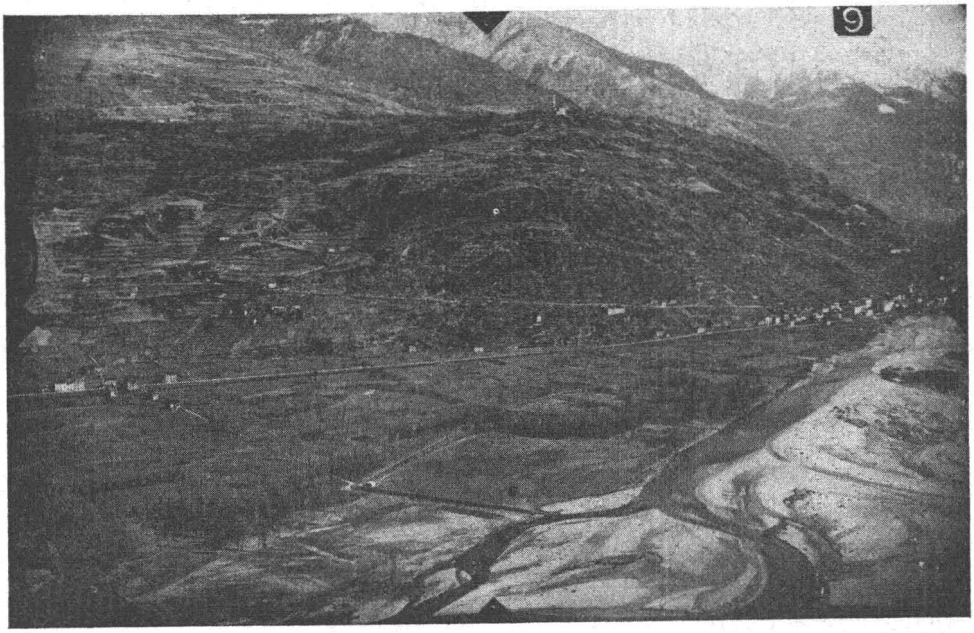


FIG. 1. The I.R.T.A. Plotter.

graduate study at "Politecnico di Milano" (Polytechnical School of Milan) and "Scuola di Ingegneria di Bologna" (Bologna School of Engineering). These are full time courses of three months' duration, the students making visits during this period to commercial organizations, such as I.R.T.A., for the purpose of practical study.

The original objectives of study and research in photogrammetry, which marked the founding of I.R.T.A., resulted in the accumulation of basic data and skills which were readily converted to practical use when increased demands for surveys were made upon the company. In addition to practical training on company equipment, I.R.T.A. personnel served as trainees, in field and office with the Wild Company of Switzerland and with mapping organizations in that country. My investigations showed that this intensive training, together with a company policy which continually stressed high standards of performance, accounted for an unusually successful record of performance.



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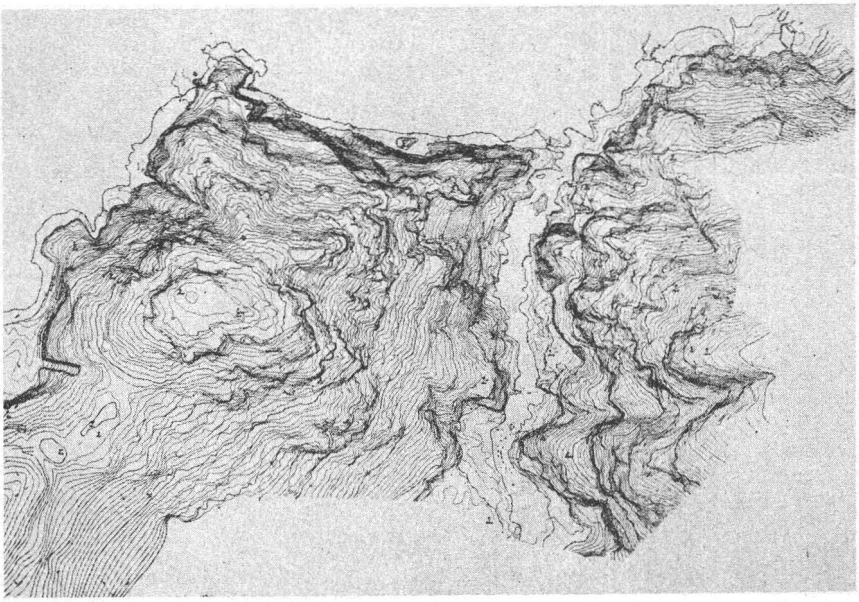


(b)

FIG. 2. (a) Valtellina. (b) Map of Valtellina.

By 1935, the volume of business made it necessary to supplement the WILD autograph operated by the company. I.R.T.A. placed an order with the manufacturing department of the S.I.P.I. company for a plotter which would include a number of new operating principles and new mechanical features. S.I.P.I.

had an engineering staff and a completely equipped machine and instrument shop. It was also fortunate in having available the services of Ing. Robert Zurlinden of Switzerland, designer of photogrammetric instruments. The new plotter was in process of design and manufacture for two years, not an unreasonable period for a piece of equipment of this nature. The plotter (Fig. 1) is based on Porro-Koppe principles. The coordinatograph or plotting table forms an inverted "L" with the main part of the instrument, making it feasible for one

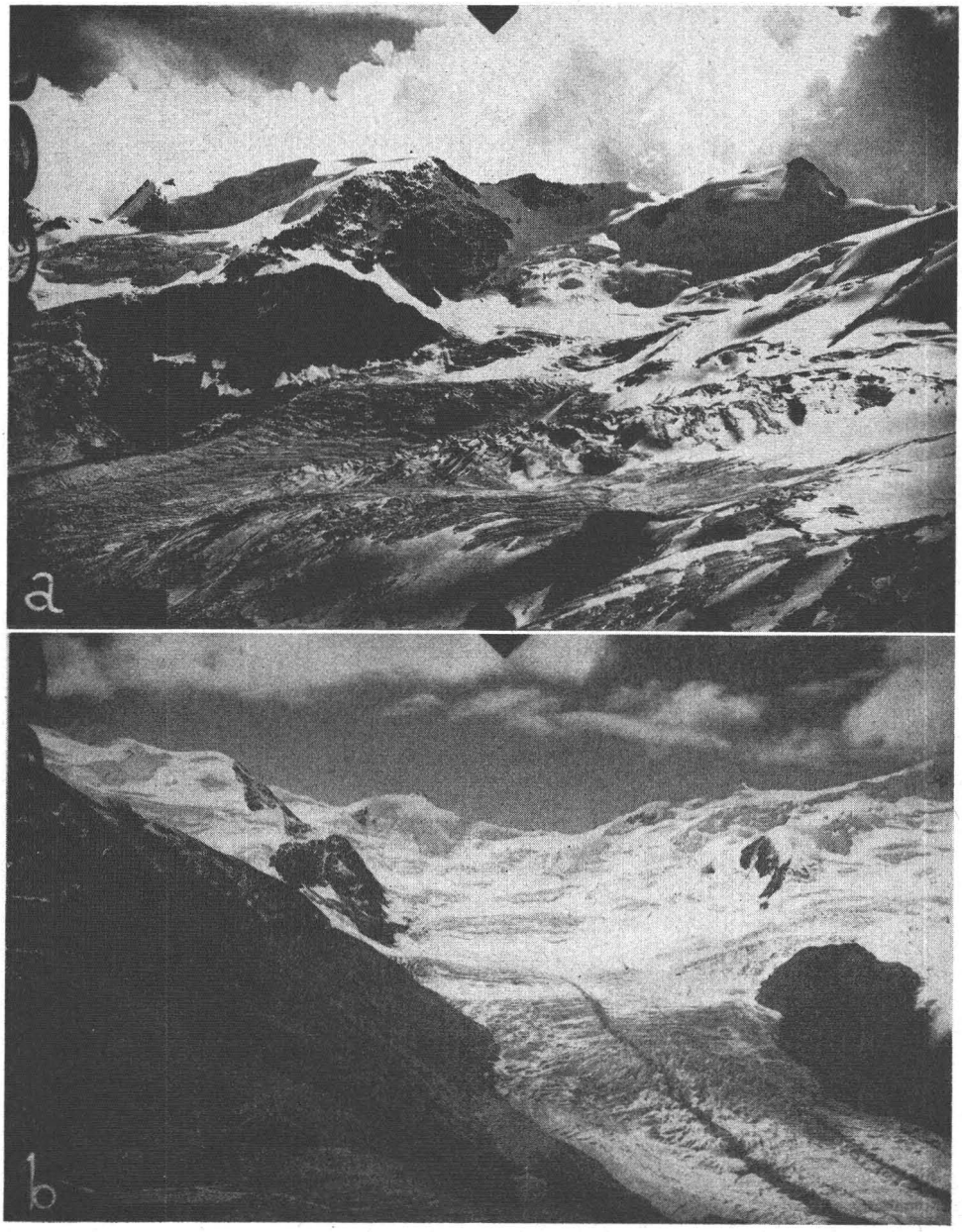


FIG. 3. (a) Ghiacciao dei Forni. (b) Ghiacciao dei Forni (close up).

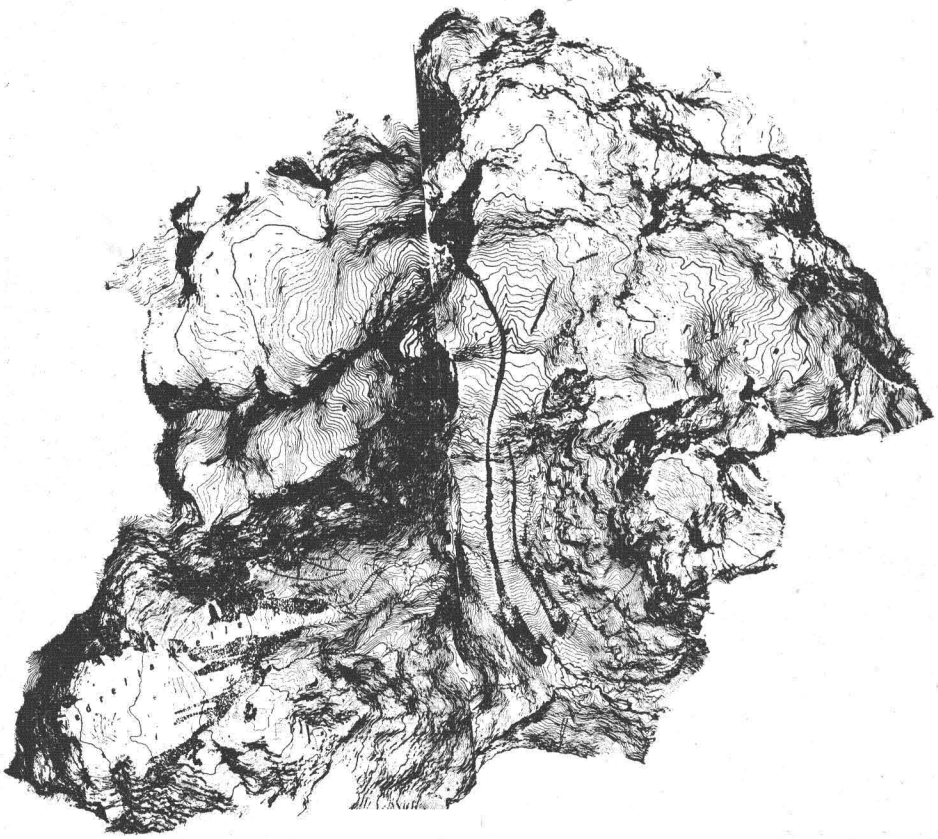


FIG. 3. (c) Map of area pictured in 3a and 3b.

person to operate the machine. Before the instrument was accepted for project work, exhaustive operating and field tests were made. It proved to be an instrument of full precision characteristics.

The description and operation of the WILD A-2 autograph have been well covered in the existing literature on stereoscopic plotting instruments but since no similar information on the I.R.T.A. plotter has been published, I think a further description of the instrument will prove of interest.

I had the privilege of inspecting and operating both instruments over a period of several days. Like the WILD A-2 autograph, the I.R.T.A. plotter utilizes the original glass plate camera negatives. The three characteristic motions are present—X and Y, actuated by left and right handwheels and Z, by means of a right footplate. All motions and linkages are smooth and efficient in operation.

The plate holders are readily accesssible to the operator, featuring a simple and efficient seating and adjusting mechanism. The plotting scale or ratio gears are all mounted in one convenient location and interchange of gears is made at this one point. A greater range of scales is provided for, than is usually available with similar types of plotting instruments, including provision for both metric and English scales. A left foot pedal raises and lowers the plotting pencil and a simple mechanical feature automatically rotates the pencil holder as it touches the paper. This insures a definite impression and a round dot in spotting operations. The pencil holder is interchangeable with a microscope which is used in

the adjustment and orientation of the model to plotted control. These features characterize the coordinatograph which has a plotting accuracy of $\pm$ 0.08 mm.

All scales and verniers which record the orientation and parallax values, pertaining to the stereoscopic model, are visible to the operator from a sitting or standing position in front of the instrument. The engraving of the divisions and numerals is deep and well defined, making magnification unnecessary. In some

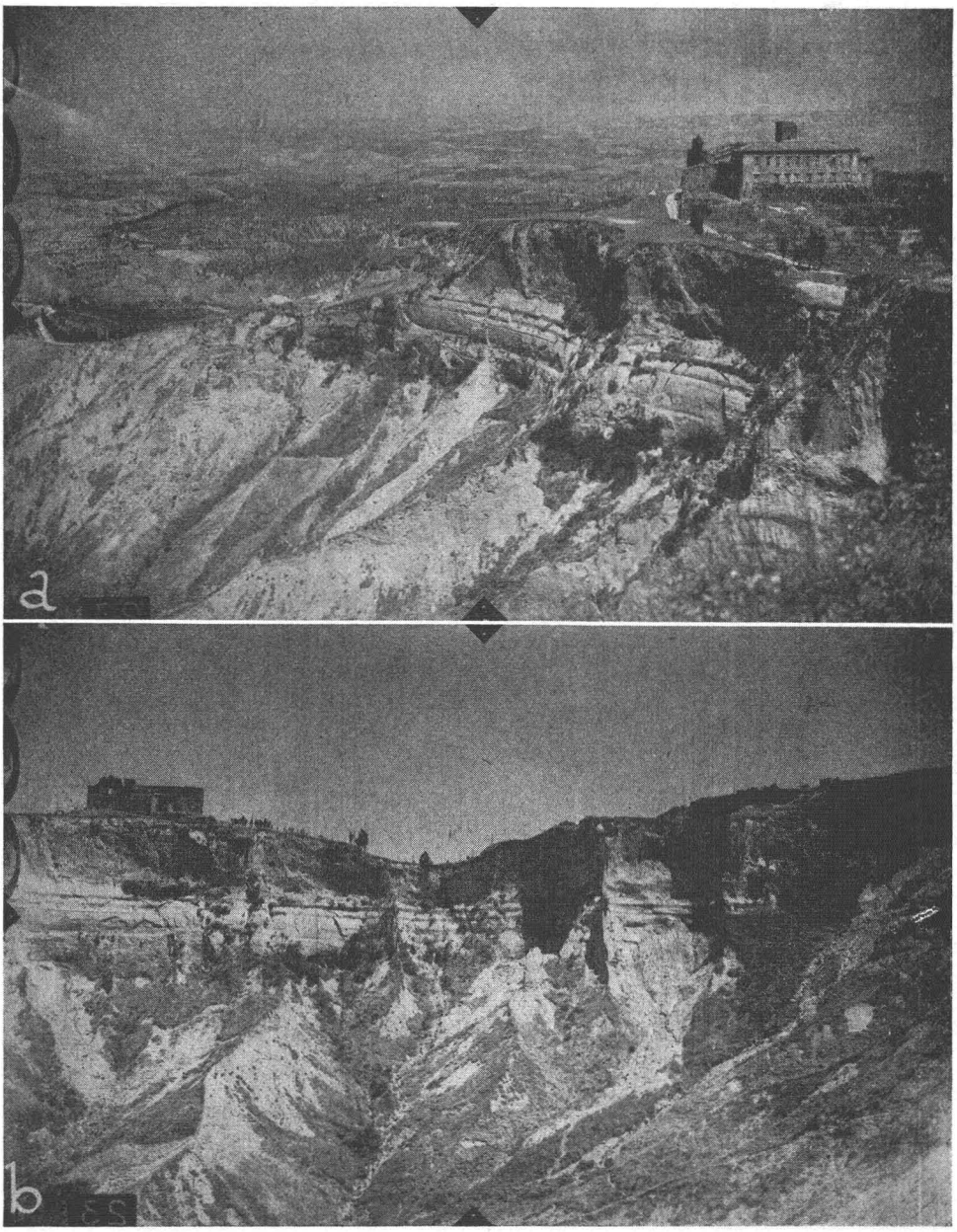


FIG. 4. (a) Volterra. (b) Volterra.

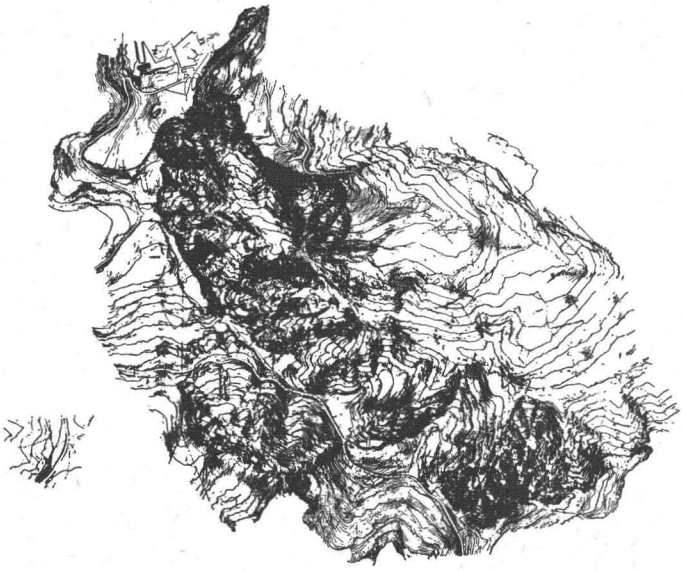


FIG. 4. (c) Map of Volterra Area.

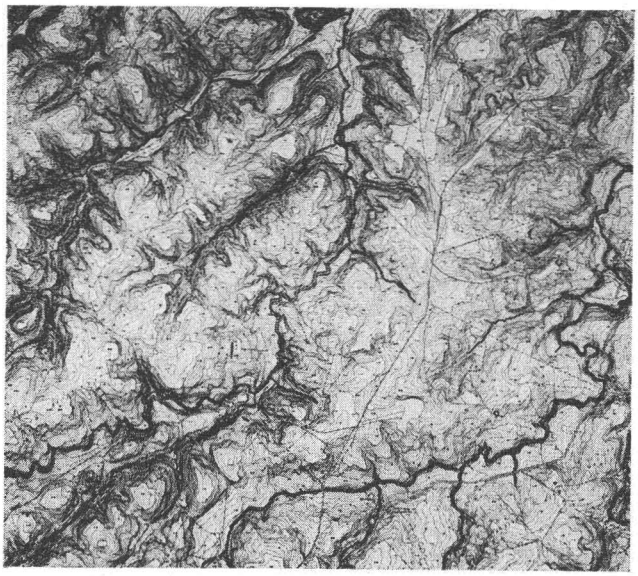
cases contrasting metals are used between base scales and verniers and are used in other places to enable the operator to quickly identify a particular motion. All principal movements include both fast and slow motion. Rapid motion is usually accomplished by disconnecting the gears and sliding the member along precision machined tracks or columns. Both the instrument proper and the coordinatograph have these smooth acting rapid motion features.

The features and motions described and the improved position of the drawing table make for less strain and greater efficiency on the part of the operator and consequently more consistent production and accuracy.

I also examined and operated the WILD autograph which has been in almost continuous operation since 1928. The A-2 is designed for both terrestrial and aerial photographs and it is on this instrument that I.R.T.A. has produced a considerable number of jobs utilizing terrestrial photographs. On the two instruments, more than 75 projects have been completed for a list of purposes almost as numerous. The volume of work completed by I.R.T.A. totals approximately 30,000 hectares (74,100 acres) of terrestrial mapping and 650 km.^{2} (250 sq. miles) of aerial mapping. These are the figures to 1942, when I.R.T.A. suspended operations due to the war. Scales ranged from 1:200 to 1:5,000 and contour intervals from $\frac{1}{2}$ meter to 5 meters. The company also completed a contract covering the extension of ground control by aerial triangulation methods. The results of this project were published in 1937 by the Ministry of Finance, Cadastral Division, Rome, in an article by Dr. Ing. Ottolenghi entitled "Applicazione di triangolazione aerea in un rilievo aerofotogrammetrico sul Po" (Application of Aerial Triangulation in an Aerophotogrammetric Survey on the Po).

A short description of several projects should prove of interest:

VALTELLINA REGION (Figs. 2a, b): Scales—1:5,000; 1:2,000; 1:1,000; 1:500; 1:200. Contour Intervals—5M; 2M; 1M. Area—4,500 hectares. Terrestrial mapping project for damsites and reservoir studies. This project was the first job prepared on the WILD autograph by the S.I.P.I. company. This was in 1928.



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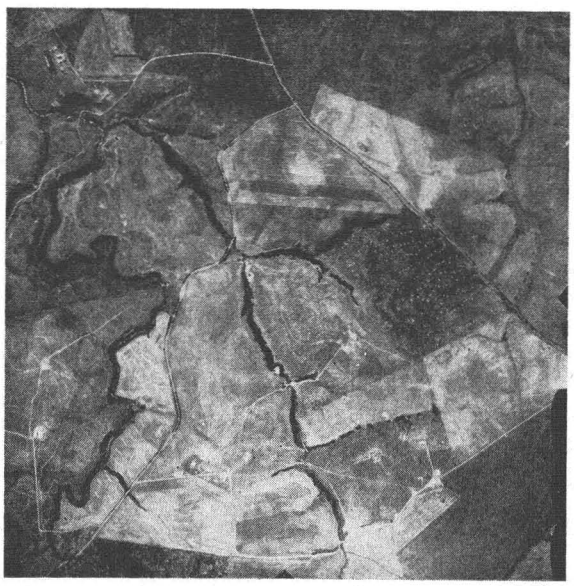

(b)

FIG. 5. (a) Map of Agro Romano area. (b) Photograph of portion of area shown in Fig. 5a.

CHIACCIAO DEI FORNI (FORNI GLACIER) (Figs. 3a, b, c): Scale—1:5,000. Contour Interval—5M. Area—4,000 hectares first year, 2,000 hectares each successive year.

Utilizing terrestrial photographs, this glacier, in the Italian Alps, was mapped for eleven consecutive years for hydrological studies. The first year a complete map of both glacier and adjacent terrain was made. In subsequent

(a)

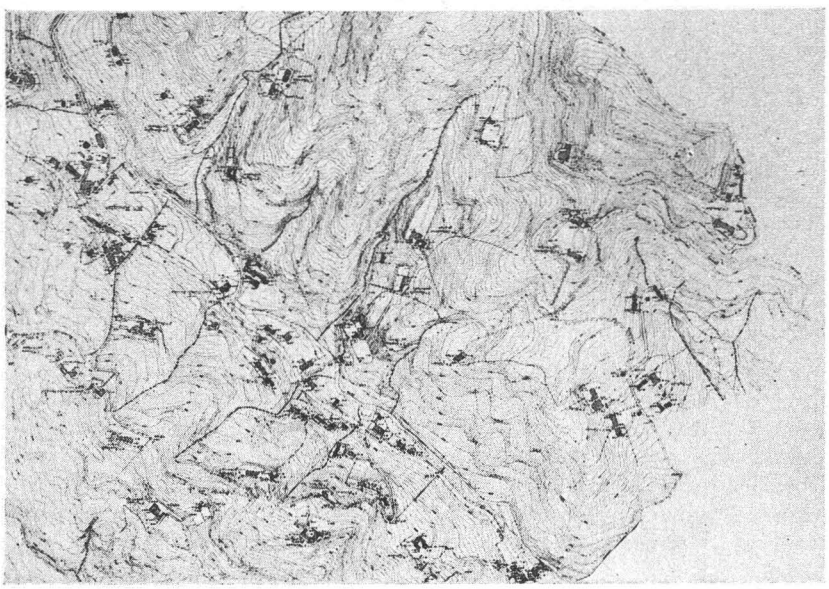

FIG. 6. (a) Torino. (b) Map of Torino area.

years, the glacier proper was contoured. The complete series of maps made possible determinations of the stability of the glacier as a potential source of water for power purposes.

VOLTERRA (Figs. 4 a, b, c): Scales—1:5,000 and 1:2,000. Contour Interval—1M. Area—150 hectares.

This project included the detailed contouring of a large eroded gully with precipitous sides. The enormous and continuous rate of erosion of the clay-

like soil had placed an important highway, an historic monastery, orchards and small buildings in danger of collapse. Corrective measures were planned and executed on the basis of the maps produced.

AGRO ROMANO (Figs. 5a, b): Scales—1:5,000 and 1:2,000. Contour Intervals—1/2M; 1M; 2M. Areas—36,000 hectares at 1:5,000 and 7,700 hectares at 1:2,000.

This detailed topographic map was prepared in connection with the drainage project of the marshy area south of Rome which we may remember as the "Pontine Marshes" project. This was one of the most successful agricultural and resettlement projects carried out under the Fascist regime. The land was not strictly a flat swamp or marsh as we know it in the United States;

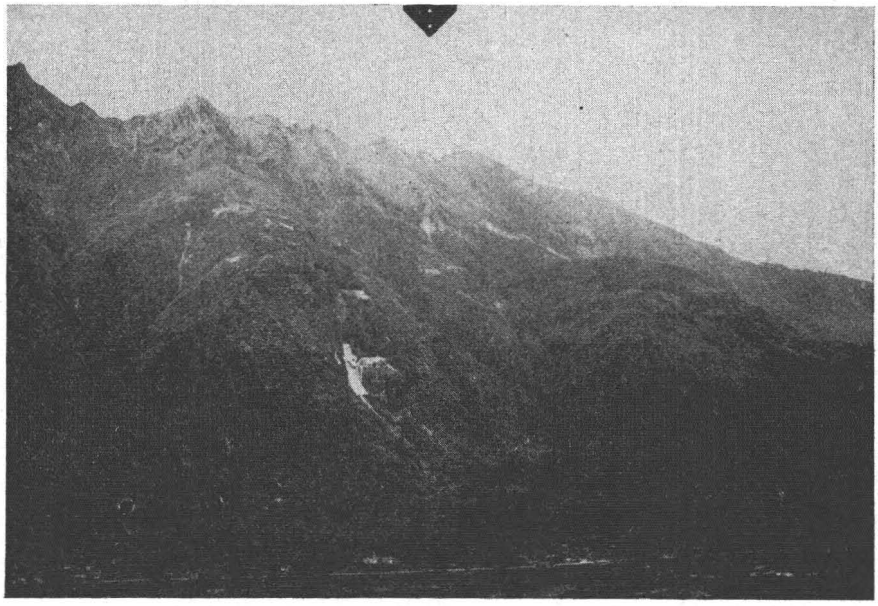

FIG. 7. Candoglia.

the terrain was slightly rolling but of a spongy nature, requiring an extensive program of artificial drainage. After the completion of the drainage program, the land was parcelled out and given over chiefly to the raising of wheat. Several planned communities were laid out for housing the farmers and their families. For mapping and recording these individual plats, the same aerial photographs were used in the preparation of detailed cadastral maps at a scale of 1:2,000.

TORINO (TURIN) (Figs. 6, a, b): Scale 1:2,000. Contour Interval—2M. Area —3,200 hectares.

These maps, made from aerial photographs, showed contours and cultural detail of the City of Turin, Italy, drawn on 45 sheets. Its use was chiefly for city planning purposes.

CANDOGLIA (Fig. 7): Scale—1:2,000. Contour Interval—2M. Area—220 hectares.

This was a terrestrial mapping project of the Candoglia Marble quarry in the north of Italy, not far from the Italian-Swiss border city of Domodossola. Briefly, the purpose of the topographic map was to provide estimates of the

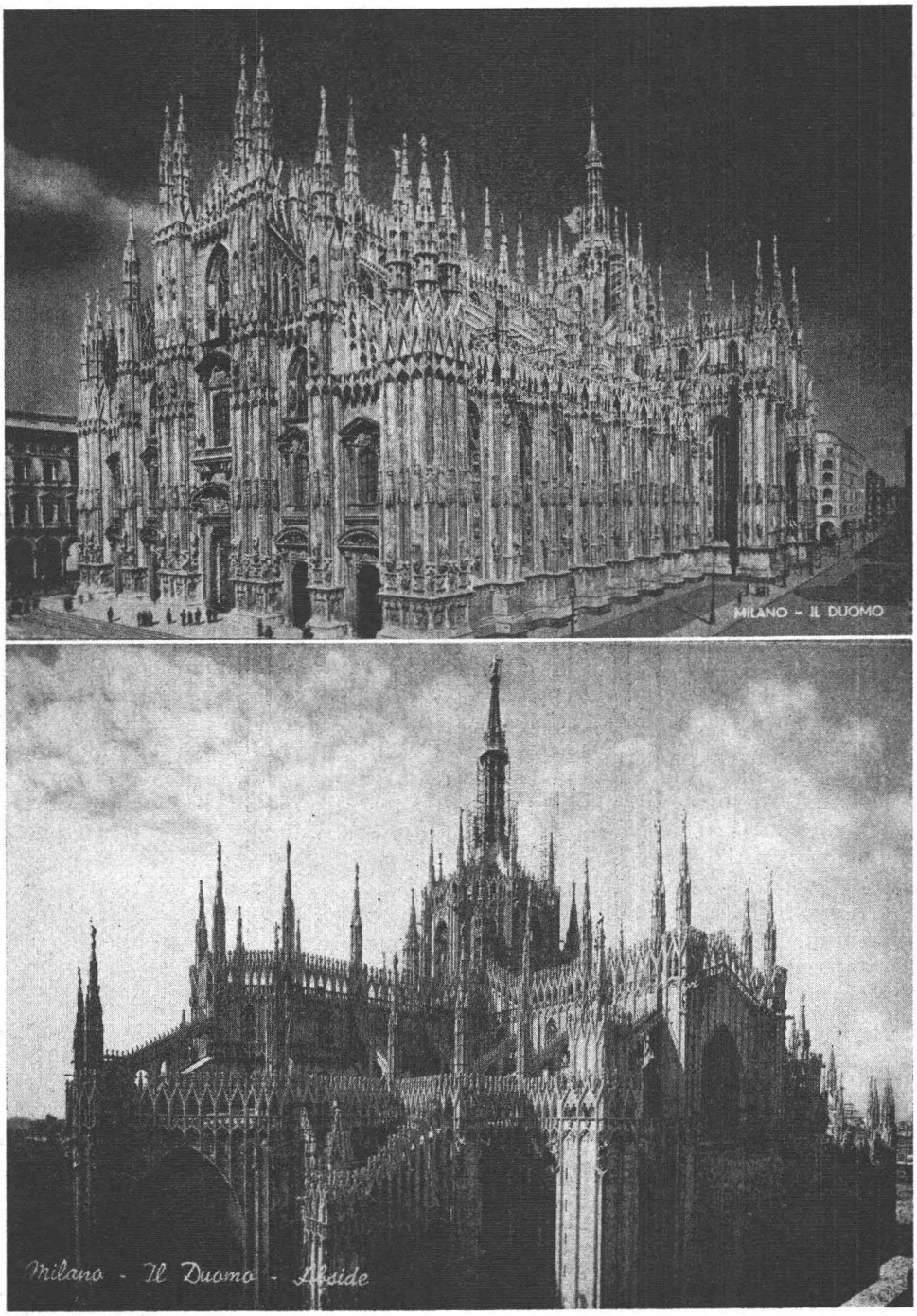

FIG. 8. Two views of Milan Cathedral.

quantity of marble still available in the quarry and to provide data for planning road locations. There is such an interesting story connected with this job, related to photogrammetry, that it will bear telling.

Candoglia marble, pinkish in tone and translucent when newly cut and polished, is the unusual stone used in the construction and maintenance of "Il Duomo," or the Milan Cathedral (Figs. 8a, b), one of the architectural masterpieces of Europe. There is a saying in Milan that "Il Duomo is never finished," though construction was started about the year 1386. It is for this reason that the word "maintenance" has special significance for, unfortunately, the beautiful Candoglia marble weathers rapidly in the humid climate of north Italy. The cathedral is so vast and its exterior so lavishly adorned with statuettes, balustrades and spires that the maintenance and replacement of the decayed stone carvings is a continuous process employing an architect and a score of sculptors and stone masons. Not only in the interior of the great cathedral, but high on the main façade overlooking the Piazza del Duomo (the Plaza), the interested visitor can find busts and inscriptions attesting to the genius of the long line of architects who have had the magnificent cathedral in their tender care through almost five centuries. These architects were not confined to maintenance alone, but they could exercise any creative genius in designing and building a new Gothic staircase, a delicately-carved minaret, or an unusual balustrade high above the marvelous flying buttresses that support the massive walls. Visitors may climb narrow winding stairs connecting successive roof levels and bell towers, and at every turn find age old marble crumbling to dust, alongside a newly sculptured column or statuette.

The Candoglia quarry has been the source of the special marble used in the building and subsequent maintenance of the cathedral. Administering the reconstruction work and operating the quarry is a group known as "Fabbrica del Duomo," which loosely translated means, "Workshop of the Cathedral." For the work of this group, a special tax was levied upon the Milanese about a decade ago, the money to be used for an expanded program of reconstruction and maintenance. One of the first expenditures authorized was for the topographic map of the quarry.

For purposes of replacing a badly deteriorated Gothic stairway tower, designed and installed by an architect long since gone, a search was made for the original plans. These and some others were found to be missing from the engineering and architectural files of the cathedral. This situation came to the attention of the I.R.T.A. company and it was suggested by I.R.T.A. that the plan and details of the elaborate tower be reproduced by photogrammetric means, using terrestrial or, rather, "roof-top" photographs. A test was authorized by the cathedral engineers. The photo-theodolite was set up at several stations high on the stone roof of the cathedral and the resulting stereo pairs were oriented and contoured in the WILD autograph. Figure 9 shows a typical pair of the photographs and the results of the first drawing of plan and profile from the pictures. The plotting scale was 1:50 with accuracy of contour or outline within 1 cm. The results of the test created considerable enthusiasm for the method, especially since war clouds were then gathering over Europe and this experiment suggested a means for producing plans for later restoration of possible bomb damaged or destroyed sections of the cathedral. However, no action was taken by the cathedral authorities on this plan until Italy was well into the War, and I.R.T.A. had suspended operations due to wartime conditions.

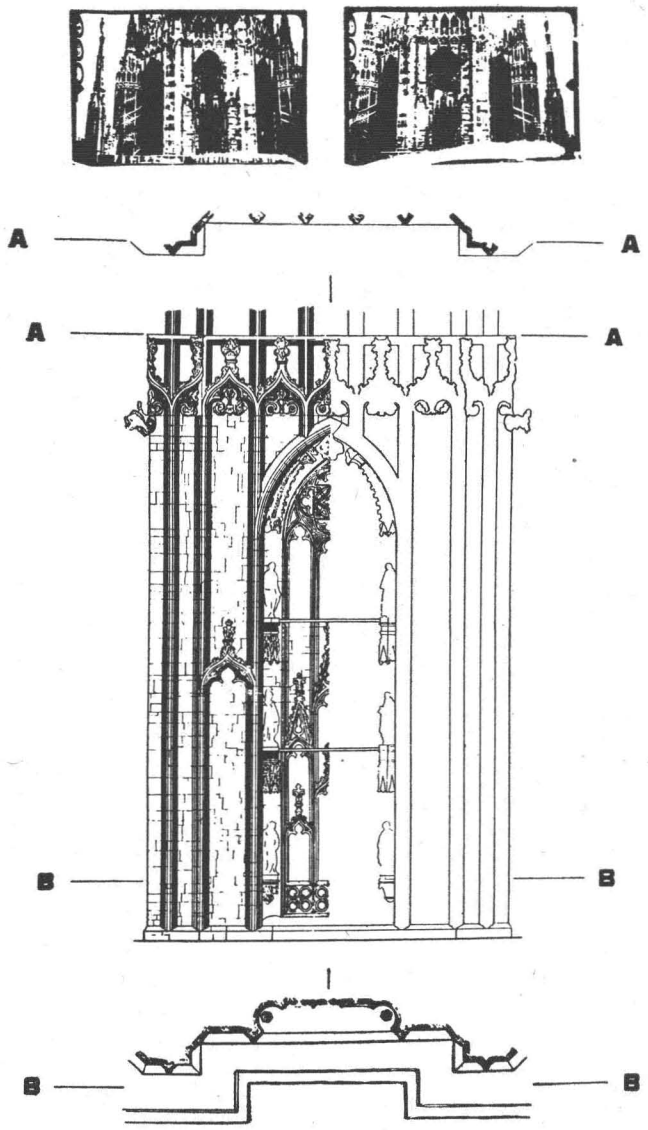

FIG. 9. Detail of Milan Cathedral. Prepared by photogrammetric means.

The preparation of architectural, sculptural, and engineering details by photogrammetric means is not new but I believe this is one of the most interesting applications and one which is worthy of the record.

Some of the same problems well known to commercial operations in the United States confronted the growing I.R.T.A. company. One of these was the necessity for intensive training of a small group of personnel in a number of the operations entering into photogrammetric surveys. The I.R.T.A. company built a versatile, intensively trained group of key personnel. It was evident that this policy of flexibility went a long way toward insuring complete understanding of job requirements and attainment of specified results.

Another problem which proved more difficult of solution than would be the case in this country was that of finding suitable aircraft for taking aerial photographs for plotting instrument work. Very few types of Italian aircraft even approached the fundamental requisites for a mapping airplane. The plane which was actually used by I.R.T.A. over a period of years was an "RO-5," powered by an 80 h.p. motor. Since all contour plotting was at comparatively large scales, high operating ceiling was not a factor. The cruising speed at mapping altitude of 80–90 m.p.h. was quite satisfactory for the comparatively large scale photos required. However, this plane was extremely unstable, difficult to fly on a straight course, and above all, the pilot and photographer worked in open cockpits. Considering these handicaps, the resulting photographs appeared remarkably uniform for scale and comparatively regular in alignment. Later, the company chartered a larger, twin engined airplane especially converted for photographic work and with considerably more comfort for the mapping crew.

The aerial camera producing the photographs for both plotting instruments is a WILD plate camera of 165 mm. focal length, producing exposures 13cm. $\times$13 cm. in size. Replaceable magazines contain 10 plates each. The original plate negatives are used in the instrument for contouring operations.

Estimating and planning of topographic projects by I.R.T.A. proceed along regular lines. Reference is of course made to existing maps and control data. The Istituto Geografico Militaire has covered all of Italy with a uniform set of topographic maps, scale 1:50,000 with 50 meter contour interval. In many areas, as needs warrant and funds become available, duplicate coverage at scale 1:25,000 with 25 meter contour interval is being produced. As regards control surveys, there has been established throughout Italy a network of basic control of first and second order accuracy. These nets are rather closely spaced and are exceptionally well monumented. For each 1:50,000 quadrangle, there has been published a booklet or folio of control, providing a full description of the horizontal and vertical points within and adjacent to the sheet, their geographic and rectangular coordinates, and a very artistic sketch of each point. These folios can be purchased as companion pieces to any topographic sheet in the country. I think this is an extremely convenient arrangement for obtaining basic and authoritative control data for any section of a country and is a procedure which our own mapping agencies might consider seriously when the size of appropriations are more in line with actual mapping and control needs in the United States.

Another point of interest as regards topographic mapping procedure in Italy is the correspondence between standards of map scale and contour interval. Thus, 1:50,000, interval 50 m.; 1:25,000, interval 25 m.; 1:10,000, interval 10 m.; 1:5,000, interval 5 m.; etc. This standardization was effected by the I.G.M. in 1925. Considering that Italy is substantially mountainous in character, this relationship of scale and interval works out quite well but, in areas of low relief, intermediate contours and frequent spot elevations are shown.

My examination of the work and list of clients of the I.R.T.A. company indicated a complete acceptance in Italy of the photogrammetric method for topographic surveys. This acceptance is due in large measure to the efforts of Dr. Ottolenghi and his staff. Scales are generally larger and contour intervals smaller than those specified in this country. Scales of 1:500 to 1:2,000 and intervals of 1 meter and 2 meters are most frequently specified. Map accuracy specifications as we know them in the United States have not been standardized in Italy, but inspection of profiles and spot checks run on I.R.T.A. work showed

average position accuracy of cultural detail to be 0.2 mm. and contour accuracy averaging approximately one fourth the interval. These are regular working standards of I.R.T.A. and are achieved and offered to clients on a fully competitive price basis.

Original manuscript is prepared on metal mounted sheets and in special cases, I.R.T.A. uses specially coated glass plates and precision pointed stylus for the plotting work. This work on glass is exceptionally clean and sharp, not only contour lines but all culture and even lettering, being hand etched through the emulsion. The I.R.T.A. company has also used the aluminum foil mounted paper which we knew in the United States as "Correctostat" paper.

The inking and drafting work on finished sheets is of unusually high quality, including all lettering which is hand rendered in a variety of styles. Stickup lettering as adopted in the United States has not been used in Italy. In the matter of culture, it is the practice of I.R.T.A. to show great detail in all large scale mapping, such as individual trees and grass plots in towns, monuments and statues, exact outlines of buildings and entrance gates, complete track detail in railroad yards and trails, drains and boulders in open country. Reproduction of the maps is usually accomplished on tracing cloth or by lithographic printing in black and white.

After 20 years in the field of aerial mapping, during which time I had the opportunity to learn something of the operations of such American installations as the Brock System, Hugershoff and Zeiss stereo plotters, and the multiplex projector, I found in the operations of I.R.T.A. a period of development and problems of personnel and equipment similar to those of our own operations. I saw highly developed skills and advanced standards of performance in photogrammetric engineering. In their practice of aerial surveying I found a combining of both the artistry and the artisanship which have characterized the Italian people for centuries.

Although we have given due credit to the scientists and photogrammetrists of Europe for their original and basic contributions to photogrammetry, our knowledge of their work in the practical field has been limited, not only with respect to Italy, but to other countries as well.

With the hoped for return of stable conditions in Europe, we should witness the reestablishment and expansion of commercial aerial surveying. As this occurs, we should seek to learn more about the practical work being done in Europe. A great opportunity to obtain this record will exist in connection with the forthcoming quadrennial meeting of the International Society of Photogrammetry to be held in Delft in 1948. Let us hope that an appropriate committee will give this idea due consideration.