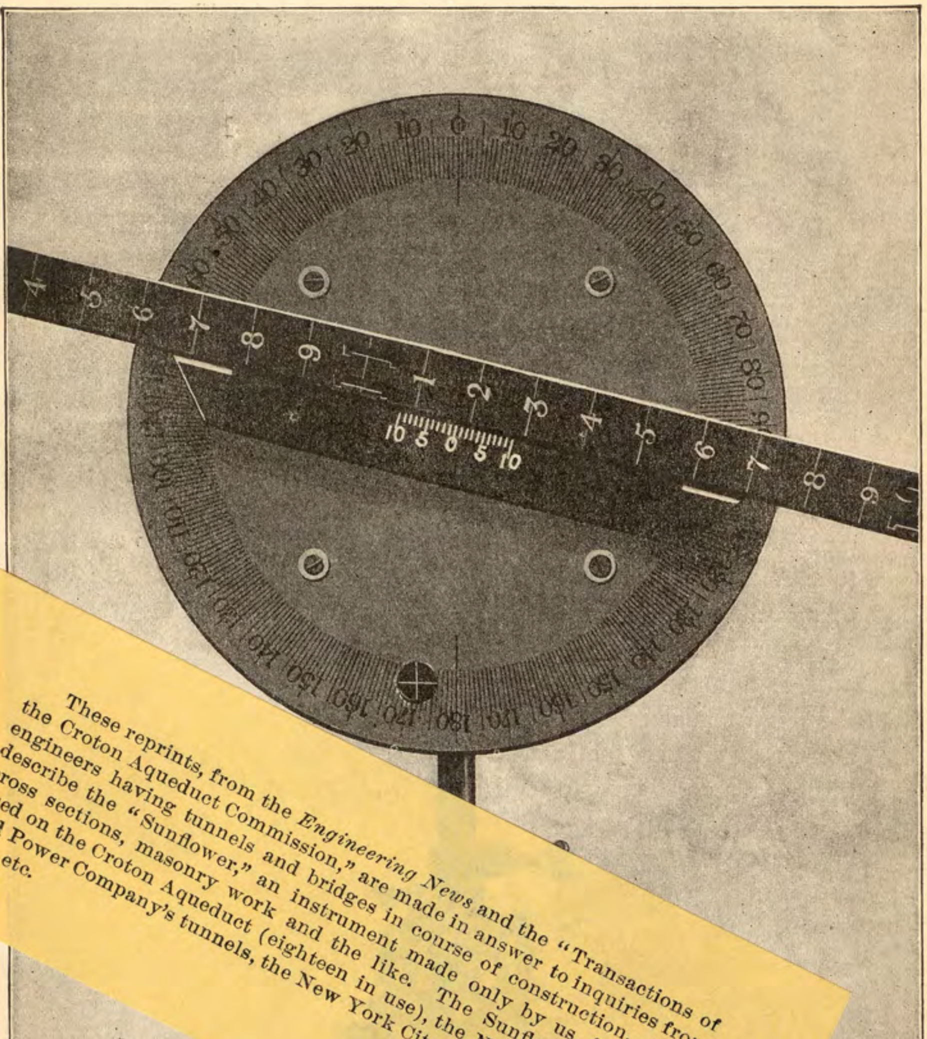
HELLER *and* BRIGHTLY'S

SUNFLOWER

FOR MAKING CROSS SECTIONS OF TUNNELS



These reprints, from the *Engineering News* and the "Transactions of the Croton Aqueduct Commission," are made in answer to inquiries from engineers having tunnels and bridges in course of construction. They describe the "Sunflower," an instrument made only by us, for tunnel cross sections, masonry work and the like. The Sunflower has been used on the Croton Aqueduct (eighteen in use), the Niagara Falls Light and Power Company's tunnels, the New York City Rapid Transit tunnels, etc., etc.

HELLER & BRIGHTLY.

Heller *and* Brightly, Philadelphia, Pa.

THE SUNFLOWER,

Or Disk for Measuring Cross-Sections in Tunnels

NEW CROTON AQUEDUCT.

[Made by HELLER & BRIGHTLY, Philadelphia.]

[From "The Transactions of the Croton Aqueduct Commission."]*

The ordinary practice of measuring the sections of a tunnel is often slow and tedious, particularly so when it is necessary to repeat them every ten feet or less, in a tunnel having a large sectional area; but to reduce this labor to a minimum the disk-measure was designed for the New Croton Aqueduct, where it is generally known as the "Sunflower." It is also useful for testing masonry work after centres are struck, to note if any settlement or distortion has taken place.

This instrument consists of a disk firmly secured to cross-pieces of wood, supported by braces *c*, which are riveted to the tube *d*. This tube, when placed in position on tripod-head, can be moved vertically, and secured to any height desired by the clamp-screw A. The disk *a*, and cross-pieces *b*, and "indicating-arm" *e*, are made of wood, but all other parts are brass.

Figure 1 is a vertical section through the "Sunflower," *a* being the disk, which is ¼ of an inch thick and 14 inches in diameter, firmly secured to cross-pieces *b*, which are 2½ inches wide and ¾ of an inch in thickness. Figure 3 represents back of disk and frame, and to the latter a circular band, *g*, is fastened with screws. This band is ⅛ of an inch thick and ¾ of an inch wide. The vertical and horizontal braces *c*, in Figs. 1 and 4, are secured to this band at *i* in Fig. 3. The space between disk and vertical tube *d*, to which the braces are riveted, is 2⅝ inches. This tube is ¾ of an inch in diameter and three feet long. The face of disk shown in Fig. 2 is graduated into degrees, from 0° to 180°. Bearing plates are inserted on face and back of disk at axis shown by black lines at *k*, Fig. 4.

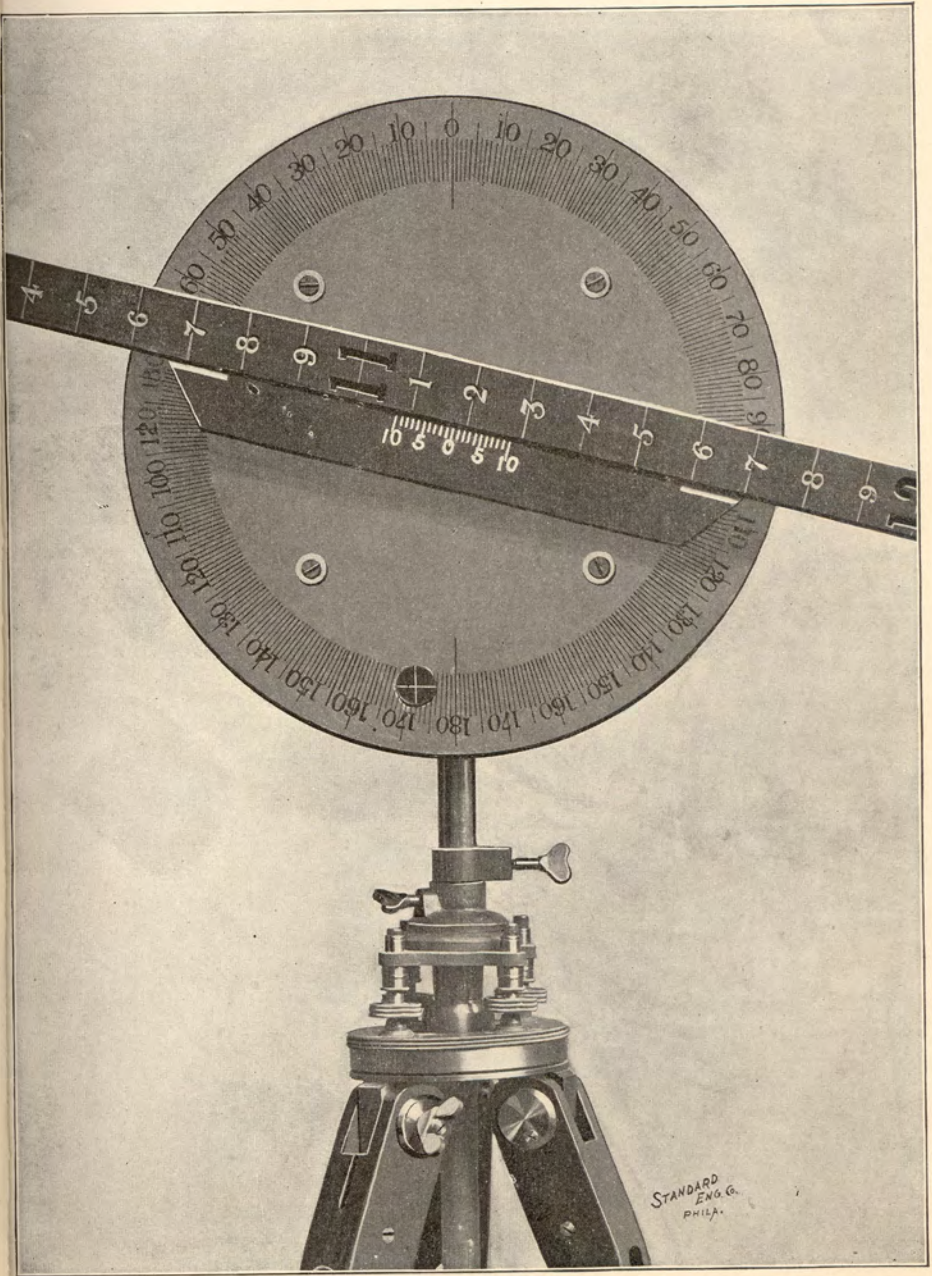
---

* This Report of the Commission was also printed in THE SANITARY ENGINEER AND CONSTRUCTION RECORD, New York, June 11, 1887.

HELLER & BRIGHTLY'S SUNFLOWER

(WITH QUICK-LEVELING TRIPOD AND EXTENSION LEGS.)

AN INSTRUMENT FOR **MAKING CROSS-SECTIONS** OF **TUNNELS**, ALSO FOR **TESTING MASONRY WORK** AFTER THE **CENTRES** ARE **STRUCK**.

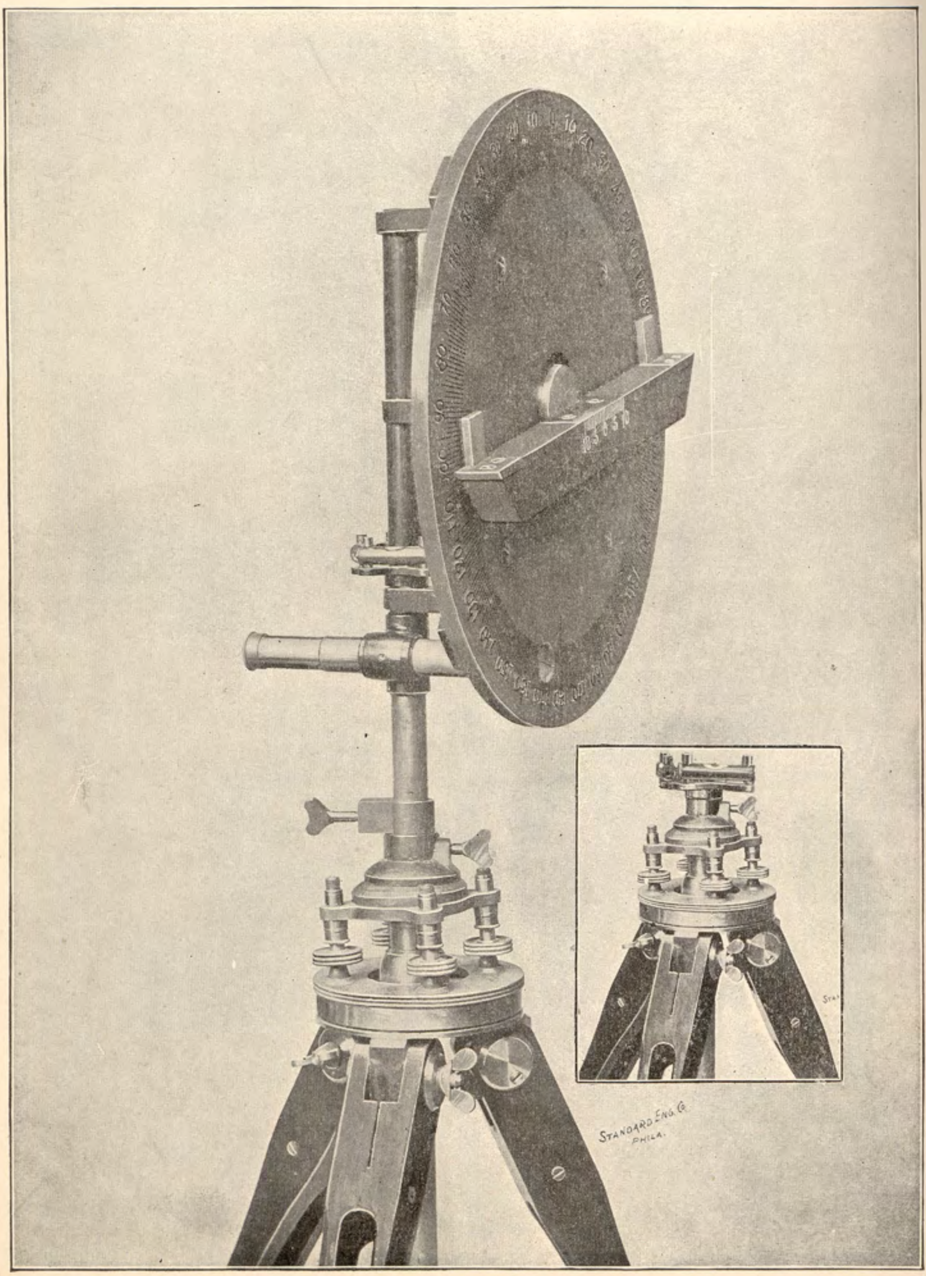


MADE BY **HELLER & BRIGHTLY**, PHILADELPHIA, PA.

HELLER & BRIGHTLY'S **SUNFLOWER**

(WITH QUICK-LEVELING TRIPOD AND EXTENSION LEGS.)

AN INSTRUMENT FOR **MAKING CROSS-SECTIONS** OF **TUNNELS**, ALSO FOR **TESTING MASONRY WORK** AFTER THE **CENTRES** ARE **STRUCK**.



MADE BY **HELLER & BRIGHTLY**, PHILADELPHIA, PA.

THE SMALL FIGURE SHOWS THE REMOVABLE LEVELING ARRANGEMENT.

ENGINEERING NEWS

AND

RAILWAY JOURNAL

ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL

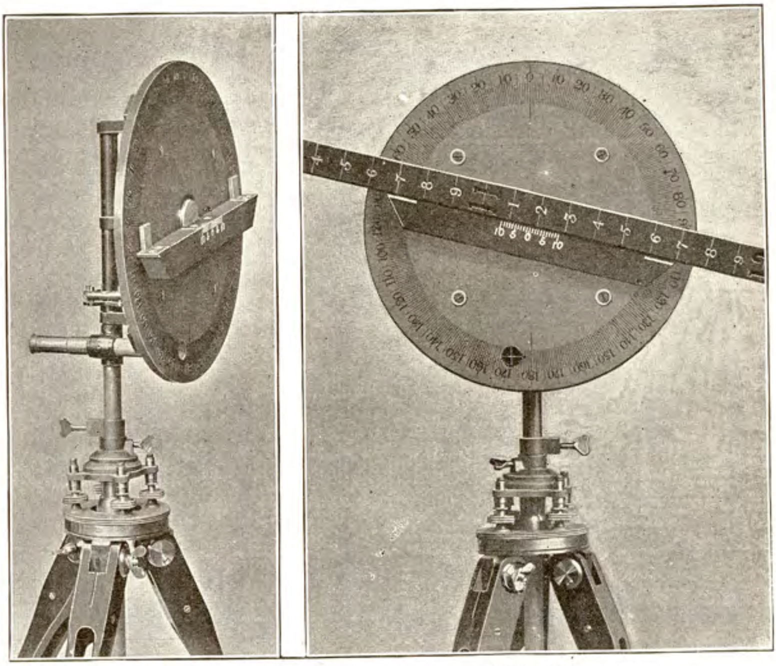
Volume XLV. No. 11. — NEW YORK, THURSDAY, MARCH 14, 1901. — $5.00 per Year. Single Copies, 15 Cents.

THE "SUNFLOWER" TUNNEL CROSS-SECTIONER

As engineers well know, the testing, or cross-sectioning, of tunnel work is a tedious operation under ordinary methods and where accuracy is required. In the construction of the Croton Aqueduct, Mr. Alfred Craven, M. Am. Soc. C. E., and now Division Engineer for the Aqueduct Commission, suggested a form of instrument for this work that has been put upon the market by Heller & Brightly, instrument manufacturers, of Philadelphia, Pa. The original instrument employed on the Croton Aqueduct was fully described in ENGINEERING NEWS of July 26, 1890, but its design and construction have been modified considerably, as will be seen by comparing the accompanying illustration with that published in our previous article. For this reason, and also because it is an unusually compact and convenient device for its purpose, we describe it briefly in this issue.

The prominent feature of the instrument is a wooden disk, 14 ins. diameter and ¼-in. thick, braced at the back to prevent warping; and from this disk the device takes its trade-name of "Sunflower." This disk, graduated on the front to degrees, numbered from 0 to 180, is supported vertically by a tubular rod, on an extension-leg tripod fitted with a quick-leveling head. Attached to the center of the disk is a revolving, metal-shod, wooden "indicating arm;" and on this arm slides a graduated tapering wooden rod either 8 or 14 feet long. These rods, however, may be of any length. Those used on the Rapid Transit Tunnel, in New York, are 20 feet long. Through the disk and attached to the tubular support is a horizonal sighting-tube, with cross-wires, which enables the user to set the center of the disk accurately upon the tunnel axis.

In use, the tubular support is set exactly plumb by two small levels at right-angles to each other. The disk can then be adjusted to any height and secured by clamp-screws; and with its center upon the tunnel axis, the measuring rod (placed on the indicating arm) measures the distance between the center of the disk and the perimeter of the tunnel at as many points in that plane as may be desired.



SIDE VIEW — FRONT VIEW

A NEW INSTRUMENT FOR MEASURING TUNNEL CROSS-SECTIONS

The disk with its attachments weighs 10 lbs., and the tripod and its head weigh 10¼ lbs., making 20¼ lbs. of total weight. In the Croton Aqueduct tunnels, from 6 to 10 minutes were sufficient for measuring a section. As the angles and distances are conveniently plotted with a protractor, the area can be measured with a planimeter. This device is also useful for testing masonry arches after the centers are struck, and for this purpose a vernier is placed upon the indicating arm for more precise measurement.

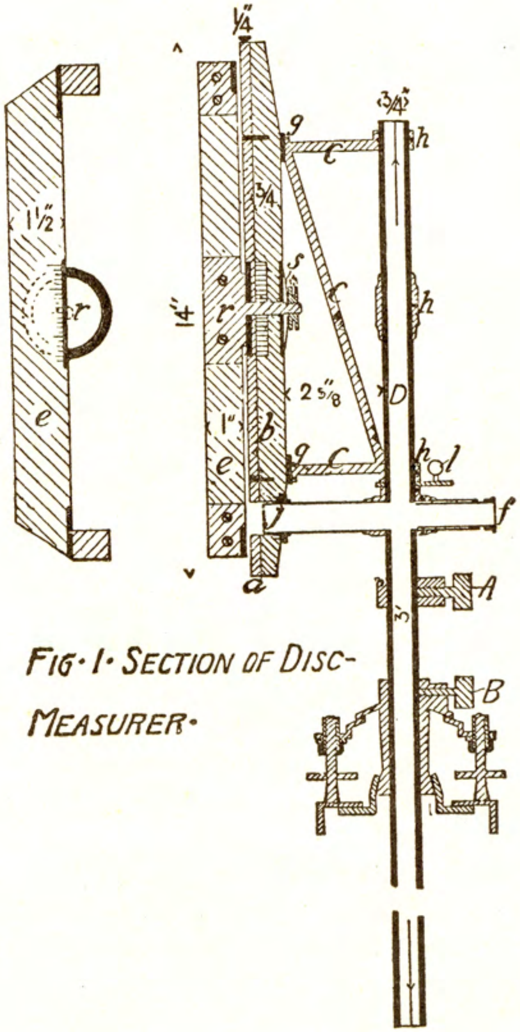
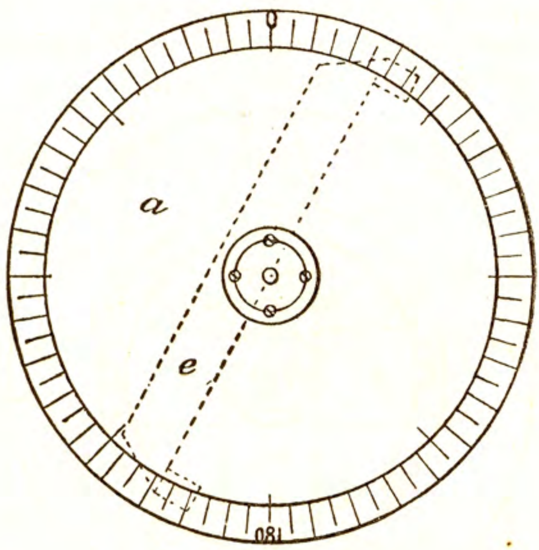


FIG. I. SECTION OF DISC-MEASURER.

Figure 4 is a horizontal section on an enlarged scale of *a*, *b*, and braces *c*, with the form of connecting the latter with the tube *d* at *h*. In Fig. 2 the dotted lines show the relative position of "indicating-arm," which is represented on plan at *e*, Fig. 1, detached from section. At each end of this "arm" brass plates project to aid in guiding the rod used in measuring the distance from the axis of the disk to the perimeter of the tunnel section. A vernier is marked on the "indicating-arm" for read-

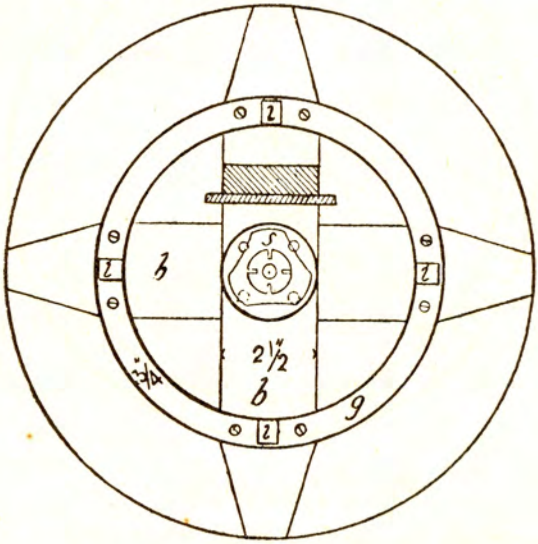


·FIG·2·FACE OF DISC·

ing distances less than half a tenth when desired for testing masonry work.

At the axis of the "indicating-arm" *r*, a solid piece of metal is firmly secured to the "indicator," and extends through to the back of the disk, where it is held in position by the spring *s* and a capstan-headed nut. This "indicator" is raised 1/8-inch from the disk by a shoulder, permitting it to revolve freely. In Fig. 3, *s* is a plan of a spring and capstan-headed nut. At *f*, Fig. 1, a longitudinal section of a "sight-tube" is shown, which consists of a plain tube with a small hole at *f* in the eye-piece, and vertical and horizontal cross-wires at *j*. Over this sighting-tube the leveling-bubbles are placed at *l*, and in plan on Fig. 6. Under the sighting-tube can be seen the clamp-screw A, which is movable on the tube *d*. When the Sunflower is set in position, this clamp rests on the tripod-head, and the disk can be raised or depressed to any desired height.

The clamp B is shown on the enlarged section of the tripod-head, Fig. 5. The black lines at *m m* represent a detached piece of metal, which is in horizontal section about $\frac{1}{32}$-inch less than a complete circle, thereby permitting the clamp B to secure the tube *d* in a firm position when the disk is set on the centre axis of the tunnel in position for measuring sections. The ball-and-socket joint is also shown in Fig. 5.



·FIG·3·BACK OF DISC·

Figure 6 is a section of a quick-leveling socket and a plan of the leveling bubbles.

This socket is a tube 5 inches long, closed at the lower end, except a small hole, which is to allow a cord to be passed through, to which a plumb-bob can be attached.

Two measuring-rods are furnished, made of pine, one being 8 feet and the other 14 feet long, 1 inch wide and 1⅜ inches in depth, made tapering in depth only from the centre to ⅝ of an inch at one end, to lessen the weight, having a metal shoe on the taper end to prevent injury when pressed against the rock face of the tunnel. The rods are divided in feet and tenths.

Directions for Using Sunflower:

The centre line of the tunnel is not preserved on the floor, where constant travel would disturb it, but by drilling holes in the roof about 50 feet apart. Into these holes pine plugs 1 ½ inches in diameter and 4 inches long are driven, and into each plug a horseshoe nail (with head flattened and having a centered eyelet), is inserted. Through the eyelets, telegraph wire is suspended vertically from two plugs, and kept in position by weights of about 25 pounds each (a stone will do). A horizontal wire can then be stretched between these two vertical ones, and will produce a

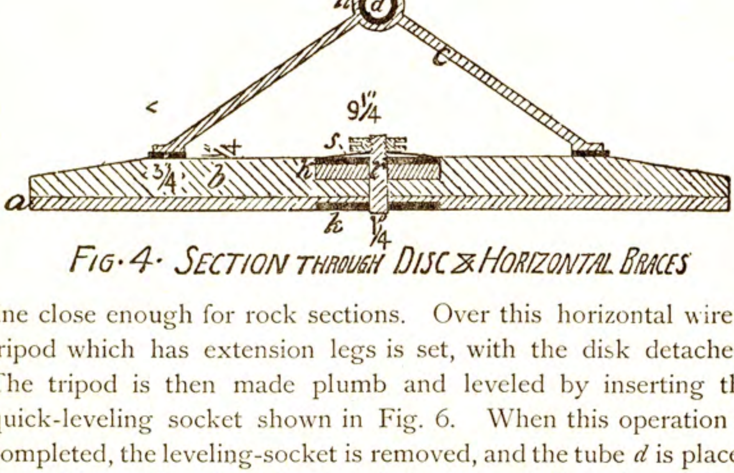
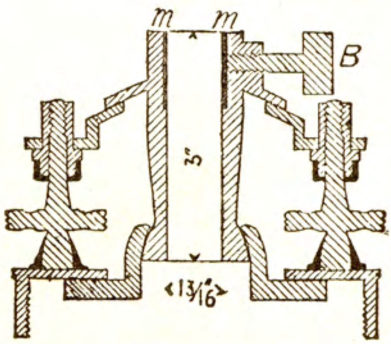


FIG. 4. SECTION THROUGH DISC & HORIZONTAL BRACES

line close enough for rock sections. Over this horizontal wire a tripod which has extension legs is set, with the disk detached. The tripod is then made plumb and leveled by inserting the quick-leveling socket shown in Fig. 6. When this operation is completed, the leveling-socket is removed, and the tube *d* is placed in position in the tripod-head, and the disk raised to the required elevation by sighting through the sight-tube to a leveling-rod held on the bench, and then fixed firm in elevation by the clamp-screw A.

The sight-tube is then turned in the direction of the vertical wire in advance of the instrument, which can be readily seen by the use of a lamp for that purpose, and fixed in position by the clamp-screw B. The disk will then be on the centre line, and in position at right angles with the central axis of the tunnel.

When more accuracy is required the line can be taken with a transit. The Sunflower is now ready for taking sections. The "indicating-arm" is set at 0°, and the measuring-rod (previously described), resting on the indicator, is extended to the perimeter of the section, and the distance is recorded. Then the indicator is moved to the next angle, the distance and angle recorded; this operation being repeated from 0° to 180°, when the rod is reversed and the opposite half of the section measured in the



FIG·5·ENLARGED SECTION THROUGH TRIPOD HEAD·

same manner. A copy of a field record is shown in Table II, and the plotting of the field notes illustrated in Fig. 8. The plotting can be done with any protractor.

Table I is the form used in the field books for recording the location of plugs driven in the roof of the tunnel for alignment. The first column is the station; the second, the number of the plug; the third, the elevation; the fourth, the roof grade, which is twelve inches above the intrado of the arch; the fifth and sixth columns, the height of the plug above or below this grade; the seventh, the name of person setting the plug; the eighth, the date; the ninth, the distance from the centered line.

TABLE I.

LIST OF THE PLUGS IN THE TUNNEL NORTH OF SHAFT NO. 29.

STATION	No.	Elevation.	Roof grade.	High.	Low.	Set by	Date.	From line	REMARKS
							1885.		
1482+46.19	16	177.47	174.29	3.18	...	C. T. F.	June 3	.....	
1481+85.74	17	185.38	183.37	2.01	...	C. T. F.	June 3	....	
1481+31.75	18	192.42	191.46	0.96	...	C. T. F.	June 3	......	Centre of shaft.
1480+98.74	19	198.397	196.41	1.99	...	M. C.	June 12	......	
1480+55.00	20	205.77	202.97	2.91	...	C. T. F.	June 12	......	Inside of shaft.
1479+87.48	21	213.30	213.10	0.20	...	H. C.	June 12	......	
1479+49.48	21	218.282	217.48	0.80	...	M. C.	Aug. 13	......	Screw blown out.

FIG. 6

QUICK LEVELING SOCKET

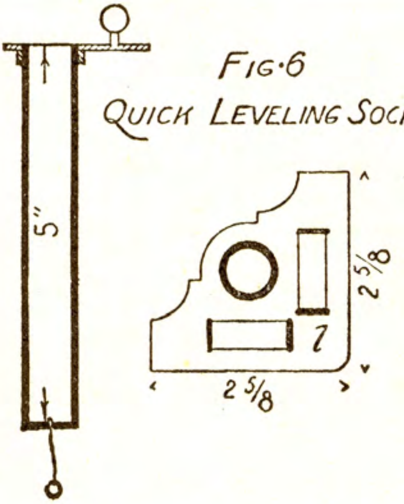


Table II represents a record of notes taken for rock excavation measured at two sections in the tunnel, with date and station of cross-section. The first and second columns give the angle and distance from centre of the disk to the perimeter of the cross-section on the east side; the second and third columns, a similar record for the west half of the cross-section. Left and right can be used in place of east and west to designate the division of the cross-section, but the latter is preferred, as it eliminates any doubt of the direction a field party may have been working in when taking the cross-sections, as the axis of the tunnel extends in a northerly or southerly direction. The note below the table, "Axis 2.2 below spring," indicates the elevation of the centre of the disk when the cross-sections were taken. The area of the cross-section can be correctly measured by setting the Sunflower at any point within the plane of the cross-section. Some engineers prefer to set the centre of the disk at a uniform elevation above or below the spring-line to give uniformity of the working-line, as ordinates can be calculated, giving the distance to the perimeter of section, a reference to which at the time of taking cross-section will determine if the excavation has conformed to the section required.

TABLE II.

November 18, 1886.				*December 27, 1886.*			
STATION 1483 + 20.				STATION 1482 + 20.			
EAST.		WEST.		EAST.		WEST.	
Deg.	Dist.	Deg.	Dist.	Deg.	Dist.	Deg.	Dist.
0	9.7	15	10.2	20	13.0	0	14.8
15	9.9	32	10.7	34	12.7	18	11.6
36	10.5	47	10.3	50	10.4	36	11.8
53	9.5	60	9.0	70	10.1	51	10.8
70	8.1	79	7.5	86	9.1	68	9.6
85	7.1	105	6.7	99	8.2	82	8.5
105	7.0	123	6.7	117	7.9	90	8.3
129	6.3	145	5.7	146	6.7	110	7.4
150	5.4	165	5.0	.....	.....	135	6.4
180	4.9	.....	......	.....	.....	150	5.2
.....	.....	.....	......	.....	.....	180	4.8
Axis 2.2 below spring of arch.				Axis 2.4 below spring of arch.			

Figures 8 and 9 represent the notes recorded in Table II, plotted to facilitate a correct computation of the areas. The form of the printed sheets used for that purpose is given in Fig. 8, with the angle of each measurement computed from the notes given in Table II. All sheets for this purpose are printed on a scale of 20 feet to 1 inch, the same scale as the arm of the protractor that is used for plotting. The axis from the spring-line is first marked on a sheet, then the centre of protractor put in position over it and pressed firmly down, which will project the pins through the paper and keep it in position, permitting the arm which revolves around the centre to be moved quickly to any point desired for plotting the notes of the cross-sections.

In Table III the field notes plotted on Fig. 8 are arranged for computing, the number of shaft, heading station and date of measurement being recorded. It is separated in two divisions, one for the east and the other for the west half of the section. The first column contains the numbers which designate the angle taken, and the second the factors required to compute the area of a triangle, which are the length of two sides and the included angle; the third column, the logarithm of the factors; and the fourth, the area. The westerly half is calculated in a similar manner; the amount of the two added together and divided by 2, will give area of the whole section. To diminish the labor of

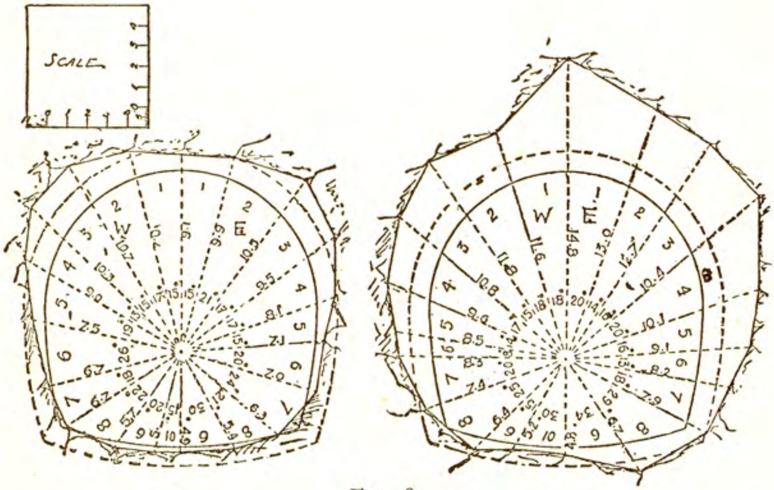


FIG. 8.

taking off the logarithms, two tables are prepared on separate sheets, one containing the copy of the logarithms of numbers from 1 to 20.9, advancing by tenths, and the other the logarithmic sines from one to sixty degrees, advancing by single degrees. The sheets in size are 8 x 10 inches. The sheet to contain the logarithms of numbers is divided into twelve columns, the ten intermediate columns being headed by the numerals 1 to 10, the first and last containing decimals 1 to 10, and the ten columns

TABLE III.

SHAFT NO. 29—HEADING STATION 1483 + 20. DATE OF MEASUREMENT, NOVEMBER 18, 1886.

EAST SIDE.				WEST SIDE.			
△	Factors.	Log.	Double Area.	△	Factors.	Log.	Double Area.
1	9.7	0.98677		1	9.7	0.98677	
	15°	9.41300			15°	9.41300	
	9.9	0.99564			10.2	1.00860	
		1.39541	24.854			1.40837	25.607
2	9.9	0.99564		2	10.2	1.00860	
	21°	9.55433			17°	9.46594	
	10.5	1.02119			10.7	1.02938	
		1.57116	37.252			1.50392	31.901
3	10.5	1.02119		3	10.7	1.02938	
	17°	9.46594			15°	9.41300	
	9.4	0.97772			10.3	1.01284	
		1.46485	29.161			1.45522	28.524
4	9.5	0.97772		4	10.3	1.01284	
	17°	9.46594			13°	9.35209	
	8.1	0.90849			9.	0.95424	
		1.35215	22.498			1.31917	20.852
5	8.1	0.90849		5	9.0	0.95424	
	13°	9.35200			19°	9.51264	
	7.1	0.85126			7.5	0.87506	
		1.11184	12.937			1.34194	21.976
6	7.1	0.85126		6	7.5	0.87506	
	20°	9.53405			26°	9.64184	
	7.0	0.84510			6.7	0.82608	
		1.23041	16.998			1.34298	22.028
7	7.0	0.84510		7	6.7	0.82608	
	24°	9.60931			18°	9.48998	
	6.3	0.79934			6.7	0.82608	
		1.25375	17.937			1.14204	13.868
8	6.3	0.79934		8	6.7	0.82608	
	21°	9.55433			22°	9.57358	
	5.4	0.73239			5.7	0.75588	
		1.08606	12.191			1.15554	14.306
9	5.4	0.73239		9	5.7	0.75588	
	30°	9.69897			20°	9.53405	
	4.9	0.69020			5.	0.69897	
		1.12156	13.230			0.98890	9.747
				10	5.0	0.69897	
			187.058		15°	9.41300	
			195.149		4.9	0.69020	
			2)382.207			0.80217	6.340
			Total Area, 191.103				195.149

between containing the logarithms. The sheet is separated into two parts, permitting the logarithms from 11 to 20 to be entered on the lower half.

On the other sheet is copied the logarithmic sines from one to sixty degrees. This is divided into eight columns, with the angles and sines placed in alternate columns. If the field notes are carefully plotted on the section sheets, the area can be computed quickly with a planimeter, and the variation from the correct area will be less than two-tenths for the whole section. The time required to measure a section of the tunnel with the "Sunflower" is from six to ten minutes. It was designed by Alfred Craven, a division engineer on the aqueduct. The weight of the disk, including all attachments, is ten pounds, and the tripod-head, with the tripod, having extension legs, $10\frac{1}{4}$ pounds, making a total of $20\frac{1}{4}$ pounds. It is manufactured by HELLER & BRIGHTLY, of Philadelphia. Two measuring-rods, eight and fourteen feet long, go with the instrument.