

**THE INTERNATIONAL SCIENTIFIC CONGRESS
HELD ON OCCASION OF THE LXXVth ANNIVERSARY
OF THE
ITALIAN MILITARY GEOGRAPHIC INSTITUTE (I.G.M.)**

The Congress was held in Florence from the 27th to the 31st October 1947; the following subjects were discussed :—

- 1° Adjustment of the European Geodetic Nets ;
- 2° Aerial Photogrammetrical Triangulation ;
- 3° Recent progress in computation of photographic objectives ;
- 4° Normalization in the optical field.

Alongside of the Congress, meetings open to the public were held by the Italian Geodetic Commission and the Centre of Gravimetric and Isostatic Studies.

The Congress, with Prof. Gino Cassinis, Director of the Milan Polytechnic School and president of the Italian Geodetic Commission, as Chairman, and Prof. Antonio Marussi, geographical engineer of the I.G.M., as Secretary, was widely attended both by Italian and foreign students. The following Nations were represented : Afghanistan, Argentina, Austria, Belgium, Bulgaria, China, Czechoslovakia, England, France, Greece, Hungary, Iran, the Netherlands, Norway, Poland, Portugal, Spain, Sweden, Switzerland, Turkey, Uruguay, U.S.A., Vatican City State. The Congress was moreover attended by Prof. Pierre Tardi, Director of the Central Bureau of the International Geodetic Association, Admiral Chester L. Nichols, Director of the International Hydrographic Bureau, and Colonel Floyd Woodworth Hough, Chief of the Geodetic Division of the U.S. Army Map Service.

The Congress was opened on the 27th October in the Town Hall (Palazzo Vecchio) by the Mayor, with a few words of welcome, and by the Chairman, Prof. Cassinis, with an introductory speech illustrating the importance of the subjects proposed for discussion.

There followed an address by General Fernando Gelich, Director of the I.G.M., who described that Institute's contribution to the solution of the problems connected with the first two subjects. General Gelich summarized the great geodetic operations of an international character carried out by the Institute from the date of its foundation, to connect the Italian geodetic net with those of neighbouring countries, and to achieve a unified system of geographic coordinates especially in the Mediterranean Basin. He then briefly described the contribution given from spatial aerial triangulation both to national and colonial cartography.

The first session of the Scientific Congress, attended by both sections, was held on the 28th in the rooms of the Exhibition of Cartography and Optical Instruments, on the subject of "Aerial Photogrammetrical Triangulation"; papers were read by Professors Dore and Solaini and by Messrs. Santoni and Bartorelli. Almost all the foreign and Italian guests were present.

Prof. Dore, Bologna University (Italy), introducing the subject, expressed the hope that through the work of this Congress a preliminary agreement would be reached enabling the various states to initiate in the 1948 International Congress of Photogrammetry a collaboration for studies and research, possibly resulting in an organization for the purpose. Only thus, by comparing the different methods used by each nation for aerial triangulation, will it be possible to carry out a thorough study of the laws of propagation of errors. After briefly mentioning the work accomplished by the other speakers, he concluded with a description of the program of studies and experiments in aerial triangulation which is being carried out in Italy in view of the forthcoming International Congress of Photogrammetry.

Prof. Solaini, Milan Polytechnical School (Italy), described the present position in regard to technical and experimental studies on spatial aerial triangulation; he mentioned the opportunities of development offered to aerial triangulation by the new Santoni and Nistri instruments, and those which the application of Radar is likely to offer in regard to the determination of the points of exposure. He went on to consider the Hallert method, in so

far as it can reduce the propagation of errors; he reported on the work carried out in these last years by Schermerhorn, Roelofs and Bachmann, in regard to accidental errors in aerial triangulation, and analyzed it critically; he finally considered the Zeller and Bachmann methods for the adjustment of aerial triangulations, and concluded by tracing a picture of the possible applications and developments in aerial triangulations.

Mr. Bartorelli, of the I.G.M., described the Institute's experimental and operative activities in the field of aerial triangulation, since the Vth International Congress of Photogrammetry held in Rome in 1938; the I.G.M. had persisted in adopting the Santoni solar method for all spatial aerial triangulation destined to control surveys requiring good accuracy, and in using the radial processes only for maps of an expeditious nature. He reported on results and approximations reached in surveys at scale 1:50,000 and 1:100,000, carried out with the Santoni solar method, in the years 1938, 1939, 1940 in Lybia and in Ethiopia, over a total of 35,000 square kms. He then dwelt on the particular method of radial triangulation and plotting adopted in Lybia in 1942 for rapid surveys at scale 1:100,000 over 42,000 square kms in Cirenaica, giving an idea of the approximations reached; he illustrated the recent experiments conducted for the purpose of judging the possibility of applying the control of the solar system to normal surveys at scale 1:25,000, gave the approximations (± 2.8 metres in height, and ± 6 metres in planimetry) reached in a chain of 20 vertices on the points of control obtained with a normal precision triangulation; and concluded by saying that, in his opinion, such an application was possible, mentioning in this regard the method of adjustment adopted which takes into account that prevalence of systematic over accidental errors which characterizes the solar methods.

Prof. Zeller, Polytechnical School, Zurich (Switzerland), illustrated his studies on the statoscopic method. He explained how in the first place the precision (± 1.7 metres) with which the statoscope can discover the difference of level between two consecutive points of exposure was determined; he then described the process (already known in part) of closing on with the help of statoscopic data, dwelling on the causes of systematic and accidental errors, particularly of those errors which show up in the welding of two consecutive stereograms, and how they can be kept within reasonable limits by corrections of transversal tilt. He also showed how, in order to separate the effects of systematic from accidental errors, it may be convenient to use the field control of a stereogram placed halfway along the aerial chain. Starting from this possibility, which has so far never been considered, he explained the method of adjustment arising from it, and gave the relevant formulas. The application of this new method of adjustment to already triangulated aerial chains has greatly reduced their average errors; furthermore a fresh aerial chain of 72 vertices, treated with the above method of adjusting and closing on, has given an average altimetric error of ± 4.9 metres and a planimetric error of ± 13.1 metres; in another chain of 40 vertices obtained with a grandangular. Wild camera the altimetric error was reduced to ± 3.1 metres, while the planimetric remained around 13 metres. Finally Prof. Zeller dwelt on the possibilities and applications open to aerial triangulation.

Mr. Santoni, Ente Italiano Rilevamenti Aerofotogrammetrici, Florence, described the principles and characteristics of the solar method and comparing it with the statoscopic method briefly examined the possibility of combining the two; he did not consider that any effective advantage could be drawn from such a combination, as in his opinion, the solar method obtains better control of the longitudinal tilt than the statoscopic, especially when the zenithal heights of the sun are inferior to 45° .

The meeting adjourned after accepting a suggestion of Prof. Solaini that Swiss and Italians should collaborate in their research work, to which Prof. Zeller and Mr. Santoni agreed.

Prof. Cassinis expressed the hope that this Congress will set the necessary premises for the creation, in the 1948 Congress of Photogrammetry, of an international organization for studies and experiments in the field of aerial triangulation.

On 29th October the discussions on the subject of the adjustment of European geodetic nets were opened.

Prof. Cassinis opened the meeting by summarizing the more recent developments of this problem reached through the efforts of the International Geodetic Association, who are studying a complete program for the purpose of bringing it towards a practical solution. Two meetings had taken place on the subject in Paris, during the summer of 1946 and in October 1947, and the conclusions reached will be dealt with at the forthcoming Congress at Oslo. He then mentioned the work carried out alongside of this initiative at Bamberg, where

Colonel Hough, of the U.S. Army Map Service, with the help of a group of German geodesists, had already, in June 1947, completed the astronomic-geodetic adjustment of the German net. These operations together with those carried out by the Baltic Geodetic Commission for the ring round the Baltic Sea, should represent the core of an eventual adjustment of European nets. Prof. Cassinis also mentioned the work done by Italy for the Mediterranean Basin, preparatory to that which will have to be undertaken on the basis of an international agreement.

Papers on this same subject were then read by Professors Boaga, Marussi and Marcantoni. Prof. Boaga, Director general of the Italian Cadastral Office, read an exhaustive historical résumé of the different stages of development through which the problem had passed from its beginnings up to the present day.

Prof. Marussi illustrated the methods that had been applied to previous operations of this kind, or that might be considered in the future; he expressed the opinion that the unification of European geodetic nets must take place in two separate and successive stages: a first stage of temporary character and average accuracy, in which existing material should be exploited without the need of new measurements on the field; this stage will be more geophysical and cartographic than geodetic in the strict sense of the word; it will be reached by choosing a series of points uniformly distributed over the continent and fixing their position on the ellipsoid with the help, not only of geodetic, but also of astronomic data available. With regard to the latter the speaker mentioned, among the various existing methods, one he had himself submitted to the Congress. The second stage, of a highly accurate character, should consist, to begin with, in the choice of an internationally agreed upon scheme of parallel and meridian chains furnished with bases and Laplace points in suitably chosen places; on such a scheme the Nations adhering to the unification program should base their future field work so as to allow of the creation — within a reasonable lapse of time — of an astronomic-geodetic frame-work over the whole European continent similar to those already existing in the U.S.A. and in the U.S.S.R. Both in the first and in the second stage it will be necessary to consider a way by which regional nets of single States can be made uniform by inserting them in the polygonal spaces of the astronomic-geodetic net. The speaker, in this connection, suggested the use of the method based on plane homographies and pseudo-homographies which Prof. Marcantoni had extended to the sphere.

Prof. Marcantoni, Pisa University (Italy), spoke on the application of the homographic method to the sphere introducing the complex variables.

Prof. Rune, Chief of the Stockholm Geodetic Office, illustrated his paper on the Bowie method of adjustment, and particularly on the use made of Laplace equations to correct geodetic azimuths. He had applied the Laplace equation, imposing the equality of the Laplace azimuths on both ends of a chain segment, assuming, therefore, the astronomic value to be different from the geodetic at both ends and not at one alone, as Bowie does.

Adm. C. L. Nichols (U.S.A.), Director of the International Hydrographic Bureau, emphasized, on behalf of the Bureau, the importance which the problem of unification of geodetic nets has at the present moment for hydrographers and navigators. He informed the Congress that, in the meeting of 23rd April 1947 held at Monte-Carlo, the Bureau had stated the urgency of such a unification, and had decided to offer their full support to the International Union of Geodesy and Geophysics in view of reaching a practical solution to the problem. The differences between the geographic coordinates of the various States were such as to be no longer acceptable; to these we must add the differences between the reference ellipsoids. With the modern electronic methods introduced in navigation (Radar, Loran, Decca, etc.) the need for precision has increased to such an extent that a world-wide geodetic unification has become a necessity.

The next to speak were Professors Boaga and Pacella, of the I.G.M., and Engineer Paroli, of the Italian Cadastral Office, who proposed three different geometric methods of effecting the passage of coordinates from one ellipsoid to another; Prof. Boaga had successfully applied his formula to the Italo-Swiss frontier; Prof. Pacella had based his studies on the Andreae formulas, while Engineer Paroli used plane coordinates to effect the transformation in question.

The discussion on the first subject was continued on the 30th October; Prof. Marussi, after summarizing what had been said on the previous day, illustrated a method for the adjustment of astronomic-geodetic polygonals, which, like the Urmajew method, is based on adjustment by coordinates; the Laplace equation, however, is here considered by means of a suitable artifice together with the equations observed for the length and the azimuths of the

geodetic lines forming the sides of the polygonal : this enables us to reduce the number of normal equations to $2V - 2$, V being the number of vertices to be adjusted. Prof. Marussi then illustrated a further method for the insertion of regional nets within the quadrilateral spaces of an adjusted astronomic-geodetic polygonal; this is based on the consideration of plane coordinates in a suitable system of projection and on a particular kind of transformation called *pseudo-homography*, derived from the usual homographies, by which it is possible to transform the original coordinates, causing four points to close on to four positions determined beforehand. The linear deformation modulus, and the maximum angular deformations of this transformation, had been calculated.

Prof. Hristov, of the Geographical Military Institute of Sofia (Bulgaria), described the methods, formulas and tables he had worked out for the Gauss-Krueger (Mercator Transverse) projection; all these are amply developed in a book published in Sofia by the Bulgarian Geographical Military Institute in 1946. Prof. Hristov foresaw that gores of 6° in breadth, like those of the international Map of the World, would come into general use in so much as they were the best suited for an international system of projection.

Colonel Hough, of the U.S. Army Map Service, and Chief of the Team of German geodesists working in Bamberg for the geodetic unification of Central Europe, announced that the U.S.A. had recently abandoned the polyconic and adopted the Gauss-Krueger projection, called "Mercator Transverse Projection" by American geodesists; this was applied by means of 6° gores, in accordance with the international World Map System. A scale correction of $0.4/1000$ was applied with a view to reducing the deformation modulus at the gores' edges. Colonel Hough then proceeded to inform the Congress that in June 1947 the Bamberg Team under his supervision had completed the astronomic-geodetic adjustment of Central European nets over an area of 1,500,000 square kms., definitely fixing 714 points on the international ellipsoid. The method applied was Bowie's with suitable improvements added to it, especially intended to avoid the dependance between latitude and longitude variations being overlooked.

Prof. Boaga then described methods discovered by the regretted Italian mathematician Levi-Civita, who had studied the geometry of small triangles formed by any curve segment on any surface. These methods applied to the representation on a plane of geodetic triangles traced on the ellipsoid, enable us to carry out on that plane the most complicated calculations. Prof. Boaga also mentioned the methods discovered by the surveyor Albani, of the Florence I.G.M., allowing of a rapid setting and solution of normal systems. He then suggested that the astronomic-geodetic method of adjustment proposed by Prof. Marussi be tried on a polygonal previously adjusted by Boersch and Krueger, according to the Helmert method.

General Gelich, Director of the I.G.M., said that the Institute would willingly accept to carry out these experiments under the supervision of Prof. Marussi.

To conclude, Prof. Boaga expressed the hope that it might soon be possible to close the geodetic ring round the Western Mediterranean which had been begun by Prof. Marussi.

Engineer De Campos Guereta, Director of the Geographic Institute of Madrid (Spain), assured the Congress that, for his part, he would furnish all data necessary for that computation.

Prof. Tardi, Director of the Central Bureau of the International Association of Geodesy, was next to address the meeting. He emphasized the importance of the problem discussed, and insisted on the need of finding a practical solution for it, which will have to be carried out in two stages : a first stage of average approximation and a second of high accuracy. The first will have to suffice for geophysic and cartographic purposes; the second for all kinds of research work. In the second stage, the divergences between the geoid and the ellipsoid will also have to be taken into account. The method of adjustment employed may be Bowie's, or rather, a very much improved edition of it, such as would consider latitude and longitude equations simultaneously; particular attention should be given to the way in which the Laplace equation is to be considered in accordance with what Prof. Rune had said, and finally the process for determining the coordinates of the point of origin will have to be thoroughly studied. Prof. Tardi believed that no nation need be concerned from a military point of view: in order to carry out the above calculations it is necessary to know only a very limited number of basic points. In the Paris meeting of the 15th October, the U.S. Army Map Service had offered to extend the computation already carried out for Central Europe to the whole continent, using the German Team of Bamberg for the purpose but the International Association of Geodesy had declined the offer. Further offers had been made by Holland and the U.S.A. The question was being studied at the present moment and would

probably be solved at Oslo in 1948. The U.N.E.S.C.O also had promised financial help which would however be forthcoming only next year. Meanwhile the computation for the Central European block had already been completed and that for the Baltic Ring, to be inserted in the former block, would be completed within 1948. In the second stage of this computation, which will be of high accuracy, the divergences between the geoid and the ellipsoid, now being calculated by the Isostatic Institute of Helsinki on the basis of gravimetric results, will be taken into account. For some geodetic junctions, Radar will probably be used, and in this connection the Navy's support promised by Adm. Nichols, will be particularly valuable. A restricted commission of technicians, 5 altogether, who are specialized in this kind of research work, will shortly be formed within the International Association of Geodesy. Italy will undoubtedly be represented on it. This commission will have to submit to the Oslo Congress those methods which they consider most suitable for a practical solution of the problem. Of particular interest was the address given to us by Adm. Nichols, on behalf of the International Hydrographic Bureau: both the support of hydrographers, and eventually their active help, will be warmly appreciated. Hydrographers might especially be concerned with the linking up by electronic means of England and Norway, England and Normandy, Crete and Egypt.

Colonel Hough then communicated, in regard to these junctions across great stretches of sea, that Prof. Bonsdorf had worked out a method which will enable us, by exploiting the solar eclipse due over the Pacific Area next year, to join the Asiatic Continent to the American across that Ocean.

Prof. Cassinis thanked Col. Hough for his important communication and closed the meeting.

The Congress was followed and completed by two meetings open to the public of the Italian Geodetic Commission and of the Centre for Gravimetric and Isostatic Studies, with Prof. Cassinis as Chairman.

Prof. Dore, Bologna University (Italy), summarized the work done by the Italian Geodetic Commission since 1865, date of its foundation. He then emphasized the necessity of increasing the number of University Chairs of Geodesy and Topography, illustrating the high ethical and educative value of Geodesy.

Prof. Cassinis described the recent contributions given to the progress of geodetic knowledge by the Centre for Gravimetric and Isostatic studies, which is connected with the Milan Polytechnic School.

Prof. Tardi brought to the Italian Geodetic Commission the greetings of the International Geodetic Association. He then described the editorial activities of that association, which can be summed up in the publication of the *Bulletin Géodésique*, the *Bibliographie Internationale de Géodésie*, and the *Travaux*.

Prof. Mader, of the Vienna Technische Hochschule, spoke on recent research work carried out in Austria on the form of the geoid; he stated that the divergence between the geoid and the ellipsoid should reach 42 metres on the Brenner without isostatic compensation, but with it, this theoretic divergence would be reduced to 11 metres. He expressed the hope that the astronomic levelling which had been undertaken some time ago on the Rome-Berlin meridian would be continued.

Prof. Marussi informed Prof. Mader that a great deal of work had been done in Italy on the deflections of the vertical and the geoid by Prof. Boaga and by himself. Prof. Boaga had studied and calculated the deflections of the vertical on the national territory. Prof. Marussi had unified in the Rome system all deflections known in neighbouring countries whose geodetic nets had been joined to the Italian one, obtaining a system of 615 deflection components in the Mediterranean Basin and the Alpine zone. With the Hayford method he had built a sample of geoidic surface which he had presented to the Congress and from which a contour map had been drawn and attached to the publication *Per l'Unificazione Geodetica del Bacino Mediterraneo*.

Prof. Mario Tenani, of the Hydrographic Institute of Genoa (Italy), read a paper on mareographic registrations in Italy, containing an historical account of the mareographic service and suggestions for its reorganization.

Prof. Solaini spoke on the levelling line between Genoa and Piacenza, the ortometric corrections for which had been determined by carrying out the gravimetric measurements

required on the field with static gravimeters and pendulums. The correction obtained, which was of 3 centimetres, turned out to be of opposite sign to that which would have been obtained with ordinary methods based on normal gravity. Prof. Solaini then gave a series of technical data on a new tripendular apparatus which is now being constructed by the Milan Centre of Gravitometric and Isostatic Studies.

Prof. Pacella, of the Italian I.G.M., described the Cunningham gravimetric apparatus used by him in Africa.

Dr. Morelli, of the Trieste Geographical Observatory, spoke on his recent work of adjustment tending to the unification of the international gravimetric reference system; for this adjustment he had only considered double junctions. He expressed the hope that the Oslo Congress might come to a definite decision in regard to a unified international system of gravimetric measures.

Prof. Boaga said he had found in the archives of the Rome University Institute of Geodesy a paper written by Prof. Reina in 1912 which would confirm some of Dr. Morelli's doubts on the present Potsdam gravimetric system.

General Gelich thanked Prof. Cassinis and all those who had attended the Congress for their contribution to the celebration of the Italian I.G.M.'s 75th Anniversary, and assured them that the Institute, while carrying on its military duties, would continue to fulfil its exceptionally important task both in civil and in scientific fields, collaborating with all cultural institutions of the World and with the International Association of Geodesy in the first place.

Along with the subjects of geodesy and photogrammetry, the two optical subjects mentioned were discussed at the Congress. A brief account of such discussions can be found in the bulletin of the Italian Optical Association.

A detailed account of all the subjects dealt with will be given in the minutes of the Congress which will be published as soon as possible by the Executive Committee.

