Stereographic Survey: The Stereoautograph

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camped at a good sealing ground. Seals are obtained then (except in a few places) entirely by the waiting method not quite accurately described by Stefansson in his 'Friendly Arctic.' Only a very exceptional white man could stand the cold long enough to hunt often by this method, or would possess the skill to kill his seal when it comes to the breathing hole. Were Stefansson to make a long coastal journey with white men only along Baffin Island, I should doubt his ability to provide food for his party and his dogs by the waiting method of sealing, the only one by which seals can be obtained round this coast during winter, within reasonable distance of land. Food, first and foremost, is the Baffin Island Eskimo's main interest, and he will invariably reply to your question as to a good winter or otherwise in terms of food, *i.e.* a hungry or not hungry winter. It will be a misfortune if these people are to be exploited by big companies, and the native encouraged to trap fur to the detriment of his hunting, and to purchase much trade goods useless to his simple mode of life. Though it is perhaps impossible of realization owing to vested interests, and the difficulties of administration, the suggestion in the late Gordon Hewitt's book 'Wild Life in Canada' that the north-land should be administered as a Crown monopoly, is a sound one. We have only to contrast Greenland's twelve thousand inhabitants, all healthy, happy, and self-supporting, with the vanishing Eskimo of the Canadian Arctic, having far greater economic resources in its waters, to realize the truth of this statement.

STEREOGRAPHIC SURVEY: THE STEREO-AUTOGRAPH

Arthur R. Hinks, C.B.E., F.R.S., Sec. R.G.S.

Read at the Afternoon Meeting of the Society, 13 February 1922.

IN the spring of 1921 M. Emmanuel de Margerie, on a visit to London, gave a very favourable account of the results obtained with the "Stereoautograph" of Von Orel and Zeiss in the survey of the Grande Combe, a hilly wooded coal-mining region in the south of France, near Nîmes. This survey had been undertaken by the *Société française de Stéréotopographie*, a company formed in Paris by M. Paul Corbin, with Colonel Talon, formerly of the *Service géographique*, as Director, and Commandant Vavon of the same service as technical chief.

The question arose, whether the method was applicable to the survey of Mount Everest; and I was directed by the President of the Royal Geographical Society to study the methods and apparatus.

Having learned from Colonel Talon that he would very gladly give me every facility, I left for Paris on the evening of 6 April 1921, and spent the greater part of the following eight days in examining the installation at the offices of the Société in the Rue Lauriston, No. 85,

and in studying the geometrical theory. A pretty full description of the general features of the apparatus, and a slight account of the theory, have been published by M. Corbin in the *Revue générale des Sciences pures et appliquées* for 30 March 1914, and to this I will refer for the mechanical details, remarking only that the instrument there figured is the model of 1911, and that some considerable improvements have been introduced into the model of 1914 which is now in use at Paris. The more important will be described in this report.

Brief History of the Method.

It is unnecessary to discuss the methods of Phototopography developed by Laussedat in France and by Deville in Canada, which depend on the measurement of identical points on pairs of plates taken on determined azimuths at trigonometrical points. The radical defect of this method is in the difficulty of identifying corresponding images of the two plates. This difficulty was removed by the invention of the stereocomparator of Pulfrich about 1903. When a pair of plates taken on parallel axes is viewed in the stereocomparator, the ground is seen in relief, and the identification of the most minute detail visible on the photographs becomes automatic; there is no longer any possibility of mistakes from misidentification.

The first application of the stereocomparator to topography seems to have been made at the Austrian Military-geographical Institute by General von Hubl about 1904. From the varying parallactic displacement of points at different distances, as measured on the stereocomparator, it was possible to calculate the distances, and from the coordinates of the points on one of the plates to calculate and plot their positions. The method was accurate but tedious.

The next step was taken by Lieut. F. Vivian Thompson, R.E., in the invention of the stereoplotter, described in the *Geographical Journal* for May 1908. The optical apparatus was essentially identical with the stereocomparator of Pulfrich. But an arm geared to the plate carriage gave the direction of the point; a milled head operating the differential slide of the plates gave the distance; a parallel ruler set from the reading of the milled head gave by intersection with the first arm the position of the point, and by intersection with a second arm geared to the vertical slide of the stereocomparator gave the height. With this machine the map was plotted point by point, and the height of each point determined. It is not possible with this instrument to work along a chosen contour exactly, and there are inconveniences in working with bases of varying length, requiring the substitution of scales which must be in general more or less inclined to the parallel ruler whose intersection with them is sought. The instrument was never brought to any great mechanical perfection, and its ingenious inventor was killed in action early in the war.

About the same time that Thompson was working out the details of his method at the S.M.E., Chatham, Lieut. von Orel was developing a similar device at the Vienna Institute, but carried it further, so that the determination of the point became automatic, requiring no setting of scales by hand. He then seems to have sought the assistance of the firm of Carl Zeiss, who on 19 December 1910 patented in Germany, without mention of von Orel's name, the apparatus which was described by Corbin as the model of 1911. The specification of the British patent, applied for 15 December 1911 and granted 26 September 1912, states that the problem has several times been solved in a limited form, and that the oldest solution is that of Thompson given in the *Geographical Journal*. The specification is couched in very general language, and the drawings attached belong to a pattern much more primitive than the model of 1911. The description is confined to the simple case of photographs taken in pairs at right angles to a horizontal base, and the drawings give no indication of the great extension of possibilities realized in the model of 1911 as described by Corbin, that the base need not be horizontal, that the photographs may be inclined to it at any angle up to about 40 degrees, and that their axes need not even be parallel. These improvements are apparently first patented outside Germany in an application made by Carl Zeiss in Austria, 19 December 1913; British application 30 April 1914, accepted 22 July 1915, that is, during the war.

A still later model is patented in Germany, 8 July 1918, and by British application dated 31 May 1920, accepted 3 March 1921, in which the limitation to horizontal axes is removed. This specification is couched in still more general terms, defined by a complicated trigonometrical formula, and five different constructions are mentioned, but there is no word of the obvious application, that the map can be plotted from pairs of air-photographs. I learned from Commandant Vavon that such a machine was in contemplation, but do not know how far it is in successful operation.

In what follows, then, I shall describe the model known as that of 1914, which in its geometry is very similar to that described by Corbin as the model of 1911.

The photo-theodolite is that described by M. Corbin as the model of 1913. It does not differ in principle from much earlier instruments, such as the well-known Bridges-Lee instrument.

The Stereograph.

The geometrical theory of the instrument is reserved for treatment later. It will suffice for the present to say that the apparatus consists of a system of levers actuated by three hand wheels, which we will call the distance wheel, the direction wheel, and the height wheel. This system is coupled on the one hand to the slides of a Pulfrich stereocomparator,

and on the other to the drawing pencil which moves over the drawing board. The height wheel is supplemented by a pedal, as it is termed—but more accurately a horizontal disc operated by the foot—which operates the same system. It is thus possible to make the three movements simultaneously. A second foot-disc operates the vertical displacement of the right-hand photograph with respect to the left.

The direction wheel moves both plates together on the principal slide of the stereocomparator; the distance wheel moves the right-hand plate horizontally with respect to the left-hand plate, with the effect that the mark in the stereocomparator appears to advance or recede with reference to the landscape; the height wheel moves the plates together on the vertical slide of the comparator, or more accurately, moves the optical system of the stereocomparator in the vertical direction over the plates, so that the mark appears to move up and down in the field of view, and can by the combined movement of the three wheels be brought into apparent contact with any point of the ground.

In tracing the horizontal plan all three wheels are operated simultaneously; the mark is made to follow the road or river or outline of building; the pencil draws the plan automatically; and a second operator stands over the drawing board to see that all is going well, and to write in any conventional signs that are needed.

In contouring, the height wheel is set so that the corresponding scale reads the interval of the contour above or below the known height of the left-hand station, the interval being corrected when necessary for refraction and curvature of the Earth; the direction and distance hand-wheels are operated to make the mark move in contact with the image in relief, and the contour is drawn automatically.

Before starting to plot from a pair of photographs a graticule is drawn on the paper (mounted as a plane-table is mounted), and the position of the left-hand station of the base and of two trigonometrically determined control points in the field are plotted. The base station is brought under a fiducial mark, about which the paper can be rotated; the mark in the stereocomparator is set on one of the control points; and the paper rotated until the plotted point comes under the pencil. The second control point gives a check. The heights of the control points are also measured on the height scale, and compared with the known trig. heights. The plotting does not begin until the positions and heights of the control points are reproduced by the apparatus with the required precision. I was not able to see the actual adjustment of a sheet at the beginning of the operation; but I was assured by Commandant Vavon that with experience it is not difficult to discriminate between the different sources of error if the control points do not come right.

I was, however, able to see that a skilled operator can reproduce his results with remarkable accuracy. The operator would specify the corner of a house on which he was going to repeat the setting, and the pencil

THE STEREOCOMPARATOR OF PULFRICH

THE STEREOAUTOGRAPH OF VON OREL AND ZEISS

By courtesy of Colonel Talon.

THE STEREOCOMPARATOR OF VON OREL AND ZEISS

By courtesy of Colonel Talon.

would come down again upon that point without any visible error, though the first setting may have been made hours before. Similarly he would repeat a contour without any appreciable deviation, and though he doubtless selected the better-defined points and the easier contours for his demonstration, I do not see how the repetition can be other than a very searching test of the method. I therefore formed the conclusion that it is fair to claim for the instrument an accuracy essentially equal to the least visible error of plotting, and am able to accept Commandant Vavon's assurance that the more one works with the instrument, the more one is astonished at its accuracy.

In hilly country such as that of the Grande Combe, the French reckon to cover from three-quarters to four-fifths of the ground by the photographs, and to fill in the dead ground by the plane-table. This is more economical than multiplying the number of pairs of photographs. The method is to plot on the stereoautograph a number of points round the margin of the dead ground, and to send this plot into the field for completion. The detail and contours of the dead ground are thus interpolated on the plane-table, and are found to fit extremely well. I naturally asked what was the result if one surveyed the dead ground independently from the trig. points, without using the detail supplied by the stereoautograph, and learned that the agreement was then not quite so good, but that the want of perfect agreement might with more justice be attributed to the errors of the plane-tabling than to the photographic survey; and I see no good reason to doubt this.

Scope of the Method.

The method of stereographic survey is pre-eminently adapted to the detailed mapping and contouring of steep and broken country on a large scale: say $1/1000$ to $1/10,000$, for the location of engineering works. The examples given by M. Corbin (*loc. cit.*) include a large open mine on a steep hillside ($1/1000$); a cliff face at Fiume ($1/1000$); a high Alpine table basin ($1/5000$); a piece of the Mont Blanc massif ($1/20,000$). It is said that the survey for the approaches to the Taurus tunnels was made by this instrument. The French company are mapping a large area in the coalfield of the Grande Combe on $1/10,000$.

I have not come across any example of a survey on smaller scale than $1/20,000$, except the map of a small area south of Keswick made by Lieut. F. V. Thompson in 1907 with his stereoplotter on $1/63,360$. It would seem that the smaller the scale, the greater the difficulty in finding stations to command a correspondingly large area, with room for a sufficient base. The base conditions, however, are not exacting, since the ends need not be at the same height; the plates need not be taken parallel to it, nor even to one another; and the length of the base is conveniently measured by the stadia bar and the micrometer screw of the photo-theodolite, mentioned below.

The photo-theodolite and subsidiary apparatus are heavy, and the present pattern perhaps not convenient for work at great altitudes. One must remember, however, that the apparatus now in use has all been designed for large-scale work of high precision. How far it should be modified for small scales and reconnaissance conditions deserves consideration and experiment.

Applicability to the Survey of the Mount Everest Region.

It appears to me that the stereographic method is especially adapted to the survey of the Kama valley or to the West Rongbuk district: both wide open valleys where stations on the flanks command extensive views. It is probably less suitable for use on a complicated plateau like that around the upper Kharta valley, where there is much dead ground from any point of view. Major Wheeler found it sufficiently hard to get photographs from single stations, in the bad weather prevailing after the end of June: to get pairs of photographs at ends of a measured base would have been much harder, and he would not have completed so many stations. On the other hand, one pair of photographs from each of two stations, north-east and north-west of the mountain, would give a map of the mountain in detail which could not be achieved by any other method. The north face of the mountain could be mapped on the scale $1/10,000$ with contour interval of 25 feet, if so sumptuous a map were desired.

For any ordinary use this would be unnecessary. But there is an aspect of the question of mapping which has never, I think, been properly examined. It is the duty of geographers to-day to lay up material for the future solution of the problem: how fast are the processes of denudation? Are tectonic changes measurable in one hundred years? No maps of the present day will be much use in settling such questions: they are not accurate enough in detail. But they might be made good enough by use of stereographic survey. I would like to make now a minutely accurate contoured map of the great razor-edge of Chomo Lönzo, of the marvellously steep walls of the great cirque below the north-east arête, and of many other fine pieces of the world where natural processes seem to be working at a great rate. To make these maps is a duty to posterity. And the reward might come as quickly as it has come to the astronomers who photographed spiral nebulae not forty years ago.

A more immediate profit could be drawn from the stereographic survey of glaciers: peculiarly difficult to survey on the ground, but very easy from the neighbouring slopes. We must have a good knowledge of glacier-variation before we can hope to deal successfully with many of the larger questions of climate, for the glacier represents a convenient integration of effects whose relative significance cannot be studied by the

ordinary uninspired methods of meteorology. I look forward to the time when systematic and periodic glacier survey will be reckoned among the more important of the scientific services of Government.

Conditions of Sale and Use of the Orel Stereoautograph.

The conditions of sale of this instrument are peculiar and demand careful examination.

First, the instrument is priced in marks which are converted into Swiss francs at the pre-war rate of exchange, and any buyer outside Germany has to pay in Swiss francs: a condition not likely to encourage foreign buyers.

Secondly, the instrument is not put on the market like an ordinary survey instrument which the buyer may use as he pleases. The policy of the makers is to grant a licence for the sole use of the apparatus in any one country, the licensee paying a heavy royalty on the gross receipts of his establishment. This method of exploitation has disagreeable features: it seems to preclude the use of the apparatus except in commercial work for profit. Happily patents do not run for ever. Nor need we believe too readily that the elegant geometry of Von Orel and the beautiful workmanship of Zeiss are not to be beaten. Indeed, the remarkable simplicity of the geometry invites the attention of inventors.

Geometrical Theory of the Stereoautograph.

Though the stereoautograph as made by Zeiss is very complicated, and the action of its inter-connected levers difficult to follow, the geometry underlying them is really very simple, and may some day be realized in a simpler way.

Fig. 1.

In the figure S_1 and S_2 are projections on the horizontal of the two stations at which the photographs are taken (S_1S_2 being called the base), and M is the point to be fixed, which is projected on the two photographs at M_1 and M_2 . The photographs are in parallel vertical planes inclined at an angle θ to the base.

Transfer the plate with optical centre S_2 to S_3 , so that it lies in the plane

of the first plate, the distance S_1S_3 being arbitrary. Draw S_3R parallel to M_1S_1M ; MR parallel to S_1S_3 ; M_3S_3Q parallel to M_2S_2M ; and RQ parallel to S_1S_2 . Join MQ .

The triangles MS_1S_2 , S_3RQ are equal, since their sides are parallel, and $S_1M = RS_3$. Hence $QR = S_1S_2$ and $QRM = \theta$, the inclination of plates to base.

Hence the triangle QRM has its side $QR =$ the base : angle $QKM = \theta$; and side RM equal and parallel to S_1S_3 : that is, its size and shape and orientation are independent of the position of M .

If then in the above figure we had given only the points S_1 , S_3 , and M_1 , M_3 , we could find the position of M by applying the invariable triangle to M_1S_1 and M_3S_3 produced, so that M and Q lie respectively on these rays, and MR is parallel to S_1S_3 .

This is the simple geometrical principle underlying the action of the stereo-autograph.

Mechanical Construction : The Stereocomparator.

The optical parts are simply the well-known Stereocomparator of Pulfrich. The two plates (numbered 1 and 3 to correspond with the geometrical figure above) are on a carriage moved horizontally by the hand-wheel labelled Direction, along the line S_1S_2 . Plate 3 has an independent movement relative to plate 1, along the same line, on an upper carriage.

The plates are viewed by two compound microscopes whose objectives O_1 and O_2 are at fixed distance apart S_1S_3 , and whose eyepieces E_1 , E_2 , receive the light from O_1 , O_2 through three reflecting prisms in each microscope.

The odd number of reversals by reflexion, combined with the normal inversion of the field in the microscope, give an image of each plate right way up but reversed right and left; if then the negatives are inserted film upwards (*i.e.* reversed R. and L.) the resulting view is correct, except that it is a negative, black for white.

Under the eyepieces are the pointers, and the plates are adjusted in their carriers so that the images of the fiducial marks fall simultaneously upon them. Plate 3 has an additional independent movement at right angles to S_1S_3 .

The whole optical system can be moved parallel to the plane of the plates along the line GH perpendicular to S_1S_3 . Thus by moving the plates under the microscopes in the horizontal sense, and by moving the microscopes over the plates in the vertical sense, the whole plates can be examined.

The Plotting of Horizontal Detail.

Two bars A and B are pivoted about fixed centres, s_1 , s_3 so that s_1s_3 is equal and parallel to S_1S_3 . A sleeve m_1 through which bar A can slide is linked to the carriage of the two plates, so that m_1 moves with plate 1 along the line S_1S_3 . Similarly the sleeve m_3 on bar B is linked to the upper plate carriage on which plate 3 moves relative to plate 1. The line of motion $S_1S_3m_1m_3$ is parallel to s_1s_3 and distant from it f , the focal length of the objective with which the plates are taken.

A bar LL' can be moved by the hand-wheel marked Distance always parallel to itself. A bar mr of fixed length equal S_1S_3 or s_1s_3 can slide along LL' ; it is connected with the bar A by a pivoted double sleeve.

A bar rq is clamped to mr at r , at an adjustable angle $= \theta$, the inclination of the plates to the base on which they were taken. And the length rq is

The Plotting of Contours.

So much for the horizontal detail. We have now to consider the question of heights.

The centre of the microscope system moves in the vertical sense along the line GH. A rod attached to the carriage slides in a fixed bearing H and carries a smooth sleeve pivoted to it at K. A rod JK turns about a pillar fixed at J in the line of s_1s_3 , distant f from GH, and slides in the sleeve K.

A rod IJ fixed at right angles to JK passes through a sleeve at I joined to a nut which is traversed along the bar LL' by a long screw turned by bevel-gear (not shown) from the hand-wheel marked Height, or from a foot-wheel connected with it. A divided scale with zero adjusted so that JO is parallel to GH, measures the displacement of I right or left, corresponding to the displacement KN of the microscopes above or below the optical centres of the plates: that is, to the height coordinate of the point on the plate. But the triangle JOI is similar to JNK; and JO is the distance coordinate of the point on the scale of the map. Hence OI is the height coordinate on the same scale; and if the divided scale is the same as the scale on which the base rq is set, the readings OI will give directly the height of the point M above S_1 .

The operation of this system of levers requires a little study. If the height wheel is turned OI is varied, the system IJK rotates about J, and the microscopes are moved in the vertical sense over the plates. This provides for the measurement of all heights in a coordinate plane parallel to the plane of the plates as taken, and distant by an amount corresponding to the distance between LL' and s_1s_3 .

If on the other hand the height wheel is left untouched, OI remains unaltered in length. But if the distance wheel is turned, and LL' is moved away from Js_1s_3 , the rod C slides in the sleeve at I; the angle IJO is decreased, and the microscopes travel downwards over the plates by an amount corresponding precisely to the diminution of vertical coordinate on the plate as a point of given height above the base is removed further from it.

By this elegant construction, therefore, the height of any point in the field above the base point S_1 may be measured on the scale OI. But alternatively, if OI is set to the vertical interval of any desired contour above or below S_1 ,* and the height wheel is left untouched, the pointer can, by moving the direction and distance wheels, be brought into contact successively with all points on the contour, and it describes the contour. This is the particular merit of the machine, that it can describe contours. Moreover, if a point from plate 1 is adjusted on a table to the left of the plate, a tracing arm carried on the microscope will trace on the print the contours in perspective: a remarkably simple and sometimes valuable property.

We have spoken of the map as traced by a point below m . This requires a drawing inaccessibly placed under the machine. In the later models a stiff bar is rigidly attached below LL' and extended to the left, to carry a pencil over a drawing board quite clear of the machine.

One more beautiful property must be mentioned. If the plates 1 and 2 are not parallel when they are taken at S_1 and S_2 , but their axes converge somewhat, they will still exhibit a relief when examined in the stereocomparator

* When the distances are great a correction of the setting must be made to allow for curvature and refraction: a single correction is generally sufficient, unless the contour which is being traced has great depth in the field.

though the perspective will be false. To make a map from such a pair of plates it is necessary only to cut the arm B in such a way that its two parts qs_3 and s_3m_3 can be clamped at an angle equal to the angle between the planes of the two plates when they were taken. But the proof of this remarkable though very simple theorem must be left to the reader.

Range of Action of the Instrument.

The stereoscopic relief is satisfactory when the relative displacement of the images is between 10 and 30 mm. The length of base must be chosen accordingly. For example, if it is desired to work to a maximum distance 15 km. and the focal length of the photo-theodolite is 200 mm., the length of the base is given by

$$\text{base} = \frac{\text{min. displ.} \times \text{max. dist.}}{\text{focal length}} = \frac{10 \cdot 10^{-3} \times 15 \cdot 10^3}{200 \cdot 10^{-3}} = 750 \text{ m.}$$

and with this base a displacement of 30 mm. will be reached for points 5 km. away. Hence with base 750 m. the limits of distance for good results are 15 km. and 5 km. It is easy to construct a diagram to show the length of base required in any given conditions.

At a given pair of stations making one base, it is usual to take three pairs of plates, respectively parallel to and inclined 30° either way to the base. But we have seen that there is no real necessity for the pairs to be parallel to one another, and this gives liberty to use the machine on pairs of plates taken for photographic survey but not intended originally for the stereoscopic method.

The positions of the camera stations, and of at least two control points in each field, must be fixed and referred to the main triangulation. The calculated coordinates of these points, plotted on the board, permit the adjustment of the board on the machine.

The machine is operated by two persons. One sits at the stereocomparator and manipulates the hand and foot wheels. The second stands over the drawing board to see that the point is actually tracing, and inserts the necessary conventional signs, figures of contours, etc.

Although the moving parts must weigh many hundreds of pounds, the movement is very smooth and easy, so that settings are made with all the precision of a micrometer. Friction is relieved everywhere by ball or roller bearings, and a very high degree of optical and mechanical accuracy has been achieved.

The Photo-Theodolite.

The tripod seems to be rather heavy and clumsy, and inferior to the standard British pattern. It has a centering head and upper plate with leveling screws. There is a central sleeve into which the cylindrical base of the camera drops, and can be clamped.

The camera body is of cast aluminium alloy. It works at fixed focus, defined by worked stops whose plane is perpendicular to the optical axis. Here, and generally throughout the construction, there are no adjustments. Everything depends on the original accuracy of workmanship, which is not in accordance with what is generally thought to be the best practice. The vertical and horizontal through the optical centre of the plate are defined by very small holes drilled in the stops, which produce small well-defined circular dots on the edges of the plate. Pierced circular drums revolving almost in contact with the lower edge of the plate record automatically the number of the station and of the plate, and the focal length of the objective.

The objective is fitted with a yellow screen, and with a lens of small power slightly excentric in front, whose rotation provides a means of adjusting the

horizontal collimation. The objective is carried on a rising front with stops working in a series of holes, and the front carries two arms extending backwards to the plane of the plate to mark the position of the horizontal through the optical centre.

A theodolite is mounted on top of the camera, with horizontal circle reading to 50 centesimal seconds, or $16''$, by verniers. It can be set by stops to read 0° , 100° , or $100 \pm 35^\circ$, or can be set to any other angle by the horizontal circle. Vertical angles are read to the same degree of accuracy. The telescope of the theodolite has internal focussing by a third lens, and the horizontal collimation is adjusted by the same device of an excentric lens. There is no adjustment to the horizontal axis for level.

For measuring the length of the base the theodolite can be rotated by a micrometer screw with hemispherical point acting on the hardened flat face of an arm which is fixed to the theodolite. The head of the screw therefore reads tangents of the angle of rotation, and allows direct readings on a stadia rod mounted at the other extremity of the base perpendicular to its length. This is elegant, but since the point of the screw works up and down the surface, it seems to be likely to wear a groove, and I understand that the French do not consider it sound.

There is a figure of the theodolite and camera, with further details, in the description by M. Paul Corbin published in the *Revue des Sciences pures et appliquées*, 30 March 1914.

The plates used are 18 cm. $\times$ 13 cm. They are very fine-grained slow plates, orthochromatic on patent plate glass.

STEREOGRAPHIC SURVEY: THE AUTOCARTOGRAPH

Lieut.-Col. M. N. MacLeod, D.S.O., R.E.

*Read with the preceding paper at the Afternoon Meeting of the Society,
13 February 1922.*

THE autocartograph is an apparatus designed by Professor R. Hugershoff, Professor of Geodesy at Dresden University, for applying the principles of stereogrammetry to aerial photographs. Until lately this principle has only been used with photographs which are taken exactly parallel and horizontal. Orel's stereoautograph applied it to photographs which are not exactly parallel, but which must be horizontal. Hugershoff claims to advance a step further and apply it to any two photographs which are sufficiently parallel to give the stereoscopic effect of relief. The autocartograph is designed to correct automatically both for non-parallelism and for tilt.

This is effected by the employment of an instrument called by the Germans a "Bildmesstheodolit." It will be advisable therefore to give a brief description of this instrument as a preliminary to that of the autocartograph itself. The Bildmesstheodolit, in its original form, consists of a telescope of low power mounted so as to rotate about two axes, one