Model 675–676	Time 45 minutes
Model 676–677	Time 45 minutes
Model 677–678	Time 50 minutes

The average time thus required was between 45 and 50 minutes. It should be noted that the tips and tilts in these pictures were in the neighborhood of 2 to 3 degrees. Furthermore, crab was present to a large extent.

During a bridging operation on the Stereoplanigraph, the models in a long bridge generally "drop off" giving rise to what is known as a *BZ* curve. After the elevations read during this vertical extension are corrected by the *BZ* curve, the corrected elevations along the line of flight can be used in the Kelsh Plotter for the *BZ* solution.

This method of transferring absolute orientation will make possible the setting up of models in the Kelsh Plotters that could not heretofore be cleared due to extensive water areas. They can now be set up in the Stereoplanigraph and quickly transferred to the Kelsh Plotters.

The method is comparatively simple and straight-forward and is not demanding of any particular great skill or dexterity to be fully utilized. It seems, therefore, that no difficulty should be experienced in training operators to follow this procedure.

PHOTOGRAMMETRIC ENGINEERING WITH A WILD PHOTOTHEODOLITE

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Abstract

In using a Wild Phototheodolite for mapping construction sites of a Hydro-Electric Scheme in the Australian Alps, it was found that the amount of field and office time will be reduced through using several tabulations. Time is always scarce when working on construction schemes. So the tables in the paper may be helpful. A new method for increasing the plotting range of the Wild A5 for terrestrial photogrammetry is also given.

TERRESTRIAL photogrammetry will make possible preparing large-scale maps of high accuracy in mountainous areas at comparatively low cost. Therefore this oldest branch of photogrammetry is still alive. As at the Boulder Dam in USA and at most of the hydro-electric schemes in the European Alps, the Snowy Mountains Hydro-Electric Authority uses terrestrial photogrammetry for large-scale mapping of various construction sites in the Australian Alps. The equipment consists of a Wild phototheodolite (plate size 10×15 cm.), 24 plateholders in two boxes, three tripods, a 2-meter subtense bar, a Wild Rangefinder (from 110 ft.–1,600 ft.) and an Abney Level. (A second phototheodolite has just arrived.) A Wild Autograph is used in the plotting.

Among the objects photographed are dam and shaft sites; excavations for dams and power stations and road; and construction camp sites. The phototheodolite is especially helfpul in checking and recording the progress in excavation and construction. This work during photographing is not interrupted or only briefly. The entire survey is completed in one or two days, thus giving an exactly timed record. The scale of the stereogram (Autograph plot) ranges from 1:120 to 1:2,400, with contour intervals of from 1 foot to 10 feet. At this scale the engineer will get all details for investigation and construction.

For this large-scale survey of important construction sites no gaps should occur. Accordingly the length of the base and the various swings and tilts must be determined exactly. The distances N and F to the nearest and farthest point of the area to be photographed are measured with the Wild rangefinder. The base length is then found according to the well known formula

$$\frac{F}{15} < b < \frac{N}{4}.$$

In planning for and in the construction of important construction projects, it is advisable, and frequently essential, to reduce the time requirement to a minimum. The following auxiliary tables for the Wild Phototheodolite and Wild A5 were prepared for reducing this time requirement. They have been of great value in both field and office operations.

Before "photographing a base," where A is the left and B is the right station, the swing or swings of the stereoscopic models together with their tilts must be determined, thus covering the whole area to be mapped. A model is built up between the *right* edge of the *left* photograph taken at the left station A and the *left* edge of the *right* photograph taken at the right station B. The picture angle of such a model is about 44 degrees corresponding to the picture angle of a single photograph. To get an overlap within the various models, the angle between their swings must be smaller than 44 degrees. The usual angle is 30° thus giving an overlap of 14°, but the size of the overlapped area depends also on the lengths of the base (Figure 1).

SWING AND TILT ANGLE

To find the angle of a swing—always measured from the perpendicular to the baseline—and to check the boundary of the various models, Table 1 is used.

Example of the Use of Table 1.—The right boundary of the area (right edge of model) is found on A at 308° with zero reading to B. The left boundary on B is found at 30° with zero reading to A. From Table 1 there is obtained for 308° at A a swing of 20°R, and for 30° at B a swing of 40°L. The photographs will be taken at 40°L, 10°L and 20°R. The setting of the horizontal circle will be: at A, telescope pointed to B, 130°, 100° and 70°. At B, telescope pointed to A, 310°, 280°, and 250°.

As the camera can also be tilted, the

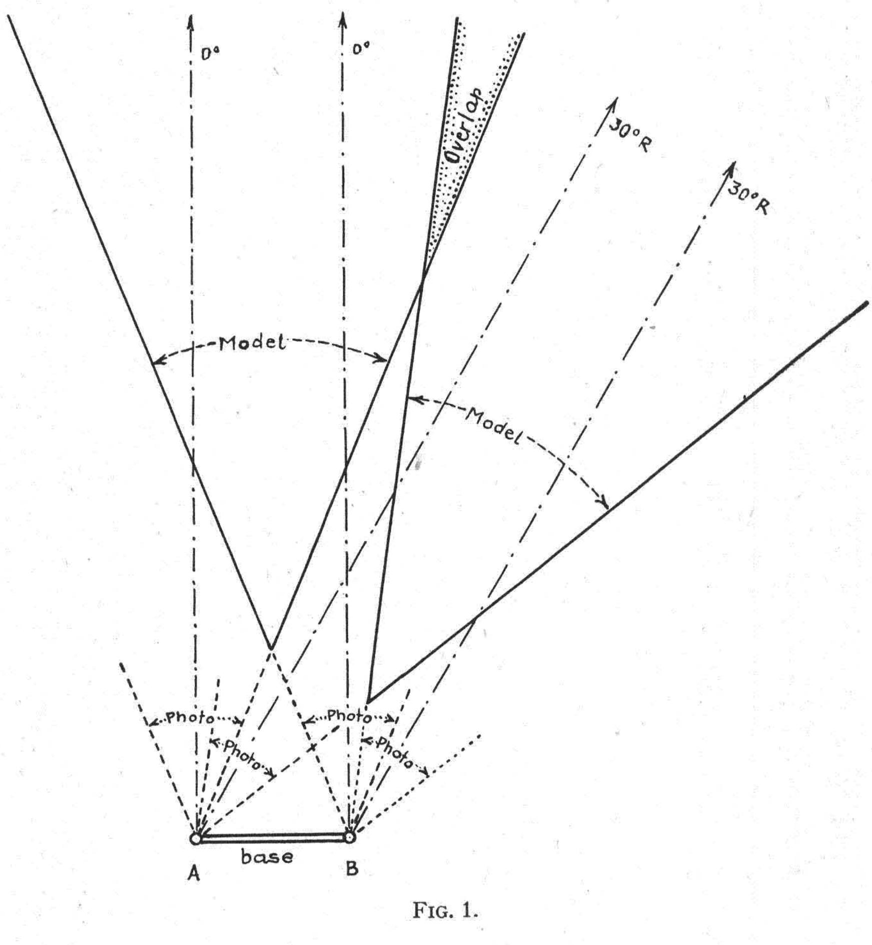

FIG. 1.

TABLE 1

(Zero reading to B) Edge of		A		(Zero reading to A) Edge of		B	
Model at	Photograph at	Swing	Setting to B	Model at	Photograph at	Swing	Setting to A
252°	208°	40° Left	130°	28°	72°	40° Left	310°
257°	213°	35° L	125°	33°	77°	35° L	305°
262°	218°	30° L	120°	38°	82°	30° L	300°
267°	223°	25° L	115°	43°	87°	25° L	295°
272°	228°	20° L	110°	48°	92°	20° L	290°
277°	233°	15° L	105°	53°	97°	15° L	285°
282°	238°	10° L	100°	58°	102°	10° L	280°
287°	243°	5° L	95°	63°	107°	5° L	275°
292°	248°	0°	90°	68°	112°	0°	270°
297°	253°	5° Right	85°	73°	117°	5° Right	265°
302°	258°	10° R	80°	78°	122°	10° R	260°
307°	263°	15° R	75°	83°	127°	15° R	255°
312°	268°	20° R	70°	88°	132°	20° R	250°
317°	273°	25° R	65°	93°	137°	25° R	245°
322°	278°	30° R	60°	98°	142°	30° R	240°
327°	283°	35° R	55°	103°	147°	35° R	235°
332°	288°	40° R	50°	108°	152°	40° R	230°

favorable tilt or tilts have to be found. The vertical picture angle is 27.7°. The prefixed tilt positions of the camera are in grads: $+7^g$, 0^g, -7^g, -14^g, -21^g, -28^g, thus giving the data in Table 2.

Example of the Use of Table 2.—The upper limit of the area to be photographed is found at +12° and the lower one at −30°. There will be two tilts, 0^g and 21^g with an overlap between them.

THE AUTOGRAPH SCALE

The autograph scale of the model is prescribed by the range of the movement of the *Z*-carriage in the autograph. The normal range is from 114 mm. to 500 mm. measured from the center of projection representing the camera objective. But with the plate-carriers tilted -28^g the range will be only 206 mm. to 500 mm. The

TABLE 2

Tilt	Upper Edge	Lower Edge
$+7^g$	+20°09′	− 7°33′
0^g	+13°51′	−13°51′
-7^g	+ 7°33′	−20°09′
-14^g	+ 1°15′	−26°27′
-21^g	− 5°03′	−32°45′
-28^g	−11°21′	−39°03′

ratios

$$\frac{\text{114 mm. (or 206 mm. resp.)}}{\text{minimum distance}} \quad \text{and} \quad \frac{\text{500 mm.}}{\text{max. distance}}$$

determine the scale ratio for the autograph scale. In Table 3 the minimum and maximum distances corresponding to various autograph scales are listed.

In choosing the autograph scale it is necessary to have in mind the drawing scale, because the ratio of autograph scale to drawing scale must be one of the ratios of the transmission gear autograph drawing table. (Table 4)

Example of the Use of Table 3.—(1) Minimum distance 220 ft., maximum distance 480 ft. and tilt -28^g gives an autograph scale 1:300.

(2) Minimum distance 450 ft., maximum distance 1,350 ft. and tilt -28^g gives two autograph scales for this model: for the foreground 1:600 and for the background 1:900.

Example of the Use of Table 4.—Autograph scale, $1/A=1:600$; drawing scale, $1/D=1:900$

$$\frac{D}{A}=\frac{900}{600}=\frac{3}{2}.$$

Upper knobs: position 2
Lower knobs: position 1 and doubled.

TABLE 3

Distances			Scale
Minimum		Maximum	
0^g tilt	-28^g tilt		
37 ft.	67 ft.	164 ft.	1:100
45	81	197	120
56	101	246	150
67	122	295	180
75	135	328	200
90	162	394	240
94	169	410	250
112	202	492	300
135	243	590	360
150	271	656	400
168	304	738	450
180	325	787	480
187	337	820	500
224	404	984	600
269	485	1,181	720
299	539	1,312	800
314	567	1,378	840
337	608	1,476	900
359	647	1,575	960
370	669	1,624	990
741	1,338	3,248	1,980
1,111	2,007	4,872	2,970
1,481	2,676	6,496	3,960
2,222	4,015	9,744	5,940
2,962	5,353	12,992	7,920
4,443	8,029	19,488	11,880
5,924	10,706	25,984	15,840

TABLE 4

RATIO U OF TRANSMISSION GEAR AUTOGRAPH→DRAWING TABLE

Ratio $\frac{D}{A}$	Position	
	Upper knobs	Lower knobs
1:1	1	1
1:2	3	2
1:3	1	3
1:4	3	3
1:6	1	D3
1:8	3	D3
2:1	2	2
2:3	1	2
3:1	2	1
3:2	2	D1
3:4	3	1
3:8	3	D1

THE DRAWING SCALE

Up to date the scale used in plotting an area surveyed with a phototheodolite has been limited by following three factors:

(1) Range of the Z-carriage to scale of the autograph, $1/A$ (effective in the Y-direction of the drawing table),

(2) Transmission ratios, $U=D/A$, between autograph and drawing table,

(3) Range of the Y-carriage of the drawing table to scale of the drawing, $1/D$.

The point, $X=500.00$ mm., $Y=0.00$ mm., at the drawing table represents the center point of the base. At this point the stationary microscope is screwed on and the drawing sheet with the plotted center of the base is brought into coincidence. The maximum distance for plotting has been D meter, starting from the base. But the spatial range of the terrestrial models is usually large and so is the scale of most of the construction plans. Thus the large ratios of the transmission gear, $U=1:4$, 1:6 and 1:8, can hardly be applied without losing space on the drawing table. A large area of the expensive, non-shrinking drawing paper will be unused between the base and the foreground of the model. Otherwise the farthest area lies often beyond the range of the Y-carriage in this scale and has to be drawn in a smaller scale which has to be enlarged to the original scale by subsequent photographic process. Therefore Dipl.-Ing. A. Zvirgzdins, Melbourne has recently suggested shifting the center point of the base beyond the drawing table. The drawing sheet is brought into correct position by means of two or more points plotted on the sheet, and situated along the known bearing of the model a suitable distance from the base center. The nearest point N is brought into coincidence with the stationary microscope, and the next one P with the movable microscope of the Y-carriage of the drawing table. When the connection is made between autograph and drawing table, the distance d(mm.) between the center of the base and the point N has to be taken into consideration, when setting the movable microscope at Y,

$$Y = z\frac{A}{D} - d,$$

where z is the reading at the z-carriage of the autograph, $1/A$ is the autograph scale and $1/D$ the drawing scale.

Zvirgzdins' suggestion increases the plotting range of the autograph consider-

TABLE 5

Scale	Feet into mm.	mm. into feet	
1: 100	3.047 994 72	0.328 084 56	
120	2.539 995 60	0.393 701 47	10 feet to 1 inch
150	2.031 996 48	0.492 126 84	12.5 feet to 1 inch
180	1.693 330 40	0.590 552 20	15 feet to 1 inch
200	1.523 997 36	0.656 169 12	
240	1.269 997 60	0.787 402 94	20 feet to 1 inch
250	1.219 197 89	0.820 211 40	
300	1.015 998 24	0.984 253 67	25 feet to 1 inch
360	0.846 665 20	1.181 104 41	30 feet to 1 inch
400	0.761 998 68	1.312 338 23	
450	0.677 332 16	1.476 380 51	37.5 feet to 1 inch
480	0.634 998 90	1.574 805 88	40 feet to 1 inch
500	0.609 598 94	1.640 422 79	
540	0.564 443 47	1.771 656 61	45 feet to 1 inch
600	0.507 998 12	1.968 507 35	50 feet to 1 inch
720	0.423 332 60	2.362 208 82	60 feet to 1 inch
800	0.380 999 34	2.624 676 46	
840	0.362 856 51	2.755 910 29	70 feet to 1 inch
900	0.338 666 08	2.952 761 02	75 feet to 1 inch
960	0.317 499 45	3.149 611 76	80 feet to 1 inch
990	0.307 878 25	3.248 037 12	
1,980	0.153 939 13	6.496 074 25	32 inches to 1 mile
2,970	0.115 454 35	9.744 111 37	24 inches to 1 mile
3,960	0.076 969 56	12.992 148 50	16 inches to 1 mile
5,940	0.057 727 17	19.488 222 74	12 inches to 1 mile
7,290	0.038 484 78	25.984 296 99	8 inches to 1 mile
11,880	0.028 863 59	38.976 445 49	6 inches to 1 mile
15,840	0.019 242 39	51.968 593 99	4 inches to 1 mile

TABLE 6

Scale	1 foot	1 inch	1 mm.	0.1 mm.
1: 100	3.05 mm.	0.25 mm.	0.33 feet	0.4 inch
120	2.54	0.21	0.39	0.5
150	2.03	0.17	0.49	0.6
180	1.69	0.14	0.59	0.7
200	1.52	0.13	0.66	0.8
240	1.27	0.11	0.79	0.9
250	1.22	0.10	0.82	1.0
300	1.01	0.08	0.98	1.2
360	0.85	0.07	1.18	1.4
400	0.76	0.06	1.31	1.5
450	0.68	0.06	1.48	1.8
480	0.63	0.05	1.57	1.9
500	0.61	0.05	1.64	2.0
540	0.56	0.05	1.77	2.1
600	0.51	0.04	1.97	2.4
720	0.42	0.03	2.36	2.8
800	0.38	0.03	2.62	3.1
840	0.36	0.03	2.76	3.3
900	0.34	0.03	2.95	3.5
960	0.32	0.03	3.15	3.8
990	0.31	0.03	3.25	3.9
1,980	0.15	0.01	6.50	7.8
2,970	0.12	0.01	9.74	11.7
3,960	0.077	0.006	12.99	15.6
5,940	0.058	0.005	19.49	23.4
7,920	0.038	0.003	25.98	31.1
11,880	0.029	0.002	38.98	46.8
15,840	0.019	0.001	51.97	62.3

ably, because factor (3) is now without any influence on the scale.

SCALE FACTORS

The measuring devices of the Wild Autograph A5 are in the metric system. The coordinates, the lengths of the base, the difference in elevation of its terminals *A* and *B* and the heights of the contour lines have to be converted into mm. according to the drawing or autograph scale respectively. The conversion factors for the usual scales are listed in Table 5. These conversion factors are based on Sears, Jolly and Johnson Value, 1927 (see "*Phil. Trans.*" A-Series, Vol. 227/1928).

1 meter = 3.280 845 58 feet, imperial
= 39.370 147 inches imperial

Example:

b = 1,000 feet and autograph scale 1:600
b' = 508.00 mm.
b' = 500 mm. and autograph scale 1:900, b = 1 476.38 feet.

During plotting it is desirable to know the values of one foot, or one inch, equivalent to mm. in plotting scale and vice versa. For this purpose Table 6 is used.

BASE COMPONENTS

The setting of the base components for the various swings is computed according to following formulas:

$$b_x = b' \cos\phi; \quad b_{z_1} = -b_{z_2} = b'\tfrac{1}{2}\sin\phi;$$

Left swing: $b_{z_1} = +$; $b_{z_2} = -$; Right swing: $b_{z_1} = -$; $b_{z_2} = +$.

The values of the trigonometrical function for the usual swing angles are given in Table 7.

TABLE 7

Swing	b_x cos ϕ	b_z $\frac{1}{2}$ sin ϕ
5°	0.996°195′	0.043°578′
10°	0.984 808	0.086 824
15°	0.965 926	0.129 410
20°	0.939 693	0.171 010
25°	0.906 308	0.211 309
30°	0.866 025	0.250 000
35°	0.819 152	0.286 788
40°	0.766 044	0.321 394

Example: b' = 50 mm.
ϕ = 20° right
b_x = 46.98 mm.
b_{z_1} = 91.45 mm.
b_{z_2} = 8.55 mm.

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NEWS NOTE

BAUSCH & LOMB WINS PATENT SUIT COVERING 60 MM TELESCOPE

A final judgment has been entered in the case of Bausch & Lomb Optical Co., Rochester, N. Y. vs. Bushnell Optical Corp., Pasadena, Calif. in the United States District Court at Los Angeles.

Bausch & Lomb had sued the Bushnell concern for infringement of patents covering the Bausch & Lomb 60 MM "Balscope Sr." telescope, a compact, lightweight scope which was designed for amateur astronomers, bird students, target shooters and general viewing purposes. The patents were held valid and infringed by one model of the imported Bushnell "Spacemaster" spotting scope.

In the settlement of the case, Bushnell paid royalties for past infringement and agreed to change the structure of its spotting scopes so as not to infringe the Bausch & Lomb patents.